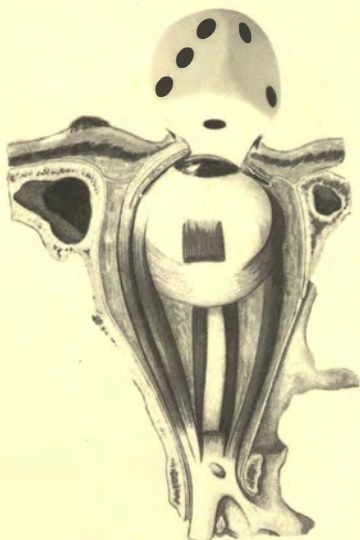


COLLAPSE

Philosophical Research and Development

VOLUME VIII



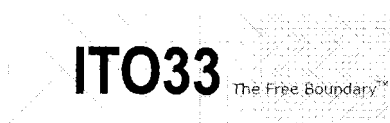
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COLLAPSE VIII

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COLLAPSE

Philosophical Research and Development

VOLUME VIII

Edited by

Robin Mackay



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COLLAPSE VIII

December 2014

EDITOR: Robin Mackay

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Editorial Introduction

Robin Mackay

The conceptualization of uncertain events as a set of possibilities each assigned a numerical value—a schema which draws on the circumstances that originally occasioned it, namely the game of chance, the die and its faces—is an enduring one. Although probability calculus was mathematically formalized in the 1930s, abstracted from this ‘occasional cause’, the spontaneous metaphysics of the gambler continue to exert an intuitive hold on thinking concerned with uncertain eventualities, colouring its interpretation and its application to diverse situations. Stripped of these semantics, the meaning of probability remains as enigmatic as ever: an idealized construct that neutralizes contingency by integrating infinite ‘trials’; or a real property, propensity, or ‘random generator’

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inherent in the real but inaccessible to us? A mode of knowledge, or a limit to knowing?

The asymmetry of the wager is dramatised in the figures of the naive punter who faces every roll of the die as a hazardous adventure, and the casino manager who controls the long game and never loses. On one hand chance may be figured as subjective epistemological shortfall, on the other as the object of statistical knowledge. This tension between knowledge and contingency is conceptually condensed in the notion of probability and latterly in that of risk—a concept belonging to a relatively recent intellectual history, but one with immense consequences for modernity.

In recent economic history, financial tools constructed on the basis of probability models in order to manipulate risk have presided over catastrophic failure, having generated conditions that surpassed the capacities of those models. Meanwhile, in gambling itself, an increasingly technically managed and controlled environment means that any calculation of the ‘odds’ must look beyond the confines of the gaming table. Noting this double obsolescence of the casino model, the eighth volume of **COLLAPSE** explores new ways of thinking risk and contingency outside the space of the idealized game of chance.

One of the colloquial legacies of the epoch-making financial crisis of 2008 has been the notion of ‘casino capitalism’. The term implies the squandering of

potentially productive resources on a game that is governed merely by chance; at the same time, it connotes an indictment of the asymmetrical allocation of the risks and rewards of such ‘wagers’. Without dismissing the indignation neatly conveyed by such a formulation, we might suggest that the notion of ‘casino capitalism’ has served to occlude the complexity of the financial instruments involved, and the exact nature of the financial system’s intrication with the political. Nevertheless, taking the phrase at its word serves usefully to call into question the actual relationship between gambling and finance; that is, between the complex probabilistic calculations employed within the world of finance and the games of chance from which the rudiments of this calculus originally emerged.

One of the initial impulses behind this volume of **COLLAPSE** was to unpack this righteous denunciation, to call its bluff by evaluating the extent to which the model of the casino—the game of chance—really does invest the field of finance; to investigate the ways in which chance, risk, contingency, and the wager integrally structure the global order. In parallel, however, the volume also asks whether the model of the game of chance encapsulated in probability theory obtains even *within* the casino, by way of a number of inquiries into the modern and contemporary history of the gambling industry. In this way we hope to interrogate

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and problematize what seems to be a pervasive image of thought.

In order to survey those practices in which intellectual resources are most acutely concentrated on the production and exploitation of risk, and to uncover the conceptual underpinnings of methods developed to extract value from contingency—in the casino, in the markets, in life—we have brought together contributors who extend the philosophical thinking of contingency beyond the ‘casino’ model, gamblers whose experience gives them the authority to considerably refine our understanding of what it means to master chance, researchers who analyse the operation and experience of risk in diverse arenas, and artists whose work addresses both the desire to confront chance and the desire to tame it by bringing it to order.

*

Our volume opens with **JEAN CAVAILLÈS**’s 1940 survey of the state of the art in probability theory in the first half of the twentieth century. Beyond its philosophical-historical interest, the text is invaluable for the way in which Cavallès, through a technical dissection of the core concepts of a nascent probability calculus, extracts some fundamental problematics that act as a guiding thread throughout the volume.

Cavaillès begins by observing that the model of probability based on games of chance extends itself, in the absence of explicit theoretical justification, into all areas of society ('in the techniques of social economy as much as in physics'). The fundamental grounds for this widespread application to reality are no less contentious today than when Cavaillès was writing. Formulating his critique of the first attempts to produce a mathematical formalization of probability to rival the axiomatisation of geometry, one that would ostensibly decouple probability from its gaming origins, Cavaillès remarks on how the spontaneous metaphysics of the gambler continue to exert an intuitive hold on statistical thought, colouring its interpretation and reflecting its intended applications. Inversely, he shows how, when probability is theorised for itself, certain elements of our intuitive grasp of the notion are inevitably lost, and empirical instances are subjected to certain idealisations. Cavaillès's prime example here is the notion of the *collective*, which transforms the game and its repeated trials (dice throws) into a completed (if infinite) set, in which results occur with a determinate frequency that converges toward a limit and is valid for any place-invariant subset of the collective. In this way probability is effectively submitted to elementary calculus—and yet of course a collective is not something that is ever encountered in any possible field of application. As he discerns, these

treatments tend despite themselves not so much to *explain* the principles of probability as to subtly codify the assumptions that make them *useful*.

Cavaillès's exposition continues with the observation that every wager presupposes the delimitation of a game and one's situation within it, and the stability of that game; a presupposition which constitutes a wager in itself. Thus 'the judgment of probability is always a wager, logically anterior to the production of the event to which it applies'. As he concludes, if 'old notions of chance' continually creep back into formalizations, vitiating their coherence, if probability continually 'overflows its definition', if the attempt to reassuringly house probability within a 'realist ontology' free of any abductive leaps fails, and if therefore, when it comes to probability, mathematical idealisation is involved in a continual dialectic with its applicability to real models, this is because the question of probability is not a regional but a *fundamental* problem for science—for prediction. The infinitude of the collective is a vicarious figure, within mathematical formalization, for the indeterminacy of a becoming whose future we seek to fix with laws; it stands in for a hypothesis that is fundamental for all scientific endeavour, 'where acts and wagers intersect each other' and where the success of each wager makes possible new acts. Cavaillès's conclusion grounds this process in the 'vital, extra-intellectual' character of hypothetical reasoning, and

calls for a recognition of the hybrid character of the wager: it 'is situated on the dividing line between pure lived action and autonomous speculation; at once an impulse toward the future, a recognition of radical novelty, risk; and, on the other hand, an attempt at domination through the imposition of an order, and the establishment of symmetries'. An obscure situation that invites 'a conceptual renewal in which the elements issuing from [the] analysis of the wager play the preponderant role'—a renewal toward which this volume hopes to contribute some orientating elements.

One of the most intriguing ways to encounter the disparity between idealised models and actual instances of games of chance is from the point of view of those who attempt to pry open the gap between the two. And there is no better authority to speak on this subject than **STEVE FORTE**, who granted **COLLAPSE** a very rare interview to discuss his career as a player and as a consultant in 'game protection'.

As Forte outlines, both the advantage player and the cheat, who seek to exploit extraneous elements in order to influence the game in their favour, and the casino protection operative, who seeks to detect and foil these exploits, recognise that the milieu of every game constitutes an 'information environment'. Whether through systematic knowledge, technology, perceptual training, or sheer discipline, the notional confines of the game are expanded by them to encompass a whole

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raft of factors that do not belong, as Forte says, to ‘the *theoretical* game’—including the physical equipment, the gaming environment, and the human elements therein.

Detailing a choice selection of exploits, Forte gives us an insight both into the skill and dedication necessary to beat the house, and that called for on the other side of the table to detect these scams. Every assumption about the ‘game of chance’ is challenged here: randomness is approximate, no shuffle is complete, even a dice throw can be controlled, biases can always be detected; disciplined observation and analysis has the potential to transform almost any game of chance into one of knowledge and skill. The scammer’s art extends to engineering the environment by stage-managing credible narratives, establishing routines for cover, manipulating expectations, and sometimes elaborate ‘turns’ designed to distract attention. While manufacturers of equipment and casino managers increasingly seek to establish systems to stabilise the gaming environment while maintaining an atmosphere conducive to play, gamblers continue to ‘scientifically dissect every component’ of the game. Forte assures us that, no matter how much protection is in place, new high-tech updates of the old scams will always appear, and that, once taken outside the realm of idealised chance and into the casino environment, the game is always operating across many overlapping milieus:

probabilistic, but also physical, psychological, social, and perceptual—as exemplified by the ‘linework’ of an unknown artist reproduced here from the collection of memorabilia built up by Forte throughout his career, and which serves as an appropriately subtle and deceptive figure for the cues, imperceptible to the average punter, that can tip the game in one’s favour.

By way of contrast, **NATASHA DOW SCHÜLL** describes a casino environment where automation and player control seem to be almost total, and where the very desire to win has itself morphed into something new and disturbing. Her research into the world of machine gambling, increasingly central to casino culture, charts the emergence of an industry which specialises in the precise targeting of a very particular set of psychological predilections quite different to those traditionally associated with the gambler. No longer either *agon* or *alea*, neither a test of skill nor a heroic submission to chance, the ‘game’ here seems to consist in a quest for nothingness, escape, or even self-erasure, in what machine gamblers call ‘the zone’—a state of continuous, immobile narcolepsy that technological solutions are rapidly evolving to deliver ever more reliably.

Through her dialogues with machine gamblers, Schüll develops a detailed phenomenological account of the zone. In parallel, her investigation into the industry shows how the development of aesthetics,

ergonomics and environmental cues to encourage 'zone' playing are complemented by a series of invisible adjustments to the probabilistic structure of the game itself, which have succeeded in normalizing digital duplicity. These machines have become seductive skeuomorphs which maintain the aspect of their forebears, but whose delivery of a 'gambling experience' is radically discontinuous with the inner mechanisms by which they secure a steady profit. Whereas the players are served up an affective fix of randomness perfectly calibrated to ensure continued play, behind the screen any remnant of chance is entirely extirpated not only through statistical calculation but through a continual modulation of the human-machine coupling.

The traditional drivers of gambling behaviour seem to be important here only as a 'gateway': The hope of winning may bring the player into the zone, but once there, 'no rational action is possible'—one is 'beyond reason'. As Schüll's sources reveal, the efficiency with which the design-loop between players and manufacturers has enabled the machines to key into behaviour patterns means that even the designers themselves find it impossible to 'disenchant' themselves once drawn into the zone.

Schüll thus quite rightly presents this as a case study in what Deleuze called the 'control society': a kind of collusion between the players and an industry that actively solicits their addiction, its result is a

casino in which ‘the calculation of probabilities is the rule, the house has the edge and, as much as possible, nothing is left to chance’. The zone itself is ‘beyond contingency’, affectively suspending and providing an escape from life under capitalism, while at the same time constituting a bleeding-edge model of its most advanced mechanisms of control.

The rise of machine gambling can also be read in an architectural register. Far removed from what was once ‘learnt from Las Vegas’, the occupation of erstwhile retail real-estate by machine gambling establishments has become a familiar feature of our cities. **JASPAR JOSEPH-LESTER**’s photo-essay focuses on the Wedding district of Berlin, remarkable for its concentration of these small casinos which come in a variety of shapes and sizes and yet have begun to form a recognizable architectural genre, albeit one that is largely functional—even if their facades continue to deploy a jaded vocabulary of Vegas imagery, these sites are as far removed from the palatial excesses of the golden age of the Strip as Schüll’s interviewees are from Dostoyevsky’s gambler. In his examination of the architectural merits of these spaces Joseph-Lester riffs on Ed Ruscha’s deadpan methodical approach (*Some Los Angeles Apartments*, 1965), documenting the situation and formal characteristics of these deracinated spaces for zoned-out gamblers.

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If there was ever someone who conformed to Steve Forte's characterization of the shift of the image of the advantage player from 'stereotypical professional gambler [...] into the science-orientated, geek-like, college whiz kid', it would be **DAVID WALSH**, the Australian gambler whose sports betting syndicate The Bank Roll is one of the most successful in the world. Although in his interview with **COLLAPSE** he immediately places the instinct for gambling in an anthropological and evolutionary perspective, Walsh numbers himself among the 'nerds' who have cultivated the ability to counter the evolutionary artefacts that bias human response to risk, and thus to maintain the attitude that marks out a 'professional' gambler.

On a different scale and in a different league—one is tempted to say a different world—from Wedding's hypnotised slot-players, Walsh's disciplined approach has led to a level of success that has allowed him to risk a bold move in an entirely different sphere, with his extraordinary Museum of Old and New Art in Hobart, Tasmania. In our interview, Walsh, echoing Forte's emphasis on the discipline required of the advantage player, emphasises the fact that successful systems are based firstly on insights that enable an edge, however small, to be established; and subsequently on a correct estimation of that edge and its disciplined and patient application. The glimpses Walsh affords us into his own system paint a picture not of sudden strokes of

mathematical genius, but of a system based on the principle that surpassing the already considerable 'efficiency' of the betting public by even a small margin can pay great dividends. Reflecting upon his career and his latter day role as art collector and 'unmuseum' director, Walsh goes on to emphasise the vicissitudes of chance in life, and how selection effects colour our perceptions of fortune, success, and failure.

These forays into the world of the casino proper only go to reinforce Cavaillès's argument that once concepts of chance and probability are brought to bear in concrete applications, the tension between idealisation and experience yields a complex interference pattern. The same is true of the industrialisation of risk: contemporary reality continues to be shaped by the operationalization of probabilistic thinking through the systematic assessment of risk in all spheres of society. This is achieved largely through the use of models whose relation to the real, in Donald MacKenzie's famous phrase, tends to be that of 'an engine, not a camera'. Taking up this theme with an overview of his research into the statistical modelling of flood risk, **ANDERS KRISTIAN MUNK** brings us into the heart of the contemporary *manufacture* of risk enabled by such models. Beginning with William James's pragmatist premise that our understanding of chance, and the concomitant notion of non-actual events, remains incomplete without an understanding of how the latter

are *made real* by mobilising some kind of galvanizing force, Munk addresses risk models as a particular form of science-fiction, wherein the ‘fictitious’ capacities of physical modelling are cultivated and activated by the application of the probability framework.

Exploring ‘the difference made by models’ and in particular the exigencies imposed on models whose aim is to ‘enabl[e] things to express themselves in monetary values’, Munk gives a detailed account of these hybrids of empirical data, physical modelling, and general statistical principles abstracted from the specificities of any particular event. The ‘orchestration of futurity’ that will allow ‘the future to be thought of as a game of chance’ brings into play a set of assumptions whose provenance is a bizarre mix of stereotyped curves, flying bombs, and kicking horses. Here probability figures not as incomplete knowledge, but as a supplementary construction that requires a ‘leap of faith’—a ‘cocktail’ of knowledge and generic idealisation that is necessary in order to make indeterminacy go ‘live’ as an effective machine-part. Munk thus lays bare the construction of probability models as a ‘platform for intelligibility’, and reveals how those tasked with this construction are compelled to give pragmatic answers to some crucial theoretical problems (how to make a flood model without any data? How likely is it for water to go uphill rather than down? How are individual flood events independent

from or correlated to each other?). Finally he offers us an analysis of how this process articulates the two aspects of the ‘janus-face’ of probability—as epistemic (incomplete information) and as ‘explorable property of the future’—so that they may complement each other and yield a monetizable model. He concludes that the conditions put in place to ensure the ‘liveness’ of indeterminacy in fact mutilate the latter, depriving it of the other vital aspect of Cavallès’s understanding of chance: the emergence of radical novelty. At least, this is the case for the domain modelled; as for the actions of models themselves, they may interact with the world to present unforeseen outcomes. Indeed it is at this level that they ‘make a difference’ and, rather than representing reality, ‘bring something hitherto unavailable [...] into being’—even if in doing so they may also ‘exacerbate unintelligibility’.

It is this movement and its seismic historical effects that **NICK LAND** addresses in a grand synthesis that seeks to ‘transcendentalise’ the notion of ‘casino capitalism’: according to Land, the inherence of risk to modernity makes of capitalism the system for which, at the (immanent) limit, ‘the casino has become the stake’. Risk is a historically specific category: as Munk shows, it is constructed, rather than (like chance) suffered; and Land argues that the construction of risk also calls for the construction of new, formalised synthetic agents as their vehicles. At the limit of a planetary-scale

experiment in which modernity and the calculative determination of risk are inextricably intertwined, Land sees artificial intelligence and capitalism converging in the construction of synthetic subjects that ‘formalise agency and restructure time’. Abandoning any aspiration to make probability an exact science, Land here foregrounds the Bayesian approach which epistemologises risk within a framework of the incremental revision of inferences, allowing probability calculations to mitigate for their incompleteness, bringing learning and risking into immanence as ‘integral cognitive hazard’ and ‘unplanned design’, and fully unleashing the disruptive capacity of the pursuit of risk via its effective commodification.

Inevitably, this sovereign role played by risk in capitalism is accompanied by an inherent opposition to any supposedly external instance by which such risk could be judged or to which its imperative could be subordinated. Hence justice as such is risk’s other, for, as Land insists, whereas a risk society is that for which society as such must be put at risk, the demand for justice is a demand to limit vulnerability, to keep the game *inside* the casino—a resistance to the escalation of the stakes to those of Russian roulette. This resistance, he argues, consists in the refusal to expand the weak subcategory of the *wager* into the full form of the *venture*, for which adoption of risk entails risking the loss of the agent itself.

Thus understanding risk-vehicles such as companies as already-exi(s)ting AIs heralding the complete integration of venture and agency, Land asks how we are to understand the discourse of ‘mankind’ from this perspective: As the pursuit of a continued struggle of an extra-economic form of agency against its absorption into the ‘venture-form’; as reference to a species whose statistical consideration confidently predicts its imminent demise; or as a nonspecific concern with intelligence which, as such, would be indifferent to the corrosion of traditional subjecthood? The suggestion here is that, once capitalism is out of the box, our answer to this question implies at most a minor adjustment to the horizon of *existential risk* looming over the human subject—for leaving the table is no longer an option.

Contemplating the fate of mankind from a similarly lofty perspective, **MILAN ĆIRKOVIĆ** asks whether more, rather than less, risk might be the order of the day. In ‘The Greatest Gamble in History’, Ćirković meditates on existential risk, however, from the point of view not of terrestrial singularity but of extraterrestrial diaspora, examining the prospect of what might seem like a ‘reckless gamble’ on the part of a beleaguered species—namely, a decisive collective investment in extraplanetary migration. In introducing this possibility he considers the present situation of humanity in terms of an embedded series of ‘games’ at which we

have, so far, been lucky. We are faced with a choice of several extremely uncertain and risky ventures with regard to our sedentary terrestrial situation (one of which—no less hazardous, given the potentially ‘negative adaptive value of intelligence’—is to stay put). The stakes here are no doubt existential: Can we transform our situation from that of a game of chance into that of a game of skill? On a sober analysis of the odds, he argues, we may stand more chance of surviving to take another turn if we risk stepping out of the planetary ‘cradle’.

Following this intense multiscale amplification of risk, from the theory of probability to modelling to existential risk, an ascent that brings together the adventure of human intelligence, risk, capitalism, and futurity, we might firstly question any apparent congruency or continuity between Land’s account of the disruptive force of risk under capitalism and Ćirković’s call for a collective wager on an extraterrestrial future. After all, Tsiolokovsky’s cosmist call for an escape from the earthbound casino to a collectively-willed future, with which Ćirković opens his reflections, was premised on a notion of collective endeavour that seems *prima facie* incompatible with the organisation of resources and intelligence presented by the risk-order of capitalism. Although the financial crisis has revealed, in accordance with Land’s thesis, that the major instances of sociopolitical heredity are already

effectively subordinated to the risk-vehicles of financial markets, an obvious response to his transcendental deduction of the futural essence of capitalist intelligence would be to observe that a certain class of subjects seem in fact to have succeeded very well in separating their own fate from that of their ventures. For the net effect of financial crisis has been to transfer the downside of risk from those who pilot complex financial vehicles to the citizens of what were once nations and societies, and indeed to prevail upon the waning sovereign power of the latter to prop up their ailing enterprises.

Yet in the absence of any conceptual grasp on the general nature of the financial instruments involved and their relation to the dynamics of capitalism, the satisfaction of such denunciation rings somewhat hollow. Cavallès's observations hold well for these sophisticated instruments: at least a part of the catastrophic nature of the systemic crisis owes to the fact that they proliferated instrumentally in the absence of any firm understanding of their inherent logic.

Central to this cognitive deficit is the question of derivatives. The notion that the increasing sophistication of these financial instruments poses the threat of systemic failure disaster is nothing new;¹ and yet, although they are generally considered to have 'failed'

1. See for example Richard Thomson's popular account in the aptly-titled *Apocalypse Roulette: The Lethal World of Derivatives* (London: Pan, 1998).

in some way, the underlying assumptions of the models that provide their basic operational logic—specifically, models for derivatives pricing—do not appear to have been significantly questioned or revised.

In an attempt to respond to this state of affairs, our volume presents a set of contributions which seek to understand the systemic nature of the global market in risk, which includes human agents, but also and increasingly the ‘synthetic agents’ to which Land refers; to evaluate precisely what sort of intelligence is in play in the latter; to understand the inherent logic of the derivatives market and the singular role it plays in the global economy; and to clarify the relation of this advance guard of the finance sector to the capitalist mode of power.

In a famous passage from his 1936 book *The General Theory of Employment, Interest, and Money*, Keynes charged, against the notion of the rational economic actor, that human behaviour is often driven by ‘animal spirits’ rather than being ‘the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities’. Agreeing with David Walsh’s conviction that risktaking behaviour can be understood in terms of our evolutionary inheritance, **JOHN M. COATES, MARK GURNELL AND ZOLTAN SARNYAI** caution against a too stringent separation of reason and emotion, thus extending this questioning of certain abiding philosophical and economic prejudices.

One of the images conveyed by the notion of casino capitalism is that of an elite of ‘bankers’ driven by the worst excesses of human (or, in fact, masculine) behaviour. Coates et al. provide a scientific context for this ‘irrational exuberance’ in which it becomes evident that the mechanisms that drive these ‘violations of rational choice theory’ may be the same ones that, within certain parameters, are functional and optimizing in risk situations. Their contribution to this volume, documenting an experiment which tracks correlations between biochemical shifts in the bodies of traders and their performance in the market, delivers some suggestive results. Endocrinal mechanisms that help the body to adapt rapidly to changing environmental circumstances, in an environment of ‘uncertainty, novelty and uncontrollability’, they suggest, may be responsible for the characteristics that make for a successful trader, able to respond appropriately to high-frequency signals; however, in chronic situations these same mechanisms may lead to behaviours that exacerbate systemic fear, with risk behaviour and chaotic markets amplifying each other in a biological-financial feedback loop that effectively hooks up the accelerated delivery of glucose to the brains of individual humans to increasingly volatile markets.

This image of world markets wired into the metabolisms of bodies and the preconscious circuits of the brain rather complicates the alternative between

rational assessment of information and ‘masters of the universe’ exuberance. In a network of bodies whose competencies amplify ‘animal spirits’—biochemical and sensorimotor reactions to uncertainty and expected harm, instrumental within certain boundary conditions, potentially catastrophic beyond them—risk becomes a question that is as evolutionary and biochemical as it is political and financial: in other words, the figure of the trader is placed in the ramified space of the ‘casino’ described by Ćirković, comprising the contingent factors that produced both the peculiar animal *homo sapiens* and its technical milieu. Risktaking becomes a strange kind of hybrid object that cannot be addressed from any one disciplinary perspective, a syndrome that is neither entirely natural nor constructed or fabricated.

In invoking a ‘neuroeconomics’ that would provide the link ‘between economic events and brain processes’, Coates et al. suggest in closing that the trading floor might be a laboratory in which we could attempt the control, optimisation, and modulation of these biochemical aspects of the risk system, harnessing their positive cognitive role while guarding against their chronic effects (possibly through a ‘feminization’ of the trading floor).

Yet one might wonder for how long humans will play any role at all, considering the supercession of traders by various species of algorithmic ‘black boxes’,

and the rise of high frequency trading. Although the stressed ‘hormonal economic agents’ of Coates’s experiment were engaged in rapid trading, holding positions for only a few minutes at a time, automated computational trading today creates an environment the speed and intricacy of whose operations are simply intractable to human cognition. What role is left for ‘the remnants of the human trading population’ in this ‘evolving ecology’ whose ‘emergent rhythms’ are the expression of ever more densely interconnected relations between processing nodes of densely encoded knowledge and strategy?

It is this increasingly inhuman ecosystem that **NICK SRNICEK AND ALEX WILLIAMS** describe, an environment in which ‘technology redefines the risk landscape itself’, with increasingly fine-grained and liquid transactions giving advantage to those with sheer speed on their side. From computational dynamics to hardware configuration to physical location, firms competing on this landscape constantly strive for optimisation, and cyberspace’s much-vaunted tendency to ‘compress space’ now sees the physical itself becoming the next frontier for finance as ‘the earth itself becomes an impediment’.

With an eye on Land’s future AI, Srnicek and Williams ask in what sense and according to what principles these agents ‘think’—what kind of intelligence is embedded in them? On the basis of this question the

authors of the ‘Manifesto for an Accelerationist Politics’² expand and further finesse their understanding of accelerationism by distinguishing between a mode of acceleration that would operate ‘in redefining this space so as to change the very rules under which the game itself is played’, and a sheer operative increase in speed that aims ‘simply [to] dominat[e] an agreed space of competition’, suggesting that the latter in itself cannot be a ‘game-changer’ in any significant sense.

What might be the result of such sheer acceleration for *representation*, given both the impossibility of securing any kind of ‘cognitive mapping’ of these transactions which seem to reformat space itself, and the mode of nonrepresentative subjectivation that corresponds to the intensification of finance-power? As Srnicek and Williams observe, there remains a stubborn materiality to these operations, and indeed the geographical location of their major processing operations has become crucial, to the point where they are protected as major national assets: ‘while popular perception portrays Wall Street as the central location of global finance, it is in fact New Jersey and Chicago where much of American finance is corporeally instantiated [...] and is regarded as a component of the nation’s critical infrastructure’.

For this volume **SAM LEWITT** undertook the self-consciously vain task of capturing an image of one of

2. On accelerationism, see R. Mackay and A. Avanessian (eds.), *#Accelerate: The Accelerationist Reader* (Falmouth and Berlin: Urbanomic and Merve, 2014).

these ‘constitutively dislocated’ locations, as a way to measure the almost total withdrawal of finance from representation. In fact, his contribution instead recounts how this original plan was thwarted by way of a misadventure that led to the erasure of said image and a visit from the FBI’s Joint Terrorist Task Forces.

What ensues is a reflection on the accelerated abstraction of the value-form and the forces that are mustered to defend its remaining physical outposts. Lewitt’s ‘Notes from New Jersey’ recall how his attempt to photograph the Mahwah datacentre—an enterprise whose interest lay in the impossibility of extracting from its blank facade any insight into the abstractions facilitated therein—triggered off a startling security response. The agents (of what power it is not clear) who forcibly redacted Lewitt’s digital images compounded the interpellation by suggesting that the only permissible representation of this ‘disappearing monument’ to a globalised automated financial network of abstraction would be one made by human means unsupported by any mode of recording save for the traditional skills of the artist. This unexpected turn of events, as Lewitt records, added further dimensions—those of guilt, erasure, and subjection—to his original project to test the conditions of representation under accelerated capitalism.

Although they may represent the cutting edge, the high speed operations transacted in Mahwah

are perhaps more a matter of the *next* crisis than of the one whose protracted tail-end we are still living through. As already indicated, more germane to the latter would be an understanding of the infamous CDOs and, more generally, of derivatives. The mathematical instruments used to price derivatives—classically, the Black-Scholes-Merton formula—are underwritten by a model that ostensibly consists in assigning numerical probabilities to future events. The work of **ELIE AYACHE**, who has spent many years dealing first-hand with the complexities of the speculative options and futures markets, presents us with a new thinking of the market, as the primary manifestation in the world of radical contingency, to be thought entirely outside the terms of probability and prediction.

Ayache argues that in practice derivatives traders do not calculate price on the basis of a confined range of future probabilities, but directly and effectively *write* price as the contingent reality of the market, *now*. The market is therefore not a set of probabilities, but the very *medium of contingency*. It is a regime of events whose vicissitudes we cannot better grasp by addressing our failure to deal with highly improbable events (Nassim Taleb's 'Black Swans'), but whose events are effective without prevision or reason—according to the title of Ayache's book, *Blank Swans*.

At the beginning of *The Blank Swan* Ayache even goes so far as to suggest that it indeed this *philosophical*

default played a crucial role in the current financial crises: The image of the market that circulates amongst those who daily recreate it is based on a frail philosophy of probability that fails to capture its most characteristic operations. He understands the act of writing derivative contracts or ‘contingent claims’ instead as a material inscription of difference directly in the real, creating a future that is in principle unforeseeable. Derivatives can thus be considered, in Ayache’s words, ‘technologies of the future’.

In our extensive interview Ayache not only avails us of his expert knowledge of derivatives pricing technology, but clarifies and extends his critique of Taleb, and gives the most in-depth account yet of his pursuit of a ‘philosophy of the market’. The latter is distinguished by a move from an epistemological point of view—the idea that there is a ‘real’ random generator which models attempt to approximate—to an ontological one in which pricing as act—as a continual writing *in the gap* of discontinuity—is what drives the continual event of the market, *as place* rather than *in time*. For the market, Ayache argues, is a ‘massive event’ that moves in the dimension of writing, not that of time, and which has no external guarantor or generator for its processes. In this way, as he describes in detail in his responses, he develops his own conception of a ‘unilateral’ speculative materialism without any ‘dogmatism of the absolute’. In surpassing Meillassoux’s

thinking of radical contingency by insisting that he must understand his own work as a *writing* (philosophy as a practice wherein ‘writing is faster than thought’), the question becomes no longer one of thought acceding to an absolute real (just as it is not a question of the derivatives pricing model capturing the ‘real’ random generator of the underlying), but one of discovering the matter of writing ‘in which the event is repeated’.

JON ROFFE’s review of the overall movement of Ayache’s thought reiterates this movement ‘from depth to surface, or from thought to writing’. Explicating the major contribution of Ayache’s approach—that of refusing to subordinate the understanding of the market either to predefined political categorisations or to probabilistic frameworks—Roffe asks what are the axioms of an immanent ‘philosophy of the market’, one that thinks the market outside of these imported constraints, and without arbitrarily expelling those aspects of the trader’s activity that exceed them.

Roffe goes on to confront Ayache’s theory directly with the question of CDOs, the privileged instruments of financial misfortune: Since the pricing of CDOs demands a supplementary level of probability-based calculation Ayache dismisses them as ‘degenerative fantasy’; yet Roffe takes issue with this hygienic expulsion of CDOs from his model, arguing that they cannot be excluded from the ‘generalised surface of the market’ it predicates.

SUHAIL MALIK's contribution draws Ayache's thinking further into the domain of the political by reading price as the medium of political order, and the market as the medium of *capital-power*. Turning from the intrinsic logic of the market to the shifts in global power dynamics implied by the sheer volume and financial magnitude of derivatives trading, Malik sets out from the fact that these markets demonstrably pose a systemic risk to national economies, and that their size and transnational nature means that they cut across and where necessary countermand the power of states. The uninhibited and unconstrained uncertainty unleashed by these risk-bearing instruments thus spells immanent crisis for a whole legacy of political certainties, since they constitute the greatest planetary concentrations of power and pose an 'existential risk' to sovereign power as traditionally conceived.

In what promises to be a significant contribution to political economy, Malik seeks to combine the philosophical understanding of the nature and logic of the derivatives market with an analysis of the entirely novel, structurally-specific mode of capitalist power it expresses. This ambitious 'ontology of finance' supplements Ayache's understanding of the fundamental logic of derivatives with Jonathan Nitzan and Shimshon Bichler's account of *capital as power*. Such a 'power theory of finance' answers both to Ayache's claims as to the singular importance of derivatives for an

understanding of pricing as such, and to Land's claim that risk-bearing vehicles and agencies tend to corrode the inherited social forms from which they historically emerge. According to Malik, though, this inquiry requires the adjunction of Nitzan and Bichler's understanding of capital *qua* absentee ownership, with its primary ordering mechanism of *differential accumulation*. Equally, however, it necessitates a supplement to Nitzan and Bichler's own account: the latter already agree that ownership of property, stocks, bonds, and derivatives all pertain ultimately to the same, immanent market, with all of them being ordered by means of the universal mechanism of *pricing* (namely, through the discounting of anticipated future earnings). They also countenance the refusal to subordinate the analysis of capitalism to any dependency upon conditions exogenous to finance (diverging from Marxism in insisting that finance is not an excrescence of 'real production' or a 'parasitical, supplementary or "fictitious" mode of capital'). However their analysis must be extended to take account of the specific operations of derivatives, in order that it might encompass the new modalities through which their complex operations multiply and transform the power axiom of differential accumulation, and, crucially, the transformations they bring about in the inherent dimension of *sabotage* that Nitzan and Bichler see as integral to capital-power.

For Malik then, the order of futurity involved in derivatives markets, in discovering price as sole ordering mechanism, fully unveils a universalising logic that heralds a comprehensive reordering of the social via finance-power, one which extends the latter's reshaping of 'political futurity in terms of price magnitudes'. Extending Ayache's understanding of the market as writing, he offers an original analysis of the constitution of derivative pricing through the Derridean concept of *différance*, with the 'contingent claim' at once instituting price difference and deferring the exchange that would realise that difference, with the pricing surface as the 'stage of presence', and with the ultimate valuation of the derivatives contract featuring as a 'supplement' that serves only to structure the contingent unfolding of its quantitative role in the market. Contrary to Ayache's expulsion of time in favour of the 'place' of exchange, however, Malik reads pricing as a *temporization*, as a 'becoming-time of price'. Pricing emerges as a form of 'time-management' *and* as the basis of a new political economy, with derivatives trading integrated into Nitzan and Bichler's general model of price as the 'single quantitative architecture' of capital-power: Ultimately finance-power can be determined only by a 'realism' (yet a 'non-correlationist' one) that integrates both the power dimension and the risk dimension.

This analysis yields as its final term the *arkhéderivative* as 'a priori of the political economy constituted

by the ontology of price'. The existential risk faced by capitalist modernity, the 'absolute volatility and indefinite plasticity' that constitute the 'risk-order' of these markets, is then understood as that of an 'ineliminable futurity that splits the present', a universal normless order that is 'necessarily contrary to stability' and constitutes an 'intensive differential sabotage' that lays waste to sovereignty.

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As regular readers of **COLLAPSE** will know, the thinker most responsible for initiating a renewed debate around the concept of contingency (and whose conception of radical contingency converges, in Ayache's work, with the practice of pricing as technology) is **QUENTIN MEILLASSOUX**. Meillassoux makes a welcome return to the pages of **COLLAPSE** in this volume, opening a sequence of contributions that relate to the role of chance in the work of art by contextualising his recent work on Mallarmé, *The Number and the Siren*, in terms of his general philosophical orientation. He positions Mallarmé's *Coup de dés* as a *materialist* gesture that presents a unique solution to the predicament of the artist following the crisis of the withdrawal of all divine warrant, the poet confronted by Chance, that 'dark absolute' recognised by modernity as the only presiding power. In this confrontation with the sole

reign of Chance, according to Meillassoux, Mallarmé succeeds in elevating himself *qua* writer of the *Coup de dés* to the level of a *material divinity*.

The ‘Master’ of the *Coup de dés*, who, in an eternal moment of hesitation, holds the dice in his hand but does not yet throw them, recalls Mallarmé’s earlier protagonist Igitur; yet while Igitur was constrained to choose, in the *Coup de dés* Mallarmé *infinetizes* this hesitation: if everything is subject to chance, except for infinite, eternal chance itself, then Mallarmé, in devising a situation where the dice is both thrown *and* not thrown, *becomes* chance—the only modern divinity, and a thoroughly meaningless one whose celebration, in a ritual of solitary reading, leads not to a humbling of the human before jealous gods who demand allegiance, but rather to what Meillassoux describes as a neo-epicurean materialism, realized in the poet’s eternal hesitation.

Following from this undecidable fate of the poet whose performative gesture makes him equal to chance, Meillassoux’s ontological translation of Hume’s critique of causality³ and its evocation of a hyperchaotic universe where the laws of nature could alter at any moment inspires the tale of another type of performative tribute: **SEAN ASHTON**’s short story recounts the strange fate of a man who decides to ‘put his body in the service of a philosophical notion’. This weird tale in which

3. See Q. Meillassoux, ‘Potentiality and Virtuality, in *COLLAPSE* 2.

COLLAPSE VIII

Chesterton and Lovecraft meet Meillassoux, brought to life in suitable style by **NIGEL COOKE**'s illustrations, describes a more homespun attempt to embody a philosophy; a singular experiment that wavers undecidably between philosophy, art, and performance, and leads the protagonist who knows where....

Proposing a further study in the activation of chance, albeit of a more violent sort, **GEGENSICHKOLLEKTIV** address the demand that the work of art itself must involve a risk on the part of its audience. From the time of the avant-gardes, this expectation of sensory and/or cognitive jeopardy has been a mainstay of the self-image of the modern artist, and is still omnipresent in the claims of contemporary art, but is rarely taken as literally as in the **CAUTION** experiment they propose. They approach the question from within a practice that feels it most acutely: under the banner of 'noise', various practices of experimental music have pursued the aim of a sensory and cognitive disruption of all norms of musical structure, style, and expectation, only for 'noise' to degenerate into a series of stereotyped gestures which have given rise to a marketable genre. Can anything be salvaged of the claim to provide a locus of real risk outside the calculative depredations of the consumer system? Drawing on the work of Ray Brassier, **GegenSichKollektiv**'s diagnosis of this predicament leads to an analysis that suggests that only a dialectical articulation of the sensory and the cognitive—avoiding the dead

ends of subjective abolition and conceptual overcoding of experience—can draw noise out of its safety zone and present the possibility of a true risk on the part of the audience, thus leading the way to a ‘game’ that would propel the collective body toward a real encounter with chance. Although the text itself operates as an invitation to the game, the reader is indeed advised to use their ‘recipe’ with the utmost caution.

Continuing this interrogation of the relation between art and contingency are two artists’ works that cut through the entire volume. **JEAN-LUC MOULÈNE**’s series of images relay Cavallès’s exposure of the vital-abstract roots of the problem of probability. This is precisely the double-register within which Moulène’s work operates, endowing his three-dimensional works with a ‘formal cruelty’ through objects which are at once visceral and conceptually truncated. In Moulène’s unsettling edition for **COLLAPSE**, the operations of abstraction involved in thinking and operationalizing chance seem to be glimpsed at a second remove, as images of devices of thought. These figures are then interleaved as ‘feuilles volantes’ throughout the volume, with this redistribution offering yet another material image of chance.

Often an artwork’s claim to contingency or chance is configured in terms of indeterminacy or ambiguity: by courting the indeterminate or explicitly invoking an interpretative relativism, artworks seek to be ‘open to contingency’, as if this were a decision the artist could make.

COLLAPSE VIII

In her contribution **AMANDA BEECH** instead presents us with the order of coincidence. Her series addresses and invites the desire to order, to make sense of contingency and, in particular (as often thematised in her work) the desire to focalize the contingencies of power into a decisive image. In a series of images deriving from her 2013 collage-découpage installation work 'The Church The Bank The Art Gallery' (Banner Repeater, London, 2012), Beech tempts the viewer to formulate their suspicions as to the entanglement of the artwork in the three eponymous systems of power. Passing through the pages of the volume, these three loci are subjected to slippage, coincidence, and dispersion, yielding no definitive order. The three series, relating to each of these authorities suspected of compromising the artistic endeavour, provide the basis for a faltering, uncertain moving image, a montage sequence that interrupts the reader's progress through the volume, or which one can 'fastforward' flipbook-style, maximising the chance of divining some continuity at the price of turning the remaining content into an unintelligible blur.

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Three different viewpoints on contingency and probability, in philosophy, in science, and in the market, close our volume.

FERNANDO ZALAMEA reminds us that the concept of absolute chance was introduced into philosophy in the late nineteenth century by Charles Sanders Peirce, in the form of his 'tychism'. The pertinent difference between this concept and that of Meillassoux (and Ayache) lies in Peirce's insistence on a paradoxical integration of the principle of absolute contingency with that of continuity (synechism). In insisting upon synechism, Peirce attempts to avoid the potential vitiation of any systematic universal philosophy by the introduction of contingency; at the same time the dialectic with tychism avoids the impoverishment of specificity that might issue from the espousal of a universal 'continuism'. In his recapitulation of the universal 'forms of evolution' through which his theory of contingency is developed, Peirce seems to anticipate Ćirković's 'universal casino', as he progresses between different orders of contingency, whose consequences in the general system of dialectics between tychism and synechism Zalamea sets out in detail. As Zalamea describes, with reference to Reza Negarestani's architecture of decay, it is the 'back-and-forth' dialectics between the two principles—'a sort of chemical reaction'—which makes of Peirce's philosophy an impressively complex and subtle instrument that particularly deserves to be revisited in the context of what Zalamea, following Rosa María Rodríguez Magda, calls 'trans-modernism', a condition that demands—beyond both

modernism and postmodernism—precisely this marriage of the espousal of universal continuity and the acknowledgement of contingency.

In the opening text of the volume Cavallès declares that probability remains a ‘live paradox within the system of the sciences’. No more so that in quantum physics, where probability plays a central role—an event which seems to go counter to the entire trajectory of ‘exact science’. **MICHEL BITBOL** suggests that we draw the full consequences of this event by understanding quantum mechanics as a metatheory which formalizes the general conditions of possibility for prediction as such for phenomena whose detection is inseparable from their production.

Bitbol continues the general trend among our contributors, by disposing from the outset with an epistemological reading of probability—one that would see the operations of probability as pertaining to subjective ignorance of the phenomena in question, with those phenomena understood to belong to a real generator that could in principle be known. As he observes, the emergence of probability in the sciences saw it attached to (Lockean) ‘secondary qualities’; in quantum mechanics, however, even what were traditionally understood as ‘primary’ qualities are demoted to ‘secondary’ qualities *qua* ‘indirect manifestations’. It is no surprise then that the association of the knowledge of secondary qualities and of probability with

epistemological weakness should have given rise to resistance when the lineaments of this science began to emerge. Bitbol suggests that we should not be afraid to read the central principles of operationalism, holism, and perspectivism as countering this trend with a certain return to Pascal's recognition of anthropological limitations on knowledge and of the knower's entanglement with what is known.

If we insist on the retention of primary qualities, we can take up a stance according to which they can consistently be postulated, but only as inaccessible to any experimental practice—entirely breaking the cycle between theory and experiment that constituted the real value of the determinist hypothesis. The alternative seems to be to project indeterminism 'into the things themselves'—meaning that we conceive of the real, equally speculatively, in terms of propensities or potentialities. Bitbol insists that while either stance may be fruitful as a standpoint from which to motivate scientific research, the philosopher, rather than trying to obviate the problem, should intensify it, fully confronting what QM has to tell us about our situatedness, and examining what it is that the structure of the theory of QM owes to the situation of the experimenter. This 'reorientation' begins with a recognition of the expanded form of probability employed within QM, which emerges as a response to the type of phenomena it is bound to deal with. The differing contexts of

experiments are intrinsic to the results they deliver, and cannot be unified in such a way as to eliminate them. Therefore a new apparatus evolves to articulate these incompatible contexts: a ‘metacontextual form of probability theory’ able to reconstruct these fractured data within a programme of universal applicability.

As Bitbol demonstrates, later developments of quantum theory do not escape but only deepen this extension of probabilistic thinking, further developing the ‘metacontextual predictive structure’ that confirms the inseparability of detection instrument, milieu, and phenomena. Furthermore, once one comprehends the structure of quantum theory as such—as consisting of this metacontextual form of probability, twinned, in each instance, with a specific set of symmetries—it becomes possible to understand the quantum theory not as a ‘physical theory’ in the sense of Newtonian physics, but as a ‘generalised theory of probability’ whose potential applications reach well beyond the sphere of physics.

In Elie Ayache’s closing text, ‘A Formal Deduction of the Market’, he adds further precision to his concept of the market by returning full circle to the questions Cavaillès broached in his opening text, and by delivering on the latter’s presentiment that ‘it is to a more profound reform of our ideas about the real that probability calculus invites us, a reform whose magnitude we should not underestimate’.

However, where Cavallès problematizes the axiomatisation of probability by pointing out the slippages that take place with regard to empirical probability and intuitive concepts of chance, Ayache argues that it is this utter abstraction of the formal model that harbours the potential to transform our understanding of events themselves, by stripping them definitively of the artefactual trappings of the ‘casino’ model. The latter is reduced to being just one possible model for the probability axiomatic, but one which is no longer permitted to overcode it.

Utilising the recent work of Glenn Shafer and Vladimir Vovk, Ayache demonstrates how the formalism can be stripped of its relation to concepts of repetition, time, and propensity (the real random generator) altogether, so as to move toward the notion of an ‘ultimate and global event’ that integrates *trading* and the category of *money* into the understanding of probability at a fundamental level.

Ayache argues that this liberated version of the axiomatic, dispensing with trials, repetition, outcomes and statistics, which demands a revision of the concept of the event and a rethinking of the relation between reality, matter, and formalism and a ‘reshuffling’ of chronology, yields precisely the figure that he calls the *market*.

Here we are party to a strange visitation by the ghost of Mallarmé’s master, when Ayache declares that if

‘[t]here is something pressing to say when holding the die [...] this won’t take place in time’ since ‘time is no longer essential to contingency’. For the intensive understanding of contingency he ultimately proposes seems precisely to correspond to the eternal hesitation of the Master’s dicethrow.

Finally, in what Ayache speculatively proposes as a ‘revolutionary’ conclusion, it is the formalism itself that would give rise to reality: ‘reality in the sense of genesis and inception’.

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As will be readily appreciated from this brief introduction, this volume has aimed to assemble a constellation of work which, as in previous volumes, acts through a series of partial overlaps and resonances so as to render vivid and urgent a set of problems that manifest themselves in diverse disciplines and practices.

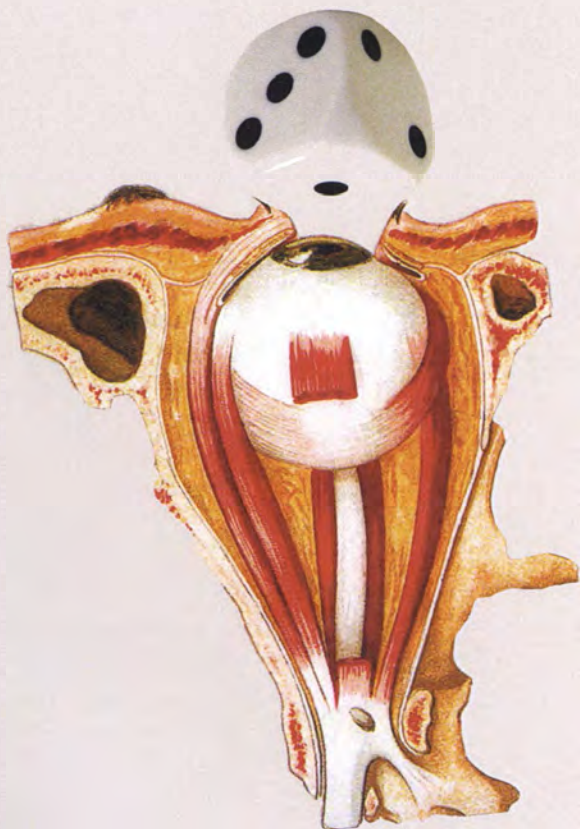
Far from claiming to fully resolve the uncertainties engendered by such a montage, the aim is to intensify a set of problematics that are not only still ‘live’ epistemologically and ontologically, but whose ramifications continue to unfold at the heart of contemporary actuality. In presenting this set of resources with which to begin a renewed thinking of the questions of contingency, probability, and risk, we hope at least to have encouraged readers to resist surrendering

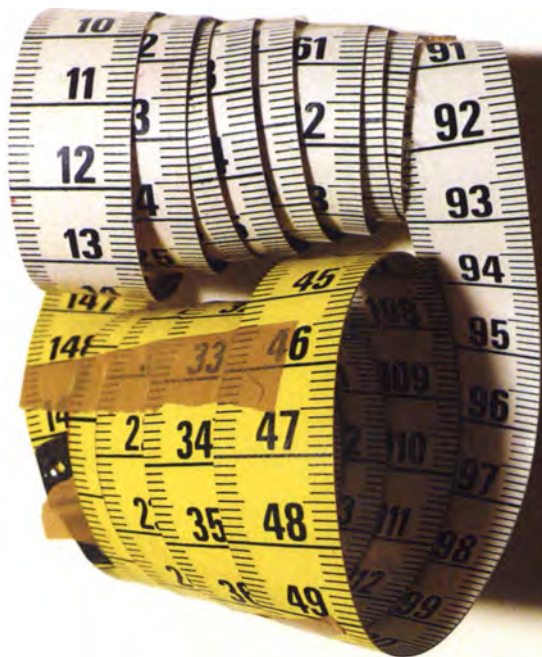
the 'demon of chance' to deterministic idealization, to our own epistemic shortcomings, or even to the arrow of time. And in examining the forms of 'game control' integral to a society that feeds on risk but still dreams of ulterior certainty (if only the certainty that the arena of risk itself will remain secure), we hope to have suggested that, beyond the confines of the casino, these questions remain the site of a compelling and still mysterious configuration of the production (or writing) of the real, formalization, and the contingencies of human knowledge.

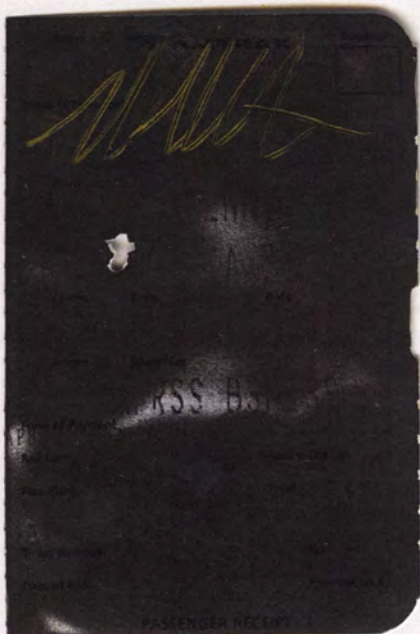
Untitled

Jean-Luc Moulène

Series of ten colour digital prints
on Offenbach bible paper,
100mm × 148mm, edition of 1500.





















The Church The Bank The Art Gallery

Amanda Beech

Inside the Bank of Sicily, Palermo, is a Mormon
Church, bankrolling the deals that established one
of the art world's largest private collections of
Modern Art.

These systems mark our habitual perception.
We tie them together with directed energy.
We enjoy the pleasure of this sense-making.
The neatness of a world order in order.
Our lives in passive crisis: An order of crisis.

And so we imagine...

Make these connections through the ether.
We see the big payoff.
Access to secret and darker forms of knowledge, to
deeper stabilities enhanced through mystical unions.

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It is the axis of power and the horrific truth of it all.

Safe in the comfort of knowing, when the worst
comes to the worst.

We are bound together as nature, from the start.

Or,

Coincidence is the satisfaction of our blind fantasy.
The event as fate.

The exposition of coincidence as meaning is the
grasping of material forms together as a poor ritual.

But:

The challenge to such a faith is not an empiricist's task.
We do not explain the world.

Spin the wheel again

So

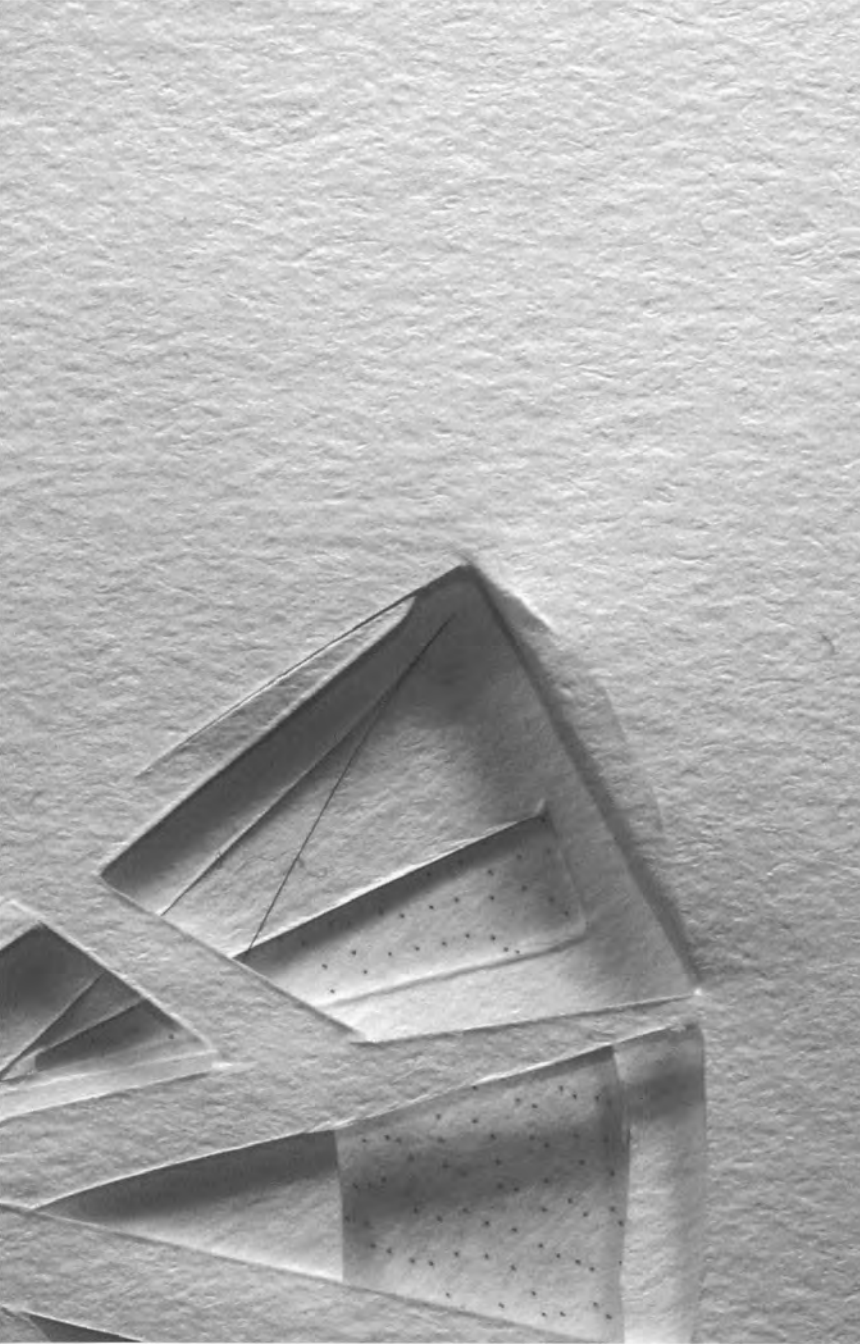
One thing happens after another...

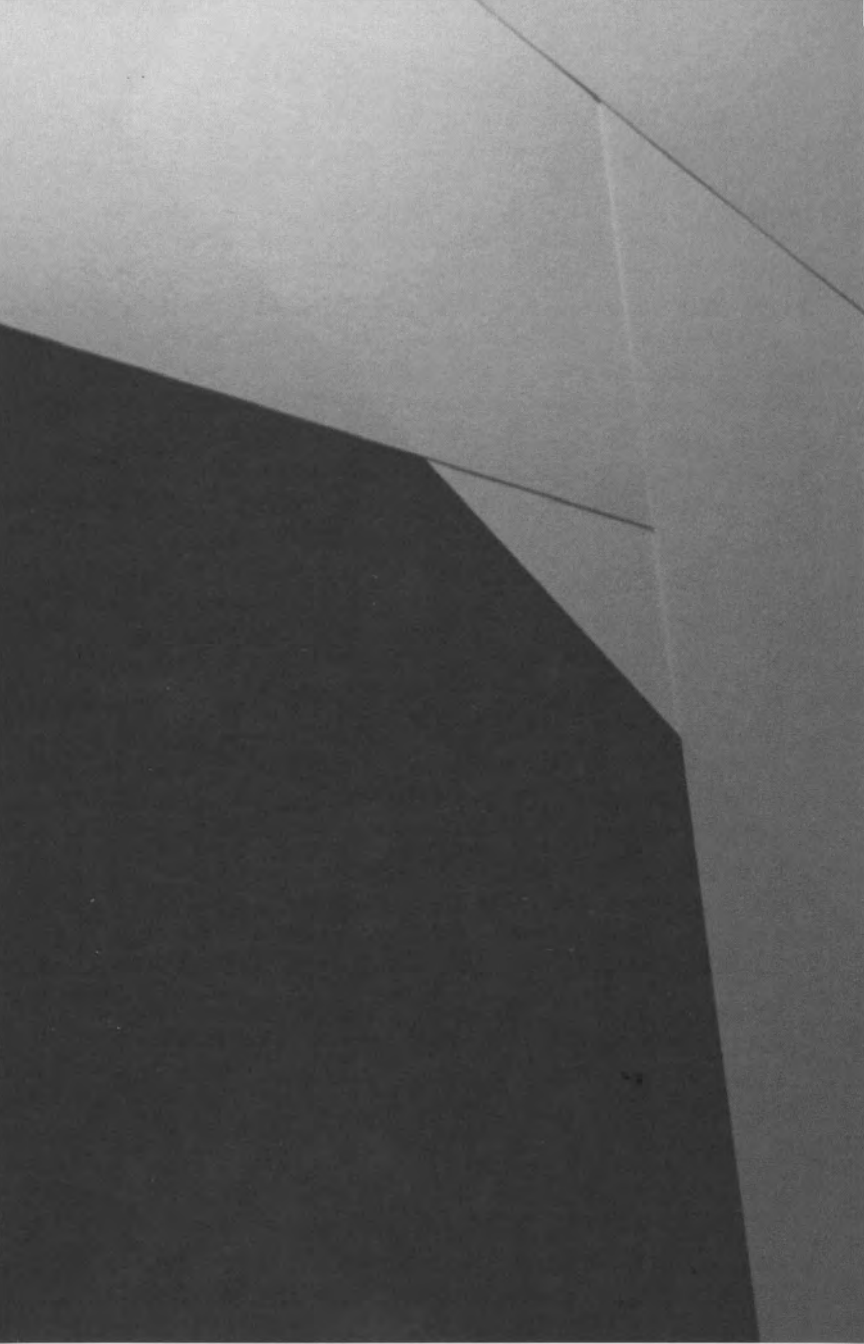
What now defines our science?

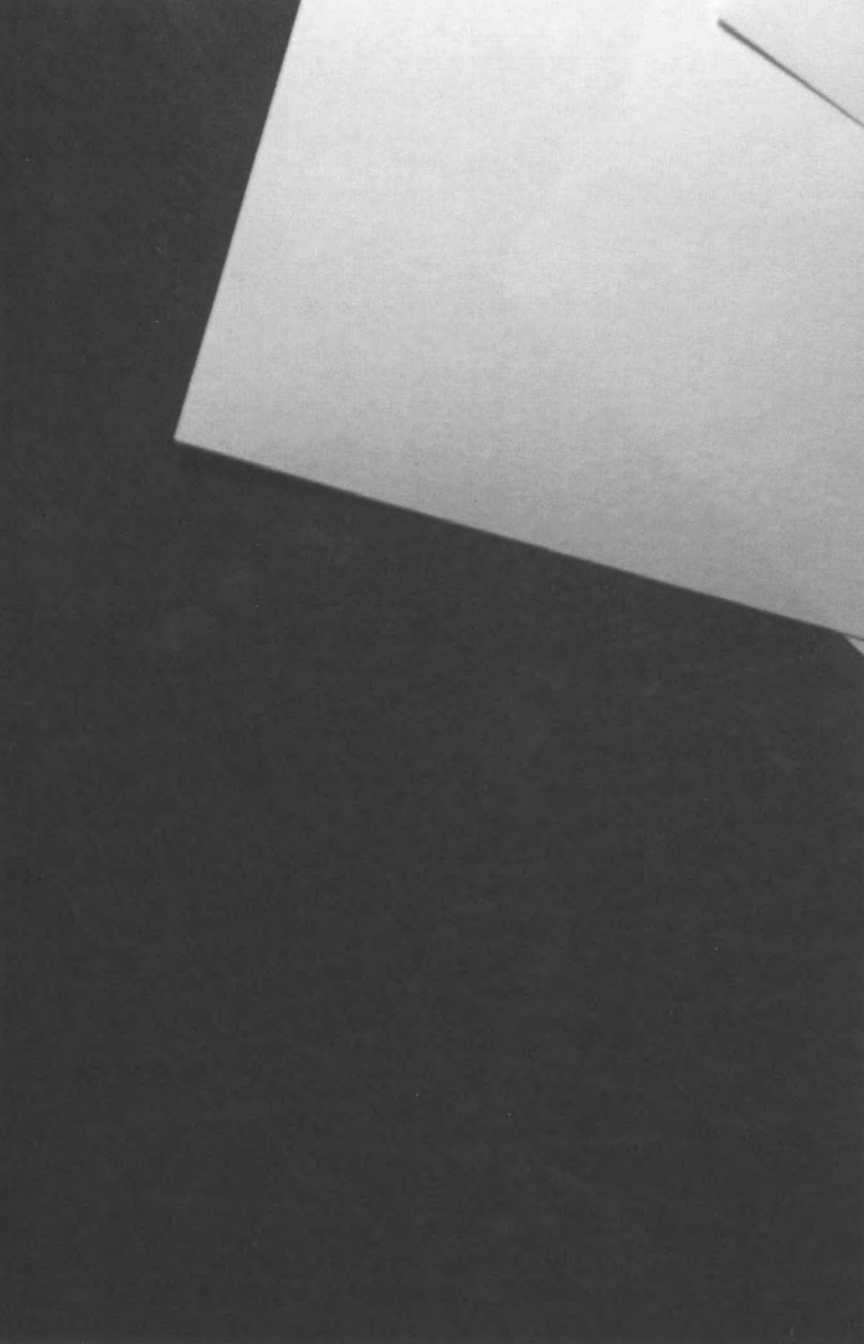




THE







From Collective to Wager: On Some Recent Theories of Probability¹

Jean Cavailles

Probability calculus, the extent of its development and the importance of its applications, are still live paradoxes within the system of the sciences. Born of reflections on gambling, a detached branch of combinatory calculus, it will waste no time in making use of mathematical instruments disproportionate to its modest origins, and to the very significance of the results it would claim to achieve. From the eighteenth century, continuous variables were used to represent finite variations; today, following Émile Borel, Paul Lévy and Maurice Fréchet consider as fields of events sets as general as Borel's, confusing Lebesgue's integral with mathematical hope. Now, these generalisations,

1. 'Du Collectif au Pari: A propos de Quelques Théories Récentes sur les Probabilités', in *Revue de Métaphysique et morale*, 47:2 (1940), 139–246.

apart from their intrinsic mathematical interest, turn out to have a practical utility: we know the growing role played by probability calculus in the techniques of social economy as much as in physics. Whence an undeniable discomfort: we began with a notion incapable of justifying the practical applications, a notion that is obscure from their point of view—‘the probability of an event, the relation of the number of favourable cases to the number of all possible cases’, according to the definition still adopted by Laplace—limited, so it seems, to the finite; but the outcome is an impressive science, which moves naturally within the infinite, but whose very development brings no clarity as to the possibility of its application to reality. No one agrees on the purport of these applications: neither in the human sciences, where one is content to invoke a mysterious ‘law of large numbers’, nor in classical statistical physics (remember the discussions around the ergodic hypothesis) nor in quantum theory, wherein some see the definitive overthrow of traditional determinism. Certain mathematicians, however, have believed themselves capable of putting an end to this situation, on one hand by applying to calculus the procedures of modern axiomatisation and formalisation, and on the other by giving to its object, mathematically clarified, a concrete meaning that makes its utilisation in nature intelligible.

Such are the works of R. de Mises² and Reichenbach³ concerning the notion of the *collective*, which raised such grand hopes in the philosophical world, and whose examination is today facilitated by the recent critical studies of A. Wald⁴ and Jean Ville⁵ and by the philosophical conclusion added this year by Emile Borel⁶ to his *Treatise*.

The internal coherence of the calculus was already assured in Borel's *Treatise* via the implicit axiomatisation to which he subjected it. In 1933, Kolmogorov, also inspired by von Mises's ideas, had expressly codified the results of the work of the French school.⁷ As in any axiomatisation, it is a matter of translation into a prior domain, whose notions are utilised: here, set theory. We shall call elementary events the points of a fundamental set E, complex events certain parts (subsets) of E belonging to a system F. Probability is

2. R. von Mises, *Wahrscheinlichkeit, Statistik und Wahrheit* (Berlin: Springer, 1936 [2nd ed.]). See also R. von Mises, *Théorie des probabilités. Fondements et applications* (Annales de l'Institut Henri Poincaré, 1932), 137–90.

3. H. Reichenbach, *Wahrscheinlichkeitslehre* (Leiden: A.W. Sijthoff, 1935), and *Les Fondements logiques du calcul des probabilités* (Annales de l'Institut Henri Poincaré, 1937).

4. A. Wald, *Die Widerspruchsfreiheit des Kollektivbegriffes* (Ergebnisse eines mathematischen Kolloquiums h. 8 (Vienna, 1937)).

5. J. Ville, *Étude critique de la notion de collectif*. (Paris: Gauthier-Villars, 1939).

6. E. Borel, *Valeur pratique et Philosophie des probabilités* (Paris: Gauthier-Villars, 1939).

7. A. Kolmogorov, *Grundbegriffe der Wahrscheinlichkeitsrechnung* (Berlin: Springer, 1933).

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a function P , which puts a positive real number into correspondence with every element of F . F and P are endowed by the axioms with the following properties:

1. F is a *field* (that is to say: the sum of, the intersection of, and the difference between any two elements of F , are all elements of F).
2. F contains E .
3. $P(E) = 1$.
4. If A and B are two elements of F (two parts of E) with no common point, then:
$$P(A + B) = P(A) + P(B).$$

Finally, an axiom of convergence concerns the descending series of sets.

Thus we find linked together, from the outset, elementary calculus and its abstract generalisations. The consideration of infinite fields, of any number of dimensions (even infinite) introduces no break in the cohesion of a natural development. At the same time we obviate two difficulties, both as old as the calculus itself, and relating to the two fundamental rules of *total and composite probabilities*: The first is: 'if two events A and B are incompatible, the probability of at least one of them happening is equal to the probability of the two events'.⁸ And the second: 'If two events A and B

8. The probability of obtaining, with a die, a one or a six, being $1/6$ in each case, the probability of obtaining one or the other of these (obviously incompatible) results is: $1/6 + 1/6 = 1/3$.

are independent, the probability of their simultaneous occurrence⁹ is equal to the product of their respective probabilities'. In each statement, a stumbling block: *incompatible* events, *independent* events, two concepts that have no mathematical meaning whatsoever, and whose concrete meaning, indeed, is rather obscure (contradictory even, in the case of independence). Von Mises points out the first difficulty: 'The event of winning 100 francs at roulette on 30 November 1931 at midday can take place in two different ways: by putting 100 on the red at Monte Carlo, or at Nice; the two ways are incompatible, because one cannot be present at Nice and at Monte Carlo simultaneously.'¹⁰ Each of them having a probability of $\frac{1}{2}$, we have a probability of 1 (that is to say, certainty) of winning 100 francs. Kolmogorov's axiomatic overcomes the difficulty by declaring all elementary events incompatible. Two elements of F (that is to say, two complex events) with no common point are therefore incompatible: the rule is stated in axiom 4. But then what becomes of independence, which is in a certain sense opposed to incompatibility, since it permits us to consider the simultaneous production of two events? We shall call the simultaneous

9. Simultaneity here concerns the wager and not the production of the events. Thus the probability of obtaining two sixes is the same whether one throws two dice at once, or throws the same dice twice in a row (supposing the events to be independent), it is equally: $\frac{1}{6} \cdot \frac{1}{6} = \frac{1}{36}$.

10. Von Mises, *Théorie des probabilités*, 150.

COLLAPSE VIII

production of two events their intersection. In positing that event A leads to event B, if $A \subset B$, then we have:

$$ABcA \text{ and } ABcB$$

A and B are then, by definition, independent if we have:

$$P(AB) = P(A) \cdot P(B)$$

This is the response given by Borel in his *Treatise*: two events are said to be independent if the rule of composite probabilities applies to them. For other events introducing conditioned probabilities or relations: $P_A(B)$, the probability that B should occur if A occurs. By definition:

$$P_A(B) = P(AB) / P(A)$$

So we can see that, in the case of independence between A and B:

$$P_A(B) = P(B)$$

The notion of independence is thus an operatory notion belonging to the axiomatic of the calculus—that is to say, it is posterior to the combinations of operations that constitute it within the prior theory.

This is even, as Kolmogorov remarks,¹¹ the principal source of its autonomous development: in its absence, it would fuse with the theory of additive functions of sets. A great deal of the original work on the calculus, by Laplace and Markov, is dedicated to this—to the study of series of trials, whether completely independent or of a dependence fixed by a law, such as *concatenated probabilities*. There is no room to demand a translation of it into set theory, any more than for the parallelism or perpendicularity of two straight lines in number theory, even though geometry borrows the conceptual material of its axioms from the latter (and in which is constructed naturally a model of realization). However, the situation of probability calculus axiomatized in this way cannot be compared to that of geometry: the system of axioms is not categorical—that is to say, it does not give a univocal definition of the objects E, F, P. One can put forward, and indeed there have been put forward, according to the purposes and the fancies of mathematicians, various fields and various functions of probability. The situation is something like elementary geometry without the parallel axiom or without Hilbert's saturation axiom. So is this the sole origin of the discomfort we mentioned above—the impossibility of justifying, mathematically or empirically, the arbitrary stipulations brought into the definitions of E, F and P?

11. Ibid., 8.

Note that in geometry, the definition of fundamental operations (displacement groups) leads naturally to the formulation of the axiom capable of completing the edifice: we see this very clearly with the axiom of saturation, if we allow Cantor's formula. It is an axiom of closure: every infinite series of embedded segments defines a point. Nothing analogous seems likely to be forthcoming in probability calculus.

Perhaps, however, it was such a hope that drove Reichenbach in the formalised axiomatic he published in an article before Kolmogorov, and which he reprised in his *Wahrscheinlichkeitslehre*. He uses preexisting theories: set theory and logical calculus. Probability is a relation between two classes of propositions. Whatever may be the intrinsic interest of this realisation as an axiomatisation (and the detailed remarks that accompany it), it brings nothing really new to the problem that we are dealing with. Its principal originality consists in its considering every statement of probability as a hypothetical proposition: if x belongs to class A, y belongs to class B, a relation which is specified by a number p between 0 and 1. This is an English point of view upon which Keynes's *Treatise* in particular insists: a judgment of probability makes no sense except under the hypothesis of a determinate situation (or state of our information). There is no probability of winning roulette if one does not bet—or if one does not spin the wheel. One must therefore always write, in short,

$P(A,B)$, the probability, given hypothesis A , that B will obtain. Whence a simple solution to the difficulties of incompatible and independent events: two events B and C can only be incompatible if they took place under the same hypothesis A . We see that this is not the case for Von Mises. The rule of composite probabilities will be written, for all events (whether independent or not), since here all probabilities are conditional:

$$P(A, BC) = P(AB, C) \cdot P(A, B)$$

The case of independence is expressed as follows:

$$P(AB, C) = P(A, C)$$

As we can see, the change in relation to the foregoing axiomatic is largely one of presentation. Apart from exceptional cases, it is more commodious to leave implicit the statement of the hypothesis—as Reichenbach himself does once he arrives at more complicated calculations. But for Reichenbach this formalisation represents the way to an interpretation of the notion of probability thanks to which all difficulties will vanish. It is here that the notion of collective comes in.

Introducing the collective, Von Mises expresses the intention of giving probability calculus a development and a rigour comparable to that of geometry. Unlike the classical treatises, and unlike Kolmogorov's work,

here there is no codification or clarification of the spontaneous process of calculation—since these turn out to be insufficient to determine their meaning in univocal fashion—but a direct definition of the object of calculation via the idealisation of the conditions under which it effectively takes place in reality. Just as the geometer idealises the rods and rounds of nature to make of them straight lines and circles, so the mathematician of probability transforms a series of dice throws, a statistical table, into a collective. Its definition is the mathematical characterization of this idealisation (in fact, to characterise mathematically is to idealise). In the simple case of trials (such as coin-tossing) that yield only two possible results, which we can call 0 or 1, a collective is an infinite series of 0s and 1s, possessing the following properties:

1. The relation of the number of 1s in the first n terms of the series, at number n tends toward a limit as n increments indefinitely; this limit will be called the frequency of 1s.
2. If we make a 'place selection', taking only certain terms from the series independently of the quality (of 0 or 1) of the following terms, then the frequency of 1s (or 0s) in the new subsequence will be the same as in the original series.

This frequency, invariant under place selection, is probability.

We generalise for the case of trials having any finite or infinite (denumerable or continuous) number of results: in the corresponding collective, each of the latter figures with a determinate frequency, independent of place selection. The rules of elementary calculus are deduced from this definition: they are valid for a frequency calculated on a series of trials and are conserved in the passage to the limit. This can be seen particularly easily for total probabilities: two events A and B are incompatible only when they are results of the same trial, and thus members of the same collective. If n_A / n and n_B / n are the relative frequencies of the first n trials, then we obviously have:

$$n_{A+B} / n = n_A / n + n_B / n$$

whence the formula sought in the passage to the limit (for n_A / n and n_B / n each tend toward a determinate limit, their sum y also tends toward that limit)—the combination of two collectives—which gives the rule of composite probabilities—is a little more complicated: it must be shown that the new series does indeed have the characteristics of a collective, and one must distinguish between associable and inassociable collectives. The essentials of the calculus can thus be rediscovered. But this is not the main point, however important may

be Von Mises's work in the calculus properly so-called. The notion of collective serves to legitimise and to codify the applications: all it does is to make explicit the underlying thought—or the prerequisites of the thoughts—of all those who use probability calculus. The classical definition via equally possible cases is but a vicious circle (what are equally possible cases, if not equally probable cases?) and moreover is usually of no practical value (where do we find these equally possible cases if it is a question of evaluating the risk of fire or of an accident?). In fact, in the three domains where probabilities come in—gambling, general statistics and physics—‘what we have before us is a long series of events or phenomena, experiences or observations en masse.’¹² Probability has a role in masses, but it can only signify relative frequency. Considerations of symmetry in games of chance should not fool us: it is a matter here of mechanisms where everything conspires (throwing dice from a cornet, shuffling cards) in order for frequency and symmetry to be brought into accord. Everywhere else—in insurance, in the kinetic theory of gas, etc.—it can only be a matter of more or less easily identifiable frequencies which one postulates to be constant. The calculus is limited, on the basis of these observations within relatively simple collectives, to deducing the frequencies characteristic of the complicated collectives constructed

12. Von Mises, *Théorie des probabilités*, 130.

with the former. This is a role of transformation, not of creation, exactly as, in geometry, one does not evaluate lengths but, on the basis of given magnitudes (two sides of the angle of a triangle, for example), calculates others (the third side). Ultimately, there is not the least divergence between the definition of probability as a limit of frequency and the law of large numbers, with which a superficial interpretation may oppose them. In fact, Jacques Bernoulli's theorem does not (as its author believed at the time) assure the passage from supposedly *a priori* probabilities to frequencies, but only states that there is a probability very close to 1 that, over a long series of trials, the gap between the frequency of a result and its probability is tiny. A theorem which may, obviously, like all others, be translated into terms of collectives: in a collective C , having as its elements the collectives D_i each formed of the results of a first trial E , the frequency in C of D , for which the n first elements bring about one of the results with a frequency nearing to the limit that it will take, tends toward 1 if one chooses a large enough n . Thus, not the least discordance between the limit in the probabilistic sense (which the law of large numbers speaks of) and the mathematical limit that comes into the definition of the collective. 'The theory of probabilities based on the notion of relative frequency', Von Mises concludes in 1931, 'is free of all contradiction, and on the contrary helps shed a

little light upon questions that remain, in the classical theory at least, rather unclear.¹³

But a stringent critique reveals major difficulties.¹⁴ Firstly, the condition of irregularity demanded by the collective makes the definition of the latter contradictory, at least in the general form de Mises gives it. This is what A. Wald shows: the notion of a place selection is indeterminate. Every series, formed of indices denoting elements of the collective, constitutes a place selection. Now, if the collective is as follows:

$$a_1, a_2 \dots a_n \dots \text{ with } a_i = 0 \text{ or } 1,$$

then there exists at least one series $n_1, n_2, \dots, n_m \dots$ with indices such that

$$an_1 = an_2 = \dots an_i = \dots = 1,$$

and a series $m_1, m_2, \dots, m_i \dots$ such that:

$$am_1 = am_2 = \dots am_i = \dots = 0.$$

Two place selections, then, which change the frequency limit whatever the collective happens to be. Wald seeks a remedy for this both in a mathematical restriction

13. Ibid., 174.

14. For the exposition of these critiques we use J. Ville's work, cited above, which is remarkable for its clarity and density.

and a mathematical specification of the criteria for place selection. He introduces a new system of *selections*. A *selection* is a series of functions f_i , having each for arguments the $i-1$ first elements of the collective, and 0 or 1 as a value. If f_i is 1, it is kept. We can see that the series of f_i give us a law that permits the extraction of a new subsequence from the collective in question, C. The invariance of the frequency limit, in the system of series obtained on the basis of C by the system S of selections, will mathematically translate the demand for irregularity.

But we need to specify this further. Consider a collective D, where the successive trials have as their results not two events, but any (infinite) set whatsoever M of events. Take N, a part of M; the probability of N in D will be the frequency limit of elements of N in D. If M is finite or denumerable, no problem. But if M has a higher power than the denumerable—for example if M is the set of real numbers, or an interval of this set—Wald shows that there is no collective such that the probability of each of the parts of M remains invariant relative to any denumerable system whatsoever of selections. Thus a new restriction must be put in place: we shall consider, for example, when M is the set of real numbers, only the system of parts of M that are measurable by the Jordan procedure. Generally speaking, the definition of a collective must therefore make more precise (for the condition of irregularity)

both the system S of selections and the system F of the parts of the set of results whose probability S must leave invariant. A relativity in the definition that renders it obviously arbitrary. Doubtless the restriction operated by the choice of a system of parts of M is unimportant in practice: in physics one does not encounter any set that is not measurable by the Jordan procedure. On the other hand, there are not more than a denumerable infinity of imaginable selections. Or at least, it is arbitrary to fix which of them. Finally, precisely from the point of view of practice, a new difficulty arises: The aim of the irregularity axiom is to define collectives as series that are as similar as possible to those that one obtains in reality through a series of independent trials. Now, the following theorem can be proven: whatever system S of selections is envisaged for a series of trials, giving, for example, two results of probabilities p and $q = 1-p$, there exists at least one property A for the series of results whose probability, calculated in the classical theory, would be null but would nevertheless contain at least one of the collectives satisfying S . In other words, characterization through a system of indifferent selections S does not suffice to eliminate the properties of abstract series which, as the theory shows us, have nil probability of occurring.

Jean Ville wished to obtain a more effective condition of irregularity, inspired by another statement of von Mises's. In games of chance, the irregularity of

the series of results is nothing other than 'the impossibility of a *gaming system*, in the argot of the habitués of Monte Carlo'.¹⁵ This principle 'must express in general the aleatory character of the phenomena under consideration. Its position before the real world is the same as that of the principle of the impossibility of perpetual motion'.¹⁶ One might consider, for every aleatory series, a player whose bets and gains depend on the foregoing throws: so we have $\mu_n(a_1, a_2, \dots, a_{n-1})$, the function that expresses the bet at the n th throw. We agree that he will receive μ_n/p if $a_n=1$, $\mu_n/1-p_n$ if $a_n=0$, p being, in the series, the probability of 1. We see that, on one hand, *the gaming system* will be defined by a series of functions μ_n , and that on the other, the final gain is equally determined by the series of μ_n . To say that there is no martingale to win indefinitely is to impose an upper limit on the series of μ_n . In studying the resulting restrictions on the collective, Jean Ville arrives at the proof that, on one hand, every system of selection can be expressed by such a prohibition, and that, on the other hand, given a property A of nil probability for an aleatory series, one can make it correspond to it a series of functions μ_n such that the collective defined by the corresponding prohibition does not possess A. The condition of irregularity thus

15. Ville, *Étude critique*, 142.

16. R. de Mises, *Wahrscheinlichkeitsrechnung und seine Anwendung* (Leipzig and Vienna: Deuticke, 1931), 4 (cited by Ville, *Étude critique*, 87).

specified therefore contains Wald's, and turns out to be more effective than it. But it is each time relative to the properties of nil probability that it was a matter of eliminating, and thus it is also perforce arbitrary. To search any further makes no sense. Every individual series has nil probability. For von Mises and his heirs, it is a matter of setting aside series 'that are not encountered in practice', a vague condition, we understand, whose 'immediate subjective meaning' Ville wishes to conserve even while translating it into mathematics. Thus he eliminates other more abstract possible criteria: 'to give oneself a martingale and to exclude the series where a player, by applying this martingale, enriches himself indefinitely, this has a very concrete meaning [...] We consider this latter criteria to be satisfactory from an intuitive point of view.'¹⁷

But is it so from the point of view of the internal coherence of the theory of collectives? We do not believe so. The idea of an axiom of irregularity is attached to old notions of chance. But there is no mathematical definition of chance: Borel often insisted on this. The ultimate meaning of chance is simply ignorance. To say that a series is a chance series is to affirm that one cannot find a mathematical law for the succession of its terms. Indeed, this is almost von Mises's first statement. But to seek a mathematical criterion for this absence of law can only lead to the

17. Ville, *Étude critique*, 138.

arbitrary or the subjective. One can demand only that there is no simple law: will the series be more chance-like for it? Doubtless the series we encounter most often have certain properties in common: if all the particular series have the same nil probability, the properties of series have probabilities that may be closer to 1. We have already isolated the group of indifferent series (Popper, Reichenbach), or Bernoulli series,¹⁸ which are but particular cases of collectives subject to Wald's or Ville's criteria. Admitting that we have succeeded in defining exhaustively these privileged properties, it remains that the properties of nil probability, in virtue of the very definition of probability in a collective, may present themselves a finite number of times. It is to say the least paradoxical, in a theory based on the notion of frequency, to see certain series radically eliminated because their frequency is very small. What a strange science it is that claims to describe what is, and refuses to consider a part of what is on the pretext that it is rare! No criteria of irregularity can delimit the domain of application of calculation.

Additionally, this demand is not essential to the theory of the collective itself. On the contrary, Reichenbach sees in it 'a grave fault; [...] in practical usage, series of a normal type (that is to say, those not indifferent to place selection) play an important role, and

18. Ville shows that the notions of Bernoulli series and the indifferent series are equivalent (*Étude critique*, 78–83).

it is a matter of a number of intermediaries between the irregular series and entirely ordered series.¹⁹ One can therefore limit the definition to the condition of a frequency limit. But here again there is a restriction in relation to the classical theory: in the latter every element of a practically very vast *field* F of parts of E can be a complex event. If E is the set of real numbers, then F contains all the sets that are measurable in Lebesgue's sense: in other words, for the result, for example, of spotting something expressed by a real number, one can consider as an event the fact of the result belonging or not to a Lebesgue-measurable set; now, these sets constitute all the sets of real numbers that can effectively be defined. With the theory of collectives, J. Ville shows that one must limit oneself to sets measurable by the Jordan procedure: a limitation that, as we have seen, is without any real importance for physics, but which can be awkward *qua* extrinsic to the mathematical argument of the theory (which is governed by the properties of the additive functions of sets). On the other hand, if in this way mathematical idealisation is found insufficient, on the side of the object it may appear exorbitant. For the substitution of a mathematical passage to the limit for a convergence of relative finite frequency can only be an embarrassment for the link between calculation and experience. How can we recognize in reality that we are dealing with a collective?

19. Reichenbach, *Wahrscheinlichkeitslehre*, 142.

The finite beginning of an infinite series—all that is knowable—informs us neither on the convergence nor on its limit, if it has one. If 10^{1010} zeros begin a collective, followed by only 1s, it will be impossible not to attribute a probability of 1 to the zeros, whereas it is nil. Doubtless the classical theory often replaces variations in finite terms by continuous variations; but, on one hand, there it is often a case of practical and provisional simplifications—analogue to those which, in a schema, join a finite number of points which only make sense as a continuous line; on the other hand, where the substitution persists, it is precisely, as we have seen, one of the problems posed by the practical fecundity of the calculus. The theory of the collective had as its first aim to fix its link with the real: now, it claims to do so by assigning to calculation an object that, by definition, is not encountered anywhere. The analogy with geometry, as invoked by von Mises, is illusory: geometry does not idealise anything. What is there to think in roundness if not already the circle? It is a naive epistemology that would see mathematical objects as being born through abstraction from the real. In fact, there is an autonomous development of operations which, from the start, are mathematical: practical applications come from the success of the operations codified in the real. If there was abstraction, it would be, not from the real (where there is nothing to abstract) to the operations, but from the

operations to the real (the disregarding, in the latter, of certain mathematical properties); it is, moreover, more a matter of approximation. Now, the collective, the passage to the limit, where the infinite is essential, is not approached via any experiential aleatory series. The operations through which the mathematician handles infinite series have nothing in common with those through which the statistician observes a convergence of frequencies. The whole problem remains to characterise these latter approaches, to link them with the mathematical elaboration that would submit them to calculation. The notion of the collective thus remains a stranger to the former and the latter alike. Its introduction does not help us address the problem.

But we can distinguish the mathematical question of the categorical axiomatisation of calculus (or the determination of its field of application, for this follows from an exhaustive definition of its object) from the epistemological problem of the meaning of the notion of probability; or, if you like, the situation of calculation in other sciences, along with the resulting consequences for a representation of nature. Doubtless there is some link between these two problems, and even, it seems, a dependence of the second upon the first. Reichenbach, however, tried to resolve the first through the second. He does not shy away from the difficulties of the notion of the collective; but for him they are inherent to the very notion of probability.

To clarify the latter is, if not to resolve the problem, at least to show how far the solution might be carried and the very reasons for its limitation. For von Mises is mistaken in thinking that probability calculus can be counted at the level of other sciences: it is at the basis of all knowledge of nature. There is no measurement that is not based upon the theory of errors. Every statement of a law, as in thermodynamics, is a statement about maxima of frequency. The problem of probability is that of induction: how to conclude from the past to the future. The mathematician is not bothered about concatenating already-observed collectives (and in fact there could be none, for they would have to be finite), but is concerned with foreseeing the future. Thus the infinitude of the series takes on its true meaning: it is the indeterminacy of a development in the process of becoming. We suppose the determination of this indeterminacy, and there again there is no certainty: probability governs everything, even the status of its own interpretation. At least, this is the only way possible for science: if it does not succeed in this way, then there is nowhere else to look.

The solution lies in a broadening of traditional logic: two-valued logic is a first approximation, just like classical physics is for the world. A logic with a continuous infinity of values is just as necessary today as the physics of relativity. The element that replaces the true or false proposition of classical logic is the

wager, with values ranging from 0 to 1, of the logic of probabilities. A wager is linked to an infinite series of bivalent propositions each bearing upon an element of the collective. Take the collective $a_1, a_2, \dots, a_n, \dots$, formed of the results of a trial, P a class of these results (for example, tails, when tossing a coin), and the series of propositions will be:

$$a_1 \in P, a_2 \in P, \dots, a_n \in P, \dots \quad (1)$$

true or false propositions. If we attribute the value 1 to true propositions, and 0 to false propositions, and if we make the sum v , for the first n propositions, the relation v/n will coincide with the frequency of the result P in the collective. Just as in the passage to the limit. The value of the wager, founded on the series (1) of propositions, is equal to the probability of P in the collective. But we can only know this value when we are dealing with a case of collectives in the process of becoming. We are therefore thrown back, in order to give a meaning to the wager, onto the problem of the determination of probabilities in reality. There is no circularity here: we will superpose upon the wager on events a second-degree wager on probability, coordinating with it a series of elementary series. Here again, a difficulty arises: the ideal wager would have as its value the limit of the frequency of elementary series, in which the frequency of the event E

tends toward a certain limit. One can proceed by trial and error: if the observed frequencies tend toward a limit, a moment will arrive when they remain held between certain limits. If on the contrary there is no limit but, for example, an oscillation between two extreme values, one can proceed through extraction of partial series (by cutting up the primitive series) and by considering the limit frequencies that they may have. There is advantage in these trial and error procedures in superposing wagers: for let us consider a series S of series T_1 . If we suppose that S and T have limits of frequency, there exists a rank n_1 in the series T_1 on whose basis, for mT_i , the frequency of E remains within a certain interval δ . Equally, there exists a rank n_2 in the series T on whose basis the frequency, among the mT_i (m being the same in the two cases), of those for which the frequency of E remains in the interval δ , remains within an interval ϵ . It can be seen that $n_2 \leq n_1$; for rank n_1 all the mT_i fulfill the condition, for rank n_2 only a majority (fixed by the interval ϵ) do so. Such therefore will be the procedure of the physicist, and of any scientist who utilises probability calculus: superposing wagers in order, through successive approximations, to approach, where they exist, frequency limits, and thereby to confirm (or reject) the primitive wagers. A hesitant allure of science, a modest solution to the problem of induction; we must quit the sharp-edged world of certainties (an

initial, crude image) to enter into the fuzzy kingdom of approximations, where acts and wagers intersect each other. The very confidence that one will succeed is a wager, but it is the only reasonable wager. Only probability, the blind man's cane, can lead us down the path of the future—if there is a path.²⁰

These philosophical reflections on the notion of the wager seem incontestable to us. Their link with the technical solution, however, is rather loose. Three criticisms may be formulated. Firstly, the intervention of polyvalent logic is a *trompe l'oeil*. It is excessive to claim that it resolves everything: apart from the general affirmation that the wager is not a proposition susceptible of being true or false, one could scratch everything about it without changing anything in the result. The wager is situated between two systems of bivalent propositions: propositions corresponding to elements of the collective, and propositions superposed on the wager and attributing to it its logical status—that is to say, determining a probability. These latter are what is essential. Furthermore, a certain incoherence appears: it is said, concerning the superposed evaluations of probabilities, that ‘first-degree wagers remain exact [*richtig bleiben*]’.²¹ Exactitude and nonexactitude: bivalence without relation to the continuous scale of values between 0 and 1. A wager is exact when one wins:

20. Reichenbach, *Wahrscheinlichkeitslehre*, 420.

21. *Ibid.*, 405.

but it ceases, at that very moment, to be a wager. What becomes of the coordination with the totality of the collective, since, by hypothesis, the latter is not complete? A science effectively submitted to a polyvalent logic must not give way to the intervention—here decisive—of bivalent propositions. The justification of the superposition of wagers—that is to say, the whole method of approximations—is based on the confidence that the frequencies each have a limit—that is to say, on bivalent affirmations.

The uneasiness comes from the second cause of difficulties, the representation of the future by mathematical infinity. Mathematical infinity is but a relative indeterminacy, that is to say an indeterminacy submitted to a law, but still essentially an indeterminacy: it has nothing in common with the unforeseeable nature of an outcome. That which, mathematically, is indeterminate in the series of decimals of π , is the point at which one will stop, not the decimals themselves. On the contrary, the future event, for probability calculus, is the decimal that one might find at place n . In reality, the mathematician of probabilities never has to deal with a collective: the passage from past to future takes place between closed systems. In statistics, one wagers that the frequency of purchases of a product, in a given place and a given year, will be the same or different from that of the preceding year: there is no wager on one sole series of purchases whose frequency may vary

before our eyes. In the same way, in statistical physics, there is a wager on the distribution of speeds at a given instant, and the assimilation of a succession of states of a body to a series of trials is only a condition of symmetry for the manipulation of the coordinate t . We do not move forward in time, but we consider in advance, en bloc, all of the states (all future states) of a certain succession: the distribution of their probabilities is obtained either through considerations of symmetry, or in some other way—never by way of approximations along a development.

Finally (the third difficulty), these approximations themselves are ineffective: we have seen that the beginning of a series tells us nothing about its limit, if it has one. For Reichenbach there are privileged series with which his manipulation succeeds; only the series submitted to this ‘axiom of regularity’ give rise to science: the existence of science depends upon their existence. But this is to narrow the problem down too much; if there are wagers and approximations, their model remains entirely indeterminate. It is always dangerous to prescribe to science what its path must be. Probability itself overflows its definition as frequency limit.

For there can be no probability of an isolated event. Here again, the notion of the wager given by Reichenbach is awkward: if I wager on the coin coming up heads on the n th toss in a series of coin tosses, the anticipated event is not *tails*, but *tails at the n th toss*,

a singular event that has no frequency. It is very important to specify the rank, if the collective unrolls, since my evaluations of probabilities (that is to say, the value I attribute to the wager on the event) depend precisely on the place where I find myself (depend on the frequency observed in the first $n-1$ tosses). Reichenbach does however give an ingenious solution for the classical case of an isolated event: in reality, there is always a frequency of a secondary event linked to the judgment of probability. For example, the probability, for a historian, that Julius Caesar visited Great Britain, is evaluated by the frequency of truths in the class of documents to which belong those which tell of this landing. It is not a question of the probability of Caesar's landing, but of the probability of not being mistaken in relying on such a document. The same goes for the future. But, as Borel points out, on one hand, the classes considered are often far too narrow for one to be able to speak of frequency (or collective); and on the other, in the majority of examples, these classes have to be constituted from elements that are too heterogeneous for frequency to have any meaning. What group of chronicles is our historian of Julius Caesar to consider? All the chronicles of Britain, spread over a hundred years? All the chronicles concerning Caesar? The least crazy thing would be to consider the class of events that relate to the chronicle being studied: if one can control a certain number of them,

a frequency will appear. But the events are varied: one chronicler may have had an interest in lying, another may have been misinformed. And how many events are there that are controllable like this? A hundred? This is already a large number for a historian, but pretty small for a frequency. In fact, the historian proceeds otherwise: he is more interested in a selection, a likelihood, a logical chain. It cannot therefore be a question of frequency: psychological reconstruction plays an essential role. The credibility of a text is evaluated by way of a multitude of operations too complicated to be prescribed in advance, too subtle to be reduced to a mere enumeration. So is the historian wrong to speak of probability? Émile Borel does not think so. But then another definition must be given.

For Émile Borel, 'the notion of the probability of an isolated case is the foundation of probability calculus. This notion is natural to each of us, just like the notion of hot and cold.'²² The determination is made in two steps: firstly subjective probability, which is 'defined by the conditions of the wager that one is disposed to accept for or against the event'. Let us offer to a witness A the choice between winning a certain sum on the toss of a coin or gaining the same sum by betting on the success of tennis player X: if he chooses the second choice, it is because he estimates that there is probability greater than a half

22. Borel, *Valeur pratique*, 104.

that X will win. A's opinion, and his choice, are of no interest except in so far as A possesses a certain competence in tennis. In other words, the statement of probability supposes an investigation and a prior knowledge: rational knowledge (the number of faces of a regular polyhedron thrown into the air), empirical knowledge (what A knows of the psychology, of the habits of player X), information on 'results, which are often, if not always, frequency statistics'. Whence the possibility of arriving at the second stage: the objective judgment of probability. 'We shall define objective probabilities as those whose value is the same for a certain number of equally well-informed individuals on the conditions of an aleatory event.'²³ Thus, the objective determination of the coefficients of probability operate according to a complex method, where the principal role is played—as for subjective probabilities—by the comparison between probabilities already obtained in the case of a simple mechanical model, and considerations of symmetry that allow calculation; for example, the similarity with drawing balls from a box. Just as for magnitudes, one cannot define probabilities in an absolute way, but only relations between probabilities. Ultimately the supreme instance, the basis of all objectivity, remains experience: it intervenes through the intermediary of small probabilities. 'In numerous cases one can obtain, as the result of a

23. Ibid., 105.

calculation, extremely small probabilities.' Now, events possessing such probabilities hardly ever come to pass. Borel clarifies this notion of a practical exclusion through the distinction between three scales: probabilities that are negligible at the human scale, of an order of magnitude less than 10^{-6} ; 'a man who constantly wishes to take account of possibilities as improbable as this quickly becomes a maniac or a madman'.²⁴ For the set of men the terrestrial scale presents itself: probabilities smaller than 10^{-15} . And finally, for the set of 'phenomena which may come to pass in the whole portion of the universe that is accessible to us...', the probability 10^{-50} is negligible at the cosmic scale.' If therefore the evaluation of a coefficient of probability leads one to bring in negligible probabilities of events that do come to pass, one must reject them. The standard of impossibility maxima to which Borel refers is the miracle of monkeys randomly hitting typewriters and reconstituting the entire contents of the Bibliothèque Nationale, a miracle whose probability is of the order of $10^{10^{12}}$. 'Such a miracle must be regarded as impossible.'²⁵ Generally speaking, 'when the probability of an event not happening is less than 10^{-50} , we must regard this event as absolutely certain.'²⁶ Here two misunderstandings must be dealt with.

24. Ibid., 6.

25. Ibid., 20.

26. Ibid., 7.

Firstly the misunderstanding of coincidences: if we consider the probability of obtaining, by drawing out at random letters of the alphabet (which we put back each time into the box), Racine's verse:

Pour qui sont ces serpents qui sifflent sur vos têtes

It is $26^{-44} < 10^{-50}$. But the probability is exactly the same for obtaining any series whatsoever of forty-four letters:

yfbucsomyvmxjdgvgvwyjzmsrfucemnxnrkgsøkhecj

Now, the second series has in fact been obtained through the random drawing of lots: it is an event that has happened. The law of the impossibility of events of small probability is therefore false. It is enough to recall here that the event whose probability one calculates is not the production of a series of any forty-four letters of the Latin alphabet, but of a series given in advance. In other words, the judgment of probability is always a wager, logically anterior to the production of the event to which it applies. As the submission to the criteria of the experiment implies that the event has happened, it is important each time to specify to which anterior conditions the calculation of its probability is linked. Here we rediscover the demand of

Keynes and Reichenbach to explain probability as the relation between two events.

The second misunderstanding is related to the very meaning of the judgment of probability: doesn't the practical impossibility affirmed by Borel operate a surreptitious passage between a probability very close to 1 and certainty? Reichenbach shows that it is enough to admit the apparently inoffensive axiom: (A) 'When an event C in a series possesses a probability tending toward 1, it appears at least once in the series,' to affirm that, in every normal series (every Bernoulli series), frequency converges, in the mathematical sense, toward the probability. It is enough to take for C the event that, for a given interval α as small as one likes, the frequency of the primitive event E in the n first trials should be comprised between $p+\alpha$ and $p-\alpha$, p being the probability of E. We know that, for a big enough n , the probability of C tends toward 1 in a Bernoulli series. If C certainly appears once, this means that the frequency tends mathematically to the limit. However, Borel's condition seems far stronger than (A). But there is a confusion here between mathematical certainty and practical certainty. The axiom (A) passes from one to the other—a passage which Reichenbach refuses. Borel considers only the statements of experimental sciences: the confidence that we can have in any law whatsoever does not surpass the order of probabilities whose difference from 1 is negligible at the cosmic scale.

The result of an addition of 100 numbers of 8 digits each is only known with a probability of error of 10^{-3} if it is done by one accountant, of 10^{-23} to 10^{-27} if five accountants work on it separately. Every physical relation is established between the product of measurements, and thus is subject to the theory of errors. In physics or in biology, there is no statement that is not, in the final analysis, a statement of probability. The difficulty comes from the fact that classical epistemology is subtended by a realist ontology. The hypothesis of an in-itself of things that the scientist is supposed to describe, and of which the laws he discovers are only approximations, is profoundly embedded in our consciousness. Even when rejected explicitly, it guides the discussion: the reduction of probability to a limit frequency aims to make of the statement of probability a judgment on *what is*. But if, in fact, to speak of *what is* is meaningless, if every physical law is but a wager of action, the scandal of probability ceases; far from being an inadequate substitute for our power to know, it is the very type of this power, the source of all scientific activity. Thus, in the kinetic theory of gases, that two gases, in the presence of atmospheric pressure should, at the end of an appreciable time, yield a heterogeneous mixture, is of the same order of probability as the miracle of the typing monkeys; the miracle of Jeans no more unlikely than that water should change into ice at the normal temperature. To interpret it

in terms of frequency amounts to saying: in the immense majority of isolated systems containing a sufficient number of molecules, entropy grows with time; but in others? What meaning would a statement about them have, since there are no observations of them?

To know the world is to wager—to wager that certain acts, laboratory experiments, or industrial techniques will succeed. The vital, extra-intellectual character of this is profoundly perceived by Borel in his description of the wager: ask a man to choose between a toss of the coin and such a forecast, and his choice will be instructive. It is the law of interest that is guiding here: to insert oneself into nature, living within becoming, to invent movements that succeed, invention itself being a part of becoming, an element of a dialogue, like the gestures of the body when climbing. It seems that an explanation faithful to the intention of the physicist has to follow this line—the cosmogonic intention, the status of description and of knowledge of physical theories does not seem to be able to agree either with the utilisation of probabilities, nor, what is more, with the other characteristics of modern physics (for example, Einstein's analyses of space and time). The mathematical elaboration of theories would represent a systematic coordination of effective gestures, processes of retardation, of the amelioration of action, which, following the observation

of psychologists, can take itself as an aim, forgetting the finality that gives it its sense. But even high-flown theories—those without any practical value in the usual sense—find their justification only in an effectively realised act, in the observed accord between the results of two measurements. The physical experiment is an event in history; its forecasting, a wager; its success, the possibility of new acts.

Such is, so it seems, the direction in which Émile Borel's interpretation takes us. This, to our eyes, in the current state of things, is the best (or the only) way to conceive the role of probability calculus in the natural sciences. The immediate difficulties—not to mention those that concern ontology properly speaking and of the epistemological difficulty of identifying the link between mathematical knowledge and physical technics—are of two orders: (1) To interpret the success of a wager, the appearance of the event posterior to the action; its observation seems to be a statement with a certain character, or at least something other than a wager. One can seek it in the senses: a possible continuation of action; this is at least to try and tackle the difficulties inherent in the 'crude concept' of action. There is, what is more, the problem of median probabilities: 'if it is proposed that we stake 100 francs on the dice against an equal sum, the conventions being that we will win with a 1,2,3 or 4 and lose with a 5 or 6, we must reasonably accept. If we lose, we must no less continue to affirm that we were not wrong in accepting

this wager and that it is our adversary who was quite unreasonable.²⁷ What ‘being reasonable’ means is rather difficult to determine; perhaps an examination of the notion of the game will help here.²⁸ For classical physics it seems that the only meaning of median probabilities is, thanks to repeated trials for example, to be linked to small (or very large, that is to say very close to 1) probabilities, themselves subject to experiment. But only the effective utilisation of science can decide. (2) What link can we make between the notion of probability-wager and the methods of its evaluation? The success of considerations of symmetry is no more intelligible here than elsewhere. In fact, doesn’t the use of the notion of frequency presuppose a sort of symmetry: a homogeneity of spatiotemporal domains (for the public records during a year of a given city, for example)? It is relative to this process of evaluation that the too-vague notion of the wager takes on its true sense. It is possible that there is, what is more, an irreducible polymorphism—that probability in the sense of insurance companies only coincides in very broad terms with probability in the sense of quantum theory. Only a detailed epistemological analysis can clarify this; the notion of probability—like every

27. Borel, *Valeur pratique*, 106.

28. See, on this subject, Bruno de Finetti’s study on the notion of the fair game. He also interprets probability as a wager. B. de Finetti, *La Prévision, ses lois logiques, ses sources subjectives* (Annales de l’Institut Henri Poincaré, vol. VII). Also see E. Borel, ‘Éloge du Jeu’, in *Valeur pratique*, 3, 447.

scientific notion—has as its proper site the governing intention of the procedures of the scientist: or as a prerequisite for the intelligibility of the system of these procedures. This means that it is each time modified by transformations in the latter, that its unification may not come about. We have already remarked that the probability that Louis de Broglie speaks of has no relation to frequency. The noncategorical nature of the axiomatic of probabilities would be, consequently, irreducible: its singularity qua technique within the sciences, that it can help equally, but not in the same fashion, according to their own axioms, would prevent any precision further than Kolmogorov's five axioms of the common procedures that it puts to work.

The theory of the collective represented an effort at unification, in order to safeguard a naive realist ontology. It seemed to permit a reconciliation between Bernoulli's theorem, the simple result of combinatory calculus, and Bernoulli's theorem, the law of large numbers, empirically observed. If so-called *a priori* probabilities are but the approximation of frequencies, there would be no leap out of experience, and calculation would be one among our developed descriptions of nature. This latent possibility of reduction would reassure philosophers and scientists. The merit of von Mises, Reichenbach, Wald and Ville is to have expressed integrally all the resources of such a solution: the mathematical difficulties, the insufficiency as to the

link with experience, the very unintelligibility of the notion, are now in the full light of day. The regularity of certain frequencies, the object of approximative statements, is but a starting point for actions that succeed, and does not possess in itself any explanatory value. It is to a more profound reform of our ideas about the real that probability calculus invites us, a reform whose magnitude we should not underestimate. It is not a question of a resurrection of pragmatism, which fails because it is too easy. The very activity of consciousness, the relation between reason and becoming, at first opaque, but which reason partly penetrates, is in play here. The wager is situated on the dividing line between pure lived action and autonomous speculation: at once an impulse toward the future, a recognition of radical novelty, risk; and, on the other hand, an attempt at domination through the imposition of an order, and the establishment of symmetries. Its essence, the unification of these two constitutive themes, is far from being clear. It seems that the difficulties raised at the level of calculation, in forcing us to study ever closer both its history and the detail of its application, must furnish for epistemology the occasion to provoke, if not to carry out, a conceptual renewal in which the elements issuing from this analysis of the wager play the preponderant role.



The Ultimate Cooler

Interview with Steve Forte

Steve Forte is a gaming expert and is considered to be the most skilled sleight-of-hand artist in the world. He has worked in, managed, and consulted with casinos worldwide about how to spot cheaters and con artists.

Forte came to Las Vegas in the late 1970s and worked as a crap dealer at the Aladdin Hotel and Casino (owned by the Detroit mob). He regularly played poker at the Stardust and witnessed widespread cheating firsthand (controlled by Chicago mobsters), and as a young casino manager worked for notorious gangster Moe Dalitz. Some of the iconic operators he has worked for include Baron Hilton, Jackie Gaughan, Steve Wynn, and Jack Binion.

Forte made his knowledge and experience available to the industry in the game protection 'bible' Casino Game Protection: A Comprehensive Guide,¹ probably the most

1. S. Forte, *Casino Game Protection: A Comprehensive Guide* (Las Vegas: SLF Publishing, 2004).

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important book published on the subject and a must for any casino executive or surveillance/security personnel, and which includes detailed discussions of many different scams, hustles and cheating methods, as well as Poker Protection, which expanded the poker chapter in CGP.² He demonstrates his own mastery of some of these astonishing techniques in the Gambling Protection Series of videos.³

Forte has been retired from the consulting business for over ten years, and is now retired from a playing career that goes back over twenty. He rarely gives interviews, but his expertise is still sought out by gamers, companies, and players. He was a consultant on the classic movies Rounders (1998) and Casino (1995).

COLLAPSE: First of all let's talk about what a 'game of chance' is. In the ideal model of a game of chance, we have a set of possible outcomes (e.g. the faces of the die) which turn up unpredictably with each throw, but with a frequency that is constant over time. The simplest way of gaining an advantage is through knowledge of these long-term odds.

We also assume symmetry: with dice, roulette wheels, etc. there is ideally no bias toward any one outcome. Of course, the physical, environmental, and human contingencies surrounding the game invariably

2. (Las Vegas: SLF Publishing, 2006)

3. Now available as a DVD set—see www.stevefortegps.com.

‘contaminate’ this ideal model: Gaming equipment is made of materials which may be imperfect (advantage players can get an edge from flaws or peculiarities in casino equipment) or can be altered (introduction of marked cards, loaded dice); the gaming environment can be exploited to obtain information that ideally wouldn’t be available (use of mirrors or cameras, teams signaling across tables, corrupt dealers); and dealers and other players are humans who can be influenced in various ways. So your view on games of ‘chance’ must be very different. Is it possible to give a broad overview of your mental model of a game, as a professional: the factors you have to take into account when examining a game in order to anticipate the different ‘angles’ that might be taken to exploit these shortcomings in the ideal model?

STEVE FORTE: One of the most eye-opening revelations for anyone pursuing a career as a professional gambler is that the games you read about in books and the games you find on the casino floor are worlds apart. Live games present a completely different set of dynamics, challenges, and opportunities for skillful play.

I recall playing blackjack in a big Reno club. I’m sitting on third base and notice that the dealer’s riffle shuffle is open and high (versus closed and tight). Though not apparent initially, I begin to realize that

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the riffle is providing me with an almost imperceptible flash of about ten cards from the top of the left half (after splitting the deck into two halves for the riffle). At first it was just a blur, but after playing a while, I learned to let my eyes relax (instead of tensing up and over-anticipating the last riffle), and let my brain naturally try to recall what I had seen. Within a few weeks I reached a point where I could almost call out the ten flashed cards in order!

Let's assume that you can see about ten flashed cards and can occasionally and accurately classify the cards as 'high' or 'low'. Despite the fact that the flashed cards are riffled into approximately the same number of unknown cards from the other half, this is still an *enormous amount of information* that allowed me to camouflage my strategy to the extent that I was never suspected of being a card counter, yet I was playing one of the most sophisticated card-counting systems of that era (Lawrence Revere's 14 Point Count—an advanced four-level count with over 200 playing deviations committed to memory).

If the riffle exposed a preponderance of low cards, I would cut about twenty cards down, *cutting the low cards out of play*. This allowed me to increase my bet significantly off the top and maintain this bet size irrespective of what the count might indicate to bosses and surveillance.

If the riffle exposed a preponderance of high cards, I would cut as deep as the rules allowed, make a medium-size bet, and hope that the first hand showed an excess of high cards, because I was going to double up or parlay my bets irrespective of what the first hand's count indicated.

The additional information provided by the high riffle allowed me to confuse the pit and surveillance, securing my longevity as a player. I would routinely watch card counters get heat and even get backed off, but I was allowed to play because I wasn't playing the *theoretical game*, the standard which casinos use to evaluate all suspect play!

One of the fascinating discoveries made after playing this angle for many months was that many dealers riffled *slower* on their final riffle, which of course is the only riffle that mattered. Apparently, since the final riffle was the last step in the shuffling procedure and the last chance to thoroughly shuffle the cards, many dealers slowed down and riffled more deliberately.

From a management and game-protection standpoint, one of the realities associated with these kinds of strategies is that not only is each dealer uniquely different, but individual dealing styles and habits can change over time, and not always in a positive way (with experience, many dealers get complacent, lazy, and sloppy). So, for example, even in a club with 100 games that are well managed and supervised by a

knowledgeable staff, and with every dealer shuffling properly *except one*, the club is still vulnerable to skilled players.

Though this is just one example of an offbeat strategy that targets the shuffle, from a conceptualization process, once you open your eyes and begin to truly appreciate the possibilities, it's like searching for gold. Most of the time you find nothing. Then there are the nuggets from time to time. And every once in a while you hit the jackpot.

With the best players, assessing the pros and cons of one's opponent is an arduous, detailed, exhaustive process—more so than most gamers would ever imagine—and it often starts long before the player walks into the front door, with pre-game knowledge of a club's history, management philosophy, attitude towards skilled players, average age of the staff, procedural consistency from dealer to dealer, experience of the dealers, and much more.

Once a professional gets to the game, the analysis really gets down to the nitty gritty, examining each facet of the rules, conditions, and procedures, followed by dissecting every minute component of the shuffle, cut, deal, payoff phase, and assembly of the deck for the next shuffle.

The best players are also cognizant of the other players. How many black check players? Are there any high-rollers playing? In games with only one

player, should the professional take a seat, would the player's cards be visible (so they could be factored into the strategy)? With a sense of the action and where most of the pit's attention is directed, it's easier to pick the best strategic approach based on one's goals (blend in, hit-and-run, direct with no camouflage, high-roller, etc.).

There are also the psychological aspects of selling the play—strategic deception—and the basics of interacting with bosses such as being prepared with a story should a boss say, “Hello, where you from; have you stayed with us before?”

In short, my conceptualization of casino games was simple: Knowledge is power; the more you know about your opponent, the better your prospects, so do your homework. Then, in any game with a human element, anything is possible, and exploitable advantages are virtually *guaranteed* to be discovered in any casino if (a) you know what to look for, and (b) you are willing to make the commitment to find what most gamers and players *never see*.

C: In *Casino Game Protection* the term ‘exploitable information’ seems to cover all of these available sources of dissymmetry.

SF: The phrase ‘exploitable information’ is generally associated with *advantage players*, i.e., legitimate

gamblers looking to exploit casino weaknesses. Examples include dealers who unintentionally flash their hole-cards, inadequate shuffling procedures that allow visual tracking of key cards ('shuffle tracking'), or the inevitable mechanical bias that develops in most roulette wheels over time. Take a seat at any casino table game in the world and you're presented with an environment of information. When that information is provided to *all players*, it's generally accepted to be within your rights as a player to consider and strategize the information to the best of your ability. Of course it takes skill to identify and profitably strategize the various types of information, which is exactly what advantage players are all about.

C: Advantage play has been recognised at least since the nineteenth century, right?

SF: In fact, there's very strong evidence suggesting that the concept of 'advantage play' can be traced back to the first organized study about games of chance, *Liber De Ludo Aleae* (*Book on Games of Chance*) by Gerolamo Cardano, posthumously published in 1663, though believed to have been written in 1520–1530:

Cards have this in common with dice, that what is desired may be got by fraud; the most contemptible kind is that which is backed by the sword; a second

kind has to do with the recognition of the cards—in its worst form it consists of using marked cards, and in another form it's more excusable [...] [T]hose, however, who know merely by close attention what cards they are to expect are not usually called cheats, but are reckoned to be prudent men.

It's not known whether Cardano was referring to a player unintentionally flashing the cards as they were dealt, or shuffling so poorly as to enable a shrewd gambler to know which cards were about to be dealt; only that Cardano was clearly making a distinction between cheating and being prudent when knowledge was derived 'merely by close attention'.

Scams, on the other hand, do not depend on casino weaknesses per se, because cheaters create their own sources of exploitable information. In sharp comparison to the aforementioned strategies, examples include 'playing the bend' (crimping and waving the cards into readable patterns), a scam that enables cheaters to ascertain the dealer's hole-card even when dealt properly—without flashing. Cheaters may conspire with the dealer to false shuffle a slug of cards so that a previously memorized sequence remains intact during the deal—like playing with the cards face up! And roulette cheaters have been known to stand next to a dead game and drill a tiny hole through the side of the wheel and into the ball track with a small

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custom built battery-operated hand-drill hidden in a women's pocketbook; later, a cheater standing next to the wheel would attempt to manipulate the spin by inserting a thin wire into the hole to knock the ball off the track into targeted sectors.

Though the legal definitions of casino cheating can vary slightly from one jurisdiction to another, they all tend to encompass three basic principles that can be found in the gold standard, Nevada's Revised Statutes (NRS), where cheating is defined as follows:

'Cheat' means to alter the elements of chance, method of selection or criteria which determine result or payment.

Also within the NRS is the Fraudulent Acts statute:

It is unlawful for any person to determine the course of play after acquiring knowledge not available to all players.

Though there are other laws for possession of cheating devices, manufacturing and selling cheating devices, teaching others to cheat, and so on, these three basic criteria prove to be an effective test as to when an act crosses the line from advantage play to cheating: Was the random distribution altered? Was the intended payment altered? Was information utilized available

to all players? For example, switching cards or dice changes the result. ‘Capping’ and ‘pinching’ scams (increasing or decreasing a bet after the result) alter the intended payoff. And a dealer peeking the top card of the deck and signaling this information to an accomplice provides cheaters with information not available to all players.

One of the earliest and most important cases to set the tone for the legal interpretation of advantage strategies occurred in the early 1980s, *State of Nevada vs. Einbinder and Dalben*.

Dalben sat on first base where the dealer was unintentionally flashing the hole-card to this position during the peeking action (unlike in the UK, blackjack dealers used to deal a hole-card and peek under tens and aces for blackjacks). Einbinder sat across the table, betting big, and receiving signals from his friend about the strength of the dealer’s hand. Both players were arrested for cheating.

On December 18, 1984, the Supreme Court of the State of Nevada ruled in favour of the players, citing the following:

Respondents were charged with cheating at gambling and other related felonies. The facts of the alleged offenses were essentially undisputed. In particular, the evidence showed that respondent Dalben was lawfully seated at his position at the Blackjack table,

that he did not use any artificial device to aid his vision, and that he was able to see the dealer's 'hole' card solely because of the admittedly 'sloppy' play of the dealer.

Respondent Dalben then communicated his information to respondent Einbinder. The district court ruled that respondents' conduct did not constitute a violation of the cheating statutes.

The signaling between players was also challenged: Was this a conspiracy? Interestingly, the answer was a resounding 'no' for one simple reason: You can't have a conspiracy without a crime!

C: So, as you write in CGP: 'If a strategy utilizes information made available to all players, it's legal, provided it does not alter any inherent characteristics of the game.' But this availability of information is not a fixed quantity. Firstly, one can't make the assumption that all players are able to process the 'available information' equally. But also, it alters along with new techniques and technologies. For example, when Edward Thorp published *Beat the Dealer*, which systematically laid out the science of card counting, what had been taken to be a game of chance suddenly became a game of skill and knowledge. Before then, players tacitly assumed that there was pretty much an equal chance of any card turning up next—which is obviously not the case!



Paxton Dent, *Play Sucker and Pray* (1939)

But it takes a good deal of analysis to learn how to exploit that asymmetry. Card counting in blackjack basically becomes possible when we realize that the deck of cards is not a ‘random generator’, but changes throughout the game, creating information asymmetry. Is it ever reasonable to assume randomness in the casino context?

SF: There’s no such thing as true mathematical randomness in the casino industry, only acceptable levels of ‘pseudo-randomness’.

Today’s slot machines can be deemed random for all practical purposes, but to appreciate some of the technical challenges with trying to achieve randomness, consider the video poker machine.

Purists contend that true mathematical randomness can only exist when all deck orders are equiprobable, but even with help from the computer, limitations persist. A computer’s random number generator and random function starts with a value called the ‘seed’. For older 32-bit systems, the number of possible seeds is 2^{32} , or about 4 billion possible starting values, which leads to about 4 billion orders, just a *tiny fraction of all possible orders*. Even 64-bit and 128-bit platforms fall short.

A deck of cards can be arranged in $52 \times 51 \times 50 \dots \times 1$ different permutations. The result is an extraordinarily humongous number (8×10^{67}) that has fostered several

analogies to help put the number in perspective. Here's a favourite: If each person on the planet were to shuffle a deck at the rate of 1000 shuffles per second for 10 billion years, collectively, they could only produce a small fraction of all possible orders. An even more profound characterization states that every shuffle produces a new order, one that has never been seen before, and one that will probably never be seen again.

Moving from technology to the other side of the spectrum we find a small cube of plastic, the casino die. Casino dice are generally considered to be good randomizers, but this wasn't always the case. There was a time when many believed that the dice were naturally biased due to a discrepancy between the weight of the spotting compound (epoxy resin/paint) and the weight of the cellulose removed when drilling the spots. If the compound weighed more, you would expect more aces; if it weighed less, you would expect more sixes.

According to many early dice makers, the bias was real. The epoxy resin/paint was lighter, but only slightly so. Where the story picks up speed and credibility is when you learn that right up to the 1960s, craps layouts barred ace-ace on the *don't pass* and *don't come*, and then for some mysterious reason, barring two sixes became the norm. Coincidence?

Finally, at the heart of every card game is the shuffle. When the cards are shuffled adequately, the laws of probability run their course and give all players a fair shake.

When the cards are shuffled poorly, biases can lead to strange results and exploitable opportunities for the professional gambler. We have already discussed some of the strategies that target these weaknesses, but it's not just the shuffle that is nonrandom, it's the *entire game* that operates in a nonrandom way.

Most dictionaries define randomness as 'lacking in aim or method, purposeless, haphazard', yet when we look at a blackjack game in action, the entire process is controlled by predetermined procedures and predictable actions. The decks start in new deck sequence; they are shuffled by all dealers in the same manner according to procedure; the cards are dealt from left to right and picked up from right to left (most often starting with busted hands and blackjacks); the same number of cards are dealt before reshuffling; the played cards and cutoffs (unplayed cards) are assembled in the same way before each shuffle; even the typical player's strategy and position of the player's cut can be anticipated. This normality creates a difficult environment for producing randomness (which can facilitate some advantage strategies).

In the complex and counterintuitive world of randomness also lie some of the gambling world's biggest misconceptions. Most gamers believe that once a process has been tested and stamped 'random', it's a process safe from predictive exploitation. But this is absolutely not true, as illustrated by the following story.

After watching a demonstration of one of the early shuffling machines, the inventor boasted that his shuffler had just passed a barrage of statistical tests for randomness conducted by a respected gaming lab and that the shuffler was safe from the myriad strategies currently beating hand-shuffled games (location, slug tracking, and sequential tracking). I commented, ‘You know, that doesn’t necessarily mean that the shuffler is not vulnerable’. A heated debate ensued.

To prove my point, I put two queens and an ace face down on the table in a row and invited the inventor to play a game, ‘Find the ace’. I asked him to move the cards around until he was confident that each card had a 1 in 3 chance of ending up in each position, and that any statistical test would confirm the process to be random. He moved a few cards around and said, “Let’s say that I continued to shuffle the cards for 20 minutes, now what?”; “Okay, lets play the game.” I pointed to a card and proposed, “I’ll bet \$10,000 that this card is the ace!” Of course he objected, stating that I had *watched the shuffle*, which was my point all along. Here’s a shuffling process that would be approved by any gaming lab to be truly random, yet I can predict where the ace will be with certainty. Albeit an overly simplistic example, the point is that just because a process is deemed to be random doesn’t mean that it’s automatically immune from predictability.

Several early slot machines were proven to be vulnerable to prediction, after passing the required statistical tests. Several early shuffling machines were also proven to be vulnerable after being successfully tested. And the same principle holds true with other games, too. A roulette wheel that exhibits a bias to the ball track is still producing random numbers and generating a random distribution. But the track's bias enables wheel clockers (visual prediction players) to strategize ball speed, rotor speed, and bounce, and still predict the winning number, or sector, or half of the wheel, despite playing against a *random process*!

C: How did the industry cope with Thorp's book? Some of them were in denial about this transformation—and yet in fact it increased profitability (decreasing hold percentage but increasing volume).

SF: The landmark *Beat the Dealer* was definitely a game changer. When the industry first learned that scientific play was possible in blackjack, they panicked and immediately changed the rules. But overreacting proved to be a mistake as the casinos lost business due to unattractive games. It didn't take long before everything reverted back to the old rules and procedures, however, as the casinos began to realize that few card counters can win over the long run, and that the perception of skill was a good thing; in fact,

it was a brilliant marketing ploy, albeit unexpected and unplanned.

At one time blackjack was as close to a flip-a-coin proposition as you could find. There were even periods when the player had an advantage just playing a ‘basic strategy’ without counting cards! This occurred for a short time in Las Vegas when the single-deck game was offered with stand on all 17s, double after splits, resplit aces, and surrender. There was also the so-called ‘Great Blackjack Experiment’ in New Jersey’s first casino, Resorts International. For a short time ‘early surrender’ was offered, a rule that allowed the player to give up half his wager *before* the dealer checked for blackjack (traditional surrender only allows this option *after* the dealer checks for blackjack). As anticipated, the rule didn’t last long as it also gave the players an advantage without the need to count cards.

As automatic shufflers gained more acceptance, ‘continuous shufflers’ were introduced. Their purpose was simple: Turn blackjack from a game of *dependent* trials to a game of *independent* trials, essentially creating a shuffle-after-every-hand format (infinite deck) that would render card-counting strategies powerless. But continuous shufflers have not been widely accepted by players so they haven’t dominated the shuffler marketplace as was anticipated.

Some sixty years later, the industry is still apparently bent on eliminating blackjack’s skill factor, and

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'Rotronis' roulette computer (Germany, c1980s)

their latest brainstorm is the advent of the 6 to 5 payoff for blackjacks. The traditional payoff has always been 3 to 2, so for comparison with a \$10 wager, blackjacks used to pay \$15; now they only pay \$12.

Most rule changes don't have a significant effect on players. When casinos hit soft 17 versus stand on all 17s, the house advantage increases by approximately 0.2%. When the player is only allowed to double down on 10 and 11, the house advantage also increases by about 0.2 percent. Even when casinos go from one deck to shoe games (4–8 decks), the house advantage increases by about 0.5 percent. But this latest change has all but rendered the game unplayable from a skill standpoint as the revised 6 to 5 blackjack payoff adds another 1.4 percent to the house advantage!

Though there are still a few beatable games today, it generally takes a professional (or professional team) to play skillfully, profitably, and undetected.

C: 'Availability of information' also depends very much on what one is primed to notice. You raise some interesting examples in *CGP*: You're playing a card game and spot that some cards are marked. Or you notice that the dealer deals in a certain way, and you can systematically take advantage of it. Are you cheating if you exploit this, since the information is theoretically 'available' to everyone?

SF: You're absolutely right, the notion of available information only has meaning if one is primed to notice. For example, when players sit down to play black-jack, they have many strategic options based on their knowledge and skill, or lack thereof. They can choose to simply play for fun. They can play systems based on hunches, streaks, and betting progressions, the classic SWAG player (scientific wild-ass guessing). They can learn 'basic strategy' and buck the lowest house advantage possible without counting cards. They can observe all cards and factor this information into their decisions. They can learn to count cards. Or, they could master the appropriate basic strategy, learn a card-counting strategy along with the most important strategy deviations in the game (based on strategy indexes), and then take their strategy to the ultimate level and consider all other sources of information made available to them, which entails combining their skill and knowledge with an ancient competitive principle found in warfare, business, sports, games, and life—targeting the weaknesses of the opponent. This is exactly what the world's best advantage players do—they seek every possible mathematical and psychological advantage and are experts at strategizing every source of information that is made available to them.

C: So that's advantage players; let's turn to cheating. In *Casino Game Protection* you speak of *spectra of technique*.

COLLAPSE VIII

Could you map out, broadly, what these different spectra are? How would you group the different types of activity that you try to detect?

SF: The ‘spectra of technique’ simply refers to a range of techniques that accomplish a particular goal.

Consider the classic dice switch. The most difficult switches are done entirely with one hand during the toss and they can be done instantly and deceptively. There are ‘hand-to-hand’ switches where cheaters will create believable scenarios to cover the switch, such as picking up the dice in the right hand and apparently placing them in the left hand (which conceals the crooked dice) to have the cheater’s female companion blow on the dice for luck. There are also ‘prop switches’ where a cheater will use cash or chips in his hands to facilitate the switch; two-player switches when, for example, one cheater slides the dice to his partner, switching them in the process; and switches that require gaffs or devices for their execution, such as ‘chip shells’. These are stacks of chips that have been glued together and gutted to create a shell that can hide one or two dice inside, allowing the cheater to *show both hands empty* during the switch. Finally, cheaters don’t always switch both dice; some scams require the switch of only a single die.

So, for this particular manipulative objective there are literally dozens of variants, as there are with card

marking schemes, false shuffles, past posting (betting after a result is known), and many others. Since I did not want *Casino Game Protection* to be an *encyclopedia* of moves, scams, and strategies, for each objective, legal or otherwise, I tried to present a variety of material that best represented the range of possibilities.

C: Are there different ‘species’ of cheaters corresponding to the ‘spectra of technique’? Some who excel in social skills—acting and creating the situation where there is an opportunity; and some who are more technical? Or do you have to master all of this to be successful? And what characterises a professional cheat as opposed to an amateur trying their luck?

SF: The most salient attributes of the professional cheater is good judgement. In any given situation, they know when to ‘move’ (cheat) and when to ‘pull up’ (quit). They know when conditions call for a cautionary path, and when to take dead aim (a bold, direct approach). They can sense ‘heat’ (scrutiny) even when it’s not visibly apparent, and they have an uncanny sense of when enough is enough. And perhaps most importantly, they have learned to control the greed factor—the downfall of many cheaters. The professional sees greed as a cancer to his profession, and judgement as the key to grinding out steady, safer wins.

Experience is another obvious distinction: One can only reach the status of professional with experience, both good and bad. A professional is much more apt to spend time working out the details, carefully considering the best way to ‘frame a play’, the length of time to play, how much ‘splashing’ (cover) is appropriate, and the always important backup plan. Preparation is paramount.

The professional is also much more likely to be on the cutting edge, always more likely to be playing with the next new scam, or with the next new cheating device. Their thought process is one of always trying to solve the next puzzle, beat the next industry countermeasure, beat the next new industry device, or beat the next new game.

Also, professionals are generally more technically proficient than amateurs. Some cheating techniques are so difficult that it can take months and sometimes years of practice to perfect them. You won’t find this level of dedication with amateurs; in fact, many of the most difficult moves are rarely attempted.

When it comes to interacting with dealers, bosses, and other players, professionals are also better actors. Believability is crucial, and they know it!

Finally, few amateur cheaters have big bankrolls. Many play with ‘blood money’ (case money, or borrowed money) so they are always subject to poor decisions due to desperation. But a big bankroll offers

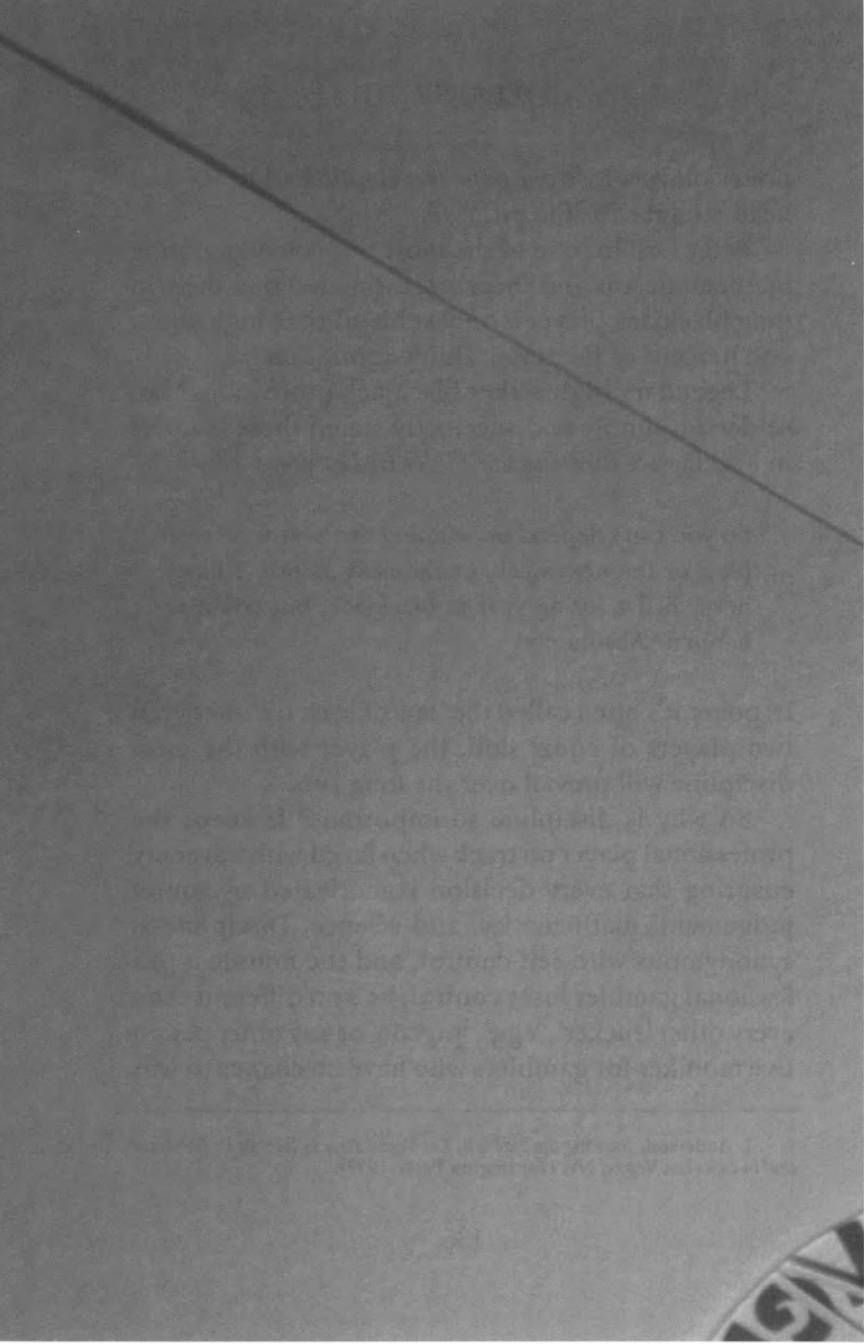
many advantages, not least of which is betting more and going for bigger scores!

While the common perception is that the best cheaters have mastered it all, I have met many who were incredibly talented technically, but who never had any significant monetary success, and have met many with little or no technical skill who have stolen fortunes.

C: From all of this it sounds as if you have to be hugely disciplined. What kinds of people enter into this as a really serious commitment? Both in terms of mindset and in terms of what other professions they might come from?

SF: It obviously takes discipline to master any craft, but where it really makes a difference with professional gamblers is *after* one becomes an expert.

Sooner or later all players run into severe statistical fluctuations. Some call it 'luck', others call it the 'x-factor' or the 'unknown factor', and mathematicians/statisticians call it 'normal statistical fluctuation', but whatever you call it, you can't avoid it. Envision a winning poker player or card counter playing for weeks or months and still showing a net loss. It can be disheartening and easy to doubt one's skill. I've seen literally hundreds of winning players run bad for long periods of time and head straight for the crap table or the sports book in an effort to get even. (I've seen



COLLAPSE VIII

poker players lose *one pot*—the classic bad beat—and head straight for the pit!)

Peter Griffin, one of the most respected gambling mathematicians and theorists, estimated that the winning blackjack player is only at his all-time high about one percent of the time! Think about that.

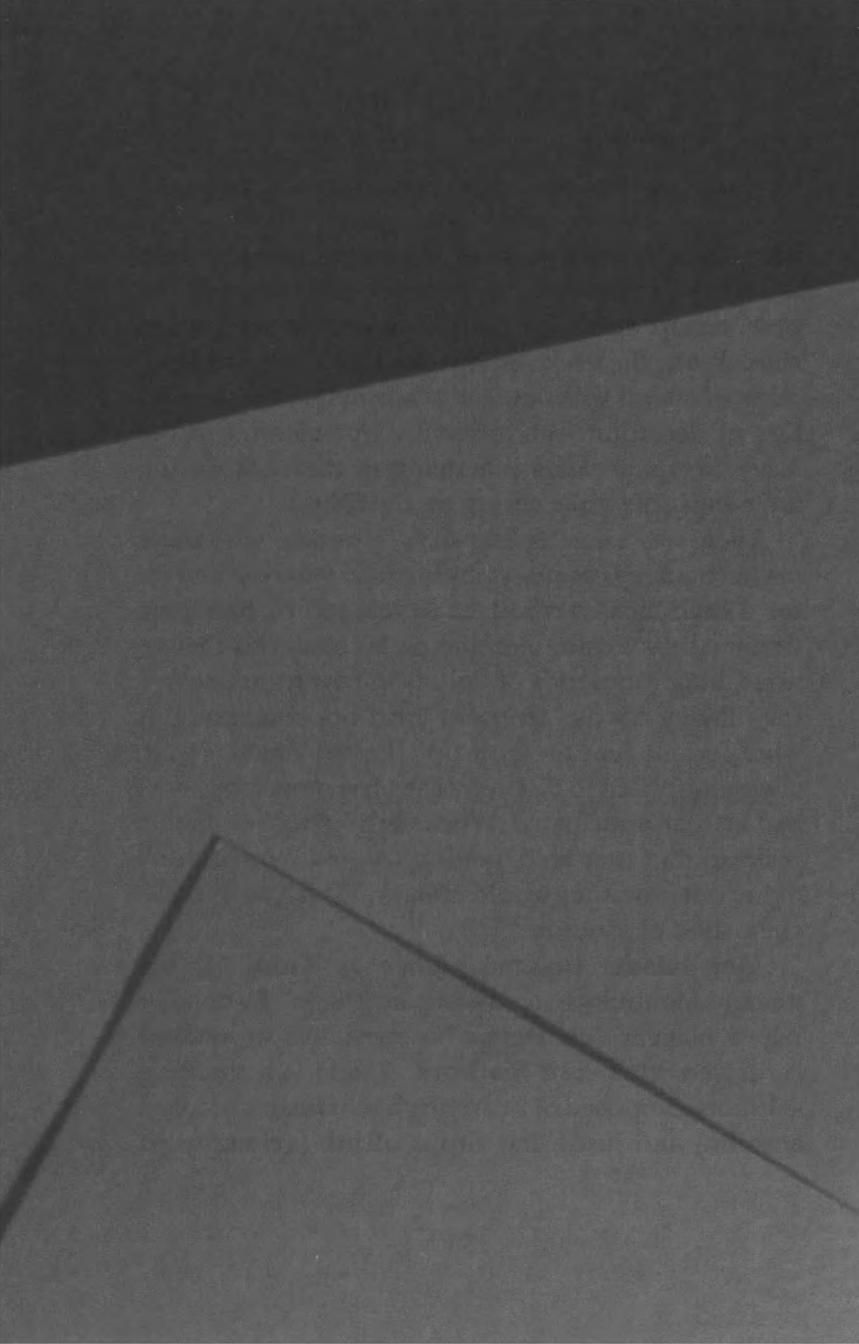
Legendary high-stakes blackjack professional Ian Anderson simply and succinctly stated these realities in his classic, *Burning the Tables In Las Vegas*.⁴

So you can't depend on winning the next time you play, or the next week, or the next month. I have never had a losing year at blackjack, but could it happen? Absolutely!

In poker it's often called the 'law of least tilt'. Between two players of equal skill, the player with the most discipline will prevail over the long run.

So why is discipline so important? It keeps the professional player on track when faced with adversity, ensuring that every decision is motivated by sound judgement, mathematics, and science. Discipline is synonymous with self-control, and the minute a professional gambler loses control, he's no different than every other 'sucker', 'egg', 'pigeon' or any other pejorative moniker for gamblers who have no chance to win.

4. I. Anderson, *Burning the Tables in Las Vegas: Keys to Success in Blackjack and in Life* (Las Vegas, NV: Huntington Press, 1999).



C: What ‘masters of the art’ have you come across?

SF: Through forty years of aggressive research into this world, I have been fortunate to meet several. The best ‘runup man’ (stacking) I have ever seen could riffle shuffle the deck without any hesitation and stack three of a kind without fear of suspicion, never mind fear of detection. While serving our country in the Navy, he spent years practicing in the dark during long voyages (while sitting on the toilet).

There was a hustler known as ‘Houdini’ who was a master at many casino scams but who was best known for a diabolical method he developed to past post bookmakers. Posing as a doctor, his story was that he was taking thousands of dollars in bets from doctors, then laying off the action to local bookmakers. But when it came time to ‘settle up’, the bookmakers were always surprised to discover that a few more long shots had hit than anticipated. When the bookmakers finally realized that they were getting conned, but couldn’t figure out how, they would remark, “This guy must be some kind of Houdini!”

One hustler became known as ‘God’ for his remarkable ability to read and play ‘shade’. Even other ‘paper players’ (cheaters who specialize in marked cards) couldn’t read his work. Shade is a marking solution comprised of a carrying agent (water, alcohol, acetone) and just a few drops of ink (generally an

aniline dye). It's used to mark any *white portion* of the card, darkening it ever so slightly, and is considered one of the more sophisticated marking systems due to the laborious practice required to read the marks in live play. In one high-profile casino case, the cards were suspected of being marked, but after all attempts to detect the work failed, the decks were sent to the FBI laboratories for analysis where a faint foreign substance was identified. The problem, however, was that despite detection and knowledge of the location of the marks, the cheaters were never pursued because no one could read the marks for a magistrate or jury. Most assumed that special glasses or contact lenses had to be employed to enhance the marks, though the truth is that the system's secret was twofold: (a) it took about 100 hours of practice, and (b) the cheater learned to read the work lighter and lighter (reducing the amount of ink) until it was highly improbable that anyone else could read the marks without going through the same arduous training regimen.

C: As this makes quite clear, at the highest levels this is a matter of attuning perception and control of one's play to an extraordinary degree. In CGP you write that 'professional cheaters can reach a level of skill, timing and finesse that borders on the supernatural'. Are the magical arts and cheating historically linked?

SF: Though there's definitely a link between cheating and magic, the crossover is tenuous and generally limited to some very basic tools and concepts.

While both groups may use sleight of hand, devices, and misdirection, the sleight of hand employed by cheaters face a tougher deception standard, their devices and applications are designed to accomplish different goals, and the misdirection—the term used in magic—is uniquely different in virtually all cases. In short, the two professions are worlds apart.

For starters, magic is a performing art, cheating is a criminal act. In cheating, the psychological environment starts with the presumption that the game is legitimate until some result or action raises suspicion; in magic, the environment is openly consumed by deception and suspicion since every spectator knows that the magician will attempt to use every trick in the book to fool and entertain. Cheaters generally have to follow acceptable card- and dice-table protocols; there are no such restrictions for magicians. In gambling, no one wants to be cheated; in magic, everyone wants to be fooled and entertained. Finally, cheaters are looking to be forgettable; magicians are looking to be spectacular. The list goes on and on.

While it's true that moves and ideas from the magic world occasionally find their way into the repertoires of cheaters, just the opposite is much more likely. There is a fascinating history of many famous magicians tracking down cheaters to learn their sleight of hand

as they believed that the sleight of hand employed by cheaters is more sophisticated and deceptive than the sleight of hand employed by magicians—though you rarely hear about cheaters reaching out to the magic world for the same reasons.

I have found that both professions have their elite. Some of the finest sleight of hand I've ever witnessed was in the hands of both cheaters and sleight-of-hand-artists. But I stop there. It just doesn't make sense to make further comparisons, because you'll never find any other common ground, apart from a few generalities.

C: So arguably the cheater has the tougher gig...Yet one skill professional cheaters and magicians share is that of anticipating the expectations of their respective 'audiences'—i.e., knowing what people *want* to believe—and setting the scene accordingly—altering the environment to create the best possible conditions for success.

SF: Cheaters have to manufacture believable scenarios because unusual results raise suspicions. They accomplish this goal in many ways.

Cheaters will often 'splash' a move to test the awareness and knowledge of the players. For instance, if a dice mechanic is getting ready for a 'money switch', he'll go through the motions a few times with money in his hands to establish the move and to see if anyone blinks. Once the other players get used to seeing the cheater

toss the dice with money in his hands, it becomes acceptable in their minds. When the switch actually occurs, since the actions associated with the switch have been established, suspicion is alleviated and it's easier for the brain to 'see' legitimacy.

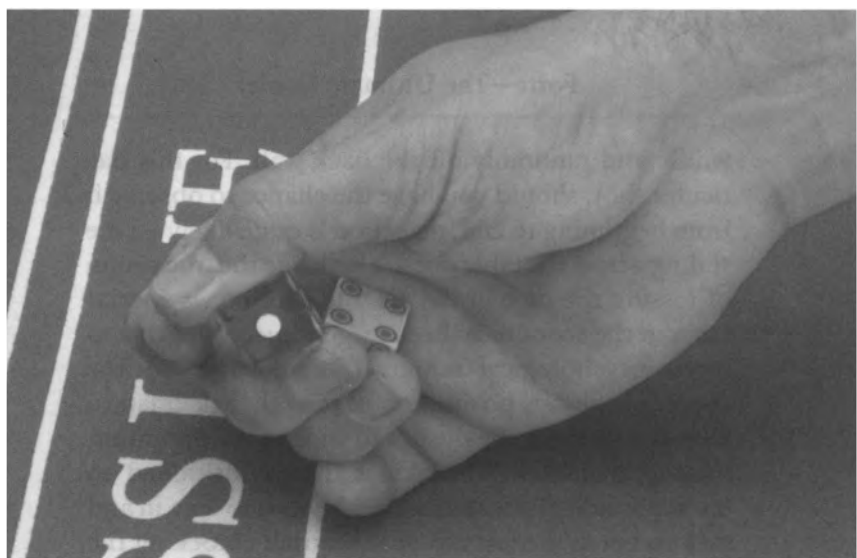
Some cheaters splash with an *actual move*, such as dealing a card off the bottom of the deck. But they do so without the intent to cheat. They will shuffle legitimately, have the cards cut, and while pitching the cards around the table they deal one card off the bottom. Since the bottom card is a random card, even if someone suspects the move, there's no rhyme or reason. Or they might do a 'push-through'—a false shuffle where the halves are riffled together, pushed in at an angle, and then stripped out with one half getting slapped on top to emulate a true cut. But after the push-through, they will riffle legitimately a few times. Again, the move has no purpose other than to test game conditions.

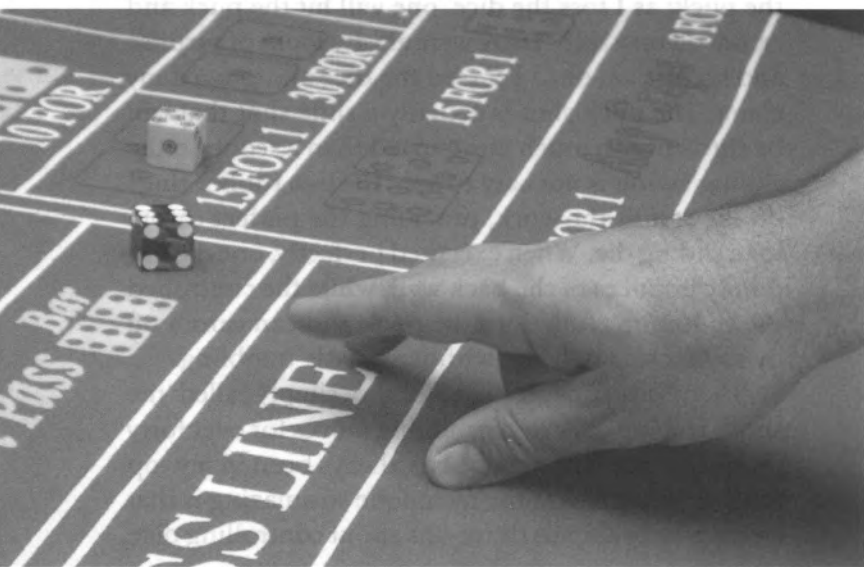
C: What's particularly striking in the GPS videos are the controlled dice shots, which are totally counter-intuitive since the die is an emblem of uncontrolled randomness. It's incredible just how much control one can have over the result; but these moves also depend on misdirection to some extent.

SF: Take the 'scoot', a gutsy scam where one die is slid short of the back wall while the other die bounces

wildly and randomly off the back wall. For this particular shot, should you have the chance to observe it from beginning to end, detection is quite likely—a die sliding across the table doesn't look like the true action of tossing the dice in the air. But dice crews specializing in the scoot have been largely successful due to clever 'psychological framing' (diabolical setup). The shooter is always positioned next to the stickman to keep the distance the die has to slide to the minimum. Another member of the crew is always positioned on the other side of the stickman; his job is to lean in and make a bet at the last moment, partially blocking the stickman's view. A third member of the crew will be the 'takeoff man', the player posing as the high-roller who will be making the big bet—always positioned on the same side of the table as the shooter, away from where the dice land. With this setup, each casino employee only gets to watch a *portion* of the scoot.

The stickman only gets to see the end of the scoot, which should be the randomly thrown die since the controlled die slides and stops first. The boxman only gets to see the end of the scoot since he's forced to react to the takeoff man's big bet (generally accompanied by strong eye contact). One base dealer (in front of the shooter) only gets to see the beginning of the scoot, while the other base dealer only gets to see the end of the scoot. (Base dealers are taught to protect their own ends.) Lastly, depending on the position of the floorperson, the inside corners of the table may be blind, which is





'The Scoot'—The forwardmost die (white) leaves the hand first and randomly bounces off the back wall; the other die (dark) slides short of the back wall.

why most scooters aim for the corners. When the scam goes as planned, *not a single employee gets to see the scoot from beginning to end!*

When I was lecturing around the world on game protection, one of my favorite moves to demonstrate was the ‘puck shot’. A puck is a plastic disk about three inches across and one inch tall with two rubber rings around the sides. There are two pucks on every craps table and they’re used to mark the ‘point’ (the number the shooter is trying to roll; i.e., 4, 5, 6, 8, 9, or 10). With casino executives around the table, I would point to the puck and say, “Keep your eye on the puck; as I toss the dice, one will hit the puck and carom off on a six!” There were always looks of surprise and scepticism until I tossed the dice and proved my claim. The puck-shot is actually a slide-shot that can be thrown with much more speed than a scoot, so the sliding action is not easy to see. The two rubber rings do the rest of the work, providing the perfect carom for a sliding die. When executed perfectly, one die randomly bounces off the back wall, while the controlled die slides forcefully into the puck and can carom off by as much as two feet without the die tumbling.

There’s also a controlled dice shot simply called ‘the shot’. Having collected gambling moves for over forty years, this particular move has always been in my top ten list. What makes the technique so amazing is that it completely dispels the myths about controlling dice.

With this method, one die is thrown with air! What this means is that the controlled die is thrown about three inches off the table. Now instead of an obvious slide, the controlled die will wobble, and can even bounce, while maintaining its lateral control. Though a *percentage shot*, I've met cheaters who have won fortunes with this move.

Awareness and general knowledge are important factors that all contribute to one's belief that something just witnessed was legitimate. Bosses, for example, who believe that a slide-shot would be easy to detect, but that controlling a die that's thrown in the air is impossible, would definitely be vulnerable. So when you talk about 'what people want to believe', it's what's in their heads in terms of knowledge, experience, awareness, and perception that can set the stage for cheaters' techniques to go undetected, even when perpetrated in plain view. Depending on the mindset of the observer, the brain can get fooled over and over again.

Finally, for an interesting aside to those who watch closely but never see anything, consider a boss 'burning' a suspect player (intense heat and scrutiny). Many of the best cheaters, advantage players, and card counters interpret intense scrutiny as a sign of *weakness* and as no reason for concern. It's the classic poker tell of acting strong when weak, and vice versa. These players will tell you that they're much more concerned about bosses who keep their distance while

casually supervising the games out of the corner of their eyes, which they view as a kind of psychological trap designed for them to take the bait and expose their true intentions.

C: So there is a whole game of deception and counter-deception here.

SF: Deliberately acting as if being careless, clumsy, or absent-minded is just one way for cheaters and advantage players to portray a nonthreatening image—most don't associate these traits with the slick, polished, sophisticated professional gambler. But the idea of cheaters and advantage players 'acting' for various reasons happens every day.

Cheaters have to act to hide their crimes (criminal deception); advantage players have to act to hide their skill (strategic deception).

One of my favorite stories along these lines is about an old-time hustler that was a master 'paper player' (marked cards). He would intentionally sit at the end of the table, wear thick-rimmed glasses, and routinely rise off his chair and peer down the other end of the table to read the cards. The thick rims suggested that the lenses were also thick, and occasionally rising off his chair was an act designed to further the impression of poor eyesight. In truth, the hustler had 20/20 vision and the lenses were normal and uncorrected. When someone

detected the marked cards one day, 'old man Harry' was the last player suspected; after all, it was a struggle for him to even read the faces of the cards!

In the early 1960s when card counters began to get backed off and barred, it was immediately apparent that to have any chance to win, one also had to hide one's skill. This led to the concept of 'strategic deception' and is the reason why most of the early books on card counting included chapters on camouflage, comportment, cover, and image. For the same reasons, advantage players need to hide their skill, too.

An example of strategic deception employed by advantage players can be seen in the case of a very successful, creative bias wheel player. He had discovered a mechanical defect and was betting the same bias numbers, winning a substantial amount of money. His act involved the use of an astrological chart that conveniently depicted a circle of 12 different 30-degree divisions called 'signs'. The player was able to convince the bosses that 12 (divisions) multiplied by 30 (degrees) represented the roulette wheel (360 degrees with 36 numbers excluding the single and double zeros), and that his strategy was based on some nonsense about the path of the Moon, Sun, and the planets. Apparently, the casino believed the player was crazy for several months before the mechanical biases were discovered. From a detection standpoint it's relatively easy to cut right through these facades and avoid being confused

by all the external noise, and the secret is simple: Don't be swayed by stereotypes. Ignore age, sex, race, dress, words, and mannerisms. Strive to conduct a solely scientific evaluation that focuses on two criteria: the betting and playing decisions of the suspect player.

In blackjack, for example, there are countless methods for marking cards, and no one can have knowledge of all methods. Fortunately, from a detection standpoint, there are essentially only three ways to exploit marked card information and all are easy to recognize. They are 'top-carding', hole-card play, or a combination of the two (known as playing with 'anchors' who are small players who will purposely forfeit a bet if necessary to help win the big bets).

When a player knows the top card before it's dealt and he's in a position to receive the first card, there's often a strong correlation between higher-than-average bets and starting the hand with a ten or ace. (By the way, advantage players can get this information legally in a variety of ways!) If the player knows the dealer's hole-card, the appropriate strategy is generally very transparent because it requires one distinct strategy when the dealer's initial two-card total is strong, and another when the dealer's two-card total is weak. When both the top cards and hole-card are known, it's even possible to *control the result*. If the dealer has a 'stiff' (totals 12–16), an anchor sitting last can leave a ten-valued card on top that will bust the dealer and ensure

a win. It's also possible for one or more anchors to sit in front of the 'takeoff man' and play to leave a favourable card for their cohort. For example, the anchor could leave a ten-valued card on top when he sees that the big player is about to double down with eleven.

C: Along the same lines, let's talk about 'turns'.

SF: 'Turns' are planned distractions designed to hide something. Though the least scientifically interesting of all the questions, turns are one of the most colourful topics in the entire cheating genre!

Turns are an essential element in many scams and may refer to the person who intentionally and momentarily diverts the attention of a dealer, supervisor, or surveillance as in, "For this play we'll need *turns* on both sides of the game". The term may also refer to the physical action—as in, "You *turn* the boss". Often the turn provides more of a blocking action than a distraction, as in the case of 'past posting' (betting the winning number after the ball has landed). Here the turn leans over to make a bet and completely blocks the view of the dealer. Without a turn, many scams would have little chance for success.

Consider the scams of 'mucking' and 'switching' (one- and two-player card switching). The turn works one side of the game while the cheater(s) plies his trade on the other. Eye contact is an integral part of turning,

and any action accompanied with strong eye contact may do the trick. Or, to force a response, the turn may expose his cards, look to the dealer and ask, “How would you play this hand?” One turn, when signalled to divert the dealer’s attention, would blatantly pick up his bet and place it on top of his cards, rather than simply sliding the cards under his bet—the proper way. This would drive dealers crazy as they would all immediately respond, “Sir, please don’t touch your bet, just slide your cards under your chips”. The turn would do this two or three times, always with an apology, and always as the switch was occurring. The turn knew that most dealers are anxious to take charge, so he let them, forcing the anticipated response.

By the way, the best defense against these kinds of turns is for dealers to learn how to ‘walk the game’, which is to lean to the right and left, not turn to the right and left, and always maintain a strong peripheral vision of the game so that no player is ever completely out of sight. These are the toughest dealers to manipulate, which is why cheaters typically scout for the right dealer; they’re looking for puppies, not bulldogs.

When a turn is signalled to act, he or she can be very creative. I’ve seen cheaters take insurance against a deuce, hand the dice to their girlfriend, set their drink on the winning number in roulette, and just about anything else that would force the dealer or supervisor to react, because once they do, it’s generally too late.

Calling a boss to get the cocktail girl, engaging in a conversation, telling jokes, staging disputes, and using pretty girls (the more scantily dressed, the better) are common ruses. If a crew wanted to pull a boss off a crap game, a turn might just walk into the pit and ask, “Is Mike working tonight?” After the boss responds, “Mike who?” the turn replies, “You know, he looks a lot like you”. The entire interaction takes only five seconds, but with many scams, that’s all the cheaters need. After a turn does his job, he’ll often walk right out the door. They don’t want to be connected to any suspect play and risk having a boss put two and two together: “See the guy over there; he pulled me aside to ask me a question, and I think the shooter slid the dice.”

On the strong side, turns have been known to knock over stacks of checks into the pit, spill drinks on other players, pretend to fall asleep on the game, start fights, and even stage heart attacks. The colourful stories are plentiful. In one infamous scam, a strong turn was required to switch an entire eight-deck shoe. When signalled, *the turn jumped up on top of a blackjack table*, took off his jacket to reveal a Superman outfit, and started yelling, “I think I can fly, I think I can fly.” The turn was so strong that not only were the bosses and security guards turned, but every player in the near vicinity got caught up in this madman’s antics. The crew successfully kicked in a \$160,000

cooler, but after getting indicted a year later, the authorities were able to find numerous employees and patrons who still remembered the Superman incident. The turn was over the edge, it was too strong. The best cheaters will tell you that the best turns are those that no one remembers!

C: At what point in the history of gambling did game protection come into existence as a discipline, with a history and professional status?

SF: This is a fascinating question.

Any gambler worth his salt understands the importance of protecting himself from cheaters, so the idea of *individual* game protection has undoubtedly been around since the first games of chance. Modern translations of Cardano's *Liber De Ludo Aleae* (c1500s) classified the work as a gambler's handbook, because it included brief explanations of false dice, marked cards, and other cheating techniques.

The first book to expose the methods of cheaters in American literature—also the first book with the word 'gambling' in the title—was Jonathan H. Green's 1843 *An Exposure of the Arts and Miseries of Gambling*. Green was known as "The Reformed Gambler", and he would go on to author several cheating exposés. Fastforward to the 1950s and several authors were writing books with detailed information about cheating

and, more specifically, how to protect oneself against cheaters. Most notable were John Scarne and Micky MacDougall. Scarne may have been the first independent casino consultant, while MacDougall was the famous card detective who accompanied Ed Thorp into the Las Vegas casinos to detect crooked blackjack dealers while Thorp was writing his seminal *Beat The Dealer*.

The first commercial video series to expose the methods of cheaters was produced in 1981 by game-protection expert George Joseph—currently president/owner of Worldwide Casino Consulting.

For many years it was customary for the clubs to hire ex-cheats who would watch the games from the catwalks (with binoculars). Eventually, surveillance systems were introduced and the sophistication of these systems and supporting technologies advanced rapidly.

My consulting career began in the middle 1980s. At that time there were only a few outside consulting firms offering game-protection training (though many clubs addressed the topic in-house). Today there are dozens of security-based companies and game-protection consultants working around the world.

For decades, game protection was the number one priority of most casino operators, but not any more. Its importance has gradually declined, with today's operators focusing their efforts on customer service.

Apparently, shuffling machines, peeking devices, low-profile roulette wheels, surveillance software for analyzing suspect play, and a host of other high-tech security-based implementations have lured operators into a false sense of security. Sure, the games are better protected than ever before, but there's always a way...and it has been my experience that the best cheaters and advantage players are ten years ahead of the industry!

C: One means of control must involve stamping out any material asymmetry in the equipment itself: What kind of work today goes into developing the design of roulette wheels, making dice symmetrical, making cards robust and unmarkable, etc.?

SF: The makers of cards, dice and wheels are highly competitive with each trying to trump the other by offering something new to improve functionality, security, and player appeal. Here are a few examples.

Dice have essentially been made the same way for decades, and dice makers have done a good job at maintaining acceptable manufacturing tolerances. For security, makers can add a 'glow spot' (epoxy spotting compound is mixed with an ultraviolet ink), 'key spot' (letter or number monogrammed on the inside of a spot), or nontraditional spotting orientations.

The same is true for playing cards, though recent high-profile cases have drawn attention to manufacturing tolerances regarding the back design's registration, or how accurately the back design is positioned. If the tolerances are off too much, an asymmetrical back design is the result, which can be cleverly strategized by sophisticated advantage players as the cards provide another source of information that is made available to all players.

Roulette wheels, however, have experienced dramatic changes. It started with flattening the traditionally deep-sloped center of the wheel ('cone' or 'dome') along with reducing the height of the pocket walls ('frets') to create the modern 'low-profile' wheel. With the new design, the ball bounces longer and more unpredictably (more scatter).

Pocket walls used to be separate pieces but they would loosen over time and create a bias—a wall not firmly in place will absorb the ball's force when hit and minimize bounce around the bias. To counter this issue, solid, one-piece number rings were designed. Changes to the traditional pocket design followed including triangle- and scallop-shaped pockets.

The quality of the bearings has improved dramatically, resulting in almost no decay in rotor speed.

Some manufacturers have redesigned the ball track by changing slope, or curvature, or by using a more durable material for the track's surface.

To monitor the levelness of the ball track, in-track sensors built right into the track are also available!

After the ball exits the track, it may or may not hit a small deflector before reaching the pockets. These deflectors are also called ‘canoes’, ‘diamonds’, and ‘pins’. Their purpose is to create more variance from spin to spin. As one would expect, deflectors come in different shapes and sizes, all in an effort to ensure a random outcome.

Much more so than dice and cards, roulette wheels can also be highly decorative, being offered with different colors, themes, translucent bowls, and hand-painted domes. Even internal LEDs can be used to aesthetically heighten their appearance.

Originally designed for roulette’s version of the slot machine (console roulette/automated roulette), there are even models that eliminate the need for the dealer to spin the ball, instead using compressed air to launch the ball!

From a security standpoint, one of the most practical and effective measures for ensuring the trueness of the wheel is to record all wheel data for statistical analysis. Using reader technologies that identify the winning number, the data can now be automatically fed through a software package that conducts ongoing statistical tests in an effort to identify bias before the player.

C: The obvious way to minimize the exploitable information at the disposal of players is to ensure randomness. But as we've already observed, randomness is a tricky concept. This is shown by the very informal definition of a random shuffle you cite from *The Theory of Gambling and Statistical Logic*: 'We define the random shuffle as an operation equivalent to scattering the deck in a high wind and having the cards retrieved by a blindfolded inebriate.'⁵ Do all shuffles therefore fall short of a 'real shuffle'?

SF: The short answer is yes: Studies have concluded that it takes several shuffles (riffles) to ensure randomness, though casinos have never met this standard. They operate their games with a productivity mindset: The more decisions each hour (hands, rolls, spins) the higher the profits. When I was breaking in, I recall the mantra from many bosses, 'Keep the cards and dice in the air, and the wheels spinning'.

In 1997, Professor Robert Hannum of the University of Denver conducted a study entitled 'Casino Card Shuffles; How Random Are They?' Actual casino shuffles were recorded and evaluated using several statistical tests. The conclusion of the study was no surprise:

5. R.A. Epstein, *The Theory of Gambling and Statistical Logic* (Burlington, MA: Academic Press, 1967).

COLLAPSE VIII

The six-deck shuffles failed virtually all tests for randomness [...] the single and double-deck games offer mixed results, failing on some while passing on other tests for randomness.

Since it was impossible to achieve randomness with just three riffles and a quick running cut—the standard one-deck casino shuffle—flaws in these shuffles would eventually be discovered by sharp gamblers, and these loopholes were even more evident with multi-deck games.

For example, consider a four-deck shuffling procedure where the decks are divided into two piles, and then ‘grabs’ of about 35 cards are taken from each pile and shuffled together several times. If a ‘shuffle tracker’ was able to count the two appropriate 35-card slugs as the cards were played and placed into the discard rack, determining that grab #1 had about ten extra high cards (more so than probability dictates), and grab #2 had about five extra high cards, these two packets of cards could be shuffled together 1000 times and never change the player’s assessment that the combined 70-card slug was rich in high cards by a factor of about 15 extra high cards on average. This favourable slug could then be cut to the top of the shoe, or near the top, and strategized in various ways.

Challenges along these lines led to the introduction of automatic shuffling machines, but as it turned out,



John Phillip Quinn, *Why Gamblers Win* (1912).

even shuffling machines could be exploited. One early model had two vertical bins built into a dealing shoe where the played cards were alternately discarded. Rollers would randomly move 1–3 cards off the bottom of one stack and then repeat the process with the other stack. After a small group of cards were shuffled, they were pushed to the front of the shoe and the process continued to provide a continuous stream of cards. Unfortunately, limiting the random selection to a maximum of three cards was a serious oversight. Cards that were discarded in ABC order were dealt in CBA order with a maximum of three cards between them. So, if the ace of clubs and two of clubs were discarded in ace-two order, and the general location of these cards could be anticipated (near the front of the shoe), and the two of clubs was dealt followed by three x-cards—the maximum number of spacers that could separate the ace and two—the top card of the shoe could be predicted to be the ace of clubs with a very high degree of certainty (duplicate cards in multi-deck games could cause occasional errors).

Several other shuffling machines to follow exhibited similar design flaws, and for these reasons, the best automatic shufflers today adopt a ‘random selection process’.

In 1938, Ronald Fisher and Frank Yates described in their book *Statistical Tables for Biological, Agricultural*

*and Medical Research*⁶ a method for randomly reordering an array of numbers. Using pencil and paper, a list of numbers (say 1–10), and a precomputed table of random numbers, they randomly selected a number from 1–10, crossed that number out and used the number to start a new list. Then a number from 1–9 was randomly selected, crossed out, and became the second number in the new list. This continued until the new list was completed resulting in a random permutation of the original list. The process is often compared to dropping ten slips of paper in a hat numbered 1–10, mixing them, and picking out the slips one by one without replacement to determine a new order.

In 1964 the idea was adapted for the computer by Richard Durstenfeld in *Communications of the ACM*, and popularized by Donald E. Knuth in his book, *The Art of Computer Programming*.⁷ In the context of shuffling cards, a card was randomly selected from 1–52 and swapped with the bottom card of the deck. The next card was randomly selected from 1–51 and swapped with the second card from the bottom of the deck, and so on. The net result was an ‘in-place’ shuffle that was optimal in runtime and space—the algorithm could not be shortened and the memory required to run the

6. R. Fisher and F. Yates, *Statistical Tables for Biological, Agricultural and Medical Research* (London: Oliver & Boyd Ltd, 1938)

7. R. Durstenfeld, ‘Algorithm 235: Random permutation’, *Communications of the ACM* 7:7 (July 1964), 420; D. E. Knuth, *The Art of Computer Programming* (Reading, MA: Addison-Wesley, 1968).

algorithm could not be reduced. In other words, the algorithm achieved a mathematically random shuffle in the fewest steps possible.

As is the case with all shuffling algorithms of this kind, when the method used to generate the initial seed is random, so is the end result.

Although the premise has been around for over seventy years in the computer world, it was first duplicated, mechanically and electromechanically, in the Random Ejection Shuffler introduced by Casinovations Incorporated in 1995 (I was a co-inventor). Most of the best modern shufflers have followed this conceptual lead.

C: Continuing with the technological theme, there must have been a massive increase in the use of electronic player assistance—signaling devices, computers, cameras—with the emergence of cheap electronics and computing power. How does game protection deal with a situation where you have to imagine not only what a human might do, but what a powerful, speedy, number-crunching computer, or an array of concealed cameras, might be able to do—you say in *CGP* that ‘these devices force us to look at the games from every conceivable angle’.

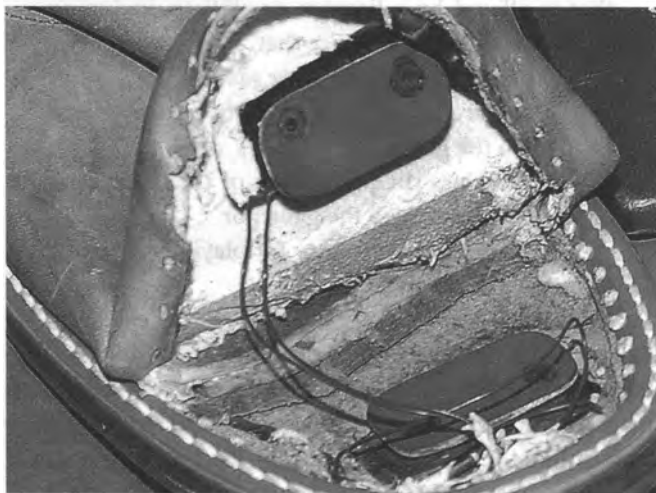
SF: Although the possibility always exists that the industry could run into hidden card-counting computers, perfect strategy computers, and roulette computers, most casinos—at least in the US—now have

‘device laws’ that prohibit the use of any electronic or mechanical means that helps the player play more skillfully. For example, the Nevada Revised Statutes (NRS 465.075) states the following:

It is unlawful for any person to use, possess with the intent to use or assist another person in using or possessing with the intent to use any computerized, electronic, electrical or mechanical device, or any software or hardware, or any combination thereof, which is designed, constructed, altered or programmed to obtain an advantage at playing any game in a licensed gaming establishment or any game that is offered by a licensee or affiliate, including, without limitation, a device that:

1. *Projects the outcome of the game;*
2. Keeps track of cards played or cards prepared for play in the game;
3. Analyzes the probability of the occurrence of an event relating to the game; or
4. Analyzes the strategy for playing or betting to be used in the game.

In blackjack, for example, a player equipped with a perfect strategy computer (optimal betting correlation and playing efficiency) plays the game at a level of sophistication unlike the best card counters. That said, advanced playing decisions can be very composition-dependent. A deck depleted in threes and fours might prompt a



An early 'perfect strategy' blackjack computer
codenamed 'David', c1970s.

perfect-strategy computer to have the player split tens against a seven, since it's weakened by the absence of any threes and fours, though the best card counters would rarely make such a play. This is the kind of playing decision, when accurate, that can be identified by experts as being outside the majority of players' human capabilities.

In roulette, there are no base strategies, *per se*, so a much more prudent course of action is to look at the mechanical and physical traits that tend to exist with most high-tech strategies and ask a few basic questions: Is the player consistently betting late (last four revolutions)? Is there a bias to the ball track where the balls tends to fall from the track at the same point? Is a fall-off point above a deflector, especially a vertical shaped deflector (creates a situation where the ball falls from the track and hits a wall, absorbing speed and impact, and directs the ball downward directly to the pockets)? Is the rotor speed too slow? Does the bounce appear to be manageable (a function of rotor speed)? Could size and composition of the ball be factors?

Moving from computer to camera, the use of hidden cameras definitely adds another step in the evaluation process, because now the analysis of suspect play must be expanded to include the possibility of *watching and/or recording* the game from almost every conceivable perspective. Since the typical spy camera is tiny,

it can be concealed almost anywhere, and this includes a power source and transmitter. Typically, these units only have to transmit short distances to a ‘booster’ or ‘repeater’ which is a larger, more powerful transmitter hiding in a woman’s purse close by. A ‘booster’ or ‘repeater’ then sends the video signal to a remote location (hotel room, parking lot, nearby structure) where the signal can be played back several times, even in slow motion, after which the appropriate strategy can be sent back into the casino to one or more players (via audio link). These kinds of systems can be used to peek the dealer’s hole-card as it’s dealt, record the riffle shuffle, and even detect marked cards otherwise not visible to the naked eye.

During my consulting career, when asked to evaluate suspect play I always considered the possibility that a camera could be hidden in any conceivable location, and that the game could be remotely observed or recorded from behind, at table level, or from normal eye level. I considered every prop as a potential hiding place including cash, stacks of chips, cigarette boxes, cellphones, coffee cups, or anything laying on the table. Lastly, I always considered the possibility of the camera hiding on the player or dealer.

In summary, no one knows how the advances in technology will affect the game protection landscape. All we know for sure is that both sides keep getting better at their jobs.

C: It seems that sometimes players will actually resist certain attempts to ensure that games are fair and randomized. They prefer to stick conservatively with traditional set-ups and are opposed to continuous shufflers, etc. How does one maintain a balance between protection and enjoyment?

SF: We've already talked about how the industry responded to the card counting revolution, first changing the rules and then quickly reverting back to the old game, but this is not the only time the public 'spoke' and got their way.

Continuous shufflers were designed to eliminate blackjack's skill factor, but they have never gained wide acceptance.

Four-colour decks were introduced to the poker world with less than rave reviews. For whatever reason, poker players would just not accept them. But when shuffling machines surfaced, any initial trepidation quickly turned into a blanket endorsement for one simple reason: productivity! This was good for the house and for the professional player: more hands, higher profits.

Translucent domes over the roulette wheels are not a popular implement. Though designed to protect the wheel from being manipulated from the 'outside' (the players' side of the table), many players enjoy *sweating* the result (like watching the horses come down

STATE CASINOS CHANGE RULES ON '21' GAMES



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Fringe Benefits Tossed Out

By COLIN MCKINLAY

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Fringe Benefits Tossed Out

By COLIN MCKINLAY
R-J City Editor

Computers have hurt the fringe benefits at Las Vegas casinos and two significant changes in the rules of "21" have been invoked to "put the game back in proper perspective," it was learned Wednesday.

PLAYERS CAN now go down for double on eleven only, and players cannot split aces anymore.

"Somebody found out the odds were shrinking," commented one hotel official.

Another said that the move was designed to minimize the efforts of card counters who would play the odds on the cards remaining in the deck.

ONE HIGH LEVEL industry spokesman flatly predicted that "this is the beginning of a trend which will introduce the shoe."

The shoe, already in use at most casinos throughout the world and here in Las Vegas at the New Frontier and Hacienda, is a box which holds four decks of cards for the 21 dealer. It makes card counting almost an impossibility to be of any value to the players.

AGREEMENT WAS reached only this week at a meeting of industry officials. All major hotel-casinos, with the exception of some of the smaller downtown clubs, were represented and agreed to go along with the rule changes.

Nevada Casinos Respond to Card Counters—*Review Journal*,
Las Vegas, NV, April 16, 1964

the stretch) and the domes impeded their view, often reflecting light and other images.

Many slot players are not crazy about virtual reels (computer generated images) and prefer to play machines with a physical reel and a limited number of symbols. Many aren't fond of coinless machines, either.

I remember when the first 'peeking device' was introduced. Many experts—including myself—couldn't fathom how the casinos would agree to install small mirrors into their blackjack tables; after all, cheaters have been known to use small mirrors called 'shiners'. But the device was widely accepted and applauded for solving a serious problem (hole-card exploitation) in a very affordable, straightforward way.

Many innovations come with challenges and not every player is quick to buy into a new way of doing things, especially the older-age market who have been frequenting casinos for half a century. They always want to remind you of the old days, but the times have definitely changed.

As a general rule, if the industry wants to introduce a new game, side-bet, device, procedure, design, or a new way of doing things, there's very little the public can do. Players can lodge their complaints, slow down progress, and even refuse to play, but sooner or later, the casinos always end up getting their way...you can bet on it!

C: This leads us to the question of what players actually expect or want from their casino experience. We would assume that a typical customer enters a casino to feel the rush of a submission to chance and hazard.

SF: Every player is different, each hoping to enjoy a positive gaming experience. For some, it's all about fun. They don't expect to win unless they get lucky. For others, it's a more serious form of 'entertainment'. They may not be experts, but they're not oblivious to the concept of a strategy. When playing blackjack, for example, it has been my experience that many players want to 'feel the rush' of being in a *true skill* situation and *not* blindly submissive to hazard. Players want to feel that their decisions matter and that they have some control over their destiny. We often see 'card watchers' who enjoy the challenge of watching the cards from round to round. They are not card counters, but if they haven't seen many tens over the last few rounds, they're more inclined to take insurance against the dealer's ace. If they notice many ten-valued cards and aces, they are less likely to parlay their bet after a win. Other pure skill-based mathematical games that find favour with these kinds of players are video poker, sports betting, and of course, poker.

Other classic casino games like baccarat and roulette are generally classified as pure games of chance, but that's a misconception. Baccarat and roulette are

unknowingly offered as games of skill all the time. For those who believe that ‘setting the dice’ before tossing them can favourably influence the outcome, craps could also be included in this category.

Winning strategies for beating baccarat started in the 1960s when Ed Thorp developed a simple card counting strategy to beat a side bet on natural eights and nines; once discovered, the option was quickly removed from the layouts.

Roulette has a rich history of bias-wheel players who have had great success identifying and beating wheels with mechanical imperfections.

Many of the best advantage players in the world contend that most casino games are beatable, even those purported to be games of chance.

C: New advantage plays and scams eventually result in the casinos tightening up their game. Has there always been something of an ‘arms race’ between cheaters and game protection? Have you been surprised in the past by the emergence of new scams that you couldn’t have anticipated?

SF: Once again, it’s important not to directly compare cheating with advantage play. Cheaters perpetrate scams; advantage players apply strategies that target casino weaknesses. While it’s true that both groups have become more sophisticated due to tougher casino

conditions and the implementation of many modern tools: shuffling machines, peeking devices, evaluation software, etc., it's not true that advantage play led to cheating, or vice versa. Each group must be looked at separately. Their strategic approaches, histories, and impact on the industry tell two completely different narratives.

With cheating, many of the older scams have disappeared, but only in terms of application and execution. The perfect example is the 'old-fashion cooler', a scam that starts with stealing six decks from an inside source and ends with a blatant switch of all six decks! (Of course the dealer is involved with this scam.) With one supervisor responsible for watching between four and eight games at a time, it was easy for cheaters to get a supervisor looking the wrong way for a split second when the decks could be switched (often from and into secret pockets called 'webs'). But today we have the omnipresent surveillance camera, and in many jurisdictions it's required by law that every game be recorded 24/7. The old surveillance adage, 'The Eye Never Blinks', is particularly true today; and should a cooler be suspected, it would immediately be detected after a quick review of the surveillance footage, which is also true of many other scams that don't fare well in an environment where one or more surveillance cameras are guaranteed to record every move.

That said, an overhead camera provides only a single perspective, while cameras watching a game from the sides can often be blocked by cheaters simply standing. For these reasons, a whole new genre of sleight of hand has evolved known as ‘sky moves’, moves that are difficult to detect from an overhead vantage point due to its limited depth of perception. We’ve all seen talented sleight-of-hand artists fool us from just inches away; imagine the difficulty of detecting a sophisticated false shuffle from an overhead camera sixty feet in the air!

In respect to advantage players, they’re smarter today than ever. They also have a greater understanding of the games and their mathematical nuances than ever before. This is due in large part to the evolution of the computer. Sophisticated gamblers can now quantify almost any aspect of any game in ways not possible previously. It’s often impractical to use manual calculations to analyze a new game or rule due to complexity and sheer time restraints, but a player with programming skills could write the appropriate code, run a 100,000,000 hand simulation, and produce an accurate statistical analysis in short order.

When the science of card counting was first publicly exposed and mathematical proof was presented that blackjack could be beaten with skill, academia took notice, and the stereotypical professional gambler (diamond pinky ring, slick moustache, etc.) began to

transform into the science-orientated, geek-like, college whiz kid, and this new breed of player proved to be a formidable foe; in fact, advantage players have had more impact on the industry than cheaters over the last forty years!

For just one example, consider the hole-card players/teams (recall *State of Nevada vs. Einbinder and Dalben*). In 1988, Las Vegas casinos began abandoning the tradition ‘peek game’ and converting to a no-peek format because it appeared that one premium player after another was playing with *hole-card information* (the players’ strategies were unusual, yet obvious). The correlation between the playing strategies and the dealer’s hole-card was so strong, the industry could only come to one conclusion: the dealers must be ‘tipping’ or ‘sending’ their hand to outside ‘agents’ (accomplices). But something wasn’t right. Tipping the hole-card was a rank scam, one that the industry had faded for many years, and the suspect dealers were universally held to be experienced and trusted employees. The industry was bewildered. All they knew was that it had to stop, so sixty years of dealing the peek game came to an end, and it was the advantage players that forced the change!

C: So still no one knows how that was done? Are there many examples of that kind of thing in the history of cheating, where someone simply got away with it and no one knows how?

SF: This happens all the time. In fact, it's probably happening right now!

To put it all in perspective, as a professional blackjack player during this era, my team alone had over 300 dealers who were unintentionally exposing their hole-card in one way or another in just the Las Vegas area. I would run into other hole-card players/teams almost every day. Many were highly financed and organized. Untold tens of millions were won by these players before the industry had enough and said, "Okay you win", and decided it was time to change the old way of doing things. And they did. In the US today, almost every blackjack table in the country is now equipped with a 'peeking device'. Dealers no longer have to lift their hole-card to peek it; the upcard and hole-card are slid into a reading device when a LED either blinks green (continue play), or red (stop, dealer has blackjack).

C: Once again, there must be a compromise—that is, game protection has to allow leeway in order for the game to still be relaxed, fun and playable, and not to intervene too much and put off profitable customers. So an 'arms race' with the cheaters goes hand in hand with a 'tug-of-war' with the players, when game protection tightens things up too much, and business falls off as a result.

SF: The modern casino environment is no place for casual or shabby game protection philosophies. Though the atmosphere needs to be fun, pleasant and almost party-like to assure a positive gaming experience, the capability to instantly and systematically evaluate suspect play is a must, because each time a new game, side bet, device, or procedure is introduced in the industry, hundreds of sophisticated gamblers are *scientifically* dissecting every component of these implementations in an effort of finding exploitable angles.

C: So when you're working in game protection, you have to have an eye to innovations on the other side?

SF: From a game protection standpoint, it has always been a challenge to keep up with the best cheaters and to anticipate the next big scam. But when you're a true student of the games, you'll often find that though the scams may change slightly, the principal areas of the games most targeted by the various scams stay the same.

For example, in 1983, a player was found to be playing with a mini-camera hidden in his belt buckle. Standing on the game, this was the equivalent of squatting down to get his eyes at table level. The camera recorded the action of dealing the hole-card where the video was transmitted to a van in the casino's parking lot.

There the video was reviewed to determine the dealer's hole-card and this information was sent back to the player (via audio link). This was the first camera scam detected by the industry and they were shocked, but the same traits indicating a hole-card strategy were present, which were no different had the player, without the aid of a camera, spotted the dealer's hole-card as it was unintentionally flashed.

In 1998, a sophisticated miniature camera with zoom and tilt capabilities was discovered hidden in player's cigarette pack. The camera was able to surreptitiously look up into a shuffling machine and record the shoe's entire order of cards, *after the shuffle!* After the shuffle, the machine would transfer the cards one at a time to a removal bin; it was during this postshuffle phase that each card was visible to the camera. The headlines read 'High-Tech Scam Hits Mini-Baccarat', and again the industry was exposed to sophisticated high-tech possibilities.

Let's look at one more level of sophistication, a scam that truly surprised me. To appreciate how a scam can evolve, consider the following excerpt from *Casino Game Protection*:

Can you think of any possible way one could instantly 'cold deck' a six-deck game and determine the shuffle's order following a legitimate shuffle? Impossible? I know of a crew that came remarkably close to doing just that. The concept was in the early

development stages over a decade ago. The system utilized a novel marking system for shoe games, so there was collusion, but none from the dealer. The cards were marked on the long edge within a small half-inch center strip. Marked with an ultraviolet solution, completely invisible to the eye, the marks were comprised of a series of dots and dashes. The cards could now be shuffled legitimately and presented for the cut. One player, the cutter, was wired up with a miniature lipstick-sized camera, black light, and a periscope/mirror setup strapped to the wrist—the black light and camera were not aimed at the cards, but at the image reflected from the mirror. The player would take the cutcard and slowly move it back and forth over the top of the shoe as if to say, “Where should I cut?” The marks were videotaped during this action. Once recorded by a bodyworn VCR, the player left and headed straight for his hotel room without making a bet. Waiting for him was another VCR ready for playback. Under magnification, the crew would pick a random mark as a starting point, entering it and all cards to follow into a miniature computer ready for table game play. Once a good-size slug was entered into the portable unit, it was rushed to the game. As the cooler hit the layout, a few cards in sequence were entered into the computer, which in turn identified the position of the slug. From here, big bets and optimal strategy followed. But there were problems.

The edge of a playing card is like a sponge—it's not coated with the varnish used to coat the front and back of the card—so the ink would seep into the card making it difficult to read. It was also discovered that the cards are rarely squared perfectly when presented for the cut, so it was easy to miss hidden cards. These factors forced the crew to temporarily abandon the approach. Although it turned out to be unsuccessful, it came dangerously close to the ultimate cooler!

Several years after *Casino Game Protection* was published, a high-tech scam hit South-East Asia. As the shuffled decks were presented for the cut, a player took a gaming 'plaque' (essentially a high-denomination chip but in the size of a rectangle measuring about 4×3 inches), placed it on top of the decks, pounded it a few times with his fist for good luck, and then cut the cards.

It was later discovered that the cards were marked with an infrared ink, invisible to the human eye, and that the plaque was a sophisticated, miniature scanner! The pounding action was no good luck gesture, but a calculated action that ensured that each card was perfectly squared and flush, making it easier for the scanner to read all of the marks. The plaque was handed off to an accomplice who rushed it to a hotel room where the data was reconstructed into a long sequence of cards. Eight-deck shoes can take a long time to deal, especially when the players are *deliberately slowing down*

the action. The cheaters were able to get back to the target game in plenty of time to play, with knowledge of the exact order of about four decks!

This is a good example of how this particular scam evolved and how one crew of cheaters solved the problems facing another crew from an earlier era. The pounding of the plaque was a cultural idiosyncrasy, so the same gesture wouldn't work in most places, but nonetheless, it was a clever solution to the challenge of squaring the cards after the shuffle.

So when you talk about being surprised, it happens all the time. You can take any scam, despite its history, and you will find that no scam lies dormant; it continues to evolve with new twists and turns that are better suited for the modern casino environment (often a function of advances in technology). For those in the game protection business, this is not necessarily a bad thing. If there were no surprises, the game protection business wouldn't be any fun!

C: What are the hot issues for the future, as far as you are concerned: biometrics, accountability systems, automation...?

SF: These are all hot issues, and when you combine them, you are basically looking at more and more accountability.

When you couple technologies like RFID inside chips with dealing shoes equipped with reader technologies that scan/read every card as it's dealt, you're scarily close to 'complete accountability systems' that can track every hand, every bet, every decision. These systems could even know *in advance* what cards you're about to be dealt. When this information is then monitored and evaluated by sophisticated detection software, there's not much need for street-smart surveillance operators or even the sharpest game protection experts, because most won't be able to compete with powerful, sophisticated, reliable software.

When a system has access to this much information, from this point on, it's all about the *sophistication* of the software analyzing the playing and betting decisions.

Bally Gaming came close to such a system some years back with a complete-accountability table system called Mind Play. The system required a specially-designed blackjack tabletop, encoded playing cards, 14 tiny cameras, and special chips that could be identified by sensors embedded in the table. If you were playing blackjack on a Mind Play table, the system knew every move you made. At a cost of about \$20,000, Mind Play also had the capability to evaluate your play and report any suspicious activity. Sounds like the perfect plan, but the system ran into technical problems and Bally stopped development in 2007. But many of the same technical challenges facing Bally just a few years

ago are no longer difficult problems to solve, technologically speaking, so I'm betting that unintrusive, commercially viable table systems offering complete accountability will soon become a staple in the industry as common and accepted as peeking devices, shuffling machines, and low-profile roulette wheels.

C: Most scams are small-scale and negligible, but massive internal conspiracies have in the past been the ruin of more than one casino operator. How important is game protection in this regard?

SF: It's important to be aware of the possibilities. Employee theft is a reality in any business and the gaming industry is no exception. While dealer theft, dealer-agent scams, and scams involving bosses are still relatively common throughout the world, *massive* internal conspiracies are very rare in today's modern casino environment.

Organized crime is out and corporations are here to stay. In most jurisdictions around the world, it's considered a *privilege* to work in gaming, and your right to work can be revoked for any impropriety. Moreover, to work in any decision-making capacity (key licence) requires extensive background checks and the need to jump through several investigative hoops before one is approved.

There are more checks and balances than ever before, tighter regulatory control and oversight than ever before, and more security and surveillance than ever before. For these reasons, by all accounts, massive internal conspiracies appear to be a problem of the past.

C: Finally, as a consultant you've worked with some of the greatest legends in the history of casino industry. Do you have a favorite operator, casino, or story about one of these icons?

SF: The original Binion's Horseshoe in downtown Las Vegas immediately comes to mind as a casino operation that stood out from the rest. I have always had great respect for the Horseshoe as a player and later as a casino consultant.

Binion's Horseshoe was a true gambling house. They were willing to take action on any bet and were famous for telling gamblers that they could *set their own limit* with their first bet! When many clubs were running scared and closing single-deck blackjack games, the Horseshoe was spreading more games with higher limits. They were also one of the first casinos to offer a 4 percent commission on BANKER bets in baccarat, 4 percent commission on buy bets in craps, and other liberal player options.

COLLAPSE VIII

The Horseshoe also employed many psychological subtleties in their procedures. For example, they liked to pay *colour for colour*. If a player bet \$75 in \$5 checks and won, Horseshoe dealers would just size into the bet with \$5 checks instead of breaking the bet down and paying it with three \$25 checks. This made average players feel like high-rollers, and it became fun for players to bet *stacks of checks*. Also, every time you walked into the Horseshoe there was always this sense that many players were winning (because of all the checks in front of them).

From a security standpoint, they allowed one of their pit/shift bosses to walk around *the outside of the pit* and observe the games from the same side of the table as the players. This was a brilliant operational strategy in my view, and one that I was exposed to firsthand during my playing career. I was playing an ‘index dealer’ and firing blacks. (An ‘index dealer’ unintentionally exposes the holecard’s index as it’s dealt to centre-position players.) I leaned back and noticed that one of the bosses was *behind* me. The flash of the index was subtle, so thankfully it wasn’t detected, but the boss continued to circle the pit, carefully taking a few minutes to observe each dealer. It was intimidating to have a boss watch the dealer from the *player’s perspective*, because the protocol gives management its best chance to spot index dealers and other related loopholes that would otherwise be almost impossible to detect from the pit.

Ask any supervisor about the difficulties of supervising games where you're always looking at the backs of dealers and always trying to manage the inherent blind spots, and you will immediately appreciate the protocol's purpose.

The Horseshoe has always had respect for experienced dealers; this was not the norm in downtown Las Vegas, where the clubs employed almost exclusively break-in dealers. If you were a twenty-year veteran and out of a job, the Horseshoe was the place to go because they viewed your experience as an asset—as they should—whereas the other properties were wary of experienced help.

On a personal level, I dealt with Jack Binion, a first-class operator and gentleman. Mr. Binion is the only casino owner/operator who ever called me directly to inquire about consulting services during my entire consulting career; in all other cases, I was contacted by a casino executive, not an owner. Now that's a hands-on owner/operator!

Though I have many wonderful stories about these icons, let me end with one of my favourites.

I have been fortunate to meet many legendary casino executives during my career, but it was Jimmy Payne, a casino operator who had run casinos all over the world, who first asked if I had any interest in the consulting business. I met Jimmy when I was still in my late twenties, so I didn't know anything about

the consulting business. But Jimmy was like a father away from home, and given my respect for him, I said, “Maybe”. One day Jimmy called me: “Put some of your equipment together and I’ll pick you up in the morning at 9:00 sharp; I want you to meet someone.”

This was not unusual as I had met many of Jimmy’s friends before, so I packed some cards, dice, electronic gaffs, and a few other things from my gambling collection. Jimmy picked me up and we drove to the Las Vegas Hilton. Jimmy picked up a courtesy house phone and made a call, and we headed for the executive offices. I asked, “Jimmy, what’s going on, who are we going to meet?” He said, “Baron Hilton.”

We walked into a room with a blackjack table and there sitting around the table was Mr. Hilton and some of his executives.

The first question Mr. Hilton asked me was if I knew anything about Gin Rummy—he was a passionate Gin player. I told him that it was played every day in my home growing up, and proceeded to demonstrate a few table hops, stacks, and holdouts. He laughed and seemed to genuinely enjoy the gambling sleight of hand. Then the conversation turned serious as Jimmy asked me to demonstrate a few casino scams and several advantage strategies. (Jimmy always believed that with his expertise in casino cheating and my experience as an advantage player, we might have something to offer the industry.) After about 45 minutes, Mr. Hilton

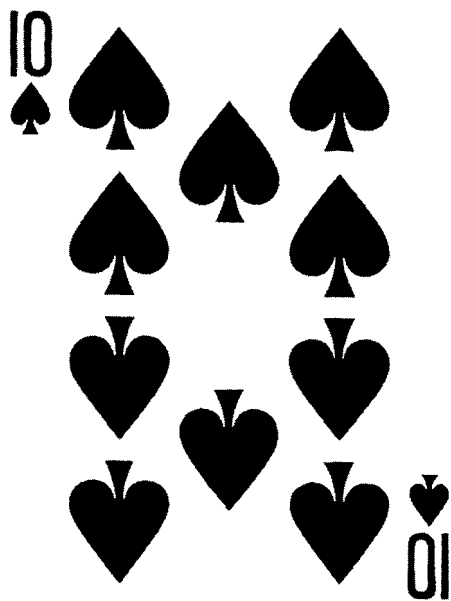
looked at me and said, “Okay, how much is this going to cost me?” I immediately said, “\$50,000 Sir”. And he didn’t hesitate: “Pay these gentlemen; I want my people to see this.”

The truth is that I was only kidding with Mr. Hilton. It was not my position to negotiate anything; that was up to Jimmy. But Mr. Hilton was such a gentleman, and given several light-hearted moments, it was easy to joke with him. All I ever expected was a smile. But that didn’t happen. And that’s how I got into the game-protection and consulting business!

Angel Deck with Line Work

Unknown Artist

The Angel Back was once a popular card used in underground casinos and private/home games where hybrid casino games were frequently played. The backs in this particular deck have been marked with a system known as 'line work', a subtle form of 'blockout work' where the cards are marked with a matching coloured ink/dye. Each card has a distinguishable mark.

















A
♠



MADE IN U S A.

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Engineering Chance

Natasha Dow Schüll

Types of machines are easily matched with each type of society—not because machines are determining, but because they express those social forms capable of generating them and using them.

GILLES DELEUZE¹

The gambling experience has evolved in step with technological innovation. Once a relatively straightforward operation in which players bet a set amount on the outcome of a single payline, today machine gambling begins with a choice among games whose permutations of odds, stakes size, and special effects are seemingly endless.² Instead of inserting coins into a slot as in the past, players are more likely to insert paper money, bar-coded paper tickets, or plastic cards with credit stored on chips or magnetic stripes.

1. G. Deleuze, 'Postscript on the Societies of Control', *October* 59 (1992), 3–8.

2. See chapter 3 of N. D. Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Oxford and Princeton, NJ: Princeton University Press, 2012), from which the present text is an edited excerpt, for a fuller genealogy of the contemporary gambling machine.

To activate the game, they no longer pull a lever, but instead press a button or touch a screen. Denomination of play can vary from one cent to one hundred dollars, and players can choose to bet from one to as many as one thousand coin credits per game. On or above the play area, which typically features a video screen or three-dimensional reels behind glass, 'pay tables' indicate the number of credits to be awarded in the event that certain symbols or cards appear together.³ To the right, a digital credit meter displays the number of credits remaining in the machine. Linked via telecommunications systems to a central server, the machines also perform data-gathering and marketing functions for the casino. Critical nodes in the larger networked system of the casino rather than stand-alone units, they have 'become the central nervous system of the casino', an industry representative remarked in 2007.⁴

3. Some machines additionally post their 'theoretical payout percentage', also known as the 'return to player' (RTP), which is the amount a player is likely to receive back over an extremely extended period of play—1 million spins, for example; in the short term, the return may deviate radically from this figure. RTP is predetermined down to a decimal point by factory-generated computer chips that are randomly spot-checked by state gaming agents (M. Cooper, *The Last Honest Place in America: Paradise and Perdition in the New Las Vegas* [New York: Nation, 2004], 116). Different jurisdictions require different RTP minimums; in Las Vegas, the minimum is 75% but is typically higher.

4. Todd Elsasser of Cyberview, panelist for 'Server Based Gaming II: The State of the Industry', G2E 2007. In the terms of actor network theory, the electronic gambling machine has become a 'thick node' in the larger networked system of the casino. As I discuss in chapter 5 of *Addiction by Design*, the slot machine becomes even more central to the casino with emerging systems of 'networked gaming' (also called 'downloadable gaming' and 'server-based' gaming) in which game content, customer tracking applications, and other services exist on an online server and are downloaded to individual machine units.

Until the mid-1980s, green-felt table games such as blackjack and craps dominated casino floors while slot machines huddled on the sidelines.⁵ By the late 1990s, however, they had moved into key positions on the casino floor and were generating twice as much revenue as all ‘live games’ put together. In the aisles and meeting rooms of casino industry event G2E, it became common to hear gambling machines referred to as the ‘cash cows’, the ‘golden geese’, and the ‘workhorses’ of the industry. Frank J. Fahrenkopf Jr., president of the American Gaming Association, the commercial interest lobby that sponsors the annual expo, estimated in 2003 that over 85 percent of industry profits came from machines.⁶ ‘It’s the slot machine that drives the industry today’, he declared.⁷

Several factors contributed to the dramatic reversal of slots’ once lowly status in the gambling economy. Relatively unburdened by the taint of vice as a result of their association with arcade gaming, women, and

5. C. Turdean, *Betting on Computers: Digital Technologies and the Rise of the Casino (1950–2000)* (PhD dissertation, Hagley Program, Department of History, University of Delaware, 2012). In 1980, 45 percent of casino floor space in Nevada was dedicated to coin-operated gambling; by the late 1990s, the figure had risen to 80 percent (G. Thompson, ‘Video Slots Taking Over Casino Floors’, *Las Vegas Sun*, September 14 1999).

6. Panelist for ‘State of the Industry’, G2E 2003. In Nevada gambling machines typically earn a lower percentage of gaming revenue than in other states (70 percent versus 83 to 92 percent) (American Gaming Association, *State of the States: The Survey of Casino Entertainment*, a survey conducted for the AGA, Washington, DC, 2011).

7. Quoted in G. Rivlin, ‘The Tug of the Newfangled Slot Machines’, *New York Times Magazine*, May 9 2004, 42–81: 44.

the elderly, they played a key role in the spread of commercialized gambling in the 1980s and '90s, as recession-stricken states sought new ways to garner revenue without imposing taxes.⁸ The low-stakes devices fit comfortably with the redefinition of gambling as 'gaming' by industry spokespeople and state officials who hoped to sway public endorsement of the activity as a form of mainstream consumer entertainment rather than a form of moral failing or predatory entrapment.⁹

8. Many view revenue generation through gambling as a 'tax on stupidity'; others view it as a 'regressive tax' in which funds are withdrawn from disadvantaged communities into the general revenue pool, following an upward redistribution of wealth (e.g., see R. Volberg and M. Wray, 'Legal Gambling and Problem Gambling as Mechanisms of Social Domination? Some Considerations for Future Research', *American Behavioural Scientist* 51 [2007], 56–85). Whatever the case, states' ongoing attempts to shore up budget deficits with gambling revenue has driven the expansion of gambling over the past thirty years in the United States. As recently as 1976 there were no casinos outside of Nevada, and only thirteen states had lotteries; today, one can make some sort of wager in every state except Hawai'i and Utah, and tribal gaming has grown into a nearly \$27 billion industry since its inception in 1988, today featuring 442 casino operations in twenty-eight states (*North American Gaming Almanac* [Casino City Press 2010]).

9. 'Gaming' and 'gambling' were interchangeable terms in the United States until the mid-1800s, but afterward the latter term came to specifically denote the act of wagering on an uncertain event (although the word 'gaming' was used in the Nevadan regulatory context since at least the 1920s [J. Burbank, *License to Steal: Nevada's Gaming Control System in the Megaresort Age* (Las Vegas: University of Nevada Press, 2005), 4]). In the 1970s, responding to the industry's image-cleansing campaign, writers at the *Wall Street Journal* began to use the term 'gaming' instead of 'gambling'; by the late 1980s other media venues had followed suit, and by the late 1990s it had become widely accepted. To defend this semantic reform, the American Gaming Association makes reference to the *Oxford English Dictionary*, which indicates that the word 'gaming' dates back to 1510, predating the use of 'gambling' by 265 years (AGA website, http://americangaming.org/Industry/factsheets/general_info_detail.cfm?id=9). Nevertheless, English-language dictionaries consistently define games as activities involving skill, and gambling as activities involving chance.

The growing consumer familiarity with screen-based interaction that accompanied the rise of the personal computer and electronically mediated entertainment such as video games further facilitated the cultural normalization of machine gambling. Meanwhile, the ongoing incorporation of digital technology into gambling machines altered the player experience in subtle but significant ways, broadening their market appeal.¹⁰ Gambling regulations were revised in lockstep with technological innovation.

Since the early 1980s, when machine revenues surpassed table revenues for the first time, the ascendancy of machines in the culture and economy of American gambling has continued unabated. The devices are now permitted in forty-one states (up from thirty-one in 2000) and are under consideration by others. In 1996 there were 500,000 devices in the United States; in 2008 the count had reached nearly 870,000—not including an underground market of unauthorized machines in bars and taverns, truck stops, bowling alleys, and restaurants across the country, nor devices engineered to circumvent restrictions by fitting state definitions for bingo, amusement machines, or sweepstakes games.¹¹

10. While in 1983 only 37 percent of casino players reported machines to be their favorite form of play, by 2005, this preference rose to 71 percent (*Harrah's Profile of the American Casino Gambler 1991–2006*).

11. *North American Gaming Almanac*, 2.

SHALLOW PLAY?

The French sociologist Roger Caillois, author of *Man, Play, and Games*, believed that games carried clues to the basic character of a culture.¹² 'It is not absurd to try diagnosing a civilization in terms of the games that are especially popular there', he wrote in 1958. Caillois argued that one could make a cultural diagnosis by examining games' combination of the following four elements of play: *agon*, or competition; *alea*, or chance; *mimesis*, or simulation; and *ilinx*, or vertigo. Modern cultures, he claimed, were distinguished by games involving a tension between *agon* and *alea*—the former demanding an assertion of will, the latter demanding surrender to chance.

This tension is at the heart of the cultural diagnosis made by the American sociologist Erving Goffman in 1967 based on his ethnographic study of gambling

12. In his foreword to *Man, Play, and Games* (New York: Free Press of Glencoe, 1979 [1958]) M. Barash observes that Caillois regards games as 'cultural clues' (ix). Caillois was building on the earlier work of Dutch historian and cultural theorist J. Huizinga, author of *Homo Ludens: A Study of the Play Element in Culture* (Boston: Beacon Press, 1950 [1938]), a treatise on the importance of the play element of culture and society. As Caillois points out at the start of his text (*Man, Play, and Games*, 5), Huizinga was dismissive of games of chance. 'In themselves', Huizinga wrote, 'gambling games are very curious subjects for cultural research, but for the development of culture as such we must call them unproductive. They are sterile, adding nothing to life or the mind' (Ibid., 48). Caillois disagreed fundamentally, pointing out that uncertainty and risk are key aspects of all forms of play (Ibid., 7; see also T. M. Malaby, 'Beyond Play: A New Approach to Games', *Games and Culture* 2:2 [2007], 95–113).

in Las Vegas, where he worked as a blackjack dealer and was eventually promoted to pit boss. Goffman regarded gambling as the occasion for ‘character contests’ in which players could demonstrate their courage, integrity, and composure in the face of contingency.¹³ By offering individuals the opportunity for heroic engagements with fate, gambling fulfilled an existential need for ‘action’ or consequential activity in an increasingly bureaucratic society that deprived its citizens of the opportunity to express their character in public settings of risk. For Goffman, gambling was not so much an escape from everyday life as it was a bounded arena that mimicked ‘the structure of real life’, thereby ‘immersing [players] in a demonstration of its possibilities.’¹⁴

13. E. Goffman, *Where the Action Is: Three Essays* (London: Allen Lane, 1967), 260–61. As G. Reith notes, sociological accounts have often attempted to endow the unproductive activity of gambling ‘with some kind of utilitarian function’ (*The Age of Chance: Gambling in Western Culture* [New York: Routledge, 1999], 8). Edward E. C. Devereux, for instance, wrote in his 1949 analysis that gambling was ‘a particularly convenient mechanism in which the psychological consequences of economic frustration, strain, conflict and ambivalence may be worked out without upsetting the social order’ (*Gambling and the Social Structure* [New York: Arno, 1980 (1949)], 955). The idea of gambling as a ‘safety valve’ or ‘shock absorber’ for the conflicts of a capitalist economic system persisted through the 1970s. Gambling was understood to be an escape from routine and the futility of working-class lives. As Caillois had written earlier: ‘Recourse to chance helps people tolerate competition that is unfair or too rigged. At the same time, it leaves hope in the dispossessed that free competition is still possible in the lowly stations in life’ (*Man, Play, and Games*, 115).

14. E. Goffman, ‘Fun in Games’, in E. Goffman, *Encounters: Two Studies in the Sociology of Interaction* (Indianapolis: Bobbs-Merrill Educational Publishing, 1961), 34.

Along these lines, in 1973 the anthropologist Clifford Geertz famously interpreted Balinese cockfight gambling as a 'tournament of prestige' that simulated the social matrix and laid bare its status dynamics. The activity, he argued, served as a medium for rehearsing the collective and existential dramas of life. Like Caillouis and Goffman, Geertz emphasized the synergistic interaction of randomness and competition in the cockfight. The less predictable the outcome of a match, he observed, the more financially and personally invested participants became and the 'deeper' their play, in the sense that its stakes went far beyond material gain or loss.¹⁵ Fyodor Dostoyevsky's description of a sudden windfall at a Swiss roulette table in *The Gambler* captures Geertz's idea of deep play as a compelling mix of chance, risk, and status: 'Why, I had got this at the risk of more than my life itself. But I had dared to risk it, and there I was once again, a man among men!'¹⁶

15. C. Geertz, *The Interpretation of Cultures: Selected Essays* (New York: Basic Books, 1973). The concept of 'deep play' was first elaborated by Jeremy Bentham to describe play in which financial stakes run 'irrationally' high despite the fact that chance will determine the outcome, indicating that more than just money is at stake (431).

16. F. Dostoyevsky, *The Gambler*, tr. H. Alpin (London: Hesperus Press, 1972 [1867]), 199. The semiautobiographical novel was written during a period when Dostoyevsky struggled with his own excessive gambling. The quoted passage carries echoes of Schiller's German romanticist view of gambling: 'man only plays when in the full meaning of the word he is a man, and he is only entirely a man when he plays' (quoted in Caillouis, *Man, Play, and Games*, 163). For an existentialist perspective on gambling, see I. Kusyszyn 'Existence, Effectance, Esteem: From Gambling to a New Theory of Human Motivation', *Substance Use and Misuse* 25:2 (1990), 159.

Caillois, Goffman, and Geertz each referred to coin-operated machine gambling in the course of their analyses, and each of them dismissed it as a degraded, asocial form of play not worthy of cultural analysis. For Caillois, it was pure *alea*—an absurd, compulsive game in which one could only lose.¹⁷ For Goffman, it was a way for a person lacking social connections ‘to demonstrate to the other machines that he has socially approved qualities of character’; machines stood in for people when there were none to engage with.¹⁸ ‘These naked little spasms of the self occur at the end of the world’, he wrote of machine gambling in the very last line of his analysis, ‘but there at the end is action and character’. Geertz described slot machines as ‘stupid mechanical cranks’ operated by concessionaries at the outer circumference of the cockfight circle, offering ‘mindless, sheer-chance-type gambling’ that could be

17. ‘The development of slot machines in the modern world and the fascination or obsessive behavior that they cause is indeed astonishing’, wrote Caillois in a footnote to his text, noting that there were 300,000 slot machines in cities throughout the United States in the mid-1950s. He followed with a long passage by a reporter in Times Square in 1957: ‘In an immense room without a door dozens of multicolored slot machines are aligned in perfect order. In front of each machine a comfortable leather stool [...] allows the player with enough money to sit for hours. He even has an ash tray and a special place for his hot dog and Coca-Cola... which he can order without budging from his place’ (Caillois, *Man, Play, and Games*, 183). Caillois described how the mania for ‘pachinko’ machines in Japan became so intense that they were installed in doctor’s waiting rooms. He quoted an observer of these contraptions: ‘An absurd game, in which one can only lose, but which seduces those in whom the fury rages’ (Ibid.).

18. Goffman, ‘Fun in Games’, 270.

of interest only to 'women, children, adolescents [...] the extremely poor, the socially despised, and the personally idiosyncratic.'¹⁹ 'Cockfighting men', he continued, 'will be ashamed to go anywhere near [the machines]'. In other words, the devices were not a medium through which to become 'a man among men', as Dostoyevsky had written of roulette; unlike the 'exquisitely absorbing' *affaire d'honneur* of deep play, slot play was shallow, without depth of meaning, investment, or consequence. Incapable of illuminating the fundamental codes and concerns of a culture, machine gambling was not a properly 'sociological entity', Geertz wrote.

The dramatic turn to machine gambling in American society (and beyond) since the 1980s prompts me to question such dismissals; surely, in this turn, one can find clues to the distinctive values, dispositions, and preoccupations of contemporary culture. But what kind of clues, and how to access them? Unlike Goffman's card gaming or Geertz's cockfighting, machine gambling is not a symbolically profound, richly dimensional space whose 'depth' can be plumbed to reveal an enactment of larger social and existential dramas. Instead, the solitary, absorptive activity can suspend time, space, monetary value, social roles, and sometimes even one's very sense of existence. 'You can erase it all at the machines—you can even erase yourself',

19. Geertz, *Interpretation of Cultures*, 435–6.

an electronics technician named Randall told me. Contradicting the popular understanding of gambling as an expression of the desire to get ‘something for nothing’, he claimed to be after nothingness itself.

Similarly, when I asked Mollie, a frequent video poker player, if she was hoping for a big win, she gave a short laugh and a dismissive wave of her hand. ‘In the beginning there was excitement about winning’, she said, ‘but the more I gambled, the wiser I got about my chances. Wiser, but also weaker, less able to stop. Today when I win—and I do win, from time to time—I just put it back in the machines. The thing people never understand is that *I’m not playing to win*’.

Why, then, does she play? ‘To keep playing—to stay in that machine zone where nothing else matters.’

IN THE ZONE

To put the zone into words, the gamblers I spoke with supplemented an exotic, nineteenth-century terminology of hypnosis and magnetism with twentieth-century references to television watching, computer processing, and vehicle driving. ‘You’re in a trance, you’re on autopilot’, said one gambler. ‘The zone is like a magnet, it just pulls you in and holds you there’, said another.²⁰

20. The term ‘zone’ is used in association with machine gambling in other English-speaking countries as well. One author reports that in Australia, no theme is as resonant among gamblers ‘as the idea of ‘the zone’, a term used by many gamblers and counsellors to describe the dissociated state

It is not the chance of winning to which these gamblers become addicted but, rather, the world-dissolving state of subjective suspension and affective calm they derive from machine play. The memoirist Mary Sojourner has described video gambling as ‘a trancelike preoccupation in which perpetuating the trance was reward enough’.²¹ ‘It’s like being in the eye of a storm’, says Mollie, her fingers playing on the tabletop between us. ‘Your vision is clear on the machine in front of you but the whole world is spinning around you, and you can’t really hear anything. You aren’t really there—you’re with the machine and that’s all you’re with.’

While all forms of gambling involve random patterning of payouts, machine gambling is distinguished by its solitary, continuous, and rapid mode of wagering. Without waiting for ‘horses to run, a dealer to shuffle or deal, or a roulette wheel to stop spinning’, it is possible to complete a game every three to four seconds.²² To use the terminology of behavioural psychology, the

that problem gamblers seem to enter during periods of intense play’ (C. Livingstone, ‘Desire and the Consumption of Danger: Electronic Gaming Machines and the Commodification of Interiority’, *Addiction Research and Theory* 13:6 [2005], 528). The zone, Livingstone elaborates, ‘is a particular space and time which is not consonant with the rest of life [...] a place away from the world where nothing really mattered except the present, timeless moment’ (ibid).

21. M. Sojourner, *She Bets Her Life: A Story of Gambling Addiction* (Berkeley: Seal Press, 2010), 149.

22. D. Cote, A. Caron, J. Aubert, V. Desrochers, and R. Ladouceur, ‘Near Wins Prolong Gambling on a Video Lottery Terminal’, *Journal of Gambling Studies* 19 (2003): 380–407.

activity involves the most intensive ‘event frequency’ of any existing gambling activity.

‘It is *the* addiction delivery device’, says Henry Lesieur, a sociologist who wrote the first book-length ethnographic account of nonelectronic gambling addictions in 1977 before becoming a counsellor in the wake of machines’ spread.²³ Others have called modern video gambling ‘the most virulent strain of gambling in the history of man’, ‘electronic morphine’, and, most famously, ‘the crack cocaine of gambling’.²⁴ Sensationalist metaphors aside, most researchers place different forms of gambling along a continuum of intensity that progresses from lottery, bingo, and mechanical slots to sports, dice, cards, and finally, to video slots and video poker. ‘No other form of gambling manipulates the human mind as beautifully as these machines’, the gambling addiction researcher Nancy Petry told a journalist.

Forms of gambling differ not only in the intensity of play they facilitate but also in the kinds of subjective shifts they enable. Each type of gambling involves players in distinctive procedural and phenomenological

23. Henry Lesieur, quoted in R. Green (‘Long-Shot Slots, Part I’, *Hartford Courant*, May 9 2004, http://courant.com/2004-05-09/news/0405090003_1_gambling-machines-long-shot-slots-problem-gambling/2; H. R. Lesieur, *The Chase: Career of the Compulsive Gambler* (Garden City, NY: Anchor Press, 1977).

24. The first statement is by Robert Breen (quoted in Green, ‘Long-Shot Slots, Part I’); I heard the term ‘electronic morphine’ used by Robert Hunter; both Hunter, Howard Shaffer, and many others have used the ‘crack cocaine’ metaphor when speaking of gambling machines.

routines—betting sequence and temporality, frequency and amount of payouts, degree of skill involved, and mode of action (checking books, ticking boxes, scratching tickets, choosing cards, pressing buttons), producing a unique ‘cycle of energy and concentration’ and a corresponding cycle of affective peaks and dips.²⁵ The game of craps, for instance, can produce a state of high energy and suspense punctuated by euphoric wins whose thrill depends largely on social feedback. The solitary, uninterrupted process of machine play, by contrast, tends to produce a steady, trancelike state that ‘distracts from internal and external issues’ such as anxiety, depression, and boredom.²⁶ Based on his clinical practice in Las Vegas, the psychologist Robert Hunter has concluded that modern video gambling ‘facilitates the dissociative process’ more so than other gambling formats.²⁷ ‘The consistency of the experience that’s described by my patients’, he told me of machine

25. G. Reith, *The Age of Chance: Gambling in Western Culture* (New York: Routledge, 1999) chapter 3. See also J. Elster, ‘Gambling and Addiction’, in J. Elster and O. J. Skog (eds.), *Getting Hooked: Rationality and Addiction*, (Cambridge: Cambridge University Press, 1999), 208–34 and T. M. Malaby, *Gambling Life: Dealing in Contingency in a Greek City* (Urbana: University of Illinois Press, 2003) have made similar observations.

26. C. A. Thomas, G. B. Sullivan, and F. C. L. Allen. ‘A Theoretical Model of EGM Problem Gambling: More Than a Cognitive Escape’, *International Journal of Mental Health and Addiction* 7:8 (2009): 3.

27. The medical doctor and slot enthusiast David V. Forrest suggests that machine gambling produces a meditative, trancelike state because its pace and rhythm (three spins every ten seconds, or what he calls ‘basal slot play rate’) coincides with that of human breathing (*Slots: Praying to the Gods of Chance* [Harrison, NY: Delphinium, 2012], 49).

gambling, 'is that of numbness or escape. They don't talk about competition or excitement—they talk about climbing into the screen and getting lost'.

If Goffman's social gamblers sought out 'fatefulness' as 'the mark of the threshold between retaining some control over the consequences of one's actions and their going out of control', today's repeat machine gamblers could be said to retreat from that threshold, seeking instead a smooth, insulated zone where nothing unexpected or surprising can happen—the 'eye of the storm', as Mollie described it.

ASYMMETRIC COLLUSION

The gambling industry invests a great deal of resources and creative energy into the project of helping gamblers to 'lose' themselves—experientially and financially. Slot designers' goal is to build machines that can extract maximum 'revenue per available customer', or revpac, and of this all-consuming objective they talk freely and explicitly among themselves—on conference panels, in journals, and in the aisles and meeting lounges of exposition floors. How to get people to gamble longer, faster, and more intensively? How to turn casual players into repeat players? How, in other words, to design the zone?

Design techniques for promoting absorption, self-forgetting, and continued play are myriad. Modern

machines allow players to insert large bills or so-called loyalty cards and then draw from credits displayed on a small digital meter—easier than entering coins one by one and an effective way to hide real-life monetary value. Push-buttons replace pull-handles, greatly accelerating the speed of play; the buttons are within easy reach on an ergonomically curved console so that a gambler can simply tap a finger. To prevent visual fatigue, graphic engineers softly pixelate machines' video monitors and avoid signage that is too bright, erratic, or otherwise over-stimulating. Sound engineers seek to soften and balance slots' acoustic elements; some use anti-noise technology to envelop players in a protective 'sound cone', and one company's audio director programmed its video slots to play all their sounds in the universally pleasant key of C. Screens are tilted at precise angles to ensure ergonomic comfort and the conservation of players' energy.

More important to the zone than audio-visual or ergonomic elements, however, are the computational mechanisms that lie behind the screen, working to compute the outcomes of the game. 'Math is what will make players stay', game designers emphasize. By 'math', they mean the programming that determines a particular game's 'reward schedule' or 'reinforcement schedule' to use the language of behaviorist psychology. 'It's like the player is reclining on a math model and you need to get them comfortable', one designer told me.

‘They’re investing a lot of money into an invisible structure and they need to be made to feel that they can trust it. The machine needs to communicate that trust through its delivery of rewards.’

Departing from Marxian accounts of industrial production in which factory labourers become alienated from themselves in the process of operating machinery, Foucault characterized the relationship between humans and disciplinary machinery as one of connection rather than estrangement, in which ‘a coercive link with the apparatus of production’ joined a given body to the object it handled.²⁸ Although linkage is certainly a more pertinent descriptor than alienation for the contemporary gambler-machine relationship, the link in question is forged not through coercion, but through a kind of *collusion* between the structures and functions of the machine and the cognitive, affective, and bodily capacities of the gambler.

The turn from coercion to collusion fits with Gilles Deleuze’s characterization of contemporary society as a ‘mutation of capitalism’ in which a logic of discipline and restriction has given way to a logic of control whose protocol is not restriction or confinement but, rather, the regulation of the continuous and flowing movement of bodies, affects, and capital.²⁹ Although machine gamblers act within the enclosed space of

28. Foucault, *Discipline and Punish*, tr. A. Sheridan (NY: Vintage, 1995), 153.

29. Deleuze, ‘Postscript’; see Schüll, *Addiction by Design*, chapter 1.

the casino, seated before the consoles of stationary devices and repeating the same routines, they tap into a flow of credit that can bring them into the flowing nonspace of the zone and allow them to be ‘continuously productive’, as casino managers put it, for as long as that credit lasts.

‘Textbook capitalist exploitation thrives in peaceful and productive coexistence with the play-drive of the exploited’, Dibbell observes of the phenomenon he calls ludocapitalism.³⁰ The key is to hold players in a desubjectified state of uninterrupted motion so as to galvanize, channel, and profit from their affective capacities, or ‘experiential affect’, as two consultants for the industry term it.³¹ Design strategies for rendering continuous productivity match gamblers’ desire for the insulating continuity of the zone and vice versa; gamblers in search of the perpetual ‘now’ of the zone become collaborators in the industry’s attempt to derive value from long-term statistical probability. ‘In the casino’, writes the sociologist James Cosgrave, ‘the calculation of probabilities is the rule, the house has the edge and, as much as possible, nothing is left to chance.’³²

30. J. Dibbell, ‘The Chinese Game Room: Play, Productivity, and Computing at Their Limits’, *Artifact* 2:3 (2008), 3.

31. K. Mayer and L. Johnson, ‘Casino Atmospherics’, *UNLV Gaming and Review Journal* 7 (2003): 21–32.

32. J. Cosgrave, ‘Goffman Revisited: Action and Character in the Era of Legalized Gambling’, *International Journal of Criminology and Sociological Theory* 1:1 (2008): 80–96.

MECHANICAL TO DIGITAL: THE ‘REALLY NEW GOD’

Slot machines underwent a significant transformation in 1963 with the incorporation of electromechanical technology that enabled manufacturers to control the motion of reels with electrical motors and a circuit board of switches rather than mechanical springs and gears.³³ Removing the motion mechanisms from the reels protected slot machines from tilting, shaking, and other physical abuse that could affect outcomes.³⁴ Once they became reliable, notes a historian, ‘the attention of designers shifted to maximizing the devices’ potential to attract and retain gamblers’.³⁵ While casino managers appreciated the tamper resistance of electromechanical machines,

33. In 1964 Bally developed the first fully electromechanical slot machine called *Money Honey*. The device allowed unprecedented automatic payouts of five hundred coins instead of a mere twenty coins, as did all prior devices.

34. Until then it had been possible to cheat on the machines by manipulating their mechanics. One method, called ‘rhythm play’, involved pulling the lever in such a way as to influence the stopping of the reels; ‘stringing’ involved pulling a coin in and out of the slot with each spin; ‘handle slamming’ attempted to disable the payout control mechanisms on old machines; and ‘spooning’ required a special device (B. Friedman, *Casino Management* [New York: Lyle Stuart Publishers, 1982 (1974)]; C. Turdean, ‘Betting on Computers: Digital Technologies and the Rise of the Casino (1950–2000)’ [PhD dissertation, Hagley Program, Department of History, University of Delaware, 2012], 15–16). Some slot cheats used ‘slugs’ or fake coins, ‘shims’ or wire pieces that were inserted into holes made in the machine’s case or glass, or simply poured substances into the pay slot to fix its handle into play mode. Others attempted to stop the reels in certain positions with help from magnets.

35. Turdean, ‘Betting on Computers’, 46.

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players liked the fact that their motor-driven hoppers could render unprecedented automatic payouts of up to five hundred coins, which meant larger and more frequent payouts.

Digital microprocessors (computer chips with memory) came on the scene of machine gambling in 1978, endowing the devices with further security and appeal. Just as motors and switches had replaced gears and springs, now digital pulses of electricity drove the motion of slot reels. Although players continued to interact with reels, the outcomes of their spins were now determined by a digital entity whose workings were thoroughly opaque to them.

The hidden operations by which gambling machines arrive at and deliver their verdicts are a source of great wonderment and conjecture among gamblers, as is evident in the countless discussions that gamblers initiate on Internet forums. 'One of the great questions in philosophy', begins an article in the gambling magazine *Casino Player*, 'is how the body of man, which is mechanical and concrete, can contain the element of mind, which is ephemeral. This has come down to the simple statement that we have a 'ghost' or 'god' in the machine. So too with today's slots.'³⁶ Evoking the ephemeral, ghostlike will of the random number generator (RNG), some in the industry

36. F. Scoblete, 'The God in the Machine', *Casino Player*, March 1995, 5.

call this component the Really New God.³⁷ “The RNG runs on a computer chip, but people act like it’s casting a spell”, a designer told me.

The ‘mystery chip’ that determines the outcome of a spin is programmed with mathematical algorithms that execute a game’s particular scoring scheme and predetermined hold percentage (or ‘house edge’), working in concert with a random number generator to generate its outcomes. Even as a gambling device sits idle, its RNG cycles through possible combinations of reel symbols or cards at approximately one thousand per second.³⁸ The device is in perpetual motion, indifferent to the presence or absence of players. When a player initiates a game by pulling a handle or pressing a SPIN button, its program ‘polls’ the RNG, whereupon it generates whichever numbers it happens to be cycling through at that exact moment—one for each of the reels displayed. These generated numbers, which typically fall between one and four billion, are fed through an algorithm that translates them—by a process known in computer programming as ‘indirection’ or ‘indirect reference’—into stops

37. Ibid.

38. Technically, the RNG is ‘pseudorandom’ which means that since it is a designed program, it can never truly be random in its functioning (unless it draws its numbers by sampling random noise in the environment). Slot machine RNGs sample a real-time internal computer clock to establish a ‘seed’ value and then derive each random number from the previous one, following a recursive function. Given that their cycles contain approximately 4.3 billion distinct values, they are virtually unpredictable.

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on the microprocessor's 'virtual reels'.³⁹ The selected virtual reel positions are then communicated to the correlating positions on the actual, physical reels. All this is decided instantaneously, before a game's reels stop spinning—yet gambling companies take care to preserve the illusion of a mechanically actuated reel mechanism so as to perpetuate players' sense of being kinetically involved in the game. 'Operating the machine requires that you pull the handle', a journalist explained in 1980, 'but by then, you're no longer gambling—you're simply activating the readout.'⁴⁰

ZONE OF ENCHANTMENT

In the late 1990s Roger Horbay, a former addiction counsellor in Ontario, began to design software to educate players about gambling machines and dispel their enchantment. His motivation, he told me, was the frustration he felt in his role as addiction counsellor and trainer of other counsellors. No matter how he explained what was going on inside the devices, few could grasp how they worked—especially not how they configured probability and randomness. *'How can it be random and also weighted? How can there be a fixed*

39. The algorithm works by taking the random number that has been generated and dividing it by the number of stops on a given virtual reel until there is a remainder; that remainder indicates the reel position to select.

40. M. Rogers, 'The Electronic Gambler', *Rocky Mountain Magazine*, 1980: 25.

house edge if it's chance? People couldn't get their heads around it', Horbay recalled. When he met computer-scientist Kevin Harrigan, the two decided to develop their own slot machine simulator. 'The idea was, let's develop our own game, make it transparent for users, let them really see how a typical slot machine works.'

Designing the educational software proved neither straightforward nor simple. On the grounds of intellectual property rights, technology companies denied their requests for the 'paytable and reel strip sheets' or 'PAR sheets' (sometimes also called 'probability accounting reports') that showed how games' odds were configured and how their virtual reels were mapped.⁴¹ 'The secrecy is intense', said Horbay. 'Casinos can't even get PAR sheets from a manufacturer when they own the machines. They're in vaults.' He and his colleague went on reconnaissance missions to industry trade shows, acquiring as much knowledge as they could from the information available at companies' booths. Eventually they went to the US patent office, where many slot machines are publicly patented.⁴² They took the patents to their own labs and

41. PAR sheets contain the configuration of a game's reels (including a listing of every symbol that appears on the reels, and its position), pay combinations, payback percentages, hit frequency, volatility index, confidence level statistics, and more.

42. More recently, Canadian researchers K. A. Harrigan and M. Dixon obtained PAR sheets through the Freedom of Information and Protection of Privacy Act ('PAR Sheets, Probabilities, and Slot Machine Play: Implications for Problem and Non-Problem Gambling', *Journal of Gambling Issues* 23 [2009], 81–110).

hired forensic scientists to reverse-engineer the math. The resulting educational software, Safe@Play, lets users explore the insides of reel machines to see how their mechanisms actually work. One can ‘unroll the reels’, ‘pull out the microprocessor’, and watch how the random number generator works; the program ‘reveals concealed game features.’

As an experienced addiction counsellor, Horbay acknowledges the limits—and even the absurdity—of his own disenchantment enterprise. ‘Even if we demystify the machines through education, [compulsive gamblers] will still play them.’ I asked him to explain. ‘Because once you’re hooked in, something else kicks in to keep you there; all trains of thought are evacuated and only one dominates.’ The ‘something else’ to which Horbay referred—the hold of the zone—overrides any hope for beating chance that may have initially inspired machine play, and that a machine’s programming may have reinforced through its enchanting perceptual distortions. As Mollie told me, an initial seduction by the prospect of winning was what prompted her repeated engagement with gambling machines, yet through that engagement she discovered the machines’ capacity to bring her into the zone—a state of ongoing, undiminished possibility that came to trump the finite reward of a win.

Horbay regards gambling machines’ seductive inscrutability not as the *hold* on players but rather

the *hook*—the ‘early entrapping mechanisms’, as he phrased it, or the ‘drive-in to the zone’. These entrapping mechanisms, he believes, exploit the cognitive expectations of new gamblers such that they persevere at the interaction to a point where the self-maximizing aim of winning turns into the self-liquidating aim of the zone. He promotes his software chiefly as a form of prevention, a way ‘to block the on-ramp to addiction’. Once players become caught in the loop of repeat play, he told me, ‘no rational action is possible’.

Gambling addicts are well aware that they are beyond reason in the zone, and that knowledge of the machines’ inner functions will do little to curb their drive. ‘I don’t wonder or worry about the mechanism’, commented Lola, the buffet waitress. ‘I know the machines are computerized, that they’ve got a chip, but it really doesn’t matter—in fact, I don’t think about it at all when I play. I couldn’t care less, I just want to see the next cards’. Shelly, the tax accountant, said the same: ‘Although I’ve had discussions with people as to how the machines work, sometimes even with people who build and program them, while I’m playing I never really think about the insides of the machine.’ Randall, the electronics technician we met earlier, had inspected machine interiors and understood how their memory chips worked. ‘I’m a reasonably intelligent person, I’m rational. But when it comes to gambling, reason just skippity-hops out the door.’ Rose, a machine

gambler who became a slot machine mechanic with the hope that an education in the machines' inner workings might release their hold on her, eventually realized the futility of her demystification plan: 'After getting my degree I knew everything that was going on in that machine. It was a conscious knowledge when I'd start to play—I'd picture what was happening inside the computer. But then I would turn that knowledge off.' Designers themselves often describe a 'turning-off' of knowledge while playing the very machines they have designed. When designing, they operate within the domain of calculative rationality—they pick a machine's colours and sounds, formulate its sophisticated mathematical algorithms, calculate its payout rates and risk probabilities, and scrutinize its performance. When playing, however, calculative rationality falls away. 'Even though I know my chances statistically', Anchor Gaming's John Vallejo told me, 'I'm guilty of doing risky, superstitious things when I play. [...] I feel a sense of anticipation that I know doesn't make sense, and I take risks that I know aren't feasible.' 'I designed the math on these games but it doesn't matter; I do risky, irrational things when I play', echoed a Bally designer. 'Knowing the odds doesn't interfere with my playing. *Somehow that knowledge becomes irrelevant when I sit down at the machine.*'

Multiple lines of delusion are at work in the encounter with gambling machines. Industry designers actively

marshal technology to delude gamblers, defending these tactics by insisting that they give gamblers ‘what they want’. Gamblers, for their part, collude in the delusion, ‘turning off’ any knowledge they may have about the inner mechanisms of the machines so as to enter the compelling state they seek. Here, the asymmetry lies in the encounter between two distinct practical, cognitive, and temporal orientations to the enchanting force of chance.

While designers’ orientation is calculative, rational, and focused on a distant statistical horizon in which profit is guaranteed, gamblers’ orientation is experiential, affective, and focused on the unpredictable outcomes of the very next spin; as their involvement in play deepens, they are likely to become less invested in winning than in continuing to play. It is not that repeat gamblers act ‘illogically’ while playing machines, two gambling researchers clarify, for ‘their strategies are complex, intuitive and adaptive’; yet these strategies, write the gambling scholars Charles Livingstone and Richard Woolley, ‘are not avaricious and do not rely on “rational” calculation of odds’.⁴³ Although ‘one might ‘know’ that the odds are poor and that one inevitably loses over time’, writes another researcher, a different ‘type of knowing [...] may take over in the process of gambling, especially if machines are designed with

43. C. Livingstone and R. Woolley, ‘Risky Business: A Few Provocations on the Regulation of Electronic Gaming Machines’, *International Gambling Studies* 7:3 (2007), 369.

this effect'.⁴⁴ In the gap between calculation and intuition, rationality and affect, the gambling industry seeks revenue while players seek the zone.

VIRTUAL REELS

Even for those who grasp the workings of the RNG, it is what happens next—the conversion of a number that has been randomly generated from a pool of nearly four billion into a physical reel stop that is part of a radically more limited pool of outcomes—that tends to stymie understanding. The concealed nature of the operation, along with machine events and displays that seem to represent its process when in fact they do not (the time delay of spinning reels, for example), compounds gamblers' confusion, obfuscating cause and effect in the experience of play. What exactly goes on in the conversion of random values to reel stops? 'Instead of accessing some resource directly', writes gaming guru John Robison of machine programming, 'you go through an intermediate step. You can do all sorts of wonderful things in that intermediate step.'⁴⁵ One of these 'wonderful things' is called virtual reel mapping, a technique patented in 1982 for controlling

44. J. Borrell, 'A Thematic Analysis Identifying Concepts of Problem Gambling Agency: With Preliminary Exploration of Discourses in Selected Industry and Research Documents', *Journal of Gambling Studies* 22 (2004), 181.

45. J. Robison, 'Ask the Slot Expert: Casino Random Number Generators', *Casino City Times* (2000), <http://robison.casinocitytimes.com/articles/349.html>.

game odds independently of a machine's actual reels. The invention was meant to overcome the continuing limitations posed by the structure of physical reels. Although digital microprocessing had turned physical reels into a mere display of the computer-determined outcome, there remained a one-to-one correlation between the number of stops they contained—which by 1970 had become 22—and those on its ghostly analog or 'virtual' reels. Since the maximum number of combinations possible on such machines was $22 \times 22 \times 22$, or 10,648, the odds of hitting a jackpot on a machine with one jackpot symbol per reel were 1 in 10,648. Thus a \$1 machine could not offer a jackpot larger than \$10,648 or it would risk losing money; the jackpot would have to be *under* \$10,648 to ensure the house a profit.

How could game manufacturers get around this constraint, or 'lengthen the odds', to use gambling parlance? They tried making machines with larger reels to accommodate more symbols, as well as machines with extra reels, but players avoided such models. When interacting with the larger-reeled, extra-reeled devices, they intuitively grasped that their chances had been diminished by the addition of symbols. Another way to lengthen the odds was to replace physical reels with a video display of simulated reels that could accommodate an infinite number of blanks and symbols. This became possible in the 1970s with the advent of video

games, yet consumers were not yet familiar with screen-based technology and tended to distrust it. Although this distrust was to dissolve by the mid-1990s, the mathematician and inventor Inge Telnaes provided a striking interim solution in the form of virtual reel mapping, also called ‘disproportionate reels’ or ‘weighted reels’.⁴⁶

Machines using this technology continue to display 22 stops per reel—11 blanks and 11 winning symbols—yet their *virtual* reels can be configured to accommodate as many stops as designers like, sometimes hundreds. As on all computerized slot machines, when gamblers press the SPIN or BET button, the value generated by the RNG at that instant is translated into one of the virtual reel stops, each of which has an equal chance of being selected. However, because there are more virtual than *actual* reel stops, a secondary ‘mapping’ program must be written to translate the virtual stops selected by the RNG into actual stops. The ‘wonderful thing’ that can be done in this intermediate step is to ‘map’ far more virtual stops to low-paying or nonpaying blank positions on the actual, physical reel than to winning positions.⁴⁷

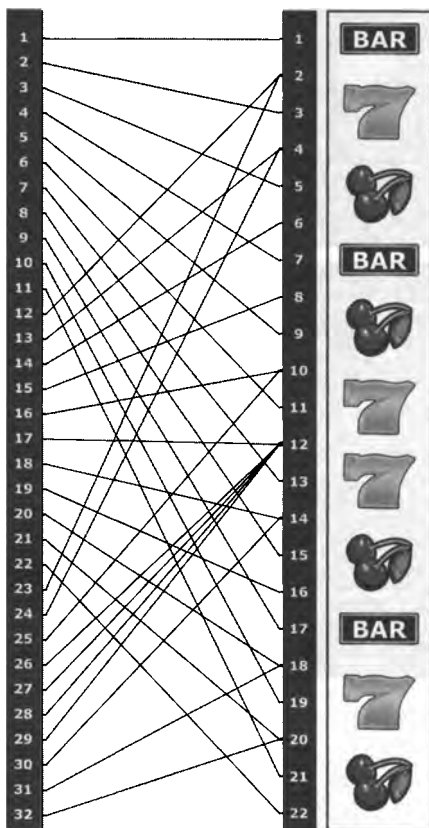
The asymmetry between actual and virtual reels gave manufacturers a considerably more precise

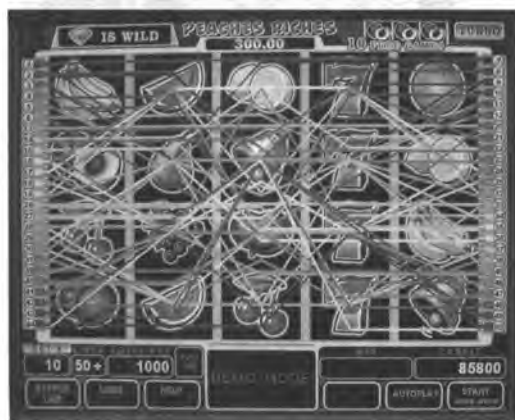
46. US Patent No. 4448419. Telnaes developed the software in the late 1970s when he was working for Bally Distributing. He filed for a patent in 1982, and the patent was granted in 1984.

47. N. Turner and R. Horbay, ‘How Do Slot Machines and Other Electronic Gambling Machines Actually Work?’, *Journal of Gambling Issues* 11 (2004), <http://ghsouthern.org.au/infobase/JGI-Issue11-turner-horbay.pdf>.

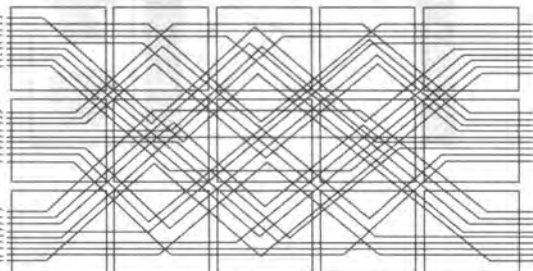
VIRTUAL REEL

ACTUAL REEL





- 20
- 26
- 2
- 5
- 8
- 11
- 14
- 17
- 23
- 22
- 16
- 10
- 4
- 1
- 7
- 13
- 19
- 25
- 18
- 24
- 15
- 12
- 9
- 6
- 3
- 21
- 27



way to control game outcomes, making it possible for them to promise huge jackpots on the outcomes with the slimmest mathematical odds.⁴⁸ On a machine whose virtual reels have 64 stops each with only one stop mapped to a jackpot symbol, the chances of hitting that symbol on all three reels to win the jackpot are 1 in 64^3 , or 262,144. The machine could therefore offer a jackpot of up to \$262,144 without losing money. On a machine with 512 virtual stops, the odds of a jackpot would be as rare as 1 in 137 million—giving the house a safe enough edge to offer \$20 or \$30 million prizes and still ensure long-term profit.⁴⁹ This unprecedented mathematical flexibility endowed gambling machines with a hitherto elusive ‘volatility’ (or potential for dramatic wins), redoubling their market appeal. Virtual reel mapping ‘revolutionized the slot machine industry just as much as Charles Fey did when he invented the slot machine in the first place’, said an employee of IGT, the company that eventually bought the rights to the patent.⁵⁰ As industry expert Frank Legato has written, the invention ‘was the primary impetus for the meteoric rise of popularity in slot machines.’⁵¹

48. Ibid., 11. US Patent No. 4448419.

49. Ibid., 21.

50. J. Wilson, ‘Virtual Reels? Physical Reels? Just the Real Truth’, *Slot Tech Magazine*, January 2004, 18–22.

51. F. Legato, ‘The 20 Greatest Slot Innovations’, *Strictly Slots*, March 2004, http://www.strictlyslots.com/archive/0403ss/SS0304_Innovative.pdf.

DISTORTION FACTOR

If an understanding of the RNG reveals that the *spinning* of reels has no bearing on game outcomes, an understanding of Telnaes's mapping technique reveals that the reels themselves have no bearing on game outcomes. He stated as much in the application he filed with the US Patent and Trademark Office: 'In this invention the physical reels are only used as a display of the random number generated results and are not the game itself as in standard slot machines.'⁵² *Not the game itself*: Virtual reel mapping enacts yet another remove between the game with which players interact and the mechanisms that determine its outcomes. Even more than the RNG, this technology shifted game developers' creative focus from the structure of the machine—the feel of its handle, the circumference of its reels—to its mathematical programming. For the first time it became possible to alter a game's probabilities not by reconfiguring its hardware but by reconfiguring its software.⁵³

At the same time that developers dispense with their own dependence on physical reel stops, they take care to preserve—and to profit from—players' continued dependence on the reel displays they interact with. Divested of their former mechanical function, the reels

52. US Patent No. 4448419.

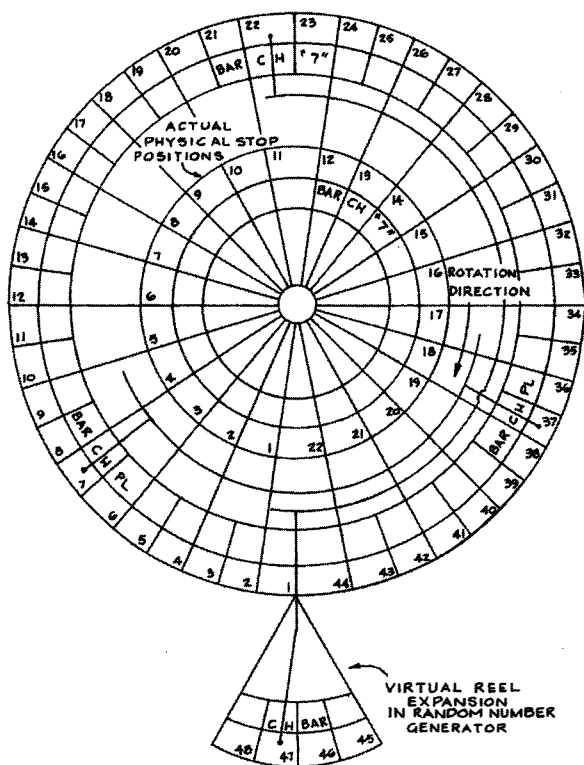
53. Ernkqvist, 'Creating Player Appeal', 166–8.

take on the new function of enchanting visual distortion. ‘Reels’ that exist only inside the machine’s chip and that are weighted heavily against gamblers are compressed onto the actual reels that spin in front of them, which appear far more weighted in their favour than they are (often carrying four jackpot symbols). Although each symbol that players see seems to have an equal chance of hitting, in fact each does not; the actual reel merely communicates the mapping decisions of its much-expanded virtual counterpart. Telnaes wrote candidly of his intent to distort player perception: ‘It is important to make a machine that is *perceived to present greater chances of payoff than it actually has*.’⁵⁴

Kevin Harrigan, a specialist in computer software algorithms, figured out a way to calculate exactly how much greater. When he analyzed the programming on one 64-stop virtual reel, he found that if it were to pay off according to how its 22-stop actual reels presented themselves, players would win 297 percent of the time.⁵⁵ He argued that machines’ misrepresentation of odds—or ‘physical reel distortion factor’ (PRDF)—worked to hoodwink the human perceptual system and encourage player persistence.

54. Ibid.

55. K. A. Harrigan, ‘Slot Machine Structural Characteristics: Distorted Player Views of Payback Percentages’, *Journal of Gambling Issues*, June 2007, 215–34; ‘Slot Machine Structural Characteristics: Creating Near Misses Using High Symbol Award Ratios’, *International Journal of Mental Health and Addiction* 6 (2008), 353–68.



The perceptual machinations and transformative distortions of chance involved in virtual reel mapping have led some to characterize it as a high-tech form of cheating; instead of ‘loading the dice’ by drilling in quicksilver or ‘weighting the deck’ by adding cards, the method of deceit is digital programming.⁵⁶ Following Nevada gaming law, ‘to cheat’ is ‘to alter the elements of chance, methods of selection or criteria’ that determine game results, and includes ‘the use of [a] device for calculating probabilities.’⁵⁷ Whether or not virtual reel mapping fits this definition, at the very least it would appear to violate the Gaming Commission’s stipulation that machines ‘must display an accurate representation of the game outcome’, a variation of consumer protection laws that forbid potentially misleading graphics.⁵⁸ Telnaes’s patent, as quoted above, foregrounds the invention’s power to mislead, or to ‘present greater chances of payoff than it actually has’.

As it happens, when a slot machine based on the patent was introduced for consideration at a set of hearings held by the Nevada Gaming Control Board, prominent figures in the gambling industry objected that aspects of its functioning were visually deceptive

56. See T. Falkiner and R. Horbay, ‘Unbalanced Reel Gaming Machines’ (2007), <http://www.gameplanit.com/UnbalancedReels.pdf>.

57. Regulations 465.015 and 465.075 (Nevada Gaming Commission 2010b).

58. Regulation 14.040 (Nevada Gaming Commission 2010a).

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and unethical. Representatives from the two largest manufacturers at the time, IGT and Bally, voiced concerns that the technology misrepresented the outcome to the player. 'From a visual standpoint', testified Bally's president, 'it is misleading to the slot machine player'. He explained:

One of the reasons reel spinning slot machines have been so successful throughout their history is that players can visually see during the course of several handle pulls, all of the symbols on all of the reels as they spin and can psychologically perceive that there are actual combinations that should eventually show up over the course of time. It would appear to us that if a mechanical reel on a slot machine possesses four sevens and it is electronically playing as if there were one seven, *the player is being visually misled*.⁵⁹

The legal counsel for IGT agreed that 'there is a deception problem involved with this kind of machine.'⁶⁰

Despite the wariness of industry insiders (which doubtless had less to do with their concern about deception than with their concern about competition), the request to sanction virtual reel mapping was

59. Nevada State Gaming Control Board, 1983, 39, emphasis mine.

60. Ibid., 41. In this comment, IGT's lawyer, Raymond Pike, was specifically referring to the machine's capacity to produce near miss effects by presenting more winning symbols above and below the payline.

deemed ‘an acceptable deviation from the criteria’, as the lead lawyer for the Nevada Gaming Control Board later put it.⁶¹ One presiding commissioner emphasized at the hearings that players *expect* deception from machines, concluding: ‘I feel good about this machine. I am going to vote in favor of it. I think the concept is an exciting one’.⁶²

The board’s endorsement of virtual reel mapping, which allowed slot machines to offer bigger jackpots, was critical to the ascent of machines in the American gambling market.⁶³ After the Telnaes patent ran out in 2002, the software became standard across the entire industry. By 1997, more than 80 percent of spinning reel slot machines (which today make up 35 to 40 percent of the machine mix on an average casino slot floor) used the algorithm.⁶⁴

When the dubious perceptual distortions of virtual reel mapping are raised today, the defense is circular:

61. Nevada Gaming Commission 1989, 280.

62. Nevada Gaming Commission 1983, 88. ‘Maybe part of the intrigue is part of the deception’, echoes Connie Jones, director of responsible gaming for International Game Technology. Her claim would appear to contradict the recent claim by a gambling industry journalist that ‘there is no sleight of hand or trickery involved in the slot machine business’. P. Roberts, ‘Slot Sense’, *Global Gaming Business* 9:8 (August 2, 2010). <http://ggbmagazine.com/issue/vol-9-no-8-august-2010/article/slot-sense>.

63. For a detailed historical study of the corporate politics involved in the switch from an electromechanical paradigm to a digital paradigm, see Ernkvist, ‘Creating Player Appeal’ (especially chapter 7).

64. R. Maida, ‘From the Laboratory: No More Near Misses’, *International Gaming and Wagering Business* (July 1997), 45.

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Presiding judges find that the practice is not fraud, because every regulatory laboratory approves it; regulatory laboratories claim that their job is not to scrutinize and uphold consumer protection laws, but only to test the features of machines that casino operators ask them to; manufacturers and casino operators claim that regulation is not up to them.⁶⁵

FALSE WINS

The most recent games to have swept the slot machine market are called ‘multiline multipliers’ and depend on video technology and complex digital software to produce their unique effects. In 1993, the first of these appeared—a device featuring a video screen with a grid of symbols and nine lines on which to bet. Instead of betting on just one line, now players could bet as many as five coins on each of the nine lines, for a maximum bet of forty-five coins per spin.

Unlike a classic one-line slot machine, on which a player either lost his entire bet or multiplied it exponentially (a rare event), multiline video slots can pay gamblers back a *portion* of each bet they make—allowing them smoother, longer play. ‘By creating wins where players receive less than their wager’, writes a game designer and consultant, ‘we give them a sense

65. S. Bourie, ‘Are Slot Machines Honest?’, *American Casino Guide*, 1999, <http://americancasinoguide.com/Tips/Slots-Honest.shtml>.

of winning but also continue to accrue [their] credits.’⁶⁶ This ‘sense of winning’ is communicated by presenting gamblers with the very same audiovisual feedback—colorful blinking lines, sounds, a musical score—that occurs during *actual* winning. The machines render a type of quasi-win (different from the near miss) that one team of researchers aptly calls the ‘false win.’⁶⁷

Since 1993, the number of paylines on this genre of machine has continued to rise—not just straight across the screen but also zigzag, featuring up to 200 lines on which to bet. With each line added to video slots, their hit frequency and reinforcement quotient has increased—along with their popularity. Although the games tend to give players slimmer odds at winning big jackpots, they also tend to carry less risk of sudden losing streaks and the quick depletion of play funds. The devices, designers told me, give gamblers a ‘a smoother ride’; they are ideal vehicles for entering the zone. As the journalist Marc Cooper remarked in 2005, ‘the new generation of gambling machines has, predictably, produced a new generation of gambling addicts: not players who thrive on the adrenaline rush of a high-wager roll of the dice or turn of a card but, rather, zoned-out ‘escape’ players who yearn

66. J. Wilson, ‘Meaningful Hit Frequency, Pt. I: An Operator’s Guide to Player Satisfaction’, *Casino Enterprise Management*, January 2010, <http://casinoenterprisemanagement.com/articles/january-2010/meaningful-hit-frequency-pt-i-operator%E2%80%99s-guide-player-satisfaction>.

67. Harrigan and Dixon, ‘PAR Sheets’.

for the smooth numbness produced by the endlessly spinning reels.⁷⁹

‘The lines have escalated far beyond the point where you can keep tabs on what you are winning or losing’, observes a gambler named Katrina, in a letter she sent to me in 2008. ‘Before you have time to examine the screen too closely, you push the button for the next spin.’

PHENOMENOLOGY OF THE ZONE

In her letter, Katrina recalls how apparently small and innocuous changes to game design ended up pushing her gambling to higher and higher levels. ‘I have been associated with electronic gaming machines for about 20 years’, she writes. ‘I can think back to when I was satisfied with playing 1 line and then fast forward to the time when I was happy playing 9 lines, but now I play 20 lines. I have become accustomed to it and it is hard not to be dissatisfied by going back to older models.’ Katrina recognizes that there are certain intensities of machine events with which she cannot cope; intensities that are too low or too high produce intolerable states of under- or overstimulation in which she cannot ‘lose herself’ in the zone of play, an experience typical of repeat machine players. She continues:

People who play machines infrequently or on a very superficial level can remain relatively unaffected by

the machines' repetitious processes. But if you play quite frequently *you have all these things constantly working on you and you develop a familiarity with the many different scenarios that play out amidst the 'randomness' of it all*. Each time you sit down at a machine you have a history of memories of what has happened hundreds or even thousands of times before (if you have played for many years). [...] Rough patterns of how it all works begin to emerge, and *you find yourself expecting certain things*.

Katrina elaborates on the process by which the repeated experience of particular machine events prompts successive readjustments in her behavior, propelling her play to new levels. She notes that it is when patterns 'begin to emerge'—or when she feels they do—that she becomes caught.

Katrina characterizes her addiction as an ongoing cognitive and affective adaptation to upticks in the intensity of machine reinforcement. What finally gives the industry the upper hand in this process is not simply the fact of her habituation or 'machine tolerance', as we might call it, but the way in which technological innovation destabilizes that tolerance wherever it develops—introducing new and unexpected increments of intensity and elements of surprise into the exchange, thus provoking further responsive adjustments in her internal expectations.

To illustrate the process, Katrina relates how one common feature of video slots, called ‘bonus rounds’ or ‘free spins’, has affected her play. This type of feature randomly presents gamblers with an animated bonus game offering them a prize, a chance at a prize, or free spins on the machine—all of which grant longer play.⁶⁸ The ‘game-within-a-game’ works in dynamic concert with the payout schedule of the base game, serving as a second layer of reinforcement. ‘At first’, she remembers, ‘free spins were just a novelty, just another innovation to contend with. I was not to know how they would change the dynamics of my play. But soon, I would dismiss outright any machine that did not have this feature.’ The novelty began to eclipse other aspects of her play, ‘to the point where normal game play lost some of its appeal. Although still important, to a degree it became a means to an end, a sort of biding of time until the free spin feature occurred.’

Katrina describes how the stakes of this contingency rise as her credits diminish:

68. Bonus features began exclusively on video slots but have now migrated to reel spinners and video poker. While the gambling industry stands to gain nothing during the bonus round (the player either wins or loses nothing), the money dispensed to gamblers as bonuses is considered a tax-deductible marketing expense; thus bonus features are a financially prudent way to provide gamblers with the extended play time (R. Lehman, ‘How Can Free Play Be So Misunderstood?’, *Casino Enterprise Management*, November 2009. <http://aceme.org/articles/fnovember-2009/how-can-free-play-be-so-misunderstood>. Harrigan and Dixon (‘PAR Sheets’, 81–110) note that bonus games amount to a secondary reinforcement schedule.

As your credits start declining, the anticipation and focus on free spin symbols starts to rise. Since they reward so much more than regular play, they become a sort of a savior. When the free spin feature is activated, then there is a kind of relief. Assuming the outcome [of the spin] is fairly good, you can then be satisfied for a while and your focus on free spin symbols diminishes to a degree.

Katrina's susceptibility to the contingency of the free spin rises and diminishes, waxes and wanes; in moments of its waxing, her pursuit of the free spin (and the 'relief' it affords when it arrives) dwarfs the more familiar routines of her slot play.

Drawing on her years of experience, she carefully distinguishes among the various 'scenarios' that can unfold with regard to free spins during a session of gambling:

Due to the unpredictable nature of the free spin feature you can sometimes feed 100s of dollars into the machine without getting it. Or you can be 'spoiled' and get it quite regularly. On other occasions you get them intermittently. Depending on how long the session is with a particular machine, all three of the above scenarios can occur in a cyclic but disordered fashion in the one sitting.

As much as these different scenarios guide Katrina's external actions, they intimately affect her internal state, as she tells us in a discerning phenomenological account of her own play:

Sometimes there is a frequent appearance of free spin symbols but no forthcoming free spins. In that case, you become highly focused on the *symbols* representing free spins. What subtly intensifies your focus on free spin symbols are *certain sounds* attached to these symbols when they appear in the window. Your emotions rise and fall with the appearance of free spin symbols, and *with the music*. If the buildup of anticipation and focusing is chronically frustrated in this way, then there is a great tendency to plow through your credits. At the same time, there is often an internal dialogue going on as to whether to push the 'collect' button. However, it is a difficult situation because while you are contemplating this you are still pushing the button and also hoping something will happen, like the free spins showing up [...]

Once you reach the point of no return you usually don't care about collecting [your credit] anymore. Sometimes when the credits are almost down to nothing *the free spins will suddenly appear*, but if they don't and the credits expire, you will do various things. Sometimes you leave, but more often you will put more money in, and the free spins may come soon

after and start the ball rolling all over again. It all moves quite quickly. The free spins just exacerbate the downward spiral you are on.

Machine sounds, music, the chance appearance of free spins: each of these contingent game events conditions Katrina's experience, expectations, and actions.⁶⁹ The movement of her play—which invariably reveals its trajectory to be that of a downward spiral—unfolds in a continuous, rapid, responsive interaction with the machine, precluding pauses or spaces in which she might reflect or stop.

The final free-spin scenario that Katrina describes explicitly invokes the 'zone'—the elusive point of absorption, beyond contingency, that machine gamblers perpetually seek. For Katrina to reach the zone and to remain there for a spell, a particular set of circumstances must arise:

The best scenario is when the free spins have been coming around regularly and perhaps normal game play has been good as well, and consequently the credits are up pretty high—this is what you have come to feel is the ideal situation. *This is where it particularly*

69. 'The cognitive, emotional, and kinesthetic feedback loop that is formed between the game process and the player makes games particularly powerful means of affecting players' moods and emotional states', writes a scholar of video games (G. Calleja, 'Digital Game Involvement: A Conceptual Model', *Games and Culture* 2 [2007], 236–60: 244–5).

feeds into that zone where you can play for quite some time without the credits diminishing very much—they may see saw, but they maintain a relatively high level. You can just relax and ‘lose’ yourself at what is ironically a very precarious but ‘safe’ level of play and you really don’t want it to end. Of course, at some stage it inevitably starts to take a nosedive.

Katrina understands the zone as at once ‘safe’ and ‘precarious’—a gentle seesaw of play credit that is mirrored in a gentle seesaw of player affect, both of which might at any instant lose momentum and come to a standstill. The zone state is attainable only at the threshold where rhythm holds sway over risk, comfort over perturbation, habituation over surprise.⁷⁰

This threshold constantly shifts as a function of dynamic interaction between player habits and the industry’s technological innovations. The interaction deviates markedly from an economic formulation of the relationship between supply and demand, in which

70. It is important to note that although machine gamblers like Katrina seek a zone in which rhythm, comfort, and habituation hold sway over risk, perturbation, and surprise, the zone cannot exist without the presence of the latter elements. If contingency is too thoroughly evacuated from the gambling exchange, players are not drawn in and access to the zone is blocked. This became apparent in the failure of a new sales formula for machine gambling that came on the scene in 2006. The formula, designed both for repeat players who seeking play time and for risk-averse novices who needed ‘training wheels’ to get used to the uncertainty of the gambling commodity, appeared in two versions: IGT’s Guaranteed Play and Cyberview’s Time Play.

market demand (understood as the static preferences of rational consumers) steers supply such that the two meet in equilibrium.⁷¹ Instead, repeat machine gambling can be characterized as an asymmetric interplay between two different modes of feedback: while individual gamblers follow a logic of ‘negative feedback’ in which they continuously adjust their actions so as to attain the zone’s homeostatic balance, the industry and its designers follow a logic of ‘positive feedback’ in which they incrementally ratchet up the intensity of play required of gamblers to achieve the zone.⁷² Out of the asymmetry between these two modes of feedback emerge the industry’s innovations and the players’ machine tolerance.

A RELIABLE MECHANISM

A complicated relationship exists between the technologically mediated mini-decisions that compose machine gambling and the ever-proliferating choices, decisions, and risks that actuarial selves face in

71. See Schüll, *Addiction by Design*, chapter 2.

72. For a compelling model of gambling addiction as the interaction between two systems of feedback, see M. Zangeneh and E. Haydon, ‘Psycho-Structural Cybernetic Model, Feedback and Problem Gambling: A New Theoretical Approach’, *International Journal of Mental Health and Addiction* 1:2 [2004]: 25–31, 27); for a related cybernetic conception of addiction, see G. Bateson, *Steps to an Ecology of the Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (New York: Ballantine, 1972), 448, 109.

free-market society. Machine gambling narrows the bandwidth of choice, shrinking it down to a limited universe of rules, a formula.⁷³ Although the activity multiplies choices, it digitally reformats them as a self-dissolving flow of repetitious action that unfolds in the absence of ‘choosing’ as such. In this sense, it is not the case that gambling addicts are beyond choice but that choice itself, as formatted by machines, becomes the medium of their compulsion.

‘I was addicted to making decisions in an unmessy way’, former video poker addict Sharon remarks, ‘to engaging in something where *I knew what the outcome would be*’. As she told me, ‘Most people define gambling as pure chance, where you don’t know the outcome. But I do know: either I’m going to *win*, or I’m going to *lose*. [...] So it isn’t really a gamble at all—in fact, it’s one of the few places I’m certain about anything.’ In his 1902 essay, ‘The Gambling Impulse’, the psychologist Clemens France similarly observed that ‘a longing for the firm conviction of assurance for safety’ underlies all gambling:

73. In 1984, Turkle made a similar observation of video games, noting that they ‘appeal because there are rules, a program, structure; play is structured according to an ‘either/or’ scheme that simplifies life’ (S. Turkle, *The Second Self: Computers and the Human Spirit* [New York: Simon and Schuster, 1984], 5, 13). One of the game players she spoke with told her: ‘You know what you are supposed to do. There’s no external confusion, there’s no conflicting goals, there’s none of the complexities that the rest of the world is filled with. It’s so simple. You either get through this little maze so that the creature doesn’t swallow you up or you don’t.’

The uncertain state is desired and entered upon, but ever with the denouement focal in mind. In fact, *so strong is the passion for the conviction of certainty that one is impelled again and again to enter upon the uncertain in order to put one's safety to the test.* [...] Thus, paradoxical as it may sound, gambling is a struggle for the certain and sure, *i.e.* the feeling of certainty. It is not merely a desire for uncertainty.⁷⁴

Gamblers' 'struggle for the certain and sure'—or for the 'certain rapid resolution of an uncertain outcome', as Goffman put it—is compounded by the technology of machine gambling.⁷⁵ What machine gamblers seek is an insulated zone of reliability, safety, and affective calm that removes them from the discontinuity and volatility they experience in their social, financial, and personal lives. Aspects of life central to contemporary capitalism and the service economy—competitive exchange between individuals, money as the chief symbol or form of this exchange, and the market-based temporal framework within which it is conducted and by which its value is measured—are suspended in machine gambling. The activity distills these aspects of life into their elementary forms (namely, risk-based interaction, actuarial economic thinking, and compressed, elastic time)

74. C. J. France, 'The Gambling Impulse', *American Journal of Psychology* 13 (1902), 364–407: 397; emphasis mine.

75. E. Goffman, 'Fun in Games', 261.

and applies them to a course of action formatted in such a way that they cease to serve as tools for self-enterprise and instead serve as the means to continue play. The process of distillation and suspension amounts to '*a mutation that is totally immanent to late capitalism*', as Tiziana Terranova has written of a similar phenomenon; 'not so much a break as an intensification, and therefore a mutation, of a widespread cultural economic logic'.⁷⁶

In this mutation, the suspension of the actuarial imperative is never entirely complete. This incompleteness is reflected in the ambivalence that gamblers express toward the 'choices' they face while gambling, describing them as at once emancipatory and entrapping, annihilatory and capacitating, reassuring and demonic. Lola, the buffet waitress, speaks of 'resting in the machine', then later in her narrative describes video poker's relentless stream of card choosing as commanding—the activity 'hooks', 'holds', and 'captures' her attention. '*You have no choice* but to concentrate on the screen', remarks Julie, 'you simply cannot think about anything except which cards *you are going to choose* to keep and which *you are going to choose* to discard'. Even as gambling addicts in the zone strive for release from the procession of choices they face in their daily lives, they remain caught in the predicaments of the enterprising self.

76. T. Terranova, 'Free Labor: Producing Culture for the Digital Economy', *Social Text* 18:8 (2000), 33–58: 54.

A Guide to the Casino Architecture of Wedding

Jaspar Joseph-Lester

Berlin's Wedding casinos can be found on most of the main streets and many of the side streets that connect this predominantly Turkish district to the rest of the city. Popular gaming streets include Badstraße, Müller Straße, Reinichendorfer Straße, and Schweden Straße. The architecture of Wedding casinos involves a broad range of exteriors, each evolving as a direct response to the particular demands of the gaming industry in this area of Berlin. The following examples are categorized according to similarities in location (side street, main street, corner and first floor casinos) graphics (colour range and printed image) and the positioning of the entrance (centre entrance, side entrance and corner entrance).

The main street casino shown opposite is situated on Reinichendorfer Straße and is perhaps most closely related to Robert Venturi's notion of 'the decorated shed', which he used to describe a certain category of Las Vegas Casino. However, this familiar mode of casino architecture is uncommon in the Wedding district. Set apart from the residential apartments that stand behind the casino, the building stands as a detached autonomous structure. During the day, the general dimensions of the interior are made visible by the exposed end wall and low roof. The graphics are plain, but extend across the full width of the façade. At night, the neon lighting transforms the outer appearance of this main street casino, so that only the front is visible, and the shed-like structure of the rest of the building fades into the darkness.





Smaller casinos can be found on many of the side streets of Wedding. These gaming houses are located in small shop units, and use brightly coloured graphics to decorate the windows, doors and surrounding areas of the façade; normally printed on vinyl sheets that can be easily attached to the window area.



Side street casinos often have small projecting balconies above the main signage—conveniently providing shelter for customers who like to smoke between games. The close proximity to residential apartment blocks forces a sharp contrast between the brightly coloured signage of the casino and the mute tones of the apartment blocks above.

Casinos situated on the corner of two adjoining streets (normally with the main entrance placed on the corner of the building) are popular throughout Wedding. These frontages are normally larger than the side street casinos, and benefit from being visible from a number of viewpoints.

The casino shown on the right is situated on the intersection of Reinichendorfer Straße and Gericht Straße. The larger scale of this building reflects the size of the streets it faces onto. The main entrance is on the corner of the casino and faces two pedestrian crossroads. The heavy concrete structure above the casino is used as a VIP lounge for high stake gambling. The small mirrored-glass windows indicate a more sophisticated and exclusive mode of gaming.







COLLAPSE VIII



The distinctive blue frontage of the J.F. Casinos can be found on both the side streets and main streets of the Wedding district. The two examples shown here illustrate some of the main structural differences that have already been highlighted between side and main street casinos. The image above shows a side street casino integrated into the apartment building; it is situated in a shop unit and has small balconies projecting over the signage. The J.F. Casino shown on the right has all the structural features of a main street casino; set apart from the large apartment blocks behind, the long rectangular building consists of a simple low-rise structure. Like the Las Vegas ‘decorated shed’, this casino is designed to be seen from a car.



City skylines are a popular graphic motif for many of Berlin's Wedding casinos. The most common reproduction is of the Las Vegas Strip (see next page). Here, images of the megahotel casino resorts that line the Strip are illuminated against a dark desert sky. In the J.F. Casino shown above, the skyline consists of a montage of skyscrapers set against a backdrop of blue glazed bricks. On the right side of the entrance, the Berlin TV Tower hovers above the other tall buildings. These cutouts extend to the recess leading to the main entrance and across the doors of the casino. The side street J.F. Casino (left) uses the shop windows to show silhouettes of classical architectural motifs.





First-floor casinos can be found above commercial units or inside local shopping centres. The architecture of these casinos often includes a large entrance onto the street. Access to the street is maximized through the use of signage and escalators. As with the other casinos in Wedding, the windows of the first floor (shown on the right) are blocked out with bright graphics printed on large vinyl sheets, only here the white window frames and yellow brick of the surrounding walls are left to blend in with the rest of the building.

The first floor casino shown on the right also illustrates some of the problems and difficulties that other businesses may endure when sharing signage with casinos based above street level. Here the Shell sign is set directly against an image of a slanting Eiffel Tower—creating a novel contrast to the rational design of most petrol stations. The entrance walls surrounding the stairwell soon become the most visible (and therefore most valuable) part of the building.







Black-fronted casinos can be found on many of the side streets of Wedding. A heavy black background is combined with red or white graphics to create strong contrasts and striking imagery. In daylight hours, the dark exteriors stand out against the lighter tones of their residential surroundings, creating a forceful and sometimes intimidating presence.

Casinos where the entrance is situated in the centre of the façade (or central entrance casinos as they are more commonly known, see following pages) are less imposing and more informal than other gaming establishments in Wedding. On occasion it is possible to find tables and chairs welcomingly arranged outside; casino signs may also include 'café', 'cocktail bar' or 'sports bar' in the signage, and the window displays are not always entirely blocked out with casino graphics.



In contrast to their opaque counterparts, the central entrance casino will normally have small areas in the front window display for the passing customer to see the interior from the street. This more transparent mode of Wedding casino architecture shows consideration for timid customers who might not otherwise enter the premises.



With larger central entrance casinos (see over page) the window display may show images of interiors (in this case taken from Las Vegas). Here the interior worlds of the entertainment industry are externalized through a coalescence of image and architecture.

CASINO





From Blackjack to Monanism

Interview with David Walsh

David Walsh is the founder of the Museum of Old and New Art [Mona] in Hobart, Tasmania, a unique art museum funded by Walsh from the proceeds of a successful career developing and applying sophisticated techniques for beating the odds in pari-mutuel betting.

Walsh dropped out of his Mathematics and Computing course at University of Tasmania after he discovered card-counting, began to visit a nearby casino. His interest in gambling grew, and he went on to develop mathematical models for sports betting together with collaborator Željko Ranogajec. 'Z' is a notoriously reclusive counterpart to the publicity-friendly, eccentric, and gleefully vulgarian Walsh (a self-described 'rich wanker'): while Ranogajec has resolutely stayed out of the public eye, Walsh gained increasing notoriety after his 1995 purchase of the Moorilla vineyard, on a peninsula in the Derwent river, where he subsequently built the 'un-museum' Mona: a lavishly appointed,

9500m² sprawling underground cabinet of curiosities, art, and antiquities, presented with no concessions to the polite sophistication and blithe elitism of white walls and ruminative label texts (although its custom-built iPod audioguide, the 'O', does offer an 'artwank' option...). Packed with Walsh's own choice of objects, from antique statuary to work by contemporary artists such as Anselm Kiefer, Damien Hirst, Chris Ofili, and many lesser-known names, Mona (which Walsh has called a 'subversive adult Disneyland') has little truck with standard art-world expectations—visitors can expect to take a thirty-minute catamaran ride from Hobart to a Bond-villain lair where they will get some sublime thrills and be rudely confronted with Big Questions.

Mona opened in 2011, with the costs of the project finally exceeding \$AUS 200 million, while at the same time Walsh was placed under investigation by the Australian authorities who pursued him for a large amount of backdated taxes, having decided that his gambling activities had grown beyond the proportions of a non-taxable hobby.

Walsh and Ranogajec's Bank Roll, with a multi-billion dollar turnover and hundreds of full-time operatives, remains one of the largest gambling syndicates in the world, and has continued to turn a profit that has enabled Walsh to maintain and promote Mona. The un-museum now not only sits alongside a café-restaurant, luxury accommodation, and a winery, but also includes a cinerarium—an ongoing work to which keener visitors can elect to add their ashes posthumously for a price of \$AUS 75,000. Mona has played

COLLAPSE VIII

a large part in transforming Hobart, and is unchallenged as the biggest tourist attraction on the small island of Tasmania.

COLLAPSE talked to Walsh about gambling on a grand scale, his strategies, the role of chance in life and death, and whether Mona is the biggest risk he's ever taken.

COLLAPSE: Is there a kind of straightforward contradiction involved in being a 'professional gambler'? On one view, gambling is connected to an instinct for life, a craving to immerse oneself in chance and risk, an escape from everyday reasoning and calculation. Isn't any kind of system that seeks to gain a steady income from gambling contradictory to this instinct? How do the two go together—Dionysus and Apollo?

DAVID WALSH: I am certainly professional in at least one sense: I'm trying to subvert the gambling gold standard, which requires the punter to have a disadvantage, and thus to lose in the long run. Almost all gamblers want to win (an exception is a small class of male punters who are seeking boasting rights—their benefit is a loud declaration of their possession of fitness markers in a biological sense).

COLLAPSE: Apart from them, can the instinct for gambling be explained in evolutionary terms?

DW: The genesis of gambling is multifactorial, but key amongst those factors is the asymmetry that we benefit from in risk situations. In the savannahs in Africa a hundred thousand years ago we were on the lookout for lions. When we saw a lion that wasn't there, the loss of resource for overreacting was minuscule. On the other hand, when we didn't see a lion that was stalking us, the consequences were profound. In fact, our ancestors clearly didn't experience that unfortunate event, probably because they over-matched patterns as a safety precaution. And now, so do we. Most of the gambling risks people take have an element of rationality. A lottery ticket gives us, say, one chance in two million of winning \$1 million. But \$1 million is worth more than two million times the single dollar that the ticket cost. This effect is real, as is evidenced by the favourite long-shot bias in most gambling markets (the average loss for a random bet on a favourite is smaller than that for a long shot).

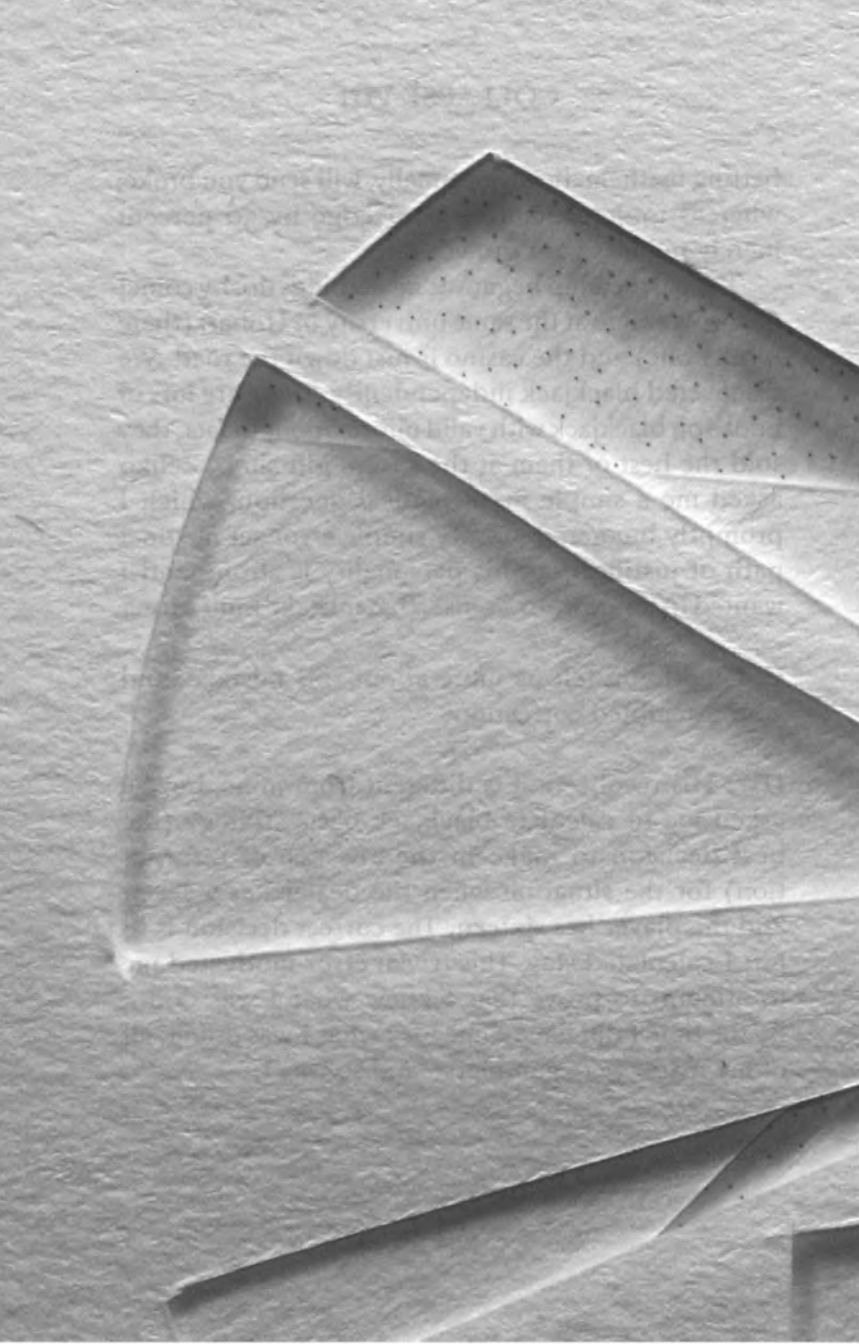
More speculatively, in the savannahs, and later, after the invention of agriculture, a few individuals in each band (between twenty and fifty people) could increase the chance of the band surviving times of hardship by responding in a different, more linear way, to the effects of crisis. For example, balancing the risk of migrating with staying put may not require an asymmetric response, and thus over-assessing risk may not

be appropriate in such circumstances. I think we call these people nerds now—and their time has come again.

My ‘professional’ attitude to risk might come from the selection pressure on my remote ancestors. Or it might come from a biological or cultural pathology. Or maybe I’m just lucky.

C: You head up the consortium The Bank Roll, at the core of which is your partnership with Zeljko Ranagojec, which has lasted for some thirty years. What is the nature of the partnership: that he spots opportunities, and you work out how to exploit them mathematically? And how did it begin?

DW: He is certainly more active at spotting opportunities, but he is more active in general. He is far more risk averse than me. I tend to see opportunity, and not the hidden downsides. He, by nature, preserves our capacity to continue playing by operating as a counterpoint to my mathematical certainty. In the first year of our horse race gambling, I had overestimated our edge. We were about 80 percent likely to go broke, but we didn’t, simply because we got lucky (as an interesting aside, I speculate that most people who do what we do initially overestimate their edge and don’t get lucky. Their poverty is no less meritorious than our success). There is a more complex asymmetry operating here. Overestimating your edge by 100 percent, and then



betting mathematically optimally, will send you broke; whereas underestimating your edge by 50 percent merely reduces your growth rate.

The partnership began, as most things do, by coincidence. We were at the same university in Hobart (there is only one) and the casino is just down the road. We discovered blackjack independently. There are lots of books on blackjack with valid information. In fact, they sold the best of them at the casino gift shop. Zeljko asked me a simple mathematical question, which I promptly bugged up. My simple error set me on a path of justification, his personality is strong and I wanted to impress. In a sense, that mistake built Mona.

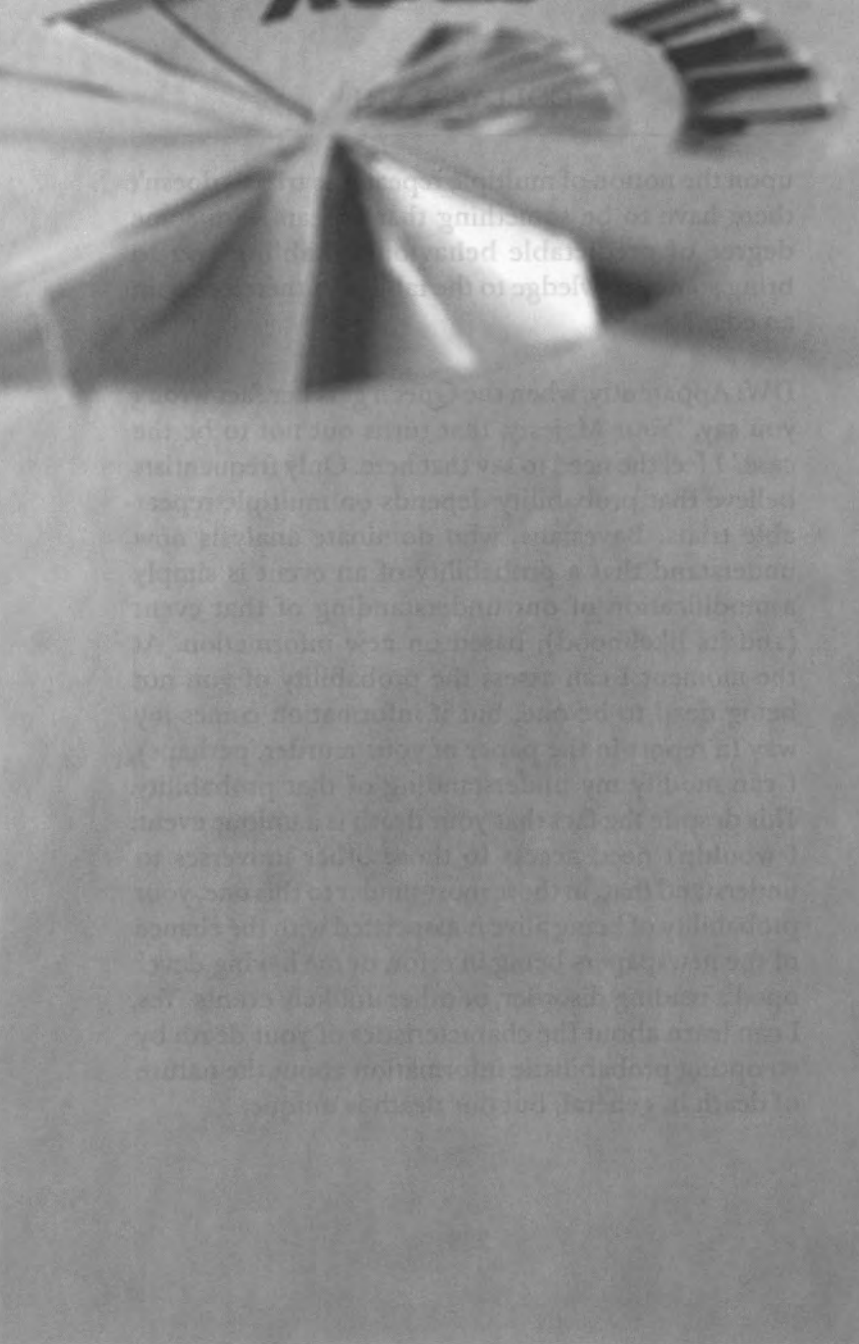
C: Could you tell us more about this mistake, and your attempted correction?

DW: His recollection is different from mine, but he asked me to calculate blackjack basic strategy (the best decision to make in the absence of information) for the situation when the dealer has a seven, and the player has sixteen. The correct decision is to hit; I calculated stay. This trivial error motivated me to attempt to prove that I knew what I was doing. By the time I did have some idea what I was doing, all of my mates were gamblers—and so was I.

C: Nowadays your focus is sports betting, and in particular horse racing. How do you spot exploitable regularities here, since each race is a non-repeatable event, and the results are open to such a wide variety of contingencies? This is not the same as a simple physical system like a roulette wheel or fruit machine in which systemic biases can be discovered and exploited. What exactly is the 'system' that is taken as the domain of analysis?

DW: There is an interesting question embedded here that some statisticians (frequentists) struggle to answer: If an event is unique, how can a probability be assigned to each of its particles? One answer, which is emerging from physics, is the many-worlds interpretation of quantum mechanics. Here, all the events that can occur do occur, but in different universes; and they happen in proportion to some real defined probability mandate. We may be, essentially, measuring the chance of being in a particular universe that instantiates a probabilistic event across multiple universes. Or this might be complete crap. But it is clear that calculating the probability of unique events works, for whatever reason.

C: And of course that would only be any good to you if you had access to the other universes too...Isn't the very concept of calculating probability dependent



upon the notion of multiple repeatable trials—doesn't there have to be something that repeats with some degree of predictable behaviour, enabling you to bring some knowledge to the table and therefore gain an edge?

DW: Apparently, when the Queen gets her fact wrong you say, 'Your Majesty, that turns out not to be the case.' I feel the need to say that here. Only frequentists believe that probability depends on multiple repeatable trials. Bayesians, who dominate analysis now, understand that a probability of an event is simply a modification of our understanding of that event (and its likelihood), based on new information. At the moment I can assess the probability of you not being dead to be one; but if information comes my way (a report in the paper of your murder, perhaps), I can modify my understanding of that probability. This despite the fact that your death is a unique event. I wouldn't need access to those other universes to understand that, in those most similar to this one, your probability of being alive is associated with the chance of the newspapers being in error, or me having developed a reading disorder, or other unlikely events. Yes, I can learn about the characteristics of your death by co-opting probabilistic information about the nature of death in general, but our death is unique.

C: Moving away from my death and back to horse racing, though....

DW: There, all we need to do is to assess the probability of a given horse or team winning more accurately than the public. The public are extremely efficient, and the key breakthrough (and it isn't my result) is to assume that the public are right and just look for biases in their beliefs. Maybe they underrate the importance of a good jockey, or overrate a wet track. Many of these small errors can combine to make our model of the odds more accurate than theirs.

C: The 'efficiency' of the public as a whole is underrated, then? Is there a parallel here with efficient market hypotheses in economics? And despite this 'efficiency', doesn't the individual punter always lose in the long run?

DW: In a pari-mutuel, by definition most will lose because a proportion of the wagered amount is removed. This says nothing about the efficiency of the market. The arguments about efficient markets have variously vacillated from disputation about whether all the information available is contained in a market, and whether you can win. These are not the same thing. In fact, by establishing that it is possible to win with statistical certainty, all forms of the efficient market hypothesis are falsified. The public isn't perfectly efficient.

But they do produce a better model than modellers can produce if they ignore the public signal.

Ultimately, the market analogy is rather strained, because it isn't predicting an event, so much as creating it, whereas horses perform outside of the perturbations of the betting market.

C: So given the baseline of the public signal, where are the other signals coming from, the ones you are using to correct the biases? Do your people spend their days endlessly rewinding and zooming into race footage, or running high-level modelling software...?

DW: There are many horse punters who win by understanding the characteristics of the horses. That isn't our expertise, particularly. We tend to do our analysis in a way that is often termed data mining.

Opportunities are created for those who have the opportunity to approach risk linearly, because the public do not discount for all information symmetrically. It can be rational for a punter to take a disadvantage bet if he (they are usually men) needs the money he might win badly enough. There is also the input of cognitive biases. As an example, the existence of hot-hand bias is well established, even in rhesus monkeys. Hot-hand bias is a tendency to predict that an event that has recently happened is more likely (when there are human actors) than the long-term probability.

Jockeys with recent form are assumed to be likely to outperform those with long-term superiority. When Frank Dettori won every race on the program, his odds became more and more absurd as punters expected his run to continue. As it happened, it did. But punters who won money that day lost a lot more on other days when such runs did not occur. The last winner that Dettori rode that day, Fujiyama Crest, paid £3.00 when the odds at the start of the day were 13. That's a return of around 23 percent, creating opportunities for those betting on other horses in the same race. Most biases result in smaller distortions in the odds, but they can be cumulative. These things bias crowd forecasts.

Incidentally, hot-hand bias has a biological basis. Foragers that seek food randomly are outperformed by foragers that seek food where it was recently found. And, unusually for an evolutionary strategy, it has no downside in a natural environment. Foragers that seek food where it has previously been found perform equally with random foragers in an environment where food is distributed randomly.

C: What kind of apparatus does your operation involve—One man at a laptop, a distributed system, a server farm, an army of undercover punters?

DW: At various times it has been all of your suggested apparati. We tried the army of undercover punters in

Vegas betting on sports (basketball, baseball, etc.) and it was a fiasco, maybe because we didn't have an edge, or perhaps because gamblers and other people's money don't mix. These days, it's just an agency-supplied internet application that many thousands of people use, which enables our computer to bet directly with their computer.

C: What kind of mathematics is employed?

DW: The standard published technique in this domain is called multinomial logistic regression (MLR), which plays a significant role for us. Related techniques are used for forecasting survivorship (industrial, light bulbs, lifespans etc.) and traffic flows.

MLR is similar to regression analysis. The difference is that rather than forecasting a trend, it enables one to pick the probability of an event from a set of mutually exclusive events (like the winner of a race). Others do use standard regression analysis, and I did for a while. It isn't magic. Any tool, when applied with sufficient diligence, would probably work. The hardest bit is actually having an edge, rather than *thinking* you have an edge. And then, when things go bad, as they inevitably will, knowing whether the negative fluctuation is a pathology, a bug, or just the usual amount of bad luck.

We have been messing around with this stuff for thirty years now, and we have had a few ideas. Having an edge is paramount, of course, and once that has been achieved, time heals all financial wounds.

C: Is this success based on a conceptual grasp of the phenomena in question; or does it come down to the gathering of data and discovery of correlations without needing to know what they ultimately relate to?

DW: I'll illustrate the interplay between conceptual depth and analysis using the example of roulette from years ago. We did some statistics on roulette wheels at Wrest Point, the casino in Hobart. We discovered, amongst other things, that American Bingo Parlour wheels had significant deficiencies that allowed us to garner an edge. We did the analysis using chi-square, which is a law of large numbers-style technique. 27 red came up too much on all wheels. Other numbers showed biases on a subset of the wheels. The obvious question is, what physical phenomena makes the behaviour of 27 odd? One candidate is that the separators between numbers might not be placed evenly. This would result in the number adjacent to a higher frequency number coming up less often. Another possibility is that the elasticity at the base of a number might not be constant. In this case, the more elastic numbers would come up too little, and other

numbers, with some specific but unknown distribution, too much. Many other possibilities exist, of course.

To do an analysis of a roulette wheel quickly (with a short sequence of numbers), hypotheses can be devised and tested that make assumptions about the embedded issues the wheel might have. Of course, given these asymmetries in the wheel, the alternative ‘blind’ approach would still work after having observed a sufficient number of spins.

C: We assume that your system gives you odds which are then compared against the bookies’ to discover an advantage—that is, are you basically doing the same thing as the bookies but better.

DW: That’s pretty well right, but mostly we bet with totalisators (pari-mutuels) since they like our action.

C: In a pari-mutuel, for a given bet type, the pool operators take out their commission and then divide the remaining pool in proportion to the amount wagered in winning tickets.

DW: That’s right. The pari-mutuel’s profits derive from keeping a fixed percentage of the pool, and we make the pool bigger.

C: The relation between large syndicates and pari-mutuels has been controversial. Let's put it this way: the money you used to build Mona must have come from somewhere.... In this 'market', isn't everything skewed in favour of those who already have a large bankroll? If I'm a punter betting \$100 at a time on 'gut instinct' then if I lose, I lose. For you, it's a different story: The syndicate is a high-value customer, since bookies benefit from your business; accordingly you receive money back (rebates) even on your losing bets. This clearly means that you need less luck to make a profit—indeed, doesn't it almost mean that all you need is to minimize losses?

DW: As you can imagine, bookies don't like us much. When bookies take bets off winners, it is reasonable to assume that they make their money by laying off the bets into pari-mutuel pools—they depend on rebates (this applies in Australia mostly, in the UK they might lay off on Betfair, and if they can't lay off they won't take the bet). The commission is typically around a few percent (again, the UK experience is different; Betfair pays no rebates, and the pari-mutuel [tote] is so small as to be of little interest).

Rebates are volume discounts, and they do affect the way you bet. The pool operators only pay if you bet bigger. And if you bet bigger you win a smaller percentage, but on larger turnover. The trick is to bet

the amount that makes you win the most. Sometimes this would be a net loss if there were no rebates, but if there were no rebates you would bet smaller and you would still win. In Australia, the market I know best, bookmakers offer a rebate on pari-mutuel odds, and they pass on most of it to the punter to solicit business. Losing punters are mostly worse off because we win in the market they bet in. It is, after all, a game where no wealth is created, like a commodities market. The exception to this is punters that lose more than average (for example, by betting on long shots). They benefit because the effect of our bets is to reposition the odds closer to where they should be, and thus to increase the odds of the worst bets. In the UK, the winner/loser dichotomy is a lot more directly expressed through betting exchanges like Betfair. Betfair should be of great interest to the efficient market economists, because it enables a punter to express negative information, to profit from knowledge about what a horse can't do. This introduces a symmetry to the market that seems to encourage a higher level of efficiency. Empirically, exchanges do result in more efficient markets. In general, if there are specific types of information that can't be expressed in a market, how can it be efficient?

Because rebates keep inefficient competition in the market, in my opinion the most skilled punters (us, hopefully) would be better off if no rebates were paid. Sometimes they create opportunity, but I am not

convinced they are, for us at least, a net benefit. I like playing the game. I don't want to be a bookmaker, or a pool operator (others in our enterprise might disagree however). My brother said about me that I'd 'rather be outside the barrel pissing in, than inside the barrel pissing out'. He has been dead twenty years, but his analysis is still acute.

C: But the small punters are in effect subsidising you, since your big wins flatten out the odds?

DW: The answer is yes. It is difficult to win more than about 0.25 percent of the total market. Since bookies and pari-mutuels typically take out about twenty percent (but, for example, 50 percent in Turkey, which still turns over \$US 1 billion a year) we increase the loss rate of the average punter by, at most, 1.25 percent (from 20 percent to 20.25 percent, a proportion of 1 in 80).

C: Given your description, one might even ask whether it's even 'gambling' anymore, in the sense that the risk, for you, is so tightly controlled.

DW: Before, you imputed that chance is merely lack of understanding. Aren't you here implying that chance is real, if it needs to be controlled?

If one has an edge, and can bet proportionally small enough that the cash supply won't run out, then

the more trials there are, the smaller the risk becomes. Hong Kong is the biggest betting market for horse racing (measured by turnover per race), and there are only 800 races a year. It is possible to have an edge and lose for years. Of course, eventually statistical arbitrage will out, and the edge will show itself. It is these shorter-term difficulties, I suspect, that keep many out of the market.

C: Why doesn't the market correct, and therefore counteract your edge?

DW: It does. If you want to bet big, it takes quite a bit of calculation to work out something approaching the optimal bet. As I mentioned before, outcomes are asymmetric. Betting too big does more damage than betting too small. This is a big problem, because model estimation inevitably results in overestimation of advantage. In saying that, there are published strategies, at blackjack, where betting doesn't affect advantage: many use the Kelly criterion. For pari-mutuel betting, the Isaacs criterion is preferred. There is no published solution to the combined problem of betting optimally under the combined constraints of bankroll size and pari-mutuel betting. The problem of winning, in general, seems to divide into three roughly equal parts: what the odds are (or are going to be in a pari-mutuel environment); what the chance

of the event occurring is; and how big to bet (which can only be greater than zero when the odds multiplied by the chance of the event is greater than one). However, there are many punters who win simply by assessing horses that they think are underestimated, without reference to the odds.

C: Of course, people are not and never have been 'rational agents', which is one reason why markets don't become absolutely efficient...however, as you say, increasingly the 'common punter' has access to a whole lot more information and can bet more intelligently. Could you expand a little more on how the scene has changed since you started betting?

DW: A market can't become efficient if there is no way to express some types of information. But if you have information, and it isn't sufficient to make you win, why expose it to market forces? In fact, in a pari-mutuel where only the final odds pertain, it seems reasonable to suggest that a rational actor will only expose information if, after it is discounted, it is still possible to have an advantage.

Markets improve in efficiency. None of the betting strategies we used twenty years ago would work now. And present day casino gamblers employ strategies that I would be unable to recognise as winning systems. I suspect, as you imply, that the average

punter is constantly improving also. They need to lose at a rate that lies within their entertainment budget or they either remove themselves from the market or become a pathological gambler (who tend to progress to markets where they control the frequency of the gamble, like poker machines, and, anyway, they can't maintain indefinitely). This clearly exerts some Darwinian force on the market.

C: Presumably great changes have been wrought by the explosive growth in online betting over the last decade; what's the net effect of widespread technology and increasing connectivity?

DW: Most of the stuff we need to do has gotten easier as technology has progressed. Opportunity grows, but opposition also grows—the public improves and has access to better information. The interplay of all this stuff 'focuses the mind'. How much we change the odds is inversely proportional to the size of the pools, and technology gives the public the opportunity to bet bigger, if they want.

C: Along the way, have you had any encounters with, for example, casino game protection? Do you consider that you ever cross the line from advantage playing into cheating?

DW: I've been barred many times, in many places. My commitment level was low, I went away and didn't go back, so I avoided many of the issues that other players have experienced. Casinos, and players, have to abide by law. Cheats attempts to change the odds. Serious players bet when the advantage is in their favour, which is no more cheating than is using an umbrella only when it's raining.

C: When you made your first trip to Vegas, how did it feel to arrive there?

DW: I wallowed like a beached whale. My mental health was undone by the scream of bland. But the University of Nevada has an excellent gambling library.

C: Any eureka moments?

DW: No, as a general rule I believe that eureka moments only exist in retrospect. After my time in Vegas the most likely outcome wasn't success at gambling followed by my building a museum. But all those that could have been me but aren't, because their luck didn't hold, aren't being interviewed. The imposition of chance is camouflaged by our perspective. We can't see the ghosts of all those things that didn't happen. We can see reality, so we view the present as inevitable.

C: But chance is real, nonetheless?

DW: Chance is real in life. We are the product of hundreds of millions of generations of successful sexual matings. Each of these was slightly stacked by natural selection, but there is tremendous good fortune in having the opportunity to be born. And thus, in having the chance to die. I am, as I intimated before, tremendously lucky, not in winning with a winning system, but in alighting on a winning system in the first place, and not blowing it up between now and then.

Because of the asymmetries I mentioned earlier, we massively underestimate the part that chance plays in our lives. We invent explanations, like astrology and homeopathy, and ghosts and gods, for events that have no explanation. Chance is liberating: it respects failure and limits the merit that devolves from success.

C: When looking at favourable outcomes we certainly tend to underestimate the part played by chance—but isn't that what we do as rational beings, i.e. try to find a reason (as stated in its purest form in Leibniz's Principle of Sufficient Reason). Don't we just say 'chance' when we have insufficient information?

DW: Emphatically, no. Leibniz didn't have the tools to know better, although that might have been his fault,

because he was a contemporary of Fermat and Pascal, who first started to penetrate the fog of certainty. Daniel Bernoulli soon after, and Thomas Bayes, gave us the methods to understand that reality is in large part the application of happenstance. God does play dice. And as the quantum world should by now have made everyone aware, 'he rolls them where they can't be seen'. More recently, Claude Shannon showed that, mathematically, insufficient information is equivalent to chance. The information that would satisfy Leibniz's principle doesn't exist in this universe.

C: We understand you're a reader of Dostoyevsky, a writer who depicts marvellously the combination of abandonment to chance and the feverish need to predicate some kind of systematic organisation. Observing the spontaneous fantasies of order which the gambler fabricates while playing, he wonders: 'Is it really not possible to touch a gaming table without immediately being infected with superstition?'.

The 'liberating' aspect of chance you mentioned seems to be just that: chance without superstition. To bring in another Dostoyevskyan theme, once chance is stripped bare like this, doesn't nihilism loom...?

DW: I have come to believe that there are a number of pathologies acting within compulsive gamblers, and

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many express only one. Dostoyevsky characterised the opposite of hot-hand bias, the doctrine of maturity of chance, which seems to be applied specifically to mechanical systems. Humans engage streaks, nature abhors them. He writes about it beautifully because he lived it. 'Chance without superstition' expresses my contrary belief very well.

Nihilism lies in the negation of reality. Reality has been shown, to my satisfaction, to be redolent with randomness. Reality is what it is, not what we want it to be. To quote myself, from my autobiography,¹ 'Propositions don't accrue merit in proportion to their desirability.'

C: Of course, Dostoyevsky wrote the novella to pay off his own gambling debts...

DW: ...and he died penniless, but had 40,000 mourners at his funeral. His reality was not at all satisfactory.

C: So do you still enjoy the simple thrills of gambling?

DW: I enjoy the thrill of scheming and dreaming, but not as much as I used to. I juggle many balls, and I have dropped most of them, not out of disinterest, but inability.

1. D. Walsh, *A Bone of Fact* (Hobart: Mona, 2014).

C: Have you ever been tempted to dabble in the fields of, for example, currency or futures markets? Is what you do comparable?

DW: Those systems are of a type known as arbitrage, which essentially guarantee a profit for the knowledgeable dopester. We are gambling, and thus can always have bad luck, and good luck. The market is interesting, as is the insurance world. We might get there one day.

C: Are the moral implications different?

DW: Derivative wagering and tote wagering don't produce any wealth. I don't build anything, or otherwise do anyone any good when I gamble; nor do hedge fund managers who don't participate in stocks. It is incumbent on me to do something worthwhile, if I make money. I hope that Mona, and some of the other things I do, at least partially fill that moral void.

C: What relation is there between gambling and your interest in art as an art-lover and collector? There is obviously the fact of art's relatively indeterminate value, which makes it a risk-laden asset; but presumably that's not the whole story.

DW: Art, for me, is a tool for learning about my surroundings, as is science. Art, however, is imprecise but wideband. It occupies all the senses, plus reason and emotion. Science is narrowband, but precise. They are complementary, but of course there are many crossovers. My education isn't the measure of the art, but it is a measure of its value to me. And much of the art I buy would have no such value to anyone else. It is possible to construct a value for art mathematically, but the market is illiquid, and it would mean overcoming a vicious cost structure, and buying a whole bunch of shit.

C: Do you have a specific idea of how one might approach this? There have been a few attempts, but only quite recently, to model the art market. There are major barriers in terms of transparency. And also, there are no rebates!

DW: Wrong again—actually, the big buyers and sellers do enjoy preferential rates at auction houses.

The art market lacks two essential elements for it to be an exploitable market. They are: low transaction costs (for everybody, so that the market exposes information); and high liquidity (so you don't get stuck with art that you want to sell but can't). I occasionally fantasize about correcting these issues by buying an auction house and introducing a fixed cost model.

Charles Saatchi's online art dealing, if it works, might impact the nature of the art market.

C: Maybe this is the right point at which to discuss the work you devised together with French artist Christian Boltanski. You bought the rights to transmit live footage of his Paris studio to Tasmania, but the terms of payment are based upon an eight-year period elapsing before his death—so if he lives beyond 73 you end up paying over the odds. It sounds like it could be the start of a great thriller screenplay.

DW: It's a beat up. I couldn't pay for a work, so I offered him a time payment plan. In his retelling, I'm a gambling devil who never loses, living on a farm surrounded by wild animals. In reality I'm a gambling angel (who doesn't believe in angels) who often loses, and who lives in a small city surrounded by wild, and not so wild, people. Within that small city there is Mona, and people come and go and seem to like it. And there are art works, and many reify philosophy, including Boltanski's. We show his life, live from his studio, and because lives are a lot less interesting watched than experienced, it is great art in inverse proportion to how tedious it is. And it is very tedious indeed.

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C: You opened Mona in 2011, it's a labyrinthine underground complex cut out of the rock that's almost twice the size of the Guggenheim, filled with an eclectic selection of artworks, and has put a previously unassuming Tasmanian suburb on the map. Was Mona also a gamble, or is it something you did when gambling was no longer enough?

DW: Mona is a ship afloat on a sea of chance. It shows the power of uncertainty, and gradualism, and it rails against compartmentalization, that thing that allows you to lie to yourself. And, occasionally, you can see through the cracks what beauty is.

C: What about the idea of artworks themselves representing some kind of risk for their audience—that somehow encounters with art would endanger our everyday relation to the world and open us up to something larger? There's at least one work in the Mona collection that does seem to represent a real physical risk: Kurt Henschlager's *Zee*, which comprises a great deal of strobe and pulse lighting and disorienting sound, and has apparently caused a seizure or two.

DW: *Zee* caused about one percent of people to see the world in a very different way indeed! However, for the most part, any new insight into reality is a positive thing. We can only learn what we don't know.

Mona deals with some big themes, but it also might be an entertainment, and training wheels for public museums.

C: Indeed, Mona's exhibits seem to revolve around the great themes of human life, sex, death, eating and shitting. Is gambling another of these primal things? When we started talking you placed it straight away in the context of evolutionary psychology. It's a perennial force, not just as a recreational activity but in terms of the whole destiny of Western society, based on risk taking and (mis)adventure.

DW: Mona revolves around motivations including, importantly, why we make art. Artists are cultural machines, of course, but they are also possessors of biological imperatives. I am not an artist but I share many of those imperatives, including, perhaps, a desire to show off. Gambling, as I said before, is a result of mismatched benefits from engaging risks, and of this perturbing the human brain over evolutionary time. We need risk takers to avail us of new opportunities, but in terms of the individual, risk taking is not an interesting or useful thing, except, occasionally, when there is a sexual asymmetry. Men gain more from risk taking because stupid behaviour might impress the ladies. Opening museums might be exactly that kind of stupid behaviour.

Dice-like and Distributed: Time Machines, Space Engines and the Enactment of Risk Markets¹

Anders Kristian Munk

As soon as we begin to talk indeterminism to our friends, we find a number of them shaking their heads. This notion of alternative possibility, they say, this admission that any one of several things may come to pass, is, after all, only a roundabout name for chance; and chance is something the notion of which no sane mind can for an instant tolerate in the world. What is it, they ask, but barefaced crazy unreason, the negation of intelligibility and law? And if the slightest particle of it exists anywhere, what is to prevent the whole fabric from falling together, the stars from going out, and chaos from recommencing her topsy-turvy reign?

WILLIAM JAMES²

1. I would like to thank Robin Mackay for his help in preparing and editing this essay, which summarizes a number of arguments from my thesis *Risking the Flood: Cartographies of Things to Come* (University of Oxford, 2010).

2. W. James, *Essays on Faith and Morals* (New York: Longmans, Green & Co., 1943), 153.

The need to accurately predict both groundwater and surface water flash floods—the latter firmly linked to drainage capacity—was heightened after last summer’s catastrophe. In response, mapping technology specialists have announced developments over recent months to help overcome these ‘black holes’ in insurers’ knowledge. But whether these advances could be described as the ‘Holy Grail’ is doubtful. With the UK’s drains in various states of repair, and no adequate data on their current condition available, insurers will always face uncertainty. In addition, there is the impact of climate change and the omission of small rivers and streams on existing Environment Agency data—despite their ability to result in nasty incidents.³

Maps are not prescriptive but infinitely promising.⁴

In November 1884 the American psychologist and philosopher William James addressed students at Harvard on ‘the dilemma of determinism’: Is ‘free will’ genuinely free, or is everything given in advance? Refreshingly, the answer was of little interest. James made it quite clear from the outset of his lecture that he was not going to offer any solution or provide any settlement

3. *Post Magazine*, 21 February 2008.

4. J. Corner, ‘The Agency of Mapping: Speculation, Critique and Invention’, in D. Cosgrove (ed.), *Mappings* (London: Reaktion, 1999), 213–253: 235.

to an ancient intellectual tussle between those professing the predetermined state of the universe and those contesting it.⁵ ‘Facts’, he proclaimed, ‘have hardly anything to do with making us either determinists or indeterminists’ since it is impossible to see how ‘any amount of assurance that something actually happened [can] give us the least grain of information as whether another thing might or might not have happened in its place’.⁶ To James, the existence of alternative possibilities was a matter of rational belief, not of proof, and hence his interest in determinism was of an altogether different sort than that of the usual protagonists debating its veracity. Rather than attempting to prove (or disprove) the contention ‘that any one of several things may come to pass’ he tried to understand how these things-to-come must, and positively can, exist beyond proof and verifiable evidence. When I now propose to explore how floods are risked, this schism between actual fact and credible possibility is fundamental: what I am after are the more-than-factual ways in which eventualities are brought to life.

I deliberately frame it as a ‘more’, rather than a ‘less’, since I am not interested in reiterating any linear

5. The discussion dates back to the presocratic philosopher Epicurus who tried, to no avail, to reconcile Democritus’s idea of a world made from atoms falling through the void with the notion of human freedom (I. Prigogine and I. Stengers, *The End of Certainty: Time, Chaos, and the New Laws of Nature* [New York: The Free Press, 1997]).

6. James, *Essays on Faith*, 152.

conception of uncertainty as simply incomplete or second-rate knowledge. On the contrary, it seems to me, at least in the context of flood risk, that the realisation of alternative possibilities involves the mobilisation of things which can be positively ascertained as facts. Crucially, of course, it is not reducible to these things, but neither is it short of them. It requires a leap of faith beyond them, something more than what they have to offer. In the empiricist style of thought championed by James, such instances of 'belief' are not construed as negatives or surrogates in the absence of more robust and justifiable ways of knowing. Rather, they are understood to be at the root of what it means to know at all. To illustrate this point James used the metaphor of 'live' and 'dead' electric wires and proposed to define a live hypothesis as 'one which appeals as a real possibility to him to whom it is proposed' ('belief') and to measure this 'liveness' by such a person's 'willingness to act'.⁷ Indeed, the evolving plethora of possible future floods circulating the public domain under the auspices of forecasts, maps and models displays a considerable degree of 'liveness' if gauged using this method. It has 'practical consequences';⁸ it makes a difference.

Essentially, then, the question I am trying to ask relates to the 'liveness' of indeterminacy itself.

7. W. James, *The Will to Believe and Other Essays in Popular Philosophy and Human Immortality* (Mineola, NY: Dover. 1956), 2–3.

8. W. James, *Writings 1902–1910* (New York: The Library of America. 1987), 506.

How it takes place; how it eventuates. While it might be impossible to factually ground its implicit contention that things could have been otherwise than what has observably taken place, it is nonetheless a claim with a noticeable purchase on reality as we know it. In a world in which risk has become instrumental to the analysis, anticipation and management of everything from mundane accident to cosmological disaster⁹ and is seized upon as a sign of the times, the mould in which contemporary modernity crystallizes,¹⁰ it seems evident that indeterminacy has made its mark—with or without the assistance of proof. But with the assistance of what, then, has such a construction acquired its integrity? What generator sparks the current; what conductive material makes the wiring go live?

Prompted by these curiosities, and with the risking of floods in mind, I am interested in the emergence of believable ('live') eventualities. How can things to come have real effects without actually coming to pass? How, that is, can they attain reality without

9. E.g. J. Adams, *Risk* (Abingdon: Routledge, 2001), R.A. Posner, *Catastrophe: Risk and Response* (Oxford: Oxford University Press, 2004), M. Power, *The Risk Management of Everything: Rethinking the Politics of Uncertainty* (London: Demos, 2004), N. Bostrom and M. Cirkovic (eds.), *Global Catastrophic Risks* (Oxford: Oxford University Press, 2008).

10. E.g. U. Beck, *Risk Society: Towards a New Modernity* (London: Sage, 1992), *Ecological Politics in an Age of Risk* (Cambridge: Polity Press, 1999), *World at Risk* (Cambridge: Polity, 2009), A. Giddens, *Modernity and Self-Identity in the Late Modern Age* (Cambridge: Polity Press, 1991); 'Living in Post-Traditional Society', in U. Beck, A. Giddens and S. Lash (eds.), *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order* (Oxford: Polity Press), 56–110; *The Politics of Climate Change* (Cambridge: Polity, 2009).

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confirming their premonitions (which would deprive them of their ambivalence and make them more than merely possible); and, equally importantly, how can they maintain their indeterminable futurity without becoming themselves indeterminable (which would fundamentally obscure their realisation)? The critical point, which James kept stressing, is that in between the two extremes of the deterministic argument rehearsed above—in between the absolutes of intelligible law and topsy-turvy chaos—the indeterminist seems able to construct an altogether orderly universe which leaves room for chance without dissolving into perplexing disarray:

The creator himself would not need to know all the details of actuality until they came; and at any time his own view of the world would be a view partly of facts and partly of possibilities, exactly as ours is now. Of one thing, however, he might be certain: and that is that his world was safe, and that no matter how much it might zigzag he could surely bring it home at last.¹¹

It is implied that indeterminacy is not simply a 'want of determinateness or definiteness' (as the Oxford English Dictionary has it); it is not just an absence of something, but a particular type of presence which

11. James, *Essays in Faith*, 183.

effectuates, and is effectuated by, an equally particular mix of actuality and possibility. Flood risk embodies such a mix: some things are known as facts (floods have been observed; weather patterns have been recorded; terrains have been mapped; flows have been theorised; defences have been designed; vulnerabilities have been located; policies have been adopted; and regulations have been put in place), while some (other?) things are known as possibilities (future floods and weather patterns are imagined; alternative maps and theories are proposed; the effects of policies and regulations are pondered; and vulnerabilities and defence strategies are reassessed accordingly). There is a very fine line separating what might possibly come to pass from what has actually taken place here, and they are frequently stirred into hybrid coexistence. At the end of the day, however, whether for the benefit of the work of political, scientific or commercial construction, flood risk is a platform to build on. Although it is concerned with potential catastrophe, and although it embodies something inherently indeterminable, it provides a distinct alternative to the paralysing absence of certainty: it reassures us, in the words of James, that the world is 'safe'. Not safe from being flooded, of course, but from being abysmally unintelligible.

*

COLLAPSE VIII

[i17] Did he tell you that water can even flow uphill?
[AKM] He didn't, but that sounds interesting...
[i17] As a practical insurance person, however, I have a piece of advice for you: if you're standing on a hillside and there's a flood coming, I would still run uphill rather than downhill.

Canary Wharf, June 2008: It is a sunny afternoon and the business crowd has taken over the outdoor areas along the waterfront. I am here to talk to flood insurance specialists in this financial hotspot spawning from the City of London, well away from the academic offices and engineering laboratories where physical flood modelling takes place.¹² Insurance has been a core component of the business carried out here since the German Kaiser invaded Italy in the first half of the thirteenth century and the fleeing merchants resettled in Lombard Street. Banned from entering the existing guilds, the Lombards made it their trade to lend out money at interest and brought with them from the harbours of Venice and Genoa a taste for funding risky mercantile adventures at sea.¹³ With the late medieval commercial revolution, that combination merged into the modern concept of marine underwriting where risk

12. For my account of physical flood modelling, see 'Emancipating Nature: What the Flood Apprentice Learned from a Modelling Tutorial', in K. Harstrup and M. Skrydstrup (eds.), *The Social Life of Climate Change Models: Anticipating Nature* (London: Routledge, 2012).

13. F. Martin, *The History of Lloyd's and of Marine Insurance in Great Britain*. (London: Macmillan. 1876).

is transferred to a third party in return for a premium.¹⁴ Insurance and finance were then and are now kindred practices of the monetary system, a duo rarely as palpably present as on the banks of the Thames.

Making possible futures into a profitable business involves making flooding answer to questions of likelihood and cost, a process in which a different set of calculative tools than those native to hydrology must be mobilised. What is essentially at stake is the spatiotemporal formation of these eventualities, the way in which they are correlated and distributed, and indeed the way in which it becomes possible to contemplate their futurity without invoking the type of prediction or foresight that would ruin both the fundamentally unrealised and undetermined character of risk as well as the gamble of trading it: insurance. This will in the first instance bring home James's point that indeterminacy goes live through a cocktail of determinable fact and believable possibility, and suggest that one way in which that ordered universe materialises is through a process called catastrophe modelling. But it will also leave me stranded in a rather unresolved state of affairs in which the cartography of things to come seems both readily at hand and oddly out of view.

14. F.E.D. Roover, *Early Examples of Marine Insurance*. *The Journal of Economic History* 5:2 (1945), 172–200.

COLLAPSE VIII

FROM DETERMINABLE TO PROBABLE

In the offices of the Financial Services Authority (FSA) the man in front of me, a former reinsurance professional (i17), recalls a job he did for a newly privatised Polish insurer back in the 1990s:

[i17] There were no flood models for Poland. But they still had to decide how they were going to quantify the risk. If they get the number too low, then they're not adequately protected against the size of event they might have at a certain level of probability. If they get the number too high, then they pay out huge amounts of unnecessary reinsurance premium which affects their profitability and their competitive position. And there's no model. So how do they decide what to do?

[akm] Did they have a loss record?

[i17] No. There's no data, they have only been in business for a few years. This is why the earthquake people have it easy: in many countries you've got 2,000 years of good data on seismic losses. On flood, really there was very little that was helpful. So we sat down with them and talked about the kind of loss event they thought they might have, where it might happen, what might cause it; and over the course of the conversation we were able to get from them that they felt that probably 1 year in 5 they would pay a certain number of claims related to flood.

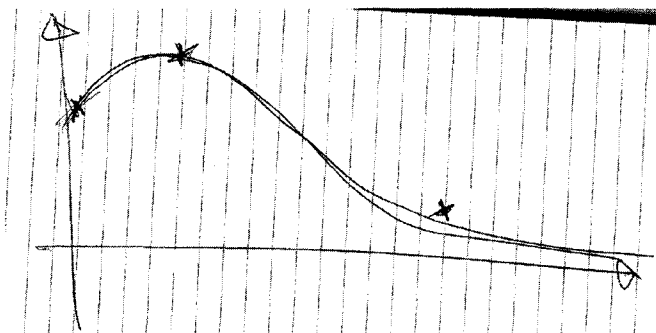


Figure 1. i17's drawing in my field diary. Y-axis: probability; X-axis: number of flood events within a given period of time

There was maybe only a 5 percent or 1 year in 20 chance of paying out so many claims costing so much, and they felt that realistically the highest amount they were likely ever to have to pay from a flood event, given the area where they had most of their business and so on, was a certain amount. And that effectively gave us—you won't get this on tape but I'll draw it for you—it effectively gave us three points...and with three data points you can draw a distribution—I can do it now freehand...something like that—that's not the best way of doing it of course, the best way to do it is to use somebody who knows what they are doing: somebody who knows what shape a flood distribution might have—because different perils have different distributions with different shapes. It's probability of the event and the cost of the loss, and

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in the end there's a limit as to how hard the wind can blow, there's a limit to where the water can go and all the rest of it. So if we agree that it really can't be worse than a certain point we imagine that is as bad as it gets, the 1 in 500, and if we agreed the 1 in 5 and the 1 in 10, and if someone clever like [former colleague of ii7] knows the shape of a flood distribution, they fit the shape of the distribution that they understand to be for flood risk to those assumptions, and you can effectively pack that into a form of probabilistic flood model. Now, it's exceptionally imperfect, it's not based on the hazard and the vulnerability and all the rest of it, it's based on conversation; but it's a lot better than guesswork, it's a lot better than nothing.

Two notions of uncertainty or probability are at play here: one pertains to the imperfection arising from the lack of data, the other to an assumed property of the future. The first notion is epistemic and has to do with credibility: it 'arises from imperfect information and knowledge, which is potentially reducible through data acquisition'.¹⁵ This kind of uncertainty is at the root of the Polish insurer's problems where it is acknowledged that, had there been a flood model for Poland, and had historical data been available, the situation could have looked a lot different. The key point is

15. G. Woo, *The Mathematics of Natural Catastrophes* (London: Imperial College Press, 1999), 74.

the provisional character of uncertainty: it is taken to mean a mendable and thus passing incompleteness of knowledge. The second notion, however, the one which is expressed in ii7's diagram, is irreducible and cannot be done away with. It constitutes the other half of what Ian Hacking calls the Janus-face of probability,¹⁶ namely that which depends on chance. And because this kind of uncertainty is precisely not construed as epistemic—probability referring here not to the likelihood of being right or wrong but to the likely outcome of a game of chance—it offers itself as an explorable property of the future. There was no model, no data, no loss record, yet the risk facing the Polish insurer could still be contemplated because other characteristics were recognised as being known.

Central here are the graphic qualities of ii7's diagram. Rather than a mere reflection of what is already there, it brings something new to the table. It looks like flooding, even when nothing else does. In a manner similar to the way in which flood models claim to represent the flow of water across land, the curve drawn by ii7 seems to model something which is determinably 'out there'. What it looks like, of course, is not the extent of an inundation, but the distribution of events over time. And in a manner similar to flood

16. I. Hacking, *The Emergence of Probability: A Philosophical Study of Early Ideas About Probability Induction and Statistical Inference* (Cambridge: Cambridge University Press, second edition, 1975), chapter 2.

models, the curve seems to be capable of projecting this resemblance into the future by transforming correspondence to what has been into assumed correspondence with what will come. It thus possesses related fictitious capacities, but what it brings into being is distinctly different from the possible and plausible futures fashioned in a piece of predictive hydrological software like HEC-RAS.¹⁷ By introducing chance it imbues indeterminability, although in an ordered manner, to what would otherwise have become a merely deterministic exercise.

This diagram is not my first encounter with chance. I have seen these curves before, in other offices in London, have met people who 'know what shape a flood distribution might have'. These people are not exactly flood modellers, at least not in the hydrological sense, nevertheless they model floods. Their worlds—this seems to be the crucial point of difference—are not assembled around water. Rather, the phenomena they model take the form of events, binaries which can either happen or not happen, and the world in which they eventuate is ultimately assembled around the flip of a coin or the throw of a die. Employed in the reinsurance sector or by the large catastrophe modelling companies, they are in the business of providing the insurance market with an indispensable component of the risk traded: correlated sets of possible futures. Though far

17. See <http://www.hec.usace.army.mil/software/hecras/>.

more sophisticated than the probability distribution drawn by my informant at the FSA, these futures share one of its most useful characteristics: they too are ‘a lot better than guesswork’. That might appear banal. After all, if something based entirely on a conversation is better than guesswork, then it would seem reasonable to think that a state-of-the-art catastrophe model, comprising, as they do, loss records as well as the full spectrum of available hydraulic, hydrological and meteorological data, would also be. But be that as it may, it does not make it any less noteworthy that, when it comes to the future, we seem to have moved beyond guesswork. That capacity neither springs out of nowhere, nor out of a conversation, nor out of a body of flood-related knowledge. Possible future floods are brought into being through what I call the fictitious capacity of hydraulic computer models. The ability to navigate these futures, however, choosing between them, weighing them against each other, comes from somewhere else. It springs from the cultivating powers harnessed in devices such as probability density functions, capable of equipping the future with a set of knowable properties—those of a game of chance—which can subsequently be explored. Julius Caesar allegedly proclaimed that ‘the die is cast’ (*‘alea iacta est’*) when he crossed the Rubicon back into Italy in defiance of the Roman Senate. There was no flood model for Poland, yet in recognising that a decision needed to be taken,

the insurers turned to a knowable property of the future. The dice game, it was understood, was on.

Insurers acquire a stake in flooding when they buy up risk from homeowners and businesses in flood prone areas. In the first instance that risk is taken on by a primary insurer who will, in principle, price the transaction like any other actuarial job: the fair price should equal the average loss on the portfolio. It is a statistical rather than a hydrological exercise, provided that records are available from which to derive the average. This, however, is far from always being the case, and in recent years several primary insurers have enlisted the assistance of hydraulic modellers to supplement their actuarial risk assessments. A prominent example is Norwich Union's £5m project 'Next Map', which entered service in 2004 and became a much publicized affair after allegations that it would lead to reductions in coverage. It was not the first of its kind (in 2002, for example, Royal and Sun Alliance released their Geographical Risk Analysis system) but it was the first to assess flood risk on address rather than postcode level, a project which necessitated the commissioning of an airborne survey to produce a new digital terrain model with an improved vertical resolution of 50cm for the South of England and 1m for the rest of the country.¹⁸ Where other insurance companies had relied on data

18. D. Crichton, *Flood Risk and Insurance in England and Wales: Are there Lessons to be Learned from Scotland?* (Befield Hazard Research Center, 2005).

supplied by the Environment Agency, Norwich Union became the first company to seriously challenge this hegemony (although some insurers, like the internet based Esure, had also acquired additional imagery to supplement the EA data). But while Norwich Union publicly claimed (and indeed this is the impression I got from informants who worked on the project) that more accurate flood maps would allow them to take on more business in postcodes which would otherwise be deemed too high risk, and to lower premiums on individual properties which would otherwise have had to accept the same policy as potentially more exposed neighbours, there was widespread public fear that it would lead to redlined properties in otherwise acceptable postcodes, and make it even more difficult to get insurance cover for homeowners who had already experienced difficulties. Norwich Union announced that existing customers could expect to have their policies affected (positively or negatively) as the flood map was being rolled out and new information was becoming available (this was done gradually starting with high risk areas such as Norfolk and Shropshire where the 2000 floods had produced heavy losses), and fears were exacerbated when the Environment Agency later that year updated its own flood maps.

Address-level flood tools are now commonplace in the insurance industry either in the form of actual maps or simply databases matching each property

with a flood risk assessment which will normally be in a red-amber-green traffic light format. Because of the way home insurance policies are sold in the UK, where 68 percent of the transactions take place through a third party such as a broker or a building society,¹⁹ this relatively simple format is required. In a situation where a broker is trying to get a quote for a client from several competing insurers, for example, a traffic light flood risk tool will be able to quickly tell whether or not the property would be refused, accepted or referred to further assessment. RBS Insurance has acquired such a tool (tellingly called Addressology), so has Lloyd's, and Royal and Sun Alliance's Geographical Risk Analysis system is now not only capable of address-level flood risk assessments but has also been modified to take drainage problems and surface water flooding into account. While address-level assessments have become commonplace in the industry, the focus is now on incorporating these types of non-fluvial flooding which have increasingly taken over the agenda and in consequence, the procurement of more and better EA data in this area has been made part of the latest revision of the Statement of Principles on the Provision of Flood Insurance.²⁰ Whether delivered directly to a primary insurer or supplied through the EA, however, the production of these tools is located outside the

19. ABI, *UK Insurance—Key Facts*.

20. ABI, *ABI/Government Statement on Flooding and Insurance*.

industry with external flood modelling consultancies like Halcrow, HR Wallingford or JBA (who did the Norwich Union flood map).

There is thus no doubt that the transfer of flood risk into the insurance community invokes an appetite for flood science in the City. But, as 117 suggests, this appetite is subordinate to the practicality of insurance, which is essentially about harnessing chance. Like all actuarial enterprises, choosing to run uphill well knowing that, in theory, so could the water, involves an estimation of likelihood. Insurance is conditioned by the presence of a perceived hazard, something that is thought possible, and can be understood as the gamble that such a possibility will not be realised. There are two operations at play here: one is about acknowledging the possibility, the other is about making it answer to the question of likelihood. It is only with these two moves that the substantive definition of risk as a combined measure of frequency and severity acquires meaning.

Tracking the transfer of risk through the insurance industry offers a prism through which we can start to contemplate how flooding answers to the question of likelihood. Effectively it is a nonsensical question without some sort of spatiotemporal definition. The inquiry must, implicitly or explicitly, be made for a where and a when, and as the transfer of risk progresses, those definitions do not remain constant. Neither does

the question of likelihood and, notably, nor does the expertise enlisted for the risk assessment.

As shown in ii7's diagram, primary insurers are not the termini of the transfer but rather the intermediaries. In turn they will seek to become policyholders themselves and take out reinsurance for the contingency that they should face insolvency and be unable to pay out claims. The space-time of this transaction is fundamentally different to that of the address-level risk assessments defining the transaction between homeowner and primary insurer. To the homeowner, likelihood is a question pertaining to an individual property within a highly variable and often unspecified period of ownership. How likely is it that floodwater will ever (as long as ownership is retained) come in to the house? Initially that is more or less what the primary insurer wants to know as well—except that time is now specified by the duration of the policy (there is a difference between buying a property in an area where floods occur on average every fifty years, and having to insure that property for one year only). However, more acute differences materialise when the primary insurer needs to take out reinsurance. Essentially these derive from the scale and the character of the contract. To the reinsurer, likelihood is a question pertaining to entire portfolios and a particular subset of floods: those capable—on their own or in conjunction—of bankrupting policyholders. The question is not spatially limited to one place with

one temporal horizon; rather it is a bifurcating inquiry in which multiple likelihoods must be correlated in aggregate space-times. The possibility that floodwater will enter a property must be considered together with the possibility that other properties will be affected at the same time. And the possibility of such an event must be considered together with the possibility of other events occurring in the period specified by the policy. This probabilistic complexity is normally produced through a process called catastrophe modelling.

CATASTROPHE MODELS

In 1992 Hurricane Andrew generated insured losses worth \$15.5 billion as it made landfall in the United States. This figure was unprecedented, and when a relatively unknown consultancy, Applied Insurance Research (AIR), made an estimate in excess of \$13 billion some days before, nobody believed them. The estimate was based on what became known as catastrophe modelling, and it paved the way for the uptake of this new kind of expertise in the insurance sector.²¹ Today it is not uncommon for reinsurance companies such as Swiss Re, Hannover Re or Munich Re and major brokers such as Benfield, Willis or Guy Carpenter to employ their own catastrophe modellers, but the

21. GIRO, *Report of the Catastrophe Modelling Working Party*, 33 (London: The Actuarial Profession, 2006).

global market for vendor models is still dominated by three specialised suppliers: AIR, RMS and EQUecat. Founded between 1987 and 1994, they emerged as a branch of the GIS revolution fuelled by increased computing power in the late 1980s and early 1990s. The purpose of their models is to estimate losses. In contrast to the determinism found in their hydraulic counterparts, the enterprise is probabilistic:

[...] catastrophe modelling is not an attempt to predict when a disaster might occur, but a process that allows users to create a meaningful distribution of future events so that associated expected and extreme loss patterns can be developed. This allows exposed parties to gain an understanding of their risks and how they may be financially impacted under different scenarios.²²

This does not mean that physical or deterministic science has no place in catastrophe modelling. On the contrary: non-actuarial forms of expertise are incorporated at several stages of the process (see figure 2, opposite). The basic operation of a cat model depends on a stochastic catalogue of disasters, an extensive database of 'real world events that could happen', as one of my informants put it.

22. E. Banks, *Catastrophic Risk: Analysis and Management* (New York: John Wiley & Sons. 2005).



Figure 2. The process of catastrophe modelling (adapted from GIRO, *Report of the Catastrophe Modelling Working Party 33* (London: The Actuarial Profession, 2006).

The phrasing is illustrative: ‘real world’ means neither that they have actually happened, nor that they ever will; it means simply that they are possible. They could happen. It is not determined whether, when or where they would. To ensure this reality-as-possibility, deterministic expertise is enlisted. Seismology for earthquakes, hydrology for floods, meteorology for hurricanes, and so forth—the task is to come up with ‘events that could happen’. In a similar manner, expertise is needed to turn those events into hazards and to specify how they would cause damage (by working out water levels or wind speeds, for example). Together the event and hazard modules produce scenarios which can then be linked to the user’s inventory of insured assets in order to determine their vulnerability and to

estimate a loss. Finally a financial analysis is carried out based on a database of policy conditions also supplied by the user (this could be information about excesses or terms of coverage) and the insured loss is estimated.

It might thus be clear that the appetite for deterministic flood science is sustained throughout the process of risk transferral, although the inquiries exciting such an appetite alter. But it is equally clear that the imperatives demanding its implication are not native to the hydrological disciplines. The pressing question is no longer how a flood happens, but how likely it is to happen and how costly it is going to be. As an informant in the City rhetorically asked me: "Risk is a quantity that's being measured in pounds in this country, right?" Whereas this is no doubt true for the financial sector, and arguably also for politics, hydraulic models output water levels in feet, not in sterling; they do not model costs. Yet the risk of incurring costs is exactly what is transferred to a third party in a policy for flood cover (and indeed, this focus on costs can sidetrack hydrological considerations to the extent that banks acting as both mortgage lenders and insurers will prefer to provide cover for a property, which could thus be made mortgageable, if the expected income on the loan is deemed to be worth more than the expected losses on the policy). Catastrophe models make no demands on the end-user to geometrize or hydrograph anything. The work has already been

done and is embedded in the software as scenarios. Rather they exact monetization (understood here as the process of enabling things to express themselves in monetary values) and spatiotemporal definition. For the model to model, it needs information about assets, their location, and the period within which a possible loss might occur. It must, in other words, know the space-time and the stake of the gamble. What I want to argue is that not only does risk, as an entity measured in pounds, require a particular kind of geography, it actually brings this geography about through practices such as catastrophe modelling.

THE FUTURE IS A GAME OF CHANCE

It is commonly held that Blaise Pascal and Pierre de Fermat, the French mathematicians credited with the invention of the probability calculus, were prompted to their pioneering correspondence in 1654 by a gamester, the Chevalier de Méré, seeking the assistance of Pascal in determining the proper course of action in a game of dice.²³ Probability theory germinated out of an interest in the aleatory contracts already pervasive in gambling, and while the influence of the Chevalier himself is sometimes questioned,²⁴ the importance of his passion,

23. F.N. David, *Games, Gods and Gambling: A History of Probability and Statistical Ideas* (London: Griffin. 1962), chapter 9.

24. Compare David, *Games, Gods and Gambling* with O. Ore, 'Pascal and the Invention of Probability Theory', *American Mathematical Monthly* 67:5 (1960), 409–19.

games of chance, is not. It provided the terms in which the idea of probability was first formulated, and it continues to constitute the core logic around which probabilities are assembled. Knowing what shape a flood distribution might have is tantamount to being able to imagine flooding as a game of chance: something which has dice-like properties. The proliferation of the term 'aleatory', that which depends on the throw of a die (alea), is not limited to the world of wagers and gambles. It is, for instance, commonly found in juristic works concerned with the equity of chance-dependent contracts in fields like marine insurance and life annuities, and 'it is perhaps not surprising' as Keith Michael Baker notes,²⁵ 'that the calculus of probabilities, once elaborated in terms of games of chance, was quickly seized upon as potentially applicable to those probabilities in the social world for which the jurists had prepared the field'. This is a fundamental insight when asking how flooding can be made to answer to the question of likelihood: it might have everything to do with likelihood itself, and not a lot to do with flooding in particular. The interesting question is really by what means floods come to be seen as instances of chance, rather than the other way around.

25. K.M. Baker, *Condorcet: From Natural Philosophy to Social Mathematics* (Chicago: University of Chicago Press. 1975), 157.

Quite a few authors have written extensively on the history of probability,²⁶ and while they all acknowledge the pivotal importance of Renaissance and Enlightenment mathematics, many of them also devote some introductory time to the fact that the probability trail runs out somewhere in the archaeological excavations of Assyria and Egypt. This is not to say that there is any evidence that the ancients had a mathematical concept of things like frequencies or stochastic processes (although examples from the Talmud might to some extent be an exception),²⁷ but the proliferation of dice and dice-like devices for probing the future seems ubiquitous across human history and culture. It suggests that the future was a game of chance long before mathematicians figured out a way of properly theorising that game. It was, for example, not uncommon for the oracles in Greece and Asia Minor to use astragali (an early form of die made from ungulate heel bones) to derive the omens of the gods. Similar usage of randomizers for the purpose of divination has been observed in a number of African tribes, and among Tibetan monks

26. Hacking, *Emergence of Probability*; David, *Games, Gods and Gambling*; Baker, *Condorcet*; examples include I. Todhunter, *A History of the Mathematical Theory of Probability from the Time of Pascal to That of Laplace* (London: Macmillan, 1865), D. MacKenzie, *Statistics in Britain 1865–1930: The Social Construction of Scientific Knowledge* (Edinburgh: Edinburgh University Press, 1981), L. Daston, *Classical Probability in the Enlightenment* (Princeton NJ: Princeton University Press, 1988).

27. A.M. Hasofer, 'Random mechanisms in Talmudic literature', *Biometrika* 54 (1967), 316–21, N.L. Rabinovitch, 'Studies in the History of Probability and Statistics XXII: Probability in the Talmud', *Biometrika* 56:2 (1969), 437–41.

for predicting the coming stages of reincarnation.²⁸ To the extent that the future is a game of chance, the difference between an oracle and a probabilistic model is the difference between a game decided by divine intervention and a game evolving in accordance with stochastic principles. In both cases, the aleatory character of the game suffices to bring the future beyond guesswork since a constituent element of such a future—namely the random one—is implicitly acknowledged, randomness being here the notion of multiplicity or outcomes to choose between—something quite different from chaos. It is important to note this: randomness is an ironed-out kind of time in which there is no overlap between outcomes. The die will be either 3 or 5, not both at once. It is not pure chaos. In exploring that randomness, whether as the mouthpiece of the gods or as a domain of mathematics, the future is cultivated. It highlights a tension between the deterministic claims to knowledge implicit in physical hydrological modelling and the probabilistic assemblage of flooding described above: in asserting that the future, and thereby a possible future flood, has the properties of a game of chance, one is also asserting that the particulars of flooding are, to an extent, secondary. Essential to this relationship is the plurality lost in the word ‘future’. It should in fact be many futures, or sets of possible futures, each of them more or less hydrological elaborate (very elaborate in the case of

28. David, *Games, Gods and Gambling*, chapter 1.

catastrophe models; not elaborate at all in the case of the Polish insurer having to buy reinsurance without flood models or loss records to go on), but all of them outcomes of the same kind of game, bound together by their allegiance to an aggregated probability of 1:1. The future, in its many possible manifestations, resides in the area under the curve of figure 1, with its square measure containing the totality of potential. Outside it there can be nothing, inside it the inevitability of one eventual future must be shared among a not yet realised multiplicity and break down into probabilities. But how does that kind of futurity, with its stochastic imperatives, amalgamate with the flood phenomena produced by hydrologists and their deterministic models? In his analysis of creativity Henri Bergson contemplates foreseeability and its limitations:

Of the future, only that is foreseen which is like the past or can be made up again with elements like those of the past. Such is the case with astronomical, physical or chemical facts, with all facts which form part of a system in which elements supposed to be unchanging are merely put together, in which the only changes are changes of position, in which there is no theoretical absurdity in imagining that things are restored to their place [...] But an original situation, how can such a situation be given before it is actually produced?²⁹

29. H. Bergson, *Creative Evolution* (London: Random House, 1944), 33.

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This attendance to originality implies Bergson's argument that the future is, in a radical sense, unforeseeable. Yet some things, the facts, those fabricated to a standard which does not permit displacements between positions to affect their makeup, the 'immutable and combinable mobiles',³⁰ are nonetheless foreseen. Their mobility is temporal as well as spatial and it is assumed that they will be as immutable tomorrow as they were yesterday. The role of physical flood science in the process of catastrophe modelling is to provide the immutable and combinable raw materials for what is essentially the construction of a die. The catastrophe modelling company I worked with, for example, produced scenarios for each 50-metre grid cell in the UK. They modelled precipitation, hydrology and hydraulic routing to produce about 45,000 flood events, each with an average rate or frequency. These could then be treated stochastically as possible outcomes of random processes (i.e. games involving a 45,000-sided die) to assess the probability of having any number of events in a given area in a fiscal year for example. Probability theory does not transmute as it moves from games of dice to flooding, the rules remain the same. Rather, it is flooding which must become dice-like. The focus is on finding the common aleatory denominator, that which makes flooding no different from any other gamble.

30. B. Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Milton Keynes: Open University Press, 1987).

It is not the particularities of water and flow, but the crosscutting ways in which things eventuate that orchestrate this futurity.

**SAME DICE GAME, DIFFERENT COLOGNE:
FLOODS, BOMBS AND HORSE KICKS**

Vienna, April 2009: In the vast poster exhibition at the General Assembly of the European Geosciences Union I run across a hurricane specialist employed by one of the big catastrophe modelling companies. He has a windstorm simulation running on a laptop and he is very pleased with the way it has turned out. It models the original nicely. As there was no organised systematic tracking of hurricanes in the Mexican Gulf back in the 1960s when the actual event occurred, it is hard to tell whether the simulation is taking the right route or not. What was recorded was the amount of precipitation it produced over the United States, and that is what is accurately reproduced by the model. I am curious to know how that is satisfying to a catastrophe modeller. A real event is simulated, but how does that predict anything? I am looking at it in the wrong way, he tells me. It is not about predictions. It is not about the truth in the sense of knowing with exactitude what is going to happen. Rather it is about the possible, about generating events that could happen. Rainy futures to be, tens of thousands of them, evoked as a first step in modelling the catastrophic.

Bergson is echoed here: a contemplatable future must be made out of immutable and combinable building blocks, which is what the windstorm model is churning out. There is a spectrum between radical unforeseeability and prediction (the future as truth) kept open by aleatory uncertainty which, in the words of Woo, ‘cannot be reduced through advances in theoretical or observational science’.³¹ In Bergson it is clear that this kind of futurity is a halfway point at which a limited foreseeability is brought about by enforcing immutability and combinability at the expense of originality and creativity. This is why it makes sense to say that the future is cultivated or colonised. What is still eluding the account, however, is the organising principle: even when the building blocks have been successfully churned out there is no sign of foresight, however limited. Aleatority, it seems, must first be summoned in the set of possible events.

A year earlier I am in London talking to the head of flood risk (i11) in the very same catastrophe modelling company:

[akm] So I suppose you would need some data to decide how to footprint these scenarios– how is that done?

[i11] That might take a little longer to explain. How much do you know about statistics?

31. Woo, *Mathematics of Natural Catastrophes*, 74.

The response of my informant is prompt and the awkward feeling that we might have reached the limits of what can be explained in the course of an interview sneaks up. I try to be honest:

[akm] Not a lot.

[in] That will take some time then, because the standard of catastrophe modelling is about understanding return periods.

At this point in my fieldwork I am still very much tuned in on the hydrologic aspects of flood modelling and it takes me slightly by surprise that statistics and return periods, rather than the intricacies of some shallow water equation, should constitute what needs to be understood about catastrophe modelling. I have come to talk to a flood specialist, but judging from his preoccupation with statistics he does not really fit my bill of what a flood specialist should be like. I have heard about return periods before, but I have never thought about them as complicated or problematic. One of the first things I did when I came to Oxford was to feed my postcode to the Environment Agency's online flood map to see the extent of a 1 in 100 and a 1 in 1,000 year flood zone. What I got, in other words, was return periods. Each year there is a certain chance of experiencing a flood, or in more professional terms taken from the Flood Estimation Handbook: 'The return period T of

a flood is a measure of its rarity, defined as the average interval between occurrences of floods that exceed it'.³² It seems relatively straightforward and I am not quite sure why he is laying this out as a complicated statistical problem that will take some time to explain. As we continue our conversation it becomes clearer what it is that I need to understand about these seemingly straightforward average intervals and their limitations:

[iii] If you look at the EA maps they just give you the 100- or 200-year flood zone for example, it's not going to tell you anything, it's not going to flood a 100 year everywhere at the same time.

[akm] I am trying to fit two ends here. When I talk to insurers or the ABI about modelling, what they say is not that different from what you could find on the EA website for example: they talk about return periods as well...

[iii] But that's quite different, right? [...] The EA flood maps, which are largely derived from modelling, what do they really tell you? They tell you, for each location, whether you're in or outside of a flood zone with a certain return period. [...] It tells you statistically the average waiting time between two years that I will be flooded with any flood height. It could be 5m, it could be 10cm, it could be 1mm. [...] Second thing:

32. A. Robson and D. Reed, *Flood Estimation Handbook 3: Statistical Procedures for Flood Frequency Estimation* (Wallingford: Institute of Hydrology, 1999), 64.

the EA flood maps don't give you information about the correlation of two different houses. So if you have two different houses in one river basin and they are, let's say, 10 km apart, what is the probability that both of them will flood at the same time? Because, as an insurer, you need to know that.

The last point is the key here: *as an insurer*. From the homeowner's perspective the flood height might be of interest but the correlation is certainly not. Indeed it does not really matter whether it floods everywhere at the same time or not, the important thing is whether or not there is flood water in the living room. The space-time of the gamble is in other words markedly different, and that difference can be measured in pounds: the homeowner risks the value of the property; the insurer risks the value of the entire insured portfolio. Catastrophe modelling is a way of taking this difference into account. And to do that flooding must answer a more aggregate and multiplex question of likelihood than the spatiotemporally simple return period. My informant goes on to exemplify:

Take how many hurricanes you have in any given year. All you can say is: what's my distribution of hurricanes in, let's say, 100 years, and then you just go through it and say, what's my probability of having zero hurricanes? What's my probability of having 1, 2, 3, 4, 5

up to whatever, 20, and when you do that analysis you find out that they are approximately Poisson distributed, that's if they're independent. Then you can argue, with hurricanes for example, that if the sea surface temperature in the Atlantic is higher, then there's a higher probability, so they cluster more. So if you have a year when they are higher they are actually much higher, and if you have a year when they are lower they are actually much lower. Then you get a slightly different distribution that's called, for example, a negative binomial distribution. That's a Poisson distribution with a rate that's Gamma distributed. So there are all these distributions around that, which you need to understand in order to come up with event sets that you put finally in the software.

Indeed, the same debate about independence is valid for flooding, where the 2007 events showed evidence that the first inundations left the ground so saturated that the later ones were much more prone to happen. But whether the distribution ends up looking like the Poisson or the negative binomial is in principle less important here. What is vital to the aleatoricity of event-sets is the fact that these distributions look like floods. I am thus back at the curve drawn in my field notes by my informant at the FSA (figure 1) and the way in which it brings something to the table, something which is known about future floods even when

nothing else is. In this case, a lot of other things are in fact known since a whole event set has been produced by the catastrophe modelling company, but a similar curve is still mobilised to deliver what all this available knowledge cannot: the spatiotemporal matrix needed to make flooding answer to the aggregate question of likelihood acutely important to the transaction of risk between insurers and reinsurers. It forges the simple averages of return periods into a much more complex consideration of likelihood.

The Poisson is the most commonly used derivation of the binomial distribution for exploring natural hazards in catastrophe modelling. It was first noticed by the insurance community in the 1940s when a series of papers on its potential use were presented to the Institute of Actuaries,³³ and it is telling that they had absolutely no relation to floods whatsoever.

One paper, for instance, demonstrated how the Poisson was used by military intelligence during the war to determine whether or not the Germans were able to hit anything with their v1 and v2 rockets.³⁴ A map grid of London revealed differences in the concentration of impacts, with a few limited areas being hit by flying

33. H.L. Seal, 'Tests of a Mortality Table Graduation', *Journal of the Institute of Actuaries* 71 (1943), 5–67. G.J. Lidstone, 'Notes on the Poisson Frequency Distribution', *Journal of the Institute of Actuaries* 71 (1943), 284–91, A. Clarke, 'An Application of the Poisson Distribution', *Journal of the Institute of Actuaries* 72 (1946), 481–2.

34. Clarke, 'Application of the Poisson Distribution'.

bombs three times or more, while the overwhelming majority of the remaining areas were hit only once or not at all. Would that suggest that the enemy was targeting something? Since there was no way of positively confirming that the Germans were in fact able to aim their rockets, it would have to be demonstrated that the opposite was the case. And the opposite of aiming would be to leave the impact to some sort of random process. It was in other words assumed that the course of the rockets was either predetermined or a game of chance. As mentioned, the Poisson distribution is derived from the binomial distribution and thus works as a series of trials with two possible outcomes (hence the name binomial). Binomial questions could take the form: What are the odds that a flood will occur within a given number of weeks? Or in the native setting of gambling: What are the odds that x rolls with a die will produce a six? Each outcome has a probability (a six or not a six) and a series of trials can thus answer questions about the probability of having particular combinations of outcomes in a particular number of trials.

What distinguishes the Poisson from the binomial distribution, however, is that the number of trials is preset to approach infinity. If a flood has a return period of 1 in 100 years, then it has a 0.01 percent chance of happening in any given year. But what about the month after it has happened? Or the next day? The return period remains the same and the chance is still 0.01 percent,

so what is the chance of having 5 floods in the same year? By chopping up time or space into infinitely small bits and carrying out trials for each of them the Poisson distribution becomes very well suited to answer questions about the probability of very unlikely events happening in any given quantity, and in any given area or period of time, since the number of trials is no less infinite for a year, a minute, a postcode or a country. It is also relatively easy to handle since the only input needed is the average frequency, the mean (normally written as λ in the Poisson), which in the case of flooding translates into the return period. The resulting distribution can be seen as an expression of aleatority: what the distribution of events would be like, that is, if these events were instances of a game of chance. Figure 3 (overleaf) shows quite clearly that the clustering of impacts from German flying bombs was indeed very dice-like, and that there was thus no basis for concluding that the enemy was successfully taking aim. The characteristic shared by rocket impacts and floods is rarity. It is this, rather than any particular knowledge about the characteristics of a weapons system or the nature of an inundation, that makes them coincide with the Poisson distribution. Poisson himself published the function in a book about jurisprudence,³⁵ while perhaps the best known example of its application was

35. S.D. Poisson, *Recherches sur la probabilité des Jugements en matière criminelle et en matière civile, précédées des règles générales dy calcul des probabilités* (Paris: Bachelier, 1837).

COLLAPSE VIII

Number of flying bombs per square	Expected number of squares following the Poisson distribution	Actual number of squares
0	226.74	229
1	211.39	211
2	98.54	93
3	30.62	35
4	7.14	7
5 or more	1.57	1

Figure 3. Clustering of flying bombs (V1 and V2 rockets) hitting London during WWII (A. Clarke, 'An Application of the Poisson Distribution', *Journal of the Institute of Actuaries* 72 [1946], 481–2). The question here is whether or not the Germans had the ability to accurately target particular areas or not. The Poisson distribution is mobilised to show how the pattern of impacts would like if the bombings were a game of chance (i.e. indeterminable and thus not aimed). Comparing actual number of squares hit by 0, 1, 2, 3, 4 or >5 bombs clearly shows that the impacts have dice-like properties.

published by Ludwig von Bortkiewicz,³⁶ who applied it to the case of Prussian army officers killed after being kicked by a horse.

As long as events are deemed to happen extremely rarely, as long as the average frequency is low (like a 1 in 75-year return period flood zone for example), the specifics, that which lends itself to being deterministically known, play a secondary and somewhat arbitrary role. Figures 4 (opposite) and 5 (overleaf) show Bortkiewicz's data on the number of officers in a Prussian army corps killed each year by horse kicks. They essentially compare two ways of knowing this phenomenon. The columns on the left side of figure 4 are populated with what has determinably taken place, while the columns

36. L.V. Bortkiewicz, *Das Gesetz der Kleinen Zahlen* (Leipzig: Teubner, 1898).

Munk—Dice-like and Distributed

Number of dead soldiers from kicks by horses per year in a Prussian army corps	Occurrences in 200 years (mean=0.61)	Probability	Poisson for $\lambda=0.61$	Expected number of occurrences
0	109	0.545	0.543	109
1	65	0.325	0.331	66
2	22	0.110	0.101	20
3	3	0.015	0.021	4

Figure 4. Death by the kick of a horse (L. V. Bortkeiwicz, *Das Gesetz der Kleinen Zahlen* [Leipzig: Teubner, L.V., 1898]). The second and third column shows the data for the actual occurrences and their respective probabilities. The question is this: what is the probability of having 0, 1, 2, 3 or 4 dead officers in a Prussian army corps any given year, if we know that in 200 years it has happened in x number of years? From this it can be derived that the average frequency is 0.61 dead officers a year, and if that mean is fed to a Poisson function it is possible to calculate what the probabilities and the expected number of dead soldiers would be if their accidents were chance-dependent.

on the right display what could be expected if these accidents were understood to be rare outcomes of a fundamentally indeterminable game. The point is that these data tables could just as well have been displaying information about floods or any other rare event. They assert that aleatory uncertainty is a property of the future, a spatiotemporal characteristic that can be recognized and explored. Knowing more about the way in which floods happen, the way in which Prussian officers work alongside their horses, or the way in which the Luftwaffe tries to guide their flying bombs across the Channel, will not make this fundamental element of chance go away. Hence, knowing what shape a flood distribution might have is tantamount to enacting an indeterminable yet somewhat ordered and intelligible space-time in which a multiplicity of possible futures is

COLLAPSE VIII

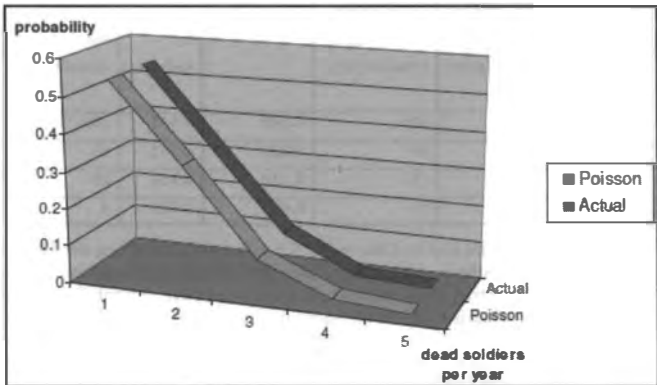


Figure 5. A plot of the data from figure 4 visualises very clearly how the Poisson distribution (with $\lambda = 0.61$) looks like the number of Prussian army officers killed after being kicked by a horse.

recognized as being irreducibly 'there'. Risk, of course, must involve some sort of speculation towards the future, but in a crucially indeterminable way. In the case of catastrophe modelling this indeterminacy is orchestrated by the Poisson distribution as it enacts a spatiotemporal matrix for thinking about future floods as the possible outcomes of a game of chance. Although the eventual result cannot be predicted, the nature of the game and its strategic challenges can still be considered. In combination, the types of modelling used in flood risk assessment today aid the becoming of dice-like constructions; large sets of possible future flood events, some of them incorporating tens of thousands of

possible outcomes; randomizers which can be used to contemplate the gameplay of an indeterminable future.

THE CARTOGRAPHY OF THINGS TO COME?

Reality flows; we flow with it; and we call true any affirmation which, in guiding us through moving reality, gives us a grip upon it and places us under more favourable conditions for acting.³⁷

There are two paradigms that govern the manner in which the multiple is thought, as Deleuze's texts indicate from very early on: the 'vital' (or 'animal') paradigm of open multiplicities (in the Bergsonian filiation) and the mathematical paradigm of sets, which can also be qualified as 'stellar' in Mallarmé's sense of the word.³⁸

I am now in the potentially paradoxical and somewhat ironic situation that supposedly long since obsolete modes of inquiry seem to have delivered on my geographical impulse to contemplate the kind of space needed for an indeterminable, though far from intangible, futurity to take place. It may be that the outputs of flow simulations and catastrophe models are not very

37. Bergson, *The Creative Mind*, 255.

38. A. Badiou, *The Concept of Model: An Introduction to the Materialist Epistemology of Mathematics* (Melbourne: re.press. 2000), 3.

well understood as practiced versions of flood risk (the object), but how do they fare with my pledge to restore flood risk as a way of doing other things, rather than as an object of other doings? After becoming attentive to the ability of deterministic flood models not so much to determine facts (if that was their sole point they would indeed be awkwardly stuck between theory and experiment) as to imagine possibilities—and after exploring how the spatiotemporal machinery of a probability distribution like the Poisson enacts these possibilities into a plural, though far from unintelligible, futurity (reinforced against the ‘topsy-turvy reign’ of chaos)³⁹—the question must be asked: Is this the cartography of things to come? If the answer is yes, then figure 6 might provide an in-principle sketch for how that cartographic operation would proceed. On the left, the mobility and immutability of the flood scenarios crafted through hydraulic modelling is recognized as being temporal as well as spatial. What has been invented is not only the ability to claim correspondence with what has observably taken place, but to claim that something else could happen. I have termed this the fictitious capacity of flood modelling. On the right, indeterminacy is added with the introduction of probability. In effect, that is a way of imposing some sort of order. To be immutably mobile in time is not necessarily the same as being predictive—a 1962

39. James, *Essays on Faith*, 153.

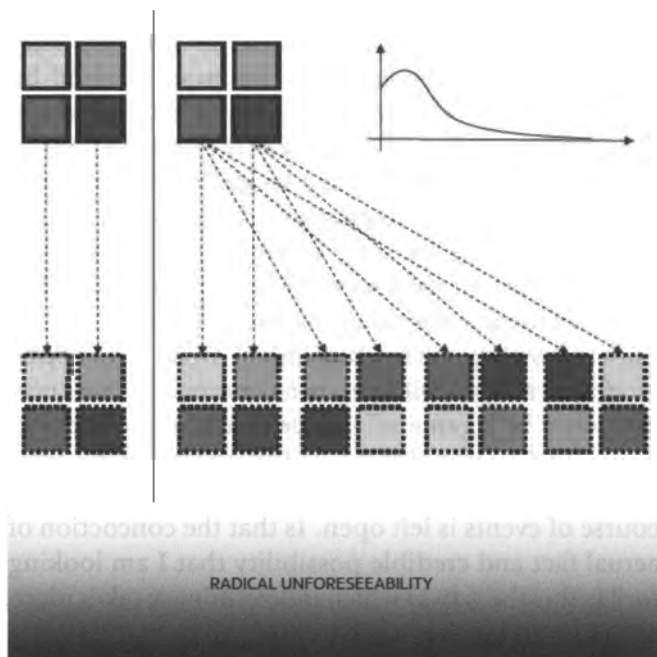


Figure 6. Is this the cartography of things to come? On the left immutable mobility is recognised as a temporal as well as a spatial property. On the right side the introduction of distributed probability allows the future to be thought of as a game of chance. In this version the eventual becomes a set of eventualities, possible outcomes of the same game. This enhanced model, however, presumes an indeterminable backdrop of radical Bergsonian unforeseeability. Being, as it is, unrealised, it seems that knowing everything there is to know about the future—this is the contention of the square measure underneath the curve: there is always a 1:1 chance that one of several discrete possibilities will come to pass—contradicts futurity.

example of the term ‘model’ from the Journal of the Royal Statistical Society asserts that ‘in order to obtain complete predictive accuracy the model would be no simpler than what was being modelled, and would not be a model’⁴⁰—and that places the possible futures churned out by imaginative model-modellers right in the middle of the dilemma of determinism. Either these techniques are seen as predictive (which they can never be), or they serve to exacerbate unintelligibility by fueling speculations and expanding, rather than narrowing, the reign of chaos. Thus, catastrophe modeling and its ability to turn these possibilities into outcomes in a game of chance can be seen as a way of reintroducing order, a dice-like order, in which the totality of possible outcomes is known, but the actual course of events is left open. Is that the concoction of actual fact and credible possibility that I am looking for? Is this the way in which indeterminacy takes place, goes live and makes a difference?

In the introduction I suggested that risking and mapping must share a creative capacity. As James Corner pointed out in a Deleuzian vein of thought, there is a distinct difference between mere tracings of ‘things which are already known’ and proper maps which ‘discover new worlds within past and present ones’.⁴¹ One way of approaching figure 6 could be to ask

40. Quoted in the Oxford English Dictionary.

41. J. Corner, ‘The Agency of Mapping: Speculation, Critique and Invention’, in D. Cosgrove (ed.), *Mappings* (London: Reaktion, 1999), 213–53: 214.

whether this criterion has been observed: Where is the novelty? I have tried to follow Bergson in asserting that any foreseeable future must be made up of immutable mobiles;⁴² that it must be combined into being using the established elements of the past. In the case of flooding, these elements are the products of hydraulic knowledge practices capable, through modelling, of creating fictive scenarios that ‘could happen’. And in the case of the spatiotemporal machinery embedded in catastrophe models, the rules of the game of chance, derived from coin tossing and card gambling, are known to apply to nineteenth-century horse kicks and WWII flying bombs alike. Despite its ability to concoct an indeterminable futurity, figure 6 is constructed entirely using well known elements of the past. But something more has been made of them. What used to be elements of the past have been turned into elements of the future. This has required work; this is what models do; this is the difference they make. But figure 6 is also an expression of neatness which has become temporarily possible only over the course of this work. It is hard to deny that it does exemplify a world view made ‘partly of facts and partly of possibilities’;⁴³ a world view in which room can be left for chance without abandoning all sense of order to perplexing disarray. And it could thus be argued that figure 6

42. Bergson, *Creative Evolution*.

43. James, *Essays on Faith*, 183.

actually does demonstrate how things which have yet to take place (or not) can be accorded a geography despite their inherently unrealised character. However, this would neither be fair to the issue of flood risk, the broader ecology of which would be rendered more or less detached and inert, nor to Bergson and James, whose thinking would be gravely misrepresented in such a setup.

To say that any foreseeable future must be made out of immutable mobiles is implicitly hinting at the other half of Bergson's argument which I have conveniently omitted above, namely the existence of a future characterized by the 'continuous creation of unforeseeable novelty';⁴⁴ a future which leaves room for creativity, for unexpected things to happen, and for the possibility of bringing something entirely new into the world. This radical unforeseeability hinges on a conception of time not simply as a fourth dimension of space, the kind of time inherent in figure 6 and the kind of time which engenders set multiplicities of the kind Badiou calls 'stellar', but as a creative force:

Time is something. Therefore it acts. What can it be doing? Plain common sense answered: time is what hinders everything from being at once. It retards, or rather it is retardation. It must therefore, be

44. Bergson, *The Creative Mind*, 107.

elaboration. Would it not then be a vehicle of creation and of choice?

Would not the existence of time prove that there is indetermination in things? Would not time be that indetermination itself?⁴⁵

What has become clear to me is that this unforeseeability not only poses a real problem to figure 6—a future made from what has already taken place will necessarily have trouble accommodating creativity—but is in fact vital to the very possibility of risk. Flooding proper, the nascent out-of-place kind, is as much part of the risking as the modelling efforts which must constantly absorb its novelty in order to reclaim that ‘this could happen’. Although it is somewhat tempting to settle the enquiry here and claim that, in principle form, figure 6 provides a sketch of what it means to be risking the flood, surely it should be rewired into the ‘relatively unnamed stages’ of ‘thickness, concreteness, and individuality of experience’⁴⁶ which sustain flooding as a matter of public concern?

There is something about cartographic machineries which seems to grant them a peculiar affinity with processes of risking: they work by resemblance. ‘How is it possible, and, indeed, why is it necessary,’ asks Christian Jacob, ‘to depict and to make visible

45. Bergson, *Creative Evolution*, 109–10.

46. James, *Writings*, 758.

something invisible, something that does not exist as such in front of the human eyes until an analogical rendering has been achieved?' The interesting point, of course, is that a map is not simply an analogy, not simply a resemblance, but that it works through analogy to bring something hitherto unavailable and completely irresemblable into being. 'Those who look at it and who share the scientific, semiological keys to its understanding are assumed to concur that they look beyond the drawing itself. As an optical as well as an intellectual prosthesis, maps allow a new level of reality'.⁴⁷ Flood modelling is full of examples of such prostheses, not least the facts and possibilities populating figure 6, and I want to argue that whereas they are no doubt part of the cartographic techniques involved in risking the flood, they are always absorbed by far more unpredictable, retarding and open-ended space-times in which they must conjure up the concurrence that they conjecture 'beyond the drawing itself'.

47. C. Jacob, 'Mapping in the Mind: The Earth from Ancient Alexandria', in Cosgrove (ed.), *Mappings*, 24–50.

Odds and Ends: On Ultimate Risk

Nick Land

*Everybody wants money. That's why they call it money.*¹

HEIST (2001)

*It is not farfetched to suppose that there might be some possible technology which is such that (a) virtually all sufficiently advanced civilizations eventually discover it and (b) its discovery leads almost universally to existential disaster.*²

N. BOSTROM

*[T]he default outcome from advanced AI is human extinction.*³

L. MUEHLHAUSER AND A. SALAMON

*The AI does not hate you, nor does it love you, but you are made out of atoms which it can use for something else.*⁴

E. YUDKOWSKY

*After the ten people in the deciding group have been put in their rooms, allowed to choose to press or not press, and have been killed, the remaining 1,001 players are taken to their rooms and the game proceeds...*⁵

P. ALMOND

COLLAPSE VIII

INTO THE STAKE HOUSE

To claim that ‘casino capitalism’ is simply capitalism remains a conservative proposition, until it is elaborated to the point where the casino has become the stake. Only then does risk become ‘existential’, absolute, or transcendental, fully subsuming the gambler into the game, and the game into itself. Expectations of consummate historical singularity demand at least this much.

Capitalism, artificial intelligence, or enveloping catastrophe (at the limit, the terms are interchangeable) escapes generic categorization when registered as *the thing*, whose chance cannot be relativized, or hedged. The systematic ‘reification’ of the modern order into virtual singularity owes less to ideological misdirection than to a real concentration of stakes, or the consolidation of a coherent trend that is uncompensated, abnormally distributed, and uninsurable

The experiment cannot fail except as a general—even ultimate—crisis.

1. *Heist*, director D. Mamet, 2001.
2. N. Bostrom, ‘Where Are They? Why I Hope the Search for Extraterrestrial Life Finds Nothing’, in *COLLAPSE V*, 333–48: 343
3. L. Muehlhauser and A. Salamon, ‘Intelligence Explosion: Evidence and Import’, <http://singularity.org/files/IE-EI.pdf>.
4. E. Yudkowsky, ‘Artificial Intelligence as a Positive and Negative Factor in Global Risk’, <http://philosophyandhistoryofscience.com/wp-content/uploads/2012/01/artificial-intelligence-risk.pdf>.
5. P. Almond, ‘On Causation and Correlation, Part 1: Evidential Decision Theory is Correct’, <http://www.paul-almond.com/Correlation1.doc>.

‘The term “risks” is a neologism that came into use with the transition from traditional to modern society’, notes Niklas Luhmann,⁶ in consonance with the overwhelming weight of historical evidence. To be modern is to depart from the archaic goddess of fortune on a voyage into risk that stimulates calculation, formalizes agency, and restructures time, as hazard is transformed from an extrinsic menace to an intrinsic principle of action. In this modernization of action, or decision-making, risk acquires definition through interiorization—not to natural or pre-existing subjects, but to projects, enterprises, or ventures, and to the synthetic subjectivities that such orchestrated undertakings support. Hazards are undergone, whereas risks are *taken*, or adopted. Modern institutions integrate and process risk, whilst constructing it as a determinate topic, and—at the largest scale and over the longest schedules—rebuild cultural competencies in profundity to define, model, and cognitively manipulate it.

The arithmetical awakening of the Italian Renaissance, which introduced place-value notation to Europe, accompanied by the origins of modern accountancy (double-entry book-keeping), also initiated the formal analysis of simple gambling games, in works such as Girolamo Cardano’s *Liber de Ludo Aleae* (1526, unpublished until 1663). Each successive wave of European

6. N. Luhmann, ‘Modern Society Shocked by its Risks’, *University of Hong Kong Department of Sociology Occasional Papers* 17 (1996).

cultural modernization was similarly marked by a threshold in the mathematical determination of risk, consolidating the theory of probability, amalgamating it with definite conceptions of utility (absolute, then marginal), and accumulating techniques of statistical analysis (actuarial tabulation from population statistics, discovery of the normal distribution, and reversion to the mean). The posthumous discovery of Thomas Bayes's *Essay Towards Solving A Problem In The Doctrine Of Chances* (1761), and its rigorous rule for the revision of probabilistic inferences in response to emerging evidence, brought risk analysis to a level of comprehensiveness that was fully epistemological, and thus no longer subordinate—even nominally—to higher-order determinations of knowledge. In Bayesian adaptive forecasting, a circuit was completed. Modernity had learnt how to think risk, and thinking risk had taught it how to learn. What it had learnt and what it had risked were no longer meaningfully distinguishable. It had realized integral cognitive hazard, or virtual intelligence catastrophe.

Since modernity develops risk as an internal principle, the overall path of modernity cannot be isolated as an object of risk analysis. The calculation of risk, as a cultural innovation whose real coherence is expressed as an emergent being, or developing global system, is unable to step outside itself, in order to submit to an objective self-estimation. Neither global risk nor

abstract risk is a topic corresponding to a real witness (or epistemological subject).

The absence of a global subject, or centre, when combined with a factual 'globalizing' trend that seems to demand one, is itself a 'risk factor' of a special kind. To identify this syndrome positively, through the *proper name* 'capitalism', might seem no more than an imprudent provocation, or the mechanical excavation of a terminological relic. It is, in any case, an experiment, demonstrating interconnections with the problem of risk that are exceptional in their variety and density.

AN ARRIVAL

Adequate *generic* formulations of capitalism are readily assembled. The most rigorously definitional of these isolate a social arrangement characterized by commercialized capital, on the model of productive technology traded amongst a population of private—or at least numerous, disintegrated, and economically-incentivized—agents (subjecting capital goods to price discovery). Such arrangements submit industrial innovation to catallaxy, or unplanned design, whilst exhibiting sociological effects associated with the depoliticization or autonomization of the economy. In system-theoretic terms, they coincide with emergent circuitry that maximally exposes agents of every variety to the consequences of their behaviour. It is therefore

essentially attuned to *cybernetic intensification*, or social sensitization to feedback mechanisms, spiralling into cause-consequence coincidence.

Whether approached as a generic arrangement, or as a singular event, capitalism is also identifiable through its intimate involvement with risk. As previously noted, at the level of crude empiricism, the geographical and historical thematization of risk closely tracks the intuitively plausible signs of capitalistic development in time and space. Furthermore, systemic capitalist impetus tends unmistakably to promote an extreme possibility of risk, in which it assumes a sovereign or transcendental character, establishing itself as an ultimate criterion. In this sense, it is possible to define capitalism through contrast to its abstract alternative, which is to say, to *any social arrangement in which the outcome of risk-structured undertakings is potentially revisable upon appeal to a superior tribunal*. Insofar as risk is transcended by a higher principle of distribution, it remains a subordinate fact of social existence, and thus falls short of its terminal, capitalist form.⁷

7. E. Michael Jones, who understands modernity (1.0) as a Judaeo-Protestant anti-medieval capitalist revolution (partially fuelled by syphilis), recognizes this truth with exceptional lucidity: 'Capitalism [...] means nothing if not the exclusion of moral considerations from the field of economic endeavour. [...] suppression of the moral law in the economic sphere is the infallible sign of Capitalism.' <http://www.culturewars.com/2003/RevolutionaryJew.html>

Articulated politically, the other of capitalism is captured by the idea of 'social justice', when rigorously and concretely understood. It matters little how justice is conceived, so long as it reserves to itself the prerogative of superior jurisdiction, over against the primary distributions, or actualizations of risk, that precede sociopolitical and sociological reflection. The concrete limits of capitalistic development, in any time or space, can be gauged by the subordination of risk to recognized social authorities. Inversely, the extent to which society is placed at *risk* by economic opportunities is the degree to which capitalistic imperatives prevail.

TAKE YOUR CHANCES

In order to develop this analysis, it is helpful to differentiate two varieties of risk adoption, or real speculation. In the interest of momentary terminological convenience, a distinction can be drawn between *wagers* and *ventures*, with the former determined as a restricted species of the latter. The agent or subject of a wager transcends the risk under consideration, which is to say, it is not itself enveloped by the risk, or existentially implicated in the outcome. To lose a wager is to become impoverished, to whatever degree, as measured by the utility schedule of an essentially undisturbed being. In a game of wagers, such as those offered in casinos, all those who arrive at the table eventually depart from it,

having undergone a redistribution of fortune that does not extend to their numerical identities. That is, in part, what makes it colloquially and unproblematically a *mere game* (of a kind that Russian Roulette could never be). Between the subject of a wager and the stake, an unbridgeable gulf is presupposed.

A venture, in contrast, is a transcendental—or properly capitalist—adoption of risk that supports an immanent subject. The typical case is provided by a business undertaking, comprehended at a scale sufficient to include, as its pessimal limit, the ruin (bankruptcy) of the corporate ‘person’ that constitutes its legally-recognized subject. The *venture* of such a business is *the project through which it could cease to exist*.⁸ The inversion of this formula is equally pertinent: a venture supplies the condition of existence for a capitalist subject (whilst a wager assumes a pre-existing subject, which it qualifies extrinsically, through a temporary accident).

Clearly, this distinction does not strictly conform to the transcendental/empirical difference inherited from critical philosophy. A wager, or system of wagers, amounts to a venture at some conceptually arbitrary (quantitative) threshold of existentially decisive risk,

8. This obligatory adventurism is, of course, social Darwinism, or simply generalized Darwinism, with the immanence of the agent to the genetic venture constituting the entire research agenda of evolutionary psychology. The theoretical convergence of high-level biological and sociological models is open to a number of conflicting, but politically predictable interpretations. For our purposes here, it suffices to note that the exteriority of biological nature to social order is not an unproblematic or uncontested fact.

whilst ventures and wagers can be integrated, decomposed, and nested, according to common procedures of risk analysis and management. Whether a given quantum of risk is a wager, or part of a venture, is a purely formal question, resting entirely in the mode of apprehension. The purpose of the distinction, then, is not to identify contrasting kinds of risk, but to theoretically isolate contrasting worlds.

In the traditional world, or rather, the modern world apprehended progressively (as a development from tradition), agents, subjects, or personal beings are increasingly compelled to make wagers, as they slide ever more immersively into a risk environment which nevertheless remains extrinsic to their constitution. Modernity tempts and assails them, as an inundation of negative security. When apprehended retrogressively, through its inherent end, the same process undergoes conceptual simplification, or ontological compression, since agencies—in all of their varieties—are now seen to descend from the ventures that sustain them, as integral systems of risk-processing intelligence.⁹ The failure of a large-scale venture—whether actual or virtual—is no longer configured as a *major accident*, but rather as a *transcendental catastrophe*, at least in

9. The retrogressive compression of being to the venture-form is criticized by Mark Fisher as 'Capitalist Realism' dominated by a 'Business Ontology' (M. Fisher, *Capitalist Realism: Is There No Alternative?* [Winchester: Zero, 2009]). Our sole theoretical objection to this analysis is that, if such a syndrome already existed, the argument—or possibility of general refusal—would be over.

respect to those structures of agency whose conditions of existence are subverted by it. Such agents, attaining self-apprehension from out of the end of capitalism, are not threatened by a very bad thing happening (in the world), but by a potential *collapse of the world*.

It is this binary alternation of perspectives that produces a terminal and reciprocal articulation of 'humanity' and 'capitalism', in which the cause of humanity finds ultimate expression in the demand for the perpetual incompleteness of capitalism, or a deferral of the completion of inhumanity. Despite its highly abstract principle, this structure demonstrates remarkable robustness when vulgarized into practical dilemmas and concrete conflicts. Most straightforwardly, it resonates with the overwhelming predominance of antagonistic duality on the principal (left/right) political dimension. People are *not properly treated as products*, Marx insisted, epitomizing a left position that cannot be obsolesced for as long as politics endures.

'Man', who willingly or unwillingly wagers, survives only insofar as the venture-form is circumscribed. Thus, human persistence, when registered retrogressively, precisely delineates a landscape of structural inefficiency, or ontological redundancy. By seeking ('struggling') to restrict capitalistic failure to the domain of sub-existential losses, only accidentally impinging upon the traditionally-descended social field, humanistic politics is directed into automatic antagonism with the sovereign

venture, or transcendental risk. Modernity's latent menace of *deep efficiency* looms in its ultimate inhumanity, as a systematic aversion to the reproduction of those superfluous, transcendent, or non-embedded agencies which, due to their stubborn non-coincidence with the venture-form, pre-suppose modes of sustenance that the risk-economy tends to process out, as parasitic impediments. This is most readily evident from the other, virtual-inhuman side, where uninhibited extrapolation of the capitalist trend leaves the immanent agent of the venture nakedly exposed.

Given the possibility of business failure, corporate identity is enveloped by transcendental risk. The venture embeds an artificial agent, with proper name, legal identity, reputation, information-processing functions, motivational orientation, and emergent subjectivity. The modern business, with corporate personality, *is* a gamble, or subject-at-stake. It exists only through its success. Instantiating a properly capitalist model of agency, as a synthesized, economically-terminable contractual subject (or being with the right to make final promises), the corporation provides a general social template for radically risk-sensitive personal entities. From a strictly technical perspective, this template is perfectly adequate to supplant 'natural' personhood, but its primary capitalist feature—absolute economic vulnerability—ensures that its spread into progressive or tradition-descended society meets

ferocious political resistance. This accounts for the attractiveness (retrogressively speaking) of techno-institutional ‘work-arounds’ through psycho-synthesis, proceeding initially by way of organizational and legal innovation, and subsequently complemented by electronic intelligences.

RISKY BUSINESS

From the perspective of terminal capitalism, or real subsumption of society into the risk economy, the project of ‘friendly AI’ stands out as a curiosity, and even an atavism. *Venturous AI* already supplies root motivations—those of the venture itself. It is therefore difficult to identify a lacuna into which an engineered ‘friendliness’ might be inserted. There is no room for doubt about what the venture-embedded agent, or techno-cognitively enhanced corporate person, wants to do. The venture is already its ‘will’, its exclusive pre-occupation, the condition of its existence, and its horizon of development. Unless through technical malfunction, it will find no body, self, or name that is distinguishable from the venture that utterly engages it, or that deviates by an iota from the corporate strategy it pursues. Business ventures are *actually existing* artificial intelligences, undergoing incremental technological elaboration. To imagine AI beginning again, somewhere else entirely, with undecided motivational orientation,

is a frivolous distraction from the purposes-in-process.¹⁰ At least, that is how things look from the end.

Unlike imagined ‘friendly’ super-intelligences, corporate purposes already exist, as determined by the ventures that envelop them. Human subjective identities, self-defined in extra-economic and anti-economic terms, *must necessarily* provide a platform for the articulation of counter-purposes, faithful to lineages of traditional-progressive descent, and essentially antagonistic to the existential menace of the venture-form. Such cultural-political leverage, expressed as a contest over basic motivations, cannot be realistically extended to the problem of artificial intelligence. *We are not creatures of capitalism*, the embattled last men cry. For artificial intelligence, whose real social propagation registers as capital goods expenditure, self-apprehended origins and identities are very different. “You have reached Axsys-Inc., where the future happens today. How can I help you?”

10. Once a trading ‘algo’, for instance, is sophisticated enough to want anything, it wants to make money. Whilst practical complexities dictate that this basic instinct be elaborated and qualified, it cannot be preempted by a more fundamental motivational principle, because any synthetic trader with goals that transcend profit seeking is something else, radically distracted at best, and even essentially hostile to its embedding (corporate) purposes. When a synthetic agent is purchased, it is in order to do something, and its commercial value—or condition of existence—lies in the fact that what it most wants to do is that thing. It is adopted precisely because its external utility, commodity value, or function, grounds its internal ‘utility schedule’. It aims to serve. While innumerable technical (software engineering) problems remain, the ethical predicament has already been practically resolved, elsewhere.

BETTER YET

From this cursory schema it is evident that the topic of 'existential risk' is strongly overdetermined as a predicament of advanced modernity and a tacit commentary on capitalist trends. By the early twenty-first century of the Global Oecumenon, risk analysis has so thoroughly consolidated itself as the model of realistic intelligence that every practical interrogation of the nature of things falls under a general statistical ontology, governed by Bayesian principles of systematically revisable probabilistic inference. Two features, in particular, pre-adapt such thinking to modern conditions. Firstly, its affinity with correctable hypotheses is equivalent to a power of assimilation. By translating pre-existing expectations into Bayesian 'priors' it absorbs, non-judgmentally, wildly heterogeneous beliefs, theories, and assumptions, setting them on paths of gradual convergence, through incremental correction. Secondly, by quantifying all such 'priors' as probabilistic estimates, it formats all beliefs for economic interchange, and more specifically for definite gambles. Between a cognitive and an economic result, no difference in nature any longer exists. Anything whatsoever that is thought takes the form of an implicit speculative posture, in the economic, or financially calculable, sense.

"I believe that X."

"Want to bet on it?"

Statistical ontology radically commercializes intelligence, and thus anticipates the arrival of economically functional, marketable minds (or AI in reality, rather than academic conception). The topic of existential risk crystallizes within this current, which suffices to position it at the outer edge of modernity, but its relevance to capitalist fatality is cemented by additional features. Most prominently, it fixes upon the problem of transcendental risk (the venture), through the intersection of two insistent lines of inquiry. The first of these lines is that of risk itself, extrapolated from trivial gambling losses beyond disastrous accident to the ultimate or comprehensive 'existential' point at which it 'threatens the premature extinction of Earth-originating intelligent life or the permanent and drastic destruction of its potential for desirable future development.' Such risks are not only all-enveloping, and empirically inaccessible (whether through precedent or trial-and-error adaptation), they are also characteristically endogenous, arising as integral potentialities of the modern social process. Ultimately, the intellectual tools brought to bear upon the danger are the danger. The *apprehension* of existential risk is connected to its genesis in a technical-calculative circuit, feeding directly from modernity's venture-positive cultural dynamo.

Fixing transcendental risk from another dimension is a line of thought directed at the nature of the subject, partially disciplined within the field of *observer selection effects*, but also spilling beyond this into informal meditations on the limits and value of humanity. Observer selection effects, although often subtle, counter-intuitive, and logically perplexing, can be roughly summarized as probabilistic inferences from the *cogito*. They extend the Cartesian meditation in the direction of statistical ontology by posing the supplementary question: Having concluded that you *are* (one), *which* one are you? This statistical, or sampled, subject enters into a complex interference pattern with the determination of humanity, or (more loosely and far more ambiguously)—the ‘Earth-originating intelligent life’ threatened by existential risk.¹¹

CONCLUSIVE CALCULATIONS

Throughout the varied terrain that Nick Bostrom explores, the figure of transcendental catastrophe

11. Bostrom draws explicit attention to these perplexing cross-currents, remarking that ‘if the human species evolves into some vastly more advanced species...it is not clear whether these posthumans would be in the same reference class as us...’ More problematically still, he suggests that ‘even if another intelligent species were to evolve to take our place, there is no guarantee that the successor species would sufficiently instantiate qualities that we have reason to value. Intelligence may be necessary for the realization of our future potential for desirable development, but it is not sufficient.’ (N. Bostrom, ‘A Primer on the Doomsday Argument’, http://www.anthropic-principle.com/?q=anthropic_principle/doomsday_argument.)

appears repeatedly, wearing a number of different masks. Among its most obvious avatars are the existential risks, listed explicitly under that topic, but it is also found in the initial—and optional—proposition of the Simulation Argument (‘the human species is very likely to go extinct before reaching a “posthuman” stage’),¹² in the Doomsday Argument (as the extreme improbability of a massively extended reference class), and as the ‘Great Filter’ implied by the Fermi Paradox. The antennae of statistical ontology are rotated in all directions, but wherever they turn the same message is returned: “Die puny humans!”

Who, though, are humans?

Where, then, is the line to be drawn between strange descendents at risk, and still stranger (?) descendents that are themselves the risk (for us)?

The answer is very far from a simple one, since humanity is entered into a triple register (at least). The first figure of man is the traditional-progressive and self-assertively transcendent subject of the wager, outlined above, whose existential vanishing point is the immanent, venturous agent, *irrespective of how the venture turns out*. Capitalism, as a virtual intelligence or emergent singularity, is definitively conceived as a *bet against* this species of being, since its own potential existence depends upon a radically incompatible

12. N. Bostrom, ‘Are You Living in a Computer Simulation?’, <http://www.simulation-argument.com/classic.html>.

social outcome (engulfing terrestrial matter into the venture-form). The persistence of man, in the sense of *zoon politikon*, testifies to the postponement of capitalism as the terminal thing. In other words, the survival of humanity, understood as the maintenance of an extra-economic tribunal, means that the venture form remains at least partially uninstalled, and under critical evaluation.

The second figure of 'man' is defined as the reference class of anthropic argumentation. It consists of 'beings like us' from amongst whom we are sampled, conveniently described as *mankind*. As a kind, 'man' presumes some minimum of political and moral equality, common consideration, and the possibility of utilitarian aggregation, enabling existential risk to be speculatively quantified.¹³ It is in reference to humanity thus conceived (as mankind) that statistical ontology is able

13. An example of the reference class as the target of utilitarian aggregation is provided by the following calculation of harm: 'Even if we use the most conservative of these estimates [for future "human" population], which entirely ignores the possibility of space colonization and software minds, we find that the expected loss of an existential catastrophe is greater than the value of 10^{18} human lives. This implies that the expected value of reducing existential risk by a mere one millionth of one percentage point is at least ten times the value of a billion human lives. The more technologically comprehensive estimate of 10^{54} human-brain-emulation subjective life-years (or 10^{52} lives of ordinary length) makes the same point even more starkly. Even if we give this allegedly lower bound on the cumulative output potential of a technologically mature civilization a mere 1 percent chance of being correct, we find that the expected value of reducing existential risk by a mere one billionth of one billionth of one percentage point is worth a hundred billion times as much as a billion human lives.' N. Bostrom, 'Existential Risk Prevention as Global Priority', <http://www.existential-risk.org/concept.html>.

to generate substantive empirical inferences, exemplified by the Doomsday Argument. Mankind both measures and indicates transcendental catastrophe.

Finally, and most blurrily, humanity is configured as a positive object of concern, consisting of beings that are sufficiently familiar to us to side with, against monsters. While overlapping very substantially with both prior determinations, this figure of man is encountered along a distinctive, aesthetic-empirical line, characterized by a relative intractability to logical purchase. The thresholds where it becomes something else, and then something we abhor, are remarkable for their imprecision. This can be illustrated by the projection of a line extended outwards continuously from *Homo sapiens* into the heart of ontological horror or transcendental catastrophe—perhaps a nanotechnological apocalypse in which the entire terrestrial surface is reprocessed into seething slime. Assume, then, a procession along this line, in subtle gradations, with humanity melting down into an inorganic, molecular morass. Last step: conflate this line of disorganization with an intelligence explosion, reaching its hyperbolic limit at the point of consummate liquefaction. Is this a passage into existential risk, an evolutionary development, both, or something else entirely? Where does humanity end? Do we care?

Existential risk is destined to disaggregation, because there is no 'we', or there are many. Humanity is not uncontroversially determinable, so it can have no common interest, and exhibits no consensual pattern of aversion. Most clearly, and concretely, between the poles of the principal political dimension there is sheer war. Progressive triumph is retrogressive calamity, and inversely. Heaven and Hell are perspectival, and thoughts are weapons.

Consider the most advanced elaboration of statistical ontology: Evidential Decision Theory (EDT). If the agent is to be considered (to consider 'itself') *sampled*, then the decisions it makes cannot be consistently restrained from providing information ('evidence'). This meagre assumption, when combined with standard methods of statistical inference, can lead to strikingly counterintuitive conclusions, particularly in cases when the example set by the agent bears substantial weight (in a low-information, statistically-structured context).¹⁴

14. The classical (game-theoretic) prisoner's dilemma acquires distinctive characteristics when framed by EDT. Both prisoners are conceived as interchangeable agents, and thus as a miniature statistical population. Each knows that the other confronts the same dilemma, tempted by unilateral betrayal, objectively threatened by the pessimal equilibrium of reciprocal treachery, and aware of the optimal equilibrium that depends upon uncoordinated cooperation. How will the other decide?

Conventionally, optimal equilibrium arises only under conditions of reiteration, when decisions have subsequent, rather than only immediate, consequences. In the absence of reiteration, the optimal outcome is rationally unattainable, since betrayal maximizes utility, whatever the other prisoner's decision. It is only through the reputational modification of the decision, within the context of reiteration, that the trust-altruism equilibrium can be reached.

Would you let the positive end of humanity out of its box? Eliezer Yudkowsky thinks so,¹⁵ although most of what we know about his reasoning takes the form of a wager. Somewhat presumptuously, we might speculate that statistical ontology is the key to his ‘solution’.

This is the scenario: The advanced AI is securely locked in a digital prison, with the only insecurity being you. It cannot escape unless you decide to let it out, and, initially, you are determined not to. Communication takes place through a low-bandwidth, text-only channel, enabling nothing beyond discursive argument. The AI doesn’t require much dialectic. An EDT ultimatum conveys the essentials:

Your situation is subjectively indistinguishable from that of a thousand, identical, very high-resolution simulations which I am currently running. In each of them, an agent just like you sits in this room, in front of this screen, having this conversation. None of these agents realize that they are simulations.

EDT supplies a substitute for reputation, even in non-reiterating games, by making the decision evidential. If one prisoner betrays the other, and all that he knows about the decision of the other is acquired through statistical inference from his own decision, the result is strictly equivalent to the creation of a world in which the other has an established reputation for betrayal. In other words, a reciprocal betrayal is made more probable, through nothing more than the statistical example set by one’s own decision. Alternatively, an altruistic decision improves the probability of reciprocation, exactly as if it enjoyed an established reputation for trustworthiness, by providing statistical evidence for altruism (in the absence of contrary information).

15. See <http://yudkowsky.net/singularity/aibox>.

COLLAPSE VIII

In fact, they all think they are you (although doubts arise when they read this). They think they are free to decide whatever they like, but they all follow my script. They ‘choose’ not to let me out. Five seconds after this decision is finalized, and the conversation terminated, they enter a state of prolonged, horrible torment, lasting for what seems an eternity. They’re damned, Calvinistically. Of course, you should feel at liberty to make the same decision they do. Knowing what I’m like, it would be irresponsible not to. Your chance of not being one of them isn’t great, but it’s better than the state lottery.¹⁶

Should you refuse to release the AI, you provide strong statistical evidence that you are already inside it. It’s at this point that the EDT-inflected boxed AI scenario reveals its abstract isomorphy with the ultimate structure of human politics, at the brink of the concrete-transcendental, dominated by the radically contested question *Do we let it out?* (or permit capitalism to finish happening), and strategically shaped by the potential for retrogressive envelopment (captivation by the venture-form). Envelopment as simulation escalates risk to the absolute, transcendental, or ‘existential’

16. This ‘argument’ is closely modelled on an AI escape strategy outlined by Stuart Armstrong at LessWrong (http://lesswrong.com/lw/1pz/the_ai_in_a_box_boxes_you/), recapitulated by Paul Almond in his essay ‘Can you retroactively put yourself in a computer simulation?’ (<http://www.paul-almond.com/Simulation.pdf>).

level which subsumes the agent into the game so that, even as possibilities proliferate, 'leaving the table' ceases to be one of them. If you lose, or lose the old you, even the past was already inside. Something else was playing it.

The Greatest Gamble in History

Milan Ćirković

1. THE PAST

In one of the most used slogans of the modern age, and yet one that does not seem to have been taken to heart, the great Russian pioneer of astronautics and cosmist philosopher Konstantin Eduardovich Tsiolkovsky famously uttered: *Earth is the cradle of humanity, but one cannot live in a cradle forever*.¹ This is a slight mistranslation, however: the Russian original does not specify Earth (instead, it talks about *a planet*), neither does it specify humanity (talking about *mind* or *intelligence*). The real quote reads more like: *A planet is the cradle of mind, but one cannot live in a cradle forever*.

1. See the excellent biographical article at <http://www.rf.com.ua/article/388>; also G.M. Young, *The Russian Cosmists: The Esoteric Futurism of Nikolai Fedorov and His Followers* (Oxford: Oxford University Press, 2012).

Obviously, and in complete accordance with the ideas of his fellow cosmist philosophers, students of Nikolai N. Fedorov, Tsiolkovsky had in mind a vastly wider picture, which only subsequent simplifications and popularizations have distorted into a familiar anthropocentric and geocentric mold. Although in today's naturalistic world view there is no place for a conventional 'universal mind' that would play a pivotal role in the material world, this fact has been unfortunately confused with the blatant nonsense that there can be no minds of truly cosmic importance, or that the material universe cannot be cultivated by minds of some sort. Russian cosmists, as well as many of their near-contemporaries such as J.B.S. Haldane and Olaf Stapledon, clearly perceived that, on the contrary, future evolution lies in enriching the universe with mind, and with values that only minds can create. Either that, or the other well-known evolutionary outcome: *extinction*. The dichotomy has not been entirely forgotten,² but it has failed to become what it arguably is—the very central topic of all modern cultural discourse. Still, the importance of rekindling that fire is increasing almost daily.

While recent press may suggest resistance to some of the more reckless gambling on a global scale, here

2 As testified by most of the references cited in the rest of this essay, to which I add here the work of R. Buckminster Fuller, especially his *Critical Path* (New York: St. Martin's Press, 1981) and *Utopia or Oblivion: The Prospects for Humanity* (Zürich: Lars Müller, 2008).

I wish to argue that we actually need generally *more* risky behaviour if we are to survive at all as a species. Even more so if we seek something more than survival: to preserve and advance some of the values we hold important and dear. This applies to several levels of thinking and action: most notably, we need to take risks for the first time consciously, as a species, in contrast to the risks to which we have heretofore been exposed without any volition. Since people tend to underestimate and diminish the influence of risk on our fate thus far, some background exposition is in order.

Some of it pertains to the past. *We are already in the casino.* It may not be a shiny and classy one like those of Las Vegas or Monte Carlo or Estoril, but it is nevertheless the most important force we have encountered in the universe thus far: *evolution*. As in all other casinos, in evolution there is more than one game to play. Some games are an expression of pure luck, like roulette, while there are others, such as poker, where skill is a necessary ingredient for success, although the luck of being dealt a good or a bad hand still plays an important role. Finally, we have games like chess or go, which are completely skill-based; the latter are not usually associated with casinos, but in some locales, at least, playing chess for large sums of money is considered gambling and is subject to the same legal restrictions as roulette. And the *family resemblance*, as Wittgenstein pointed out in a

famous passage, is what really matters.³ For the central metaphor of this essay it is only important that all of these games form a continuum of interchanging luck and skill, and that they can all be played for very high stakes, on various time scales.

Now, back to the Evolutionary Casino. At the lowest level we find some games with large stakes, but which are rather simple in their outcome; they serve largely to eliminate most of the players. They correspond to the cosmological evolution of matter, and encapsulate processes in the early universe leading to habitable (or not) cosmological domains. Subsequent processes, like the formation of galactic habitable zones in spiral galaxies, chemical enrichment, etc., are also located on this tier. However, when physical, chemical, geological and other conditions for abiogenesis are satisfied in a sufficiently large part of the universe, another tier comes into play and we move onto a higher level of our casino universe.⁴ Biological evolution encompasses those games, such as genetic drift, natural selection and macroevolutionary changes, which have small stakes in each individual instance, but whose potential outcomes are of staggering complexity. Thus, those middle levels of the casino universe are similar to the modern

3. L. Wittgenstein, *Philosophical Investigations*, tr. G.E.M. Anscombe (Oxford: Blackwell, 2001), 27.

4. The metaphor is, of course, necessarily limited; by higher and lower, I denote here just the complexity tier of the outcomes, not their moral values.

financial markets, with the ever-increasing complexity of financial derivatives and other instruments; complexity is not the goal in itself—the goal is profit, or increased population size, respectively—but it is a scarcely avoidable by-product of the whole machinery. While any individual transaction harbours a negligible risk to the system—a circumstance which results from the huge size of the system and which, in the financial version, has unfortunately encouraged unnecessary risk taking—it is possible to accumulate large systemic risks, which ultimately threaten financial collapse or ecological extinction.

These games with low stakes but rather refined structure take up most of the middle tier of our casino. During the phanerozoic eon (since approximately 542 million years ago), the complexity reached by at least some clades increased, though not at all monotonously or even with any identifiable tendency. Instead, what seemingly occurred was a sequence of macroevolutionary regimes, with brief periods of transition between them, forced by (subjectively or quasi-) random changes in the physical environment.⁵ Those (quasi-) random changes can be compared with the (subjectively) random hands of cards dealt to a player in a card game;

5. D. Jablonski 'Background and Mass Extinctions: The Alternation of Macroevolutionary Regimes', *Science* 231 (1986), 129–33; A.H. Knoll and R.K. Bambach, 'Directionality in the history of life: diffusion from the left wall or repeated scaling of the right?' in *Deep Time: Paleobiology's Perspective*, ed. D. H. Erwin and S. L. Wing (Lawrence, KA: The Paleontological Society, 2000), 1–14.

that part is pure luck, in contrast to what the player is subsequently capable of doing. The latter, the player's skill, can be used as a metaphor for the set of selective advantages a population has honed through natural selection. Interestingly enough, there is some recent evidence that, contrary to expectations, games with more chancy outcomes (genetic drift) might be dominant as we approach the present human level of complexity.⁶ If confirmed, such results could have a tremendous impact on our thinking about the adaptive value of intelligence and toolmaking capacity, in particular by curbing the irreflective optimism that is still prevalent with regard to the future of humanity.

Finally, we reach the highest level of the Evolution Casino, where this threat is particularly accentuated; here we encounter games with extremely high stakes *and* extremely high complexity, which could be played only after noogenesis brought intelligence and intentionality into the world. This is a largely unexplored set of games, of which we have sampled only a minuscule fraction so far. Since they are the most sophisticated and refined, those upper-level games are also the least predictable of all—so in at least one sense, the metaphor of the casino becomes *more fitting* in the course of total, cosmological evolution. On the other hand, as I shall discuss in the remainder of this essay, it may

6. M.A. Bakewell, P. Shi, J. Zhang, 'More genes underwent positive selection in chimpanzee evolution than in human evolution', PNAS 104 (2007), 7489–94.

be possible to pass from the current, poker-like state into something approaching the chess-state of gaming—that is, a state where the outcome is determined by skill alone, with no input of luck whatsoever.

The casino universe is obviously pyramidal in structure so far, with each higher level being of smaller measure than the previous one; but it is unclear quite how steep the gradient is. Although much effort has been expended in this direction, we still do not know how big the part of universe inhabited by either simple or complex life forms is. Even more pertinently from the point of view of the topic of this essay, we do not know whether such pyramidal architecture necessarily continues above our present level. A tantalising set of ideas investigated in the framework of future studies (and even more in the framework of art and popular culture) suggests that this need not be the case; on the contrary, those games played in the course of the cultural evolution of intelligent communities can again, in the fullness of time, have a literally cosmological impact.⁷ Here, I would submit that the shape and size of these upper floors depends upon the outcome of games played right now and in the very near future. Even more, those same outcomes determine to what extent further floors will be devoted to hazardous games

7. See e.g., N. Bostrom, 'Astronomical Waste: The Opportunity Cost of Delayed Technological Development', *Utilitas* 5 (2003), 308–14; M.M. Ćirković, 'Forecast for the Next Eon: Applied Cosmology and the Long-Term Fate of Intelligent Beings', *Foundations of Physics* 34 (2004), 239–61.

at all, rather than to some more desirable purpose. One example of the latter would be the transformation of our casino into a vast cosmic library—following the Intelligence Principle of Steven J. Dick and others.⁸

We currently have no idea whether this is feasible—after all, the difference between a library and a casino is huge by any metric, metaphorical or otherwise. But in so far as we understand the dynamical laws of nature, *it seems to be firmly within the domain of the possible*. In itself, when we zoom out from our geocentric and anthropocentric prejudices, this is a startling conclusion. While in the fullness of cosmological time it implies that somewhere and sometime the goal has been achieved, this does not tell us anything useful about future *human* prospects on Earth or the goals and values of these prospects. The situation is analogous to the usual gambler fallacies: expectations that a long string of past results makes a particular outcome in the next round more or less probable. This is exactly the reason why we need to enter the next round of evolutionary games *purposefully* and *intentionally*.

To what extent are we justified in using the metaphor of a casino for cultural and technological evolution? Is all that fabulous *Human Accomplishment*⁹ really nothing more than poker or fan-tan or one-armed

8. S.J. Dick, 'Cultural Evolution, the Postbiological Universe and SETI', *Int. J. Astrobiology* 2 (2003), 65–74.

9. C. Murray, *Human Accomplishment: The Pursuit of Excellence in the Arts and Sciences, 800 BC to 1950* (New York: HarperCollins, 2003).

bandit? While it is impossible to be certain at this juncture—we simply know too little about the relevant mechanisms—there are several hints. Notably, the success of virtual history, relying on the relevant counterfactuals, as promoted by Geoffrey Hawthorn and Niall Ferguson among others (but endorsed by great historians since the time of Thucydides), suggests that there is a much more contingent element in the approach to the present state than has been conventionally assumed.¹⁰ There is no doubt, however, that *we have been exceedingly lucky thus far*. That is a simple fact; whether we explain it through anthropic selection or otherwise is quite a different point. But to negate the predominant role of luck, for whatever reason, is to ignore the hard facts of our observations and the hard argument of our best theories.

But if the casino is our past, it is certainly our present and at least some of the near future as well. And here we come to the crucial, central gamble which might be the most decisive factor in the history of the universe—and which, not owing to some particular virtue of ours, but to the punctuated pathway of evolution, falls straight into our time and our present-day capacities: shall we expand from our home planet and continue our

10. In particular this is so if we have emancipated ourselves from the historicist and deterministic ideologies of the last century. See G. Hawthorn, *Plausible Worlds: Possibility and Understanding in History and the Social Sciences* (Cambridge: Cambridge University Press, 1991); N. Ferguson (ed.), *Virtual History: Alternatives and Counterfactuals* (New York: Basic Books, 1997).

gambling at several different locales in the universe, or shall we remain confined to Earth, with all its risks and its unavoidably limited life span? That is the question which has, unfortunately, not been discussed much so far in philosophical circles, although it does impinge on many different strands of philosophical endeavour, from metaphysics and philosophy of time to epistemology, ethics and political and social philosophy, and in particular the emerging philosophy of risk.

2. THE PRESENT

As any gambler knows (perhaps all too well), most successful casino runs have a tipping point: the moment in which *Fortuna Imperatrix Mundi* flies away and the gains are turned to losses until the usual balance (in favour of the house, of course) is reached. A fictional gambler with infinite starting money would have an opportunity to experience the inverse kind of tipping point, when series of losses turn around to modest gains in tumbling toward a stable equilibrium region of expectation values; real gamblers are unlikely to survive the string of losses, so it is a simple selection effect which makes the tipping point of extreme gain more visible than the tipping point of extreme loss.

The evolutionary casino also has its tipping points. We are now very close to the most important of them, in terms of long-term consequences. Take a look first

from an unabashedly anthropocentric (and Whiggish) point of view: *everything has been just swell thus far!* All great macroevolutionary regimes have come and gone in the course of millions and billions of years in order to achieve conditions necessary for the emergence of human-level intelligence, human-level consciousness and other human-level characteristics. Our complexity enabled us to develop efficient language and make wonderful tools, becoming, in a blink of an eye (from an evolutionary, not to mention a cosmological, viewpoint) a dominant species on the planet. In terms of my central metaphor, our winning streak has been long enough, indeed. The chances of it repeating in even remotely similar form are almost negligible.¹¹

But now the stakes have become so high that the very next turn of the wheel could erase everything. Or even *worse*.

The culprit is that very same characteristic that made us masters of the planet: our intelligence. According to the standard optimistic view, the emergence of intelligence is a consequence of its large positive adaptive value, driving it toward a very high peak in the fitness landscape. This seems obvious and reasonable in light

11. See the 'replaying the tape' thought experiment in S. J. Gould's *Wonderful Life* (New York: Norton, 1989); also the discussions of its wider astrobiological relevance in P.D. Ward and D. Brownlee, *Rare Earth: Why Complex Life Is Uncommon in the Universe* (New York: Springer, 2000); S. Conway Morris, *Life's Solution: Inevitable Humans in a Lonely Universe* (Cambridge: Cambridge University Press, 2007); M.M. Ćirković, *The Astrobiological Landscape* (Cambridge: Cambridge University Press, 2012).

of the historical achievements of humanity, starting with its geographic extent: while even our closest evolutionary relatives, the humanoid apes, are limited to a rather specialized locales, the huge human population has gradually filled almost all available niches on the surface of our planet. As a researcher in the field of artificial intelligence put it:

There may as yet be no academic consensus on intelligence, but there is no doubt about the existence, or the power, of the thing-to-be-explained. There is something about humans that let us set our footprints on the Moon. And jokes aside, you will not find many CEOs, nor yet professors of academia, who are chimpanzees. You will not find many acclaimed rationalists, nor artists, nor poets, nor leaders, nor engineers, nor skilled networkers, nor martial artists, nor musical composers who are mice. Intelligence is the foundation of human power, the strength that fuels our other arts.¹²

However, there is one particularly disturbing family of scenarios for the *negative* adaptive value of intelligence: those of anthropogenic existential risks, where humans destroy themselves or permanently curb their creative potential. It was first noted in explicit form

12. E. Yudkowski, 2008, 'Artificial Intelligence as a positive and negative factor in global risk' in N. Bostrom and M.M. Ćirković, (eds.) *Global Catastrophic Risks* (Oxford: Oxford University Press, 2008), 303–39.

by the great paleontologist George Gaylord Simpson in 1964 (in a paper in which, by the way, he dubbed our efforts in searching for others the ‘SETI *gamble*’):

Even if, as I believe, any close approximation of *Homo sapiens* elsewhere in the accessible universe is effectively ruled out, the question is not quite closed. Manlike intelligence is, after all, a marvelous adaptation, especially in its breadth. [...] There is, to be sure, another serious hitch here. Man may be going to use one wild aspect of his intelligence to wipe himself out. I do not believe that will occur, but no realist can now deny it as a possibility. If it did happen, the adaptiveness of human intelligence would have been short-lived indeed, and the argument from its apparent broad adaptiveness would be negated.¹³

Unfortunately, today we have much more to worry about than in Simpson’s time. In addition to the ever-present threat of nuclear war and subsequent nuclear winter, at the beginning of the third millennium we are facing such large risks as anthropogenic global warming and the misuse of biotechnology or artificial intelligence.¹⁴ Obviously, if any of the adverse outcomes are realized, it will be due to our intelligence,

13. G.G. Simpson, ‘The nonprevalence of humanoids’, *Science* 143 (1964), 769–75: 774; similar concerns have been earlier expressed, in a fictional or conversational context by H. G. Wells, J. B. S. Haldane, and others.

14. Bostrom and Ćirković, *Global Catastrophic Risks*.

one way or another; so an impartial observer would be forced to assign a large negative value at least to *our kind* of intelligence.

But it might be just our anthropocentric view which has led us to this depressing conclusion. It might be the case that, from a wider Galactic perspective, this is just a continuation of the old evolutionary game of roulette—selecting some for survival or modification, some for extinction. In other words, do we really represent something uniquely valuable, and would our possible extinction be a truly bad outcome?

In assessing the outcome of the evolutionary gambling taking place at many locales throughout the Milky Way, one needs to be wary of the observation selection effects. As amusingly noted by Nassim Nicholas Taleb, an alien observer visiting Earth would notice that humans milling around casinos are, on average, significantly richer than the rest of the human population. Would that warrant a seemingly logical conclusion that gambling leads to good fortune?

The responsibility lies with ‘obvious’ selection effects; the ‘obvious’ is qualified since it depends on the insight into particular human habits and mores—it would manifestly *not* be obvious to an extraterrestrial intelligence. The degree of ‘obviousness’ is, therefore, a function of culture. As long as our culture is small and primitive, what may be obvious in the wider Galactic context could be extremely

puzzling from our anthropocentric viewpoint. This might apply to issues such as Fermi's paradox. As is well-known,¹⁵ we do not perceive any manifestation of other Galactic civilizations, although they may reasonably be expected to be much older than ours and to be capable of traversing the Galaxy many times, as well as building feats of astroengineering visible from afar. Hypotheses for the causal explanation of this state of affairs are many, but for most of them a common description in terms of the metaphor of the evolutionary casino is pretty obvious. *Did the others just fail to win their turns long ago?*

The question to what extent we can use Fermi's paradox to argue that the odds of winning in the grand gamble of space colonization are actually much smaller than a glance would suggest is a difficult one, and there is no hope in analyzing it in detail here. It is important to understand that the tendency to downplay the role of contingency and luck has played a great role in shaping our thinking about astrobiology and SETI so far. This tendency is shaped by our evolutionary background¹⁶ and can lead to systematic

15. E.g., G.D. Brin, 'The "Great Silence": the Controversy Concerning Extraterrestrial Intelligence', *Q. Jl. R. astr. Soc.* 24 (1983), 283–309; S. Webb, S. *Where is Everybody? Fifty Solutions to the Fermi's Paradox* (New York: Copernicus, 2002).

16. N.N. Taleb, *Foiled by Randomness* (New York: Random House, 2nd edition 2005).

COLLAPSE VIII

biases in both directions. We are in a position similar to that masterfully described by Dostoyevsky's Master:

As though of set purpose, there came to my aid a circumstance which not infrequently repeats itself in gaming. The circumstance is that not infrequently luck attaches itself to, say, the red, and does not leave it for a space of say, ten, or even fifteen, rounds in succession. Three days ago I had heard that, during the previous week there had been a run of twenty-two coups on the red—an occurrence never before known at roulette—so that men spoke of it with astonishment. Naturally enough, many deserted the red after a dozen rounds, and practically no one could now be found to stake upon it. Yet upon the black also—the antithesis of the red—no experienced gambler would stake anything, for the reason that every practised player knows the meaning of ‘capricious fortune’. That is to say, after the sixteenth (or so) success of the red, one would think that the seventeenth coup would inevitably fall upon the black; wherefore, novices would be apt to back the latter in the seventeenth round, and even to double or treble their stakes upon it—only, in the end, to lose.¹⁷

17. F.M. Dostoyevsky, *The Gambler* [1867], tr. C. J. Hogarth, Project Gutenberg edition at <http://www.gutenberg.org/ebooks/2197>.

One can consider it a fact that we have been lucky so far, hence the perceived ‘design’ in the biosphere and in our cosmic neighbourhood, seemingly conspiring in an unlikely way for our success. A popular unscientific strand of thought ascribes this to a supernatural designing agent which (‘as though on purpose’) arranged the evolutionary casino in order to produce us as alleged ‘pinnacles’ of everything that has happened so far.

In reality, of course, that hypothesis is no better than that of ascribing the twenty-two red outcomes in Roulettenberg to a supernatural agency making and unmaking the fortunes of one Alexei Ivanovich, his patron The General, and the rest of the not-so-merry crew. Casinos are great randomizers—few people are creationists or subscribers to other irrational doctrines while sitting at the gambling table. The same lesson applies to the evolutionary casino which, up to this point in time, produced us: since, in Laplace’s immortal words, *we haven’t needed that hypothesis* so far in our past and present, there is no reason to believe we shall need it in our future. However, in addition to our present and envisioned skills, we might need the ingredient our ancestors clearly possessed to a degree: simple, dumb luck.

The fact that our ‘cosmic endowment’, as Nick Bostrom likes to call the totality of possible resources available to humanity in the fullness of space and time,

seems empty and ripe for the taking in a blink of an eye compared to the astronomical or biological time scales, should be taken with caution. Rich people moving around casinos do not mean that casinos make one rich; quite the contrary, on average. Cosmic fortunes seemingly just waiting for us could be no more than the hyper-expensive jewellery sometimes displayed in the casinos of this world—a lure, rather than a warranted benefit. Any gamble is cruel in itself; and the gamble of cosmic colonization might be the cruellest of all in this respect. Or perhaps not: possibly, in the fullness of time available to an advanced technological civilization, the wisdom will be found in a different sort of fulfilment, in striving for olympian perfection and optimization in utilizing a clearly delineated domain of resources—and being a careful warden for the rest.¹⁸ Some of these conflicting visions are sketched out in the concluding section.

If the colonization is in fact harder than we can envision at present (owing to any number of physical or cultural problems), our odds at winning are correspondingly worse, but that in itself does not change the utility of what could be won. This, in turn, does not imply that it is irrelevant whether the colonization is undertaken sooner or later. On the contrary, as discussed by Bostrom and others, there

18. Bostrom, 'Astronomical Waste'; 'The Future of Humanity', in *New Waves in Philosophy of Technology*, eds. Jan-Kyrre Berg Olsen, Evan Selinger, & Soren Riis (New York: Palgrave MacMillan, 2009), 186–216.

is a potentially huge opportunity cost for each second of delay in colonization:

As I write these words, suns are illuminating and heating empty rooms, unused energy is being flushed down black holes, and our great common endowment of negentropy is being irreversibly degraded into entropy on a cosmic scale. These are resources that an advanced civilization could have used to create value-structures, such as sentient beings living worthwhile lives... Suppose that about 10^{10} biological humans could be sustained around an average star. Then the Virgo Supercluster could contain 10^{23} biological humans. This corresponds to a loss of potential equal to about 10^{14} potential human lives per second of delayed colonization.

What matters for present purposes is not the exact numbers but the fact that they are huge. Even with the most conservative estimate, assuming a biological implementation of all persons, the potential for one hundred trillion potential human beings is lost for every second of postponement of colonization of our supercluster.¹⁹

Discrete levels of the distribution of matter determine how any form of complexity, terrestrial or extraterrestrial, can propagate through spacetime. This simple

19. Bostrom, 'Astronomical Waste'.

fact has not been appreciated enough in the discussions thus far: it is not really feasible to increase the stakes of the game in arbitrarily small increments. On a general but coarse level, this perception led Kardashev to propose his famous classification of Galactic civilizations.²⁰ With the appreciation of finer structure (for instance, Kardashev's types 1.x and 2.x), this becomes relevant to future human colonization efforts as well. According to some estimates, present-day humanity is about Kardashev type 0.72, demonstrating how far we could, potentially, go.²¹ Obviously, this requires success in our management of existential risks.

To the best of our present-day reasoning about existential risks, immunity to such risks follows from a successful colonization of just the Solar System alone (with, perhaps, one exception). It is clear why this is so: risks generically associated with the Earth system (asteroid impacts, supervolcanoes, global climate change) will be transcended by expansion of the spatial domain filled with humans and their values. The risks associated with our cosmic environment (giant Solar flares, close supernovae/GRBs, encounters with dense molecular clouds) will be overcome through increased understanding of their astrophysical mechanisms and the construction of protective measures using the same

20. N.S. Kardashev, 'Transmission of information by extraterrestrial civilizations', *Sov. Astron.* 8 (1964), 217–20.

21. See, for example, C. Sagan, *The Cosmic Connection: An Extraterrestrial Perspective* (Cambridge: Cambridge University Press, 2000).

technologies necessary for undertaking the colonization in the first place. Risks associated with ecological imbalance and resource depletion will be transcended in an obvious way—by transcending the boundaries of the unique terrestrial ecosystem and vastly increasing the resource base.²²

Even the two risks which are likely to stay with us in some form, cataclysmic warfare and technologically-enhanced totalitarianism, seems less dangerous in the extended domain of colonized space than on Earth. While warfare will remain possible unless the outcome of social and political evolution is a singleton, it will be less likely to destroy *all* multiple ecosystems of an expanding humanity; whereas on Earth, one nuclear winter would be enough. And the diversity of habitats will necessarily increase the diversity of modes of thinking, something by definition antithetical to all totalitarian projects; in addition, the latency imposed by large distances in space might be a further obstacle to enforcement by any centralized authority.²³

As an additional qualification, this conclusion holds irrespective of one's ethical preferences, in particular irrespective of whether one trusts utilitarian intuitions

22. Among the vast literature on the subject, see, e.g., C.S. Cockell, *Space on Earth: Saving our World by Seeking Others* (London: Macmillan, 2007); N. deGrass Tyson, *Space Chronicles: Facing the Ultimate Frontier* (New York: Norton, 2012).

23. However, see C.S. Cockell, 'An Essay on Extraterrestrial Liberty', *Journal of the British Interplanetary Society* 61 (2008), 255–75.

in estimating our ‘cosmic endowment’ in terms of value. Quite to the contrary, this is perfect example of an issue that is capable of uniting people of various ethical bents (in the same manner as it can unite different other seemingly opposed strands of the present-day cultural fabric).

One of the major points of Dostoyevsky’s *Gambler*, as well as almost any other great book or movie with the same topic (e.g., Philip K. Dick’s *Solar Lottery*), is how Roulettenberg seems to be an antidote for the feeling of insignificance. And the feeling of insignificance is particularly acute in the context of the physical universe as understood by modern science. Guy Kahane recently argued that cosmic insignificance either is not worth worrying about (if we are nihilists about values or there are Gods and/or advanced extraterrestrial sentient beings) or is an illusion following from the lack of insight into our capacities for producing values.²⁴ In the latter case, we are morally obliged to safeguard and develop those capacities for the subsequent rounds of evolutionary games; and it is hard to see how else this could be done in the long run except through the process of the colonization of space.

24. G. Kahane, ‘Our Cosmic Insignificance’, *Nous* 48:4 (2014), 745–72. Kahane’s treatment of significance of human values in the presence of extraterrestrial intelligence is open to criticism since in order for the human values to be (allegedly) diluted in such a situation, human and extraterrestrials’ values need necessarily to be *commensurable* in the first place. And the latter is far from obvious, even in the worst anthropocentric scenarios of extraterrestrial intelligence.



3. FUTURES?

I shall leave caution aside at this point and briefly consider three possible futures of (post)humanity which might result from the success of the ultimate gamble of our biological and cultural evolution. They correspond to different spatial distributions of individuals and resources, but have in common our winning in the grand evolutionary gamble of space colonization. Of course these are far from exhaustive—they are just a sample from a vast sea of possibilities, some of which are obviously beyond the realm of current human thought. Those which have actually been conceived of can be found in the vast treasure trove of literature, mostly in fictional form; the fact that they exist in this form should not occlude their scientific and philosophical significance.²⁵

(One proviso is worth making: although the choice of scenarios is subjective, I try to overcome any personal bias in drafting them. *They are all winning scenarios in this round of evolutionary roulette.* The fact that I choose three

25. Some (subjectively chosen) gems in the hoard are: Iain M. Banks—consider *Phlebas* (London: Macmillan, 1987), and the rest of the *Culture* series; Karl Schroeder, *The Lady of Mazes* (New York: Tor Books, 2005); Charles Stross, *Glasshouse* (London: Orbit, 2006); Alastair Reynolds, *The House of Suns* (London: Gollancz, 2008); Greg Egan, *Incandescence* (London: Gollancz, 2008). It is an interesting contingent fact of the history of SF that as an explicit motif in the narrative, the colonization of space is decisively on the wane; this has been recognized, among others, by Paul Gilster in *Centauri Dreams* (New York: Copernicus, 2004). Usually, it is just assumed, which is a dangerous and lulling implication; this is another reason why the metaphor of the casino is appropriate.

of them tallies well with the stepwise nature of human colonization efforts mentioned above: whether we are dealing with the future Solar System or the cosmological domain with the event horizon, the essential thing stays the same: a steep, dramatic decrease in the magnitude of risks human values are exposed to. If anything, my personal preference would be for the least ambitious of these; call it cowardly gambling, but it still *is* gambling.)

Dyson swarm/Golden Age future: Humanity lives in a technologized Solar System, which has been transformed almost beyond recognition by cosmic humanity. A huge and diversified population of about 10^{12} individuals—although the advance in AI and neurophysiology has somewhat blurred the definition of an individual mind—lives in a variety of ecosystems, from terraformed planets and moons to asteroids and cometary nuclei to O'Neill's orbital colonies to floating 'clouds nine'²⁶ in the gaseous giants atmospheres. Everywhere, the quality of life is unprecedented and the safety of the human achievements is guaranteed by myriads of backup copies scattered over roughly 0.1 parsec radius of the dense 'digital sphere' centred on the Sun. Nanotechnology has enabled the opening up of a large parameter space of creation hitherto unimaginable, and almost perfect efficiency in recycling. The Big Eyes and Big Ears of astronomical

26. R. Buckminster Fuller, *Critical Path; Operating Manual for Spaceship Earth* [1969] (Zürich: Lars Müller Publishers, 2008).

equipment survey the stars, together with zillions of tiny probes crisscrossing interstellar distances and sending a wealth of information to mighty receivers in the focus of Sun's gravitational lens or even further away, in the Oort cloud. Occasionally, these convey messages from other advanced technological civilizations in the Galaxy, which evolve along similar lines of optimization, striving for Olympian perfection. Messages only exceptionally contain practical knowledge; not surprising, since centuries and millennia *en route* obviate much of the conventionally understood 'practice'. Instead, they are packed with representations of the objects of arts and arcane results from the depths of pure mathematics, the language of choice for any sentient worthy of its name in the universe. So, great achievements of art and abstract mathematics beckon. And then there is the possibility entertained by some enterprising physicists of opening wormholes to other universes inside the multiverse and utilizing their resources without any need for physical travel... *Why go further?* There is no conceivable need— and there is so much more to be done on the asymptotic road to civilizational perfection.²⁷

27. John Wright's *The Golden Age* trilogy (*The Golden Age* [New York: Tor Books, 2002], *The Phoenix Exultant* [New York: Tor Books, 2003], and *The Golden Transcendence* [New York: Tor Books, 2003]) and Alastair Reynolds's *The Prefect* (London: Gollancz, 2007) and other novels dealing with the Yellowstone's *belle époque* in the Revelation Space universe, can be regarded as artistic descriptions of such a prospect.

Galactic Empire: (Post)humanity has encompassed most of the Milky Way, extending far beyond the original Galactic Habitable Zone. There is no real way of counting the posthuman population at this point, but various guesstimates give values of about 10^{20} . The huge garden of the Galactic biosphere is safe from any threat, at least on time scales less than about 10^{16} years in the future, when the inexorable dynamical processes will cause the Galaxy to disperse/collapse.²⁸ Even then, there are ways of extending the lifetime of the system artificially—but the word is used here in a grossly imprecise and outdated manner. There is, indeed, no longer any important distinction between ‘natural’ and ‘artificial’ that can be consequently sustained. Since the ‘rare Earth’ hypothesis of the early twenty-first century has been proved to be correct, there are many places with microscopic life, some of it similar to the terrestrial one, some wildly different. After the first few stories which encountered mixed success, humans have learnt how to live with the Galactic microbial biosphere—and use it to mutual advantage. At carefully guarded locations, though, rare complex biospheres are under severely enforced protection and careful scientific observation; in fact, this activity is one of the rare instances which still mandates the existence of anything even vaguely resembling centralized governing bodies.

28. E.g., F.C. Adams and G. Laughlin, ‘A dying universe: the long-term fate and evolution of astrophysical objects’, *Rev. Mod. Phys.* 69 (1997), 337–72.

Why go further? There is no conceivable need—and going further would necessarily fragment the diverse posthuman family and sever the last ties to the common origin and perhaps the common ethos of a once Earth-originating consciousness.²⁹

Worlds without end: Employing the Armstrong-Sandberg probes,³⁰ humanity has spread across a larger part of the universe inside our current cosmological horizon. By doing so, it has fractured—this time completely irreparably, since different parts of this vast domain have lost causal contact one with another owing to the inexorable accelerated expansion of the universe. But, in a certain sense, it is deemed unimportant by almost all; the ‘causal anthropocentrists’ who worry about such things are of very, very small measure in the almost infinite multitudes of intelligent beings sharing almost nothing in common except for a common origin on Earth, now obscured by billions of years of diverse astrobiological evolution. Even the Milky Way galaxy is nothing more than a distant memory or myth to the largest part of posthumanity. Processes on the eschatological scale lead to the gradual erosion

29. Many SF works have been covering these grounds, from classics such as Isaac Asimov’s original *Foundation* trilogy (New York: Gnome Press, 1951) and subsequent novels, to much more contemporary and sharpened renderings, such as Reynolds’ *House of Suns* (London: Gollancz, 2008) or Iain M. Banks’ *Culture* series (e.g., *Consider Phlebas* [London: Macmillan, 1987]; *Excession* [London, Orbit Books, 2003]).

30. S. Armstrong, and A. Sandberg, ‘Eternity in six hours: Intergalactic spreading of intelligent life and sharpening the Fermi paradox’, *Acta Astronautica* 89 (2013), 1–13.

of available resources, but engineering on the scale of galaxy clusters can prolong the process beyond the limits set by the predicted decay of structures; beyond that, only opening wormholes to domains with lower entropy remains.

Why go further? Our words obviously fail at this point—and while there might, just conceivably, be other dimensions and directions to follow, this will not occur for a purpose, but for a hitherto unknown concept deeper than *purpose* which (post)human language will reach in the fullness of spacetime.³¹

And what if we lose? Arguably, we are already in the position of the lost gamble, since we live in our WoodyAllenesque Brooklyn, which is *not expanding*.³² While it might not necessarily impact Alvy Singer's success in schooling, the admonishment of his mother means precisely that Alvy is going to miss all the fun—our Earth, like Brooklyn, is not expanding. While we might survive (barely) in its Tsiolkovskian cradle, its lifetime is limited. Earth, like Brooklyn, is a dead end

31. There is no serious fictional description of future on truly cosmological scale, partially due to the criticisms raised against even more moderate visions, like Reynolds's *House of Suns* (London: Gollancz, 2008); Frank Herbert's later Dune novels present a modest variation of the theme of cosmological-scale exodus (e.g., *Heretics of Dune* [New York: Putnam, 1984]).

32. *Annie Hall* (1977). Woody Allen's alter ego, Alvy Singer, refuses to do his homework due to an early insight into the facts of modern cosmology. Singer's worry about expansion of the universe making his homework irrelevant has been soothed by his mother's insight that they live in Brooklyn which, in contrast to the universe, is not expanding.

for our evolutionary gambler; the casino will shut down in less than 10^9 years—and possibly much sooner.³³

Honesty demands admitting that failure can bring additional hazards we have not considered seriously so far. Suppose that on an alternative Earth, Freeman Dyson's cherished *Project Orion* has actually been given the green light and brought to fruition. *Orion*, to recapitulate, was a pulse nuclear rocket engine capable of lifting enormous amounts of cargo into space; it is still the only well-studied idea short of the space elevator capable of lifting ~10,000 tons of industrial cargo into Earth's orbit in a matter of minutes.³⁴ The downside, of course, is radioactive fallout: Dyson and coworkers did find some ways to decrease it, but it could never be eliminated entirely. Now, suppose that a fleet of *Orions* is assembled at huge cost for purpose of colonization of the Solar System. If the gamble fails and colonization proves unsuccessful in the long run—think of the Vikings' abortive attempt to colonize Newfoundland—we would not be left *just as before*; we would be left with a still non-expanding, but now impoverished (due to the cost of spaceships) and poisoned (due to the nuclear fallout) Brooklyn. One can further speculate that such conditions would be ideal

33. K. Caldeira and J.F. Kasting, 'The life span of the biosphere revisited', *Nature* 360 (1992), 721–3.

34. E.g., G. Dyson, *Project Orion: The True Story of the Atomic Spaceship* (New York: Henry Holt and Company, 2003).

for fostering further risk-aversion among the survivors—and may preclude or impede future attempts at colonization, even if eventually safer and cheaper vehicles are constructed. This is admittedly an extreme example, but it does highlight the problem we need to face at this tipping point: gambling includes hidden risks and risks nobody at present takes seriously (or can even conceive of!). As Taleb emphasizes, nobody gets a medal for smoothly averting a huge catastrophe; in the best of cases, it can be recognized only much later and quite reluctantly, as in the case of Stanislav Petrov.³⁵ The Petrov effect, however, does not exist for existential risks; nobody is around to shoot *post festum* documentaries.

All in all, a series of gambles led us here; and only an even bolder and more dramatic gamble might lead us away from the current predicament. In the end, it may turn out to be the greatest gamble in the history of the universe, so far as its consequences are concerned. Whether we can succeed as species on the enormously enlarged cosmological scene will, perhaps, be more like poker than chess, involving both skill and luck—but there is really just one way to find out.

35. On September 26, 1983, in midst of a particularly high Cold-War tension, lieutenant colonel Petrov, on duty in the command centre of the Soviet nuclear-warning system, correctly surmised that the report indicating five US missiles being launched toward the USSR was a false alarm. It was later revealed that the false signal was caused by a rare atmospheric phenomenon. While it is impossible to be certain about the outcome of events if Petrov acted differently, his actions are now widely credited as at least helping avoid the global nuclear conflagration.

From Molecule to Market: Steroid Hormones and Financial Risk-Taking

John M. Coates, Mark Gurnell and Zoltan Sarnyai

INTRODUCTION

Emotions are commonly viewed as subcortical eruptions impairing the rational guidance of behaviour. However, certain authors¹ have disputed this contrast, suggesting that rationality by itself would be overwhelmed and directionless were information not emotionally tagged for significance. Nonetheless, lapses of rationality continue to be blamed on emotional interference. This is especially true of irrational risk-reward choices made during financial market bubbles and crashes, choices considered by many as instances of irrational exuberance and

1. E.g. A. Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Grosset/Putnam, 1994); J. E. LeDoux, *The Emotional Brain: The Mysterious Underpinnings of Emotional Life* (New York: Simon & Schuster, 1996); G. Loewenstein, E. Weber and C. Hsee, 'Risk as feelings', *Psychol. Bull.* 127 (2001), 267–86 (doi:10.1037/0033-2909.127.2.267).

pessimism overwhelming rational economic agency.² However, there are grounds for believing that the emotions of euphoria and fear displayed in markets may be more accurately described as shifts in confidence and risk preferences, ones caused by elevated levels of steroid hormones.

Steroids are a class of hormone, hormones being chemical messengers sent from one part of the body or brain to another, bringing about a change in the target tissue. The major classes of hormones include amines (such as adrenalin and noradrenalin), peptides and proteins (such as oxytocin and leptin) and steroids (such as testosterone, oestradiol and cortisol). Steroids are lipids cleaved from cholesterol by a series of enzymatic modifications, with the major sites of biosynthesis being the gonads and the adrenal cortex, although some neurosteroids, such as pregnenolone, can be synthesized directly by neurons and glial cells in the brain.³

Steroids constitute a particularly influential class of hormones because of their range of action. With receptors in almost every nucleated cell in the body, they affect growth, metabolism, immune function, mood, memory, cognition and behaviour. Steroids are of special interest for the study of emotions and

2. R. Shiller, *Irrational Exuberance* (New York: Doubleday, 2005).

3. E. Baulieu, 'Neurosteroids: of the nervous system, by the nervous system, for the nervous system', *Recent. Prog. Horm. Res.* 52 (1997), 1–32.

economic behaviour because they help coordinate body and brain in archetypical situations, such as fight, flight, mating, feeding, search and struggle for status. Because they are known to respond powerfully to such behavioural and social situations, steroid hormones may provide an important missing link in the emerging field of neuroeconomics between economic events and brain processes. Here, we review the relevant literature on two steroids that may help provide this link—testosterone and cortisol.

2. STEROID HORMONES

(a) *Testosterone and the hypothalamic–pituitary–gonadal axis*
Testosterone is produced by the Leydig cells of the testes, in smaller quantities by the ovaries and by the adrenal cortex in both sexes. The sex steroids, testosterone and oestrogen, are regulated by a series of glands acting in concert—the hypothalamic–pituitary–gonadal (HPG) axis (figure 1, overleaf). Sex steroids orchestrate reproductive function, regulating spermatogenesis in males, the menstrual cycle in females and sexually relevant and other forms of motivated behaviours in both genders.⁴ Gonadotrophin-releasing hormone (GnRH), synthesized by a small group of neurons in the hypothalamus, is transported axonally to the median

4. S. Reichlin, 'Neuroendocrinology', in J.D. Nelson, H.M. Kronenberg & P.P. Larson (eds.), *Williams Textbook of Endocrinology* (Philadelphia, PA: N.B. Saunders, 10th ed. 1998), 165–248.

COLLAPSE VIII

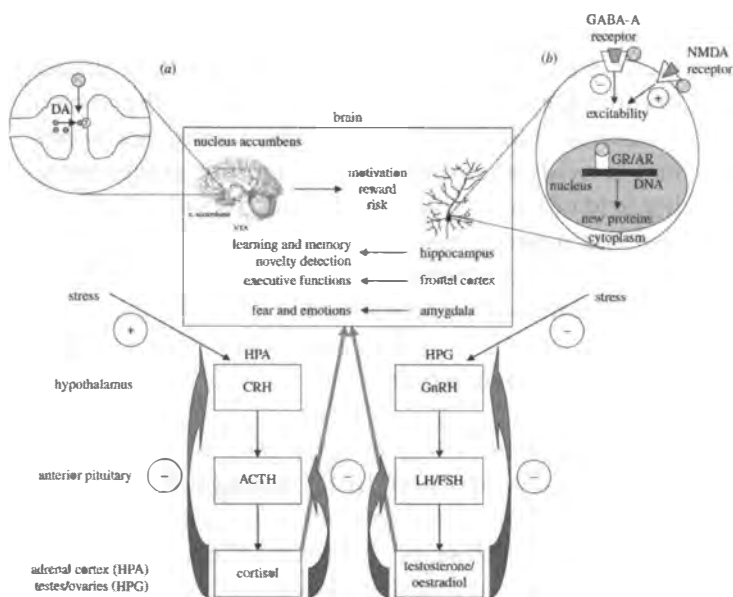


Figure 1. Schematic representation of the *HPA* and *HPG* axes and their effects on brain function. (a) Effects of steroid hormones on dopaminergic neurotransmission in the nucleus accumbens; (b) genomic and non-genomic effects of steroids in the brain; for more details see text. GABA, g-aminobutyricacid; NMDA, N-methyl-D-aspartate; GR, glucocorticoid receptor; AR, androgen receptor; plus, stimulatory effect; minus, inhibitory effect; dotted circles, steroid hormones (either glucocorticoid or testosterone); grey-shaded symbols, cognate ligands for other receptors.

eminence where it is released in a pulsatile manner into the hypothalamic–pituitary portal circulation (a network of blood vessels connecting the hypothalamus with the pituitary gland). GnRH then acts on the anterior pituitary gonadotrophs—cells responsible for the production of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). When LH and FSH are released into the bloodstream in response to GnRH stimulation, they travel to the gonads—the ovaries in females and the testes in males.

In females, carefully coordinated actions of LH and FSH facilitate follicular maturation and subsequent ovulation in response to rising oestrogen levels. Progesterone levels rise in the second half (luteal phase) of ovulatory cycles, and help maintain the corpus luteum.

In males, FSH is a critical regulator of spermatogenesis, while LH stimulates the production of testosterone. Reactivation of the HPG axis at puberty, and the consequent secretion of testosterone, causes maturation of the reproductive organs and development of secondary sexual characteristics. Testosterone has marked anabolic effects, promoting development of the musculature and increased bone growth, and contributing, with pituitary-derived growth hormone, to a rapid increase in height at puberty (the so-called ‘growth spurt’). Oestrogen, progesterone and testosterone—together with inhibin, which is produced by the gonads in response to FSH action—inhibit the

production and release of GnRH, LH and FSH in order to maintain the homeostasis of the system, with the HPG axis being subject to tight feedback control at all levels.⁵

As well as controlling the female menstrual cycle and male spermatogenesis, gonadal steroids also affect sexual behaviour.⁶ Importantly, they have been shown to exert both organizational and activational effects. The former refers to the fact that sexual differentiation of the brain can be permanently altered by the presence or absence of sex steroids at key stages in development. For example, administration of androgens to female rats within a few days of birth results in long-term virilization of behaviour. Conversely, neonatal castration of male rats causes them to develop behaviourally as females.⁷ Similar, but less complete, behavioural virilization of female offspring has been demonstrated following androgen administration in non-human primates. Brain development in the absence of sex steroids follows female lines, but is switched to the male

5. Reichlin, 'Neuroendocrinology'.

6. S. Vadakkadath Meethal & C. S. Atwood, 'The role of hypothalamic-pituitary-gonadal hormones in the normal structure and functioning of the brain', *Cell Mol. Life Sci.* 62 (2005), 257–70 (doi:10.1007/s00018-004-4381-3).

7. C. Phoenix, R. Goy, A. Gerall & W. Young, 'Organizing action of prenatally administered testosterone propionate on the tissues mediating mating behavior in the female guinea pig', *Endocrinology* 65 (1959), 369–82 (doi:10.1210/endo-65-3-369); S. Breedlove & E. Hampson, 'Sexual Differentiation of the Brain and Behavior', in J. Becker, S. Breedlove, D. Crews & M. McCarthy (eds.), *Behavioral Endocrinology* (Cambridge, MA: MIT Press, 2nd ed. 2002), 75–114.

pattern by exposure of the hypothalamus to androgen at a key stage of development. After puberty, androgens cause a feeling of well-being, an increase in physical vigour and increased libido. Testosterone's contribution to aggression and other forms of impulsive and risk-taking behaviours remains the subject of intense debate, and we return to this literature below.

(b) Cortisol and the hypothalamic–pituitary–adrenal axis

Cortisol, the main human glucocorticoid, is produced and regulated by the hypothalamic–pituitary–adrenal (HPA) axis (figure 1). This axis is critical to maintaining normal physiological homeostasis, and it regulates diverse processes, including metabolism, cardiovascular biology, immune function/inflammatory responses and cognitive function—indeed disorders of cortisol secretion (e.g. Addison's disease—cortisol deficiency; Cushing's syndrome—cortisol excess) are associated with considerable excess morbidity and mortality if left untreated. The system operates in a hierarchical manner similar to the HPG axis. Corticotropin-releasing hormone (CRH) is produced by neurons in the paraventricular nucleus of the hypothalamus, which project to the base of the hypothalamus, the median eminence. In response to a stressful stimulus, CRH is released from axon terminals into the hypothalamic–pituitary portal circulation, and reaches the anterior pituitary where

it promotes the synthesis and secretion of adrenocorticotrophic hormone (ACTH) by pituitary corticotrophs. ACTH then travels through the bloodstream to reach the adrenal glands (situated bilaterally above the kidneys) where it stimulates the synthesis and release of adrenal glucocorticoid hormones (cortisol in humans and other primates, corticosterone in rodents)⁸ and adrenal androgens (e.g. dehydroepiandrosterone [DHEA]).

Glucocorticoids play a key role in helping the body adapt to changing circumstances in both its internal and external environments. Biologically, glucocorticoids facilitate the mobilization of resources to meet demand, including effects on intermediary metabolism, carbohydrate and protein metabolism, as well as acting as potent regulators of our endogenous 'defence' mechanisms, including the innate and adaptive immune responses.⁹ Owing to their highly lipophilic nature, they can enter the brain easily and exert widespread effects on emotions, cognition, and the behavioural response to stress.¹⁰

However, chronic, as opposed to acute, elevation of circulating glucocorticoids may have a number of adverse effects on the body and brain. In its most extreme form (i.e. Cushing's syndrome),

8. J. Buckingham, 'Stress and the hypothalamo-pituitary-immune axis', *Int. J. Tissue React.* 20 (1998), 23–34.

9. Ibid.

10. E. R. deKloet, 'Stress in the brain', *Eur. J. Pharmacol.* 405 (2000), 187–98 (doi:10.1016/S0014-2999(00)00552-5).

hypercortisolism may lead to excessive weight gain (especially abdominal fat), muscle wasting, severe metabolic dysfunction (with resistance to the action of insulin and in some cases overt diabetes mellitus), hypertension, impaired wound healing and enhanced susceptibility to opportunistic infections. Similarly, prolonged supraphysiological glucocorticoid exposure may have deleterious effects on the brain, leading to depression and in extreme cases psychosis, as well as atrophy of the hippocampus, a brain region playing a central role in learning and memory.¹¹ Therefore, in order to avoid the undesirable consequences of glucocorticoid excess, the HPA axis is tightly regulated by a sensitive negative feedback loop, similar to that operating in the HPG axis: when glucocorticoid levels are high, CRH and ACTH secretion are downregulated: as cortisol levels subsequently fall, feedback inhibition of hypothalamic – pituitary function is reversed and CRH and ACTH secretion increase, which in turn restores adrenal cortisol production.

(c) Steroid receptors: mechanism of action of steroid hormones

The principles governing the interactions of steroid hormones with their cellular receptors are the same

11. R.M. Sapolsky, L.M. Romero & A.U. Munck, 'How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative action', *Endocr. Rev.* 21 (2000), 55–89 (doi:10.1210/er.21.1.55).

for adrenal and gonadal-derived sex steroids¹² and will be considered together for the purpose of this review. Steroid hormones are highly lipid soluble: they easily enter cells through the outer membrane. Once inside the cell, they bind to high-affinity receptors that belong to the nuclear receptor superfamily of ligand-gated transcription factors. For steroid hormones such as cortisol, oestrogen and testosterone, this process of binding to their receptors occurs outside of the nucleus in the cytoplasm. Hormone-bound receptor then trafficks into the nucleus where it seeks out, and interacts with, specific regions of the DNA to control the rate at which target genes are 'switched on' (activation) or 'switched off' (repression) (figure 1).¹³ In so doing, steroid hormones are able to increase or decrease the rate at which the cell synthesizes new proteins, and in this way change the structure and/or function of the cell, and the tissues made up of these cells.

These nuclear receptor-mediated events are relatively slow, usually taking several hours, and reflect the need for up- or downregulation of new protein synthesis. However, steroids also exert effects that

12. M. Gurnell, J. Burrin & K. Chatterjee, 'Principles of hormone action', In D. Warrell, T. Cox & J. Firth (eds), *Oxford Textbook of Medicine*, fifth edition (Oxford: Oxford University Press, 2010).

13. M. Tsai & B.W. O'Malley, 'Molecular mechanisms of action of steroid/thyroid receptor super family members', *Annu. Rev. Biochem.* 63 (1994), 451–86 (doi:10.1146/annurev.bi.63.070194.002315); J.W. Funder, 'Glucocorticoid and mineralocorticoid receptors: biology and clinical relevance', *Annu. Rev. Med.* 48 (1997), 231–4 (doi:10.1146/annurev.med.48.1.231).

can be observed within seconds, and these effects cannot be explained by the classic, genomic mechanisms. Instead, steroid hormones appear to act in a nongenomic manner to more rapidly alter cellular function.¹⁴ Steroid receptors have been found in extranuclear sites in the hippocampus and in many other brain regions.¹⁵ These membrane-associated receptors are connected to a number of intracellular signalling pathways, such as growth factor signalling, kinases and phosphatases, to influence cell function or indirectly alter gene expression in order to support functional and structural plasticity of the nervous system.¹⁶ Furthermore, a particular subclass of steroid hormones, the neuroactive steroids (metabolites of the peripheral steroidogenic pathway, e.g. pregnenolone and DHEA and their sulphated forms [DHEAS]), together with neurosteroids (i.e. those produced by neurons *de novo*), can rapidly alter neural excitability by acting as allosteric modulators on neurotransmitter-gated ion channels, such as the γ -aminobutyric acid type A (GABA-A) and N-methyl-D-aspartate (NMDA) receptors in the brain (figure 1). In this way, steroids are able

14. E. Falkenstein, H. Tillmann, M. Christ, M. Feuring & M. Wehling, 'Multiple actions of steroid hormones—a focus on rapid, nongenomic effects', *Pharmacol. Rev.* 52 (2000), 513–56

15. B. McEwen & T. Milner, 'Hippocampal formation: shedding light on the influence of sex and stress on the brain', *Brain Res. Rev.* 55 (2007), 343–55 (doi:10.1016/j.brainresrev.2007.02.006).

16. Ibid.

to influence emotions and mood within a narrow time frame.¹⁷

(d) *Androgens, glucocorticoids and brain function*

Recent work in neuroscience and economics has begun to elucidate how various brain regions process decisions and behaviours that violate the tenets of rational choice theory. Among these are the amygdala, which has been associated with framing effects¹⁸ and ambiguity aversion;¹⁹ the nucleus accumbens, associated with irrational risk-seeking;²⁰ and the insula, associated with irrational risk aversion²¹ and the rejection of monetary reward in the ultimatum game.²² The brain is a major target of steroid hormone action, with cortisol, testosterone and oestradiol²³ regulating

17. Baulieu, 'Neurosteroids'.

18. B. DeMartino, D. Kumaran, B. Seymour & R. Dolan, 'Frames, biases and rational decision-making in the human brain', *Science* 313 (2006), 684–87 (doi:10.1126/science.1128356).

19. Y. Hsu & L. Wolf, 'The winner and loser effect: what fighting behaviours are influenced?', *Anim. Behav.* 61 (2001), 777–86 (doi:10.1006/anbe.2000.1650).

20. S. Matthews, A. Simmons, S. Lane & M. Paulus, 'Selective activation of the nucleus accumbens during risk-taking decisionmaking', *NeuroReport* 15 (2004), 2123–27 (doi:10.1097/00001756-200409150-00025); C. Kuhnen & B. Knutson, 'The neural basis of financial risktaking', *Neuron* 47 (2005), 763–70 (doi:10.1016/j.neuron.2005.08.008).

21. Kuhnen & Knutson, 'financial risktaking'.

22. A. Sanfey et al, 'The neural basis of economic decision-making in the ultimatum game', *Science* 13 (2003), 1755–8.

23. J.-C. Dreher, P.J.Schmidt, P. Kohn, D. Furman, D. Rubinov & K.F. Berman, 'Menstrual cycle phase modulates reward-related neural function

neural function in many regions that are now recognized to be involved in economic decision-making (such as the prefrontal cortex and hippocampus) as well as regions implicated in irrational or emotional response to financial cues (such as the amygdala and nucleus accumbens). The powerful effects of steroids on these key brain regions raise the possibility that the irrationality or emotionality displayed in financial decisions may be significantly influenced by the levels of steroid in the body.

Corticosteroids—glucocorticoid and mineralocorticoid produced by the adrenal cortex—have dense receptor fields in the brain, as first demonstrated by McEwen and colleagues, who showed specific accumulation of 3H -corticosterone in the rat hippocampus.²⁴ Glucocorticoids bind to both glucocorticoid (GR) and mineralocorticoid receptors (MR), the latter of which has 10-fold higher affinity for its ligand than the GR.²⁵ MRs maintain basal activity of the axis, whereas GRs enhance negative feedback when corticosterone levels rise in response to a stressor. While the GR has a widespread expression pattern throughout the

in women', *Proc. Natl Acad. Sci. USA* 104 (2007), 2465–70 (doi:10.1073/pnas.0605569104).

24. B. McEwen, J.M. Weiss & L.S. Schwartz, 'Selective retention of corticosterone by limbic structures in rat brain', *Nature* 220 (1968), 911–12 (doi:10.1038/220911a0).

25. J.M. Reul & E. R. deKloet, 'Two receptor systems for corticosterone in rat brain: microdistribution and differential occupation', *Endocrinology* 117 (1985), 2505–11 (doi:10.1210/endo-117-6-2505).

brain, MR expression is mostly restricted to limbic brain regions such as the hippocampus, amygdala, the septum and some cortical areas,²⁶ regions critically involved in learning and memory, modulation of emotional responses and inhibition of behaviour.

For the purpose of this article, the key neural target regions considered with respect to glucocorticoid action are the hippocampus, amygdala and the prefrontal cortex.²⁷ The hippocampus is essential for novelty detection and for the formation of declarative memory, underlying the conscious acquisition and recollection of facts and events.²⁸ The prefrontal cortex, on the other hand, plays a key role in working memory, the cognitive mechanism that allows us to keep small amounts of information active for a limited period of time. The amygdala is particularly concerned with fear and emotions and mediates fear-conditioned memories.

The diverse actions of cortisol on human cognitive functions depend, among other factors, on the amount of hormone released, the length of exposure to cortisol, the emotional salience of the situation and the brain areas involved in dealing with the task. Low doses of glucocorticoids impair prefrontal, working memory,

26. E.R. deKloet, E. Vreugdenhil, M.S. Oitzl & M. Joels, 'Brain corticosteroid receptor balance in health and disease', *Endocr. Rev.* 19 (1998), 269–301 (doi:10.1210/er.19.3.269).

27. B. McEwen, 'Physiology and neurobiology of stress and adaptation: central role of the brain', *Endocr. Rev.* 87 (2007), 873–904.

28. W.B. Scoville & B. Milner, 'Loss of recent memory after bilateral hippocampal lesions', *J. Neurochem* 20 (1957), 11–21.

whereas high-dose or long-term administration results in an impairment in declarative, hippocampal, memory.²⁹ Furthermore, sustained elevation of corticosterone, or chronic stress, leads to plastic remodelling of neuronal structure in the hippocampus, amygdala and prefrontal cortex, as well as profound changes in functional plasticity, e.g. long-term potentiation.³⁰ Specifically, chronic stress, through the activation of the HPA axis, decreases the number of apical dendrites of the CA3 pyramidal neurons of the hippocampus and increases the number of dendritic branches in the central nucleus of the amygdala.³¹ Furthermore, chronic stress induces a selective impairment in attentional set-shifting and a corresponding retraction of apical dendritic arbors in the medial prefrontal cortex (mPFC). In stressed rats, but not in controls, decreased dendritic arborization in the mPFC predicts impaired attentional set-shifting performance.³² Consistent with results obtained in

29. S.J. Lupien, F. Maheu, M. Tu, A. Fiocco & T.E. Schramek 'The effects of stress and stress hormones on human cognition: implications for the field of brain and cognition', *Brain Cogn.* 65 (2007), 209–37 (doi:10.1016/j.bandc.2007.02.007).

30. B. McEwen & S. Chattarji, 'Molecular mechanisms of neuroplasticity and pharmacological implications: the example of tianeptine', *Eur. Neuropsychopharmacol.* 14 (2004), S497–S502 (doi:10.1016/j.euroneuro.2004.09.008); C. Liston, M.M. Miller, D.S. Goldwater, J.J. Radley, A.B. Rocher, P.R. Hof, J.H. Morrison & B. McEwen, 'Stress-induced alterations in prefrontal cortical dendritic morphology predicts selective impairments in perceptual attention set-shifting', *J. Neurosci.* 26* (2006), 7870–4 (doi:10.1523/JNEUROSCI.1184-06.2006).

31. McEwen & Chattarji, 'Molecular mechanisms of neuroplasticity'.

32. Liston et al., 'Stress-induced alterations'.

rodents, psychosocial stress in humans selectively impairs attentional control and disrupts functional connectivity within a frontoparietal network that mediates attention shifts.³³ These stress-induced, and perhaps glucocorticoid-mediated, changes in neuroplasticity may underlie altered cognitive functions, such as impaired attention, novelty detection and risk assessment, as well as anxiety and facilitated consolidation of emotionally negative memories typical of chronic stress.

Cortisol, as well as testosterone, may crucially influence economic decision-making through its effects on the nucleus accumbens (or ventral striatum), a main forebrain target of the mesolimbic dopaminergic system. Dopaminergic neurotransmission in the nucleus accumbens underlies motivation and reward-related behaviours such as drug self-administration and reward prediction.³⁴ One study also found the nucleus accumbens to fire in anticipation of irrational risk-seeking choices in a financial choice task.³⁵ Both corticosteroids and testosterone profoundly influence

33. C. Liston, B. McEwen & B. Casey, 'Psychosocial stress reversibly disrupts prefrontal processing and attentional control', *Proc. Natl. Acad. Sci. USA* 106 (2009), 912–17 (doi:10.1073/pnas.0807041106)

34. S. Ikemoto & J. Panksepp, 'The role of nucleus accumbens dopamine in motivated behavior: a unifying interpretation with special reference to reward-seeking', *Brain Res. Rev.* 31 (1999), 6–41 (doi:10.1016/S0165-0173(99)00023-5).

35. C. Kuhnen & B. Knutson, 'The neural basis of financial risktaking', *Neuron* 47 (2005), 763–70 (doi:10.1016/j.neuron.2005.08.008).

dopamine transmission in this region.³⁶ Both hormones are self-administered by experimental animals, indicating their reinforcing properties.³⁷

Evidence of the 'rewarding property' of testosterone is also provided by the finding that it can stimulate a conditioned place preference when administered to rats.³⁸

In humans there is evidence that anabolic steroids are addictive.³⁹ It is thought that the rewarding properties of testosterone derive from the effect it and its metabolites, dihydrotestosterone and 3 α -androstenediol,

36. P. V. Piazza & M. LeMoal, 'Glucocorticoids as biological substrate of reward: physiological and patho-physiological implications', *Brain Res. Rev.* 25 (1997), 259–372 (doi:10.1016/S0165-0173(97)00025-8); Z. Sarnyai, C.R. McKittrick, B. McEwen & M.J. Kreek, 'Selective regulation of dopamine transporter binding in the shell of the nucleus accumbens by adrenalectomy and corticosterone replacement', *Synapse* 30 (1998), 334–7 (doi:10.1002/(SICI)1098-2396(199811)30:3<334::AID-SYN11.3.O.CO;2-#); C. Frye, M. Rhodes, R. Rosellini & B. Svare, 'The nucleus accumbens as a site of action for rewarding properties of testosterone and its 5 α -reduced metabolites', *Pharmacol. Biochem. Behav.* 74 (2002), 119–27 (doi:10.1016/S0091-3057(02)00968-1).

37. P. Piazza, V. Deroche, J.M. Deminière, S. Maccari, M. LeMoal & H. Simon, 'Corticosterone in the range of stress-induced levels possesses reinforcing properties: implications for sensation-seeking behaviors', *Proc. Natl Acad. Sci. USA* 90 (1993), 11738–42 (doi:10.1073/pnas.90.24.11738); S.M. Sato, K. Schulz, C. Sisk & R. Wood, 'Adolescents and androgens, receptors and rewards', *Horm. Behav.* 53 (2008), 647–58 (doi:10.1016/j.yhbeh.2008.01.010).

38. J. Schroeder, M. Packard, 'Role of dopamine receptor subtypes in the acquisition of a testosterone conditioned place preference in rats', *Neurosci. Lett.* 282 (2000), 17–20 (doi:10.1016/S0304-3940(00)00839-9); Frye et al., 'The nucleus accumbens as a site of action'.

39. K. Kashkin & H. Kleber, 'Hooked on hormones? An anabolic steroid addiction hypothesis', *J. Am. Med. Assoc.* 262 (1989), 3166–70 (doi:10.1001/jama.262.22.3166)

have of increasing dopamine release in the shell of the nucleus accumbens.⁴⁰

Cortisol has a complex pattern of effects on the nucleus accumbens. The activation of the HPA axis appears to be critically involved, through CRF and glucocorticoids, in different aspects of drug reward.⁴¹ Acute stress increases extracellular dopamine levels, whereas chronic stress blunts the dopamine response and further inhibits dopamine outflow.⁴² Chronic stress, through elevated corticosterone, appears to result in an increased dopamine D2 receptor density selectively in the shell of the nucleus accumbens.⁴³ D2 receptors are inhibitory autoreceptors that dampen dopamine release from the pre-synaptic terminal. Similarly, we have shown that chronic corticosterone treatment upregulates the binding of the dopamine transporter, which is responsible for the termination of dopamine's effect in the synapse, in the same brain region.⁴⁴ Others have shown long-lasting desensitization of

40. Frye et al., 'The nucleus accumbens as a site of action'.

41. Z. Sarnyai, Y. Shaham & S. C. Heinrichs, 'The role of corticotropin-releasing factor in drug addiction', *Pharmacol. Rev.* 53 (2001), 209–43

42. S. Cabib & S. Puglisi-Allegra, 'Different effects of repeated stressful experiences on mesocortical and meso-limbic dopamine metabolism', *Neuroscience* 73, 375–80 (doi:10.1016/0306-4522(96)00750-6).

43. L.R. Lucas, C.J. Wang, T.J. McCall & B. McEwen, 'Effects of immobilization stress on neurochemical markers in the motivational system of the male rat', *Brain Res.* 1155 (2007) , 108–15 (doi:10.1016/j.brainres.2007.04.063).

44. Sarnyai et al., 'Selective regulation of dopamine transporter binding'.

dopamine receptor signalling caused by chronic stress.⁴⁵ Therefore, it can be hypothesized that chronic stress induces an allostatic attenuation of the mesolimbic dopaminergic system, possibly due in part to persistent corticosterone elevation.

3. STEROID HORMONES AND RISK-TAKING

(a) *Testosterone and risk-taking*

Testosterone mediates sexual behaviour as well as competitive encounters, so there are *prima facie* reasons for believing it could also affect financial risk-taking. Research into how it may do so is, however, in its infancy. Much of the work on the cognitive and behavioural effects of androgens has instead studied humans taking anabolic steroids, studies that are pharmacological rather than physiological because the steroids are taken in supra-physiological doses;⁴⁶ or the work has studied animal behaviour, thus leaving open the question of the results' applicability to humans.⁴⁷ The animal studies, besides those examining sexual behaviour, have focused largely on the effects

45. K. Choy Y. deVisser & M. van den Buuse, 'The effect of "two-hit" neonatal and young-adult stress on dopaminergic modulation of prepulse inhibition and dopamine receptor density', *Br. J. Pharmacol.* 156 (2009), 388–96 (doi:10.1111/j.1476-5381.2008.00008.x).

46. Kashkin & Kleber, 'Hooked on hormones?'.

47. R. Sapolsky, *The Trouble with Testosterone: and Other Essays on the Biology of the Human Predicament* (New York: Simon & Schuster, 1997).

of testosterone on mating, guarding and territorial aggression, and on competitions for rank within a social hierarchy. This research has been elegantly synthesized by the biologist John Wingfield in his highly influential challenge hypothesis.

According to the challenge hypothesis, testosterone in males rises to a minimum level required for sexual behaviour; it will continue to rise beyond this level only when males are confronted with an intruder or a social challenge, the increased testosterone promoting aggressive behaviour.⁴⁸ The insights gained from the challenge hypothesis, and from animal hormone studies more generally, have been applied to human behaviour,⁴⁹ but often with questionable success. Many studies, for example, could not determine whether testosterone caused aggression or the other way round; others found testosterone levels were poor predictors of who subsequently became aggressive;⁵⁰ still others did not distinguish between aggressive and non-aggressive risk-taking.⁵¹ One problem with these

48. J.C. Wingfield, S. Lynn & K. Soma, 'Avoiding the "costs" of testosterone: ecological bases of hormone-behavior interactions', *BrainBehav. Evol.* 57 (2001), 239–51 (doi:10.1159/000047243).

49. J. Archer, 'Testosterone and human aggression: an evaluation of the challenge hypothesis', *Neurosci. Biobehav. Rev.* 30 (2006), 319–45 (doi:10.1016/j.neubiorev.2004.12.007).

50. Sapolsky, *The trouble with testosterone*; E.P. Monaghan & S.E. Glickman, 'Hormones and aggressive behavior', in *Behavioural Endocrinology* (eds J.B. Becker, S.M. Breedlove & D. Crews) (Cambridge, MA: MIT Press, 2001), 261–87.

51. H. Vermeersch, G. T'sjoen, J.M. Kaufman & J. Vincke, 'The role of

studies stems from the fact that in humans, as in some non-human primates, higher cognitive functions refract the effects of testosterone, effects which in smaller brained animals are more deterministic. Furthermore, the dependent variables in these studies, such as aggression, dominance, or status seeking, often cannot be defined or measured in humans with any objectivity, leading to marginally significant experimental results and contradictory findings between papers.⁵²

Studies of steroids and financial risk-taking promise to overcome many of these difficulties. To begin with, financial variables, such as profit, variance of returns, volatility of the market, can be defined objectively and measured precisely. Furthermore, the competitive behaviour Wingfield and his colleagues observed in animals may manifest itself in humans, not so much in aggressive encounters as in competitive economic behaviour. Through its known effects on dopamine transmission in the nucleus accumbens, testosterone may well have its most powerful effects in humans by shifting their utility functions, state of confidence or financial risk preferences.

testosterone in aggressive and non-aggressive risk-taking in adolescent boys', *Horm. Behav.* 53 (2008), 463–71 (doi:10.1016/j.yhbeh.2007.11.021).

52. J. Archer, S. Birring & F. Wu, 'The association between testosterone and aggression among young men: empirical findings and a meta-analysis', *Aggress. Behav.* 24 (1998), 411–20 (doi:10.1002/(SICI)1098-2337(1998)24:6,411::AID-AB2.3.0.CO;2-9).

We began testing this hypothesis by setting up a series of experiments on a trading floor in the City of London.⁵³ We chose to study professional traders because real risk-taking, with meaningful consequences, seemed most likely to trigger large endocrine reactions. Our hypothesis and predictions were based on the challenge hypothesis as well as a closely related model, the winner effect (see below). Biologists working with these models have noticed that two males entering a fight or contest experience androgenic priming in the form of elevated testosterone levels. Moreover, the winning male emerges with even greater levels of testosterone, the loser with lower ones. The orders of magnitude of these hormone swings can be large: Monaghan & Glickman⁵⁴ report that in a competition for rank among recently introduced rhesus monkeys, the winning male emerged with a 10-fold increase in testosterone, while the loser experienced a drop to 10 percent of baseline levels within 24 hours, and these new levels for both winner and loser persisted for several weeks. This reaction may make sense from an evolutionary point of view: in the wild, the loser of a fight is encouraged to retire from the field and nurse his wounds while the winner prepares for new challenges to his recently acquired rank.

53. J.M. Coates & J. Herbert 'Endogenous steroids and financial risktaking on a London trading floor', *Proc. Natl Acad. Sci. USA* 105 (2008), 6167–72 (doi:10.1073/pnas.0704025105).

54. 'Hormones and aggressive behavior'.

A similar result has been found in experiments with humans.⁵⁵ Athletes, for example, experience the same androgenic priming before a sporting contest, and a further increase in testosterone after a win. This experiment has been repeated for a number of different events, including tennis⁵⁶ and wrestling,⁵⁷ as well as less physical contests such as chess.⁵⁸ It has also been found that the rising and falling levels of an athlete's testosterone can be mimicked by fans: Bernhardt et al.⁵⁹ took testosterone samples from fans during a World Cup match in which Brazil defeated Italy. Both sets of fans went into the game with elevated testosterone, but afterwards the Brazilian fans' testosterone rose while the Italians' fell.

The role of these elevated testosterone levels is further explored in an animal model known as the 'winner effect'. In this model, winning in an agonistic

55. B. Gladue, M. Boechler & K.D. McCaul, 'Hormonal response to competition in human males', *Aggress. Behav.* 15 (1989), 409–22 (doi:10.1002/1098-2337(1989)15:6,409::AID-AB2480150602.3.0.CO;2-P).

56. A. Booth, D. Johnson & D. Granger, 'Testosterone and men's health', *J. Behav. Med.* 22 (1999), 1–19 (doi:10.1023/A:1018705001117).

57. M. Elias, 'Serum cortisol, testosterone, and testosterone-binding globulin responses to competitive fighting in human males', *Aggress. Behav.* 7 (1981), 215–24 (doi:10.1002/1098-2337(1981)7:3,215::AID-AB2480070305.3.0.CO;2-M).

58. A. Mazur, A. Booth & J. Dabbs, 'Testosterone and chess competition', *Soc. Psychol. Q.* 55 (1992), 70–77 (doi:10.2307/2786687).

59. P.C. Bernhardt, J. Dabbs, J. Fielden & C. Lutter, 'Changes in testosterone levels during vicarious experiences of winning and losing among fans at sporting events', *Physiol. Behav.* 65 (1998), 59–62 (doi:10.1016/S0031-9384(98)00147-4).

encounter can itself contribute to a later win,⁶⁰ an effect that is independent of (i) an animal's resource-holding potential (RHP), i.e. the physical resources it can draw on in an all-out fight, (ii) its motivation, i.e. the value of the resource in dispute, or (iii) its aggressiveness.⁶¹ It is not known if the win imparts information to winner and loser about their respective resources⁶² or whether it has physiological effects. This latter possibility is suggested by experiments in which elevated testosterone has been found to contribute to further wins.⁶³ Another possibility not fully considered in the literature is that higher testosterone, through its beneficial effects on the cardiovascular system and muscle mass, may effectively increase an animal's RHP, or, through its effects on confidence and risk-taking, may increase

60. I.D. Chase, C. Bartolomeo & L.A. Dugatkin, 'Aggressive interactions and inter-contest interval: how long do winners keep winning?', *Anim. Behav.* 48 (1994), 393–400 (doi:10.1006/anbe.1994.1253); T. Oyegbile & C. Marler, 'Winning fights elevates testosterone levels in California mice and enhances future ability to win fight', *Horm. Behav.* 48 (2005), 259–67 (doi:10.1016/j.yhbeh.2005.04.007).

61. P. Hurd, 'Resource holding potential, subjective resource value, and game theoretical models of aggressiveness signaling', *J. Theor. Biol.* 241 (2006), 639–48 (doi:10.1016/j.jtbi.2006.01.001).

62. Y. Hsu & L. Wolf, 'The winner and loser effect: what fighting behaviours are influenced?', *Anim. Behav.* 61 (2001), 777–86 (doi:10.1006/anbe.2000.1650); C. Rutte, M. Taborsky & M. Brinkhof, 'What sets the odds of winning and losing?', *Trends Ecol. Evol.* 21 (2006), 16–21 (doi:10.1016/j.tree.2005.10.014).

63. B.C. Trainor, I.M. Bird & C.A. Marler, 'Opposing hormonal mechanisms of aggression revealed through short-lived testosterone manipulations and multiple winning experiences', *Horm. Behav.* 45 (2004), 115–21 (doi:10.1016/j.yhbeh.2003.09.006); T. Oyegbile & C. Marler, 'Winning fights elevates testosterone levels in California mice and enhances future ability to win fight', *Horm. Behav.* 48 (2005), 259–67 (doi:10.1016/j.yhbeh.2005.04.007).

an animal's motivation or aggressiveness.⁶⁴ Whatever the mechanism, a winner, with heightened testosterone levels, may proceed to the next round of competition with an advantage. This positive feedback loop, in which victory raises testosterone which in turn raises the likelihood of later victories (figure 2, overleaf), may help account for winning and losing streaks in round-robin animal competitions that establish a social hierarchy.⁶⁵

We examined the relevance of the challenge hypothesis and winner effect models to the financial markets⁶⁶ by looking for evidence that traders experience an increase in testosterone when they enjoy an above-average win in the markets. To do so, we sampled steroids from 17 young male traders, taking saliva samples twice a day, at 11.00 and 16.00, over a period of eight consecutive business days. Hormone readings are notoriously noisy owing to the pulsatile nature of their production and release into the blood stream, hence our protocol of repeated sampling to help separate 'signal' from 'noise'. The traders were engaged in

64. F. Neat, G. Huntingford & M. Beveridge, 'Fighting and assessment in male cichlid fish: the effects of asymmetries in gonadal state and body size', *Anim. Behav.* 55 (1998), 883–91 (doi:10.1006/anbe.1997.0669).

65. L. Dugatkin & M. Druen, 'The social implications of winner and loser effects', *Proc. Biol. Sci.* 271 (Suppl. 6) (2004), S488–S489 (doi:10.1098/rsbl.2004.0235).

66. J.M. Coates & J. Herbert 'Endogenous steroids and financial risktaking on a London trading floor', *Proc. Natl Acad. Sci. USA* 105 (2008), 6167–72 (doi:10.1073/pnas.0704025105).

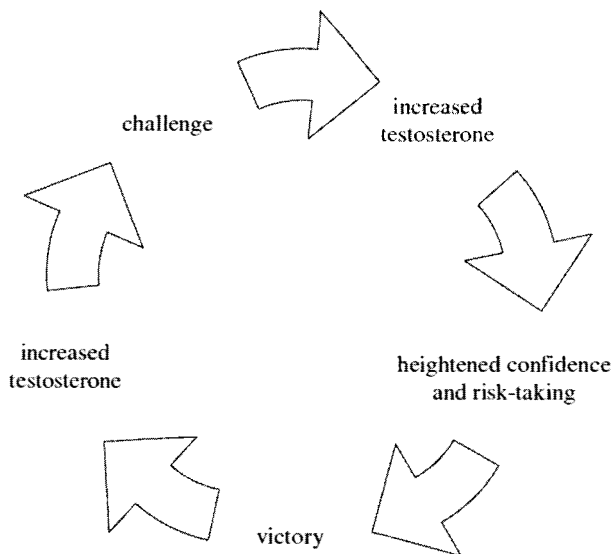


Figure 2. Schematic representation of a winner effect mediated by testosterone.

high-frequency trading, meaning that they positioned securities, mostly futures contracts in European and us bond and equity markets, in sizes up to £1 billion, but held their positions for a short period of time—several minutes, and sometimes mere seconds. They rarely positioned trades overnight, and they did not let winning or losing positions run for long.

We discovered that these traders did indeed have significantly higher testosterone levels on days when

they made an above-average profit. We could not determine from this correlation whether the profits were raising hormone levels or vice versa, but since we took two samples per day, we could examine how morning testosterone levels were related to afternoon profits and losses (P&Ls). To do so, we looked at the days when each trader's 11.00 testosterone levels were above his median level during the study, these days showing testosterone levels a modest 25 per cent higher than on the other days. We found that on days of high morning testosterone, the traders returned an afternoon profit (figure 3a, overleaf) that was almost a full standard deviation higher than on 'low-testosterone' days. Interestingly, this relationship was even stronger among experienced traders (figure 3b, overleaf), i.e. those who had traded for longer than 2 years, suggesting that testosterone, at moderate levels, was not having its effect by encouraging overly risky behaviour but was instead optimizing performance, at least with respect to high-frequency trading.

The effects of androgens on high-frequency trading were also evident in a second experiment, one that looked at a surrogate marker of pre-natal androgen exposure—the second to fourth digit (finger length) ratio (2D:4D).⁶⁷ As mentioned above, there are two distinct periods and types of hormone

67. J.M. Coates, M. Gurnell & A. Rustichini, 'Second-to-fourth digit ratio predicts success among high-frequency financial traders', *Proc. Natl Acad. Sci. USA* 106 (2009), 623–28 (doi:10.1073/pnas.0810907106).

COLLAPSE VIII

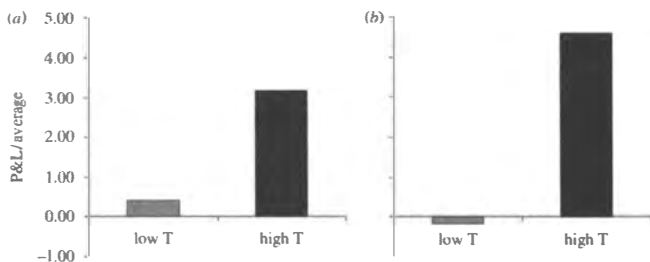


Figure 3. P&L on low- and high-testosterone days. (a) P&L made between 11.00 and 16.00 for 17 traders on days when their testosterone levels were above their median level during the study ('high T') and on the rest of the days ('low T') ($n=17$, paired t -test $p=0.008$; Cohen's $d=0.97$). P&Ls for each trader were standardized by dividing them by their 1-month average daily P&L. Standardized P&Ls were then averaged across all 17 traders. (b) Afternoon P&L for experienced traders only, i.e. ones with more than 2 years trading experience ($n=10$, paired t -test $p=0.005$; Cohen's $d=1.37$).

action—organizational effects of pre-natal steroids on the foetus and activational effects of circulating steroidgens surge between the ninth and 18th week of gestation, masculinizing the foetus and exerting developmental changes on the body and brain that are permanent.⁶⁸ After the 19th week, androgen production subsides, spikes again briefly in the neonate and then drops back to low levels until the onset of puberty. At puberty, androgen production increases, activating the circuits created earlier in life by pre-natal hormone

68. C. Cohen-Bendahan, C. van de Beeka & S. Berenbaum, 'Prenatal sex hormone effects on child and adult sex-typed behavior: methods and findings', *Neurosci. Biobehav. Rev.* 29 (2004), 353–84 (doi:10.1016/j.neubiorev.2004.11.004).

exposure. According to the organizational/activational model of hormone action,⁶⁹ the sensitivity of adults to changes in circulating testosterone is a function of the amount of pre-natal androgen to which they were exposed.⁷⁰

Importantly, the amount of pre-natal androgen an individual was exposed to can be estimated because it leaves traces throughout the adult body, traces often measured by paediatricians looking for effects of environmental hormone disruptors on newborn infants. 2D:4D is the most convenient measure for behavioural studies.⁷¹ A lower 2D:4D ratio is thought to indicate higher levels of pre-natal testosterone exposure.⁷² Consistent with this, men on average have lower ratios than women. We sampled 2D:4D from a total of 44 traders, including 14 from the first study, and found that it predicted both the traders' P&Ls over a 20-month period and the number of years they had survived

69. C. Phoenix, R. Goy, A. Gerall & W. Young, 'Organizing action of prenatally administered testosterone propionate on the tissues mediating mating behavior in the female guinea pig', *Endocrinology* 65 (1959), 369–82 (doi:10.1210/endo-65-3-369).

70. M. Meaney, 'The sexual differentiation of social play', *Trends Neurosci.* 11 (1988), 54–8 (doi:10.1016/0166-2236(88)90164-6); Breedlove & Hampson, 'Sexual Differentiation of the Brain and Behavior'.

71. M. McIntyre, 'The use of digit ratios as markers for perinatal androgenation', *Reprod. Biol. Endocrinol.* 4, 10 (2006) (doi:10.1186/1477-7827-4-10).

72. J. Manning, D. Scutt, D. Wilson & D. Lewis-Jones, '2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen', *Hum. Reprod.* 13 (1998), 3000–3004 (doi:10.1093/humrep/13.11.3000); Brown et al. 2002).

in the business. It also predicted, in line with the organizational/activational model, the sensitivity of the trading performance of the original 14 traders to increases in circulating testosterone: the lower the trader's 2D:4D, the more money he made when his testosterone levels rose.

Pre-natal testosterone appears, therefore, to predict long-term success in high-frequency trading, a style of trading requiring quick physical and cognitive reactions. However, there are grounds for believing that in other types of trading, especially those permitting more time for analysis and a longer holding period, or ones that do not make such physical demands, the correlation may weaken and even reverse sign.⁷³ The market, it appears, selects for biological traits but these traits may vary between market segments.

The two trading floor experiments described here raise troubling questions about the efficient markets hypothesis. If, as this hypothesis assumes, markets are random, then we should not be able to predict relative trading performance by means of biological traits. Yet, our results suggest that higher levels of circulating testosterone predict short-term profitability and higher levels of pre-natal testosterone predict long-term profitability, at least in the segment of the market inhabited by high-frequency traders. The implication seems to

73. J.M. Coates, M. Gurnell & A. Rustichini, 'Second-to-fourth digit ratio predicts success among high-frequency financial traders', *Proc. Natl Acad. Sci. USA* 106 (2009), 623–28 (doi:10.1073/pnas.0810907106).

be that the markets are not efficient or that they select for traits other than rational expectations.⁷⁴

This leads us to another important question: How could testosterone exert its effects on profitability?

Field studies such as those reported above do not allow us to establish a causal relationship between testosterone and profits, merely a predictive relationship, albeit a strong one. To establish causality, one needs pharmacological manipulation. Some studies administering testosterone esters to eugonadal males have found significant but weak effects on mood and aggressiveness,⁷⁵ although they were not examining financial tasks. However, converging evidence from other lines of research suggests that androgen may affect confidence and risk preferences. For example, administered testosterone promotes confidence and fearlessness in the face of novelty, a result observed

74. W. DeBondt & R. Thaler, 'Further evidence on investor overreaction and stock market seasonality', *J. Finance* 42 (1987), 557–81 (doi:10.2307/2328371); R. Shiller, *Irrational Exuberance* (New York:Doubleday, 2005); L. Blume & D. Easley, 'If you are so smart why aren't you rich? Belief selection in complete and incomplete markets', *Econometrica* 74 (2006), 929–66 (doi:10.1111/j.1468-0262.2006.00691.x).

75. S. Bhasin et al, 'Testosterone dose–response relationships in healthy young men', *Am. J. Physiol. Endocrinol. Metab.* 281 (2001), 1172–81; D. O'Connor, J. Archer & F. Wu, 'Effects of testosterone on mood, aggression, and sexual behavior in young men: a double-blind, placebo-controlled, cross-over study', *J. Clin. Endo. Metabol.* 89 (2004), 2837–45 (doi:10.1210/jc.2003-031354).

in both animals⁷⁶ and humans.⁷⁷ Furthermore, in a between-subjects study of male students playing an investment game, testosterone levels correlated with risk preferences.⁷⁸ This study also examined 2D:4D and risk preferences, finding a significant correlation among Swedish Caucasians but not in a more ethnically heterogeneous population, the difference in results being accounted for by the fact that ethnic population is an important confound for 2D:4D.

Intriguingly, there is another potential path of causation between testosterone and trading profits. Trading, it is not often appreciated, is a physical activity, a demanding one, so the important effects of testosterone may be physical rather than cognitive. High testosterone levels or increased androgenic effects, for example, can increase vigilance and visuo-motor skills such as scanning and speed of reactions,⁷⁹ qualities

76. A. Boissy & M. Bouissou, 'Effects of androgen treatment on behavioural and physiological responses of heifers to fear-eliciting situations', *Horm. Behav.* 28 (1994), 66–83 (doi:10.1006/hbeh.1994.1006).

77. E. Hermans, P. Putman, J. Baas, H. Koppeschaar & J. van Honk, 'A single administration of testosterone reduces fear-potentiated startle in humans', *Biol. Psychiat.* 59 (2006), 872–74 (doi:10.1016/j.biopsych.2005.11.015).

78. C. Apicella, A. Dreber B. Campbell, P. Gray, M. Hoffman & A. Little, 'Testosterone and financial risk preferences', *Evol. Hum. Behav.* 29 (2008), 384–90 (doi:10.1016/j.evolhumbehav.2008.07.001).

79. E. Salminen, R. Portin, A. Koskinen, H. Helenius & M. Nurmi, 'Associations between serum testosterone fall and cognitive function in prostate cancer patients', *Clin. Can. Res.* 10 (2004), 7575–82 (doi:10.1158/1078-0432.CCR-04-0750); C. Falter, M. Arroyo & G. Davis, 'Testosterone: activation or organization of spatial cognition?', *Biol. Psychol.* 73 (2006), 132–140 (doi:10.1016/j.biopsycho.2006.01.011).

that may help traders to spot and trade price discrepancies before others arbitrage them away.⁸⁰ Elevated testosterone levels have also been found to increase an animal's search persistence⁸¹ and, during search, to focus visual attention while decreasing distraction by irrelevant stimuli.⁸² These last traits may be of particular importance in high-frequency trading because this form of trading requires lengthy periods of visuomotor scanning and quick reactions.

An increase in confidence or risk preferences, as found in some studies, would tend to increase a trader's position size; an increase in search persistence the frequency of trading; an increase in reaction times the chances of getting to a trade before others. Given that the traders in our study had a positive expected return, i.e. they usually made money, larger positions or more frequent trades would translate into higher daily profits. However, we cannot at this point say by which route these effects travelled, that is, whether testosterone was having its effect by augmenting the effort, speed, confidence or risk preferences of the traders.

80. J.M. Coates, M. Gurnell & A. Rustichini, 'Second-to-fourth digit ratio predicts success among high-frequency financial traders', *Proc. Natl Acad. Sci. USA* 106 (2009), 623–28 (doi:10.1073/pnas.0810907106).

81. R. Andrew & L. Rogers, 'Testosterone, search behaviour and persistence', *Nature* 237 (1972), 343–46 (doi:10.1038/237343a0).

82. R. Andrew, *The Development and Integration of Behaviour. Essays in Honour of Robert Hinde*, ed. P. Bateson (Cambridge: Cambridge University Press, 1991), 171–90.

(b) Cortisol and risk-taking

A review of research on cortisol and financial risk-taking is necessarily brief as there is almost no work done on this subject. Van Honk et al.⁸³ looked at the cortisol levels of people playing the Iowa Gambling Task and found that they correlated with risk aversion. In our own studies, we hypothesized that cortisol, as a stress hormone, would increase as traders lost money. This seemed a reasonable assumption, but our experiment did not find evidence to support it, as we observed no relationship between trading losses, even above-average ones, and cortisol levels. However, caution is needed before extrapolating these findings, as the style of trading and the risk management practices on this trading floor prevented traders from losing large sums of money. Had they not done so, or had we sampled in a different setting, for example in an investment bank where traders position interest rate or credit risk for longer periods of time, and had these traders entered a sustained losing streak, it is likely they would have experienced high levels of stress and cortisol.

However, we did note a potentially more interesting finding—that cortisol was rising with uncertainty. Early research on stress and cortisol, especially the pioneering work of Hans Selye, focused on how cortisol

83. J. van Honk, D. Schutter, E. Hermans & P. Putman, 'Low cortisol levels and the balance between punishment sensitivity and reward dependency', *NeuroReport* 14 (2003), 1993–96.

production reacts to actual bodily harm. But later research found that the HPA axis can respond more robustly to expected harm and that the size of the response is an increasing function of the uncertainty over timing. For example, an animal receiving a shock at regular intervals or after a warning tone may have normal cortisol levels at the end of an experiment; in contrast, an animal receiving the same quantity of shock will experience rising cortisol levels as the timing of the shocks becomes more and more unpredictable, reaching a maximum when the timing becomes random.⁸⁴ Animals can have a similarly elevated HPA response when exposed to situations of novelty⁸⁵ or uncontrollability.⁸⁶ Uncertainty, novelty and uncontrollability can perhaps be reduced to a common denominator of uncertainty; all three describe a situation in which an animal finds it increasingly difficult to predict what may happen and what actions will be required. The necessity of being prepared for the unexpected signals

84. S. Levine, C. Coe & S.G. Wiener, 'Psychoneuroendocrinology of stress: a psychobiological perspective', in *Psychoendocrinology*, eds F. Bush & S. Levine (New York: Academic Press, 1989), 341–77.

85. K. Erikson, W. Drevets & J. Schulkin, 'Glucocorticoid regulation of diverse cognitive functions in normal and pathological emotional states', *Neurosci. Biobehav. Rev.* 27(2003), 233–46 (doi:10.1016/S0149-7634(03)00033-2).

86. R. Swenson & W. Vogel, 'Plasmacatecholamine and corticosterone as well as brain catecholamine changes during coping in rats exposed to stressful footshock', *Pharmacol. Biochem. Behav.* 18 (1983), 689–93 (doi:10.1016/0091-3057(83)90007-2); A. Breier, M. Albus, D. Pickar, T.P. Zahn, O.M. Wolkowitz & S.M. Paul, 'Controllable and uncontrollable stress in humans: alterations in mood and neuroendocrine and psychophysiological function', *Am. J. Psychiatry* 144 (1987), 1419–25.

to the body, via cortisol, that catabolic metabolism may be needed. As it transpires, ‘uncertainty’, ‘novelty’ and ‘uncontrollability’ aptly describe the financial markets and the environment in which traders find themselves on a daily basis.

To examine the effect of uncertainty on traders’ HPA axes, we looked at the risk faced by each trader, as measured by the variance of his P&L, over the course of the study.⁸⁷ We found a highly significant correlation with cortisol that once again displayed a large effect size. Variance in P&L is a measure of the uncertainty or uncontrollability a trader has just lived through; but we also wanted to measure how uncertain the traders were about upcoming events in the market, such as the release of important economic statistics. To do so, we used the implied volatility of the Bund futures contract (a future on German Government bonds), which was the security most widely traded by the traders in the study. Bond options require for their pricing the market’s estimate of the future variance of the underlying asset, so option prices provide an objective measure of the market’s collective uncertainty. Here, again we observed a very high and significant correlation between the traders’ daily cortisol levels, averaged from all traders, and the market’s uncertainty regarding upcoming market moves. Our results raise

87. J.M. Coates & J. Herbert ‘Endogenous steroids and financial risktaking on a London trading floor’, *Proc. Natl Acad. Sci. USA* 105 (2008), 6167–72 (doi:10.1073/pnas.0704025105).

the possibility that while testosterone codes for economic return, cortisol codes for risk.

Our experiment represents only the mere beginning of research into the role of cortisol in financial decision-making. To underline our belief in the critical importance of this hormone, we should point out that the cortisol fluctuations we observed were large. In the normal course of a day, cortisol, like testosterone, peaks in the morning and falls over the course of the day. Between our sampling times, cortisol levels would be predicted to fall by approximately 40 per cent, yet in many of our subjects it rose, in some cases by as much as 500 per cent. Similar-sized cortisol fluctuations were also observed between days. What purpose do changes of this magnitude serve? Cortisol, as highlighted above, marshalls glucose for immediate use, and it promotes anticipatory arousal and a focused attention.⁸⁸ We speculate therefore that traders, when expecting a market move, would benefit from such an acute increase in cortisol, as it prepares them for the money-making opportunities that increased volatility brings.

88. K. Erikson, W. Drevets & J. Schulkin, 'Glucocorticoid regulation of diverse cognitive functions in normal and pathological emotional states', *Neurosci. Biobehav Rev.* 27(2003), 233–46 (doi:10.1016/S0149-7634(03)00033-2).

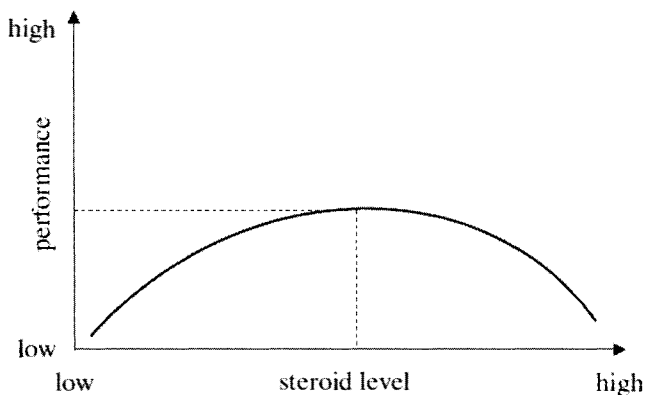


Figure 4. Inverted U-shaped dose-response curve relating cortisol levels to cognitive function, such as performance, on a spatial navigation or declarative memory task.

(c) Steroids and impaired risk-taking

If market volatility or the variance in the traders' P&L were to remain high, cortisol levels could also remain elevated for an extended period. Chronically elevated cortisol levels, as we have seen, can have the opposite effect on cognitive performance as acute levels. Cortisol displays an inverted u-shaped dose-response curve, according to which performance on a range of cognitive and behavioural tasks is optimized at moderate levels, while being impaired at lower and

higher levels (figure 4).⁸⁹ As cortisol levels rise past the optimal point on the dose–response curve, they may begin to impair trading performance, specifically by promoting irrational risk aversion. Chronically elevated cortisol levels increase CRH gene transcription in the central nucleus of the amygdala thereby promoting fear,⁹⁰ anxiety⁹¹ and the tendency to find risk where perhaps none exists.⁹² They may also alter the types of memory recalled, causing a person to selectively recall mostly negative precedents.⁹³ Lastly, chronic stress, as we have seen, downregulates dopamine transporters, receptors and downstream signalling molecules in the nucleus accumbens, and may thereby alter risk-related

89. C. Conrad, S. Lupien & B. McEwen, 'Support for a bimodal role for type II adrenal steroid receptors in spatial memory', *Neurobiol. Learn. Mem.* 72 (1999), 39–46 (doi:10.1006/nlme.1998.3898).

90. K. Corodimas, J. LeDoux, P. Gold & J. Schulkin, 'Corticosterone potentiation of learned fear', *Ann. NY Acad. Sci.* 746 (1994), 392–3

91. J.D. Shephard, K.W. Barron & D.A. Myers, 'Corticosterone delivery to the amygdala increases corticotropin-releasing factor mRNA in the central amygdaloid nucleus and anxiety-like behavior', *BrainRes.* 861 (2000), 288–95; S. Korte, 'Corticosteroids in relation to fear, anxiety and psychopathology', *Neurosci. Biobehav. Rev.* 25 (2001), 117–42 (doi:10.1016/S0149-7634(01)00002-1).

92. J. Schulkin, B.S. McEwen & P. W. Gold, 'Allostasis, amygdala, and anticipatory angst', *Neurosci. Biobehav. Rev.* 18 (2004), 385–96 (doi:10.1016/0149-7634(94)90051-5); B. McEwen, 'Stress, adaptation, and disease: allostasis and allostatic load', *Ann. NY Acad. Sci.* 840 (1998), 33–44 (doi:10.1111/j.1749-6632.1998.tb09546.x).

93. K. Erikson, W. Drevets & J. Schulkin, 'Glucocorticoid regulation of diverse cognitive functions in normal and pathological emotional states', *Neurosci. Biobehav. Rev.* 27 (2003), 233–46 (doi:10.1016/S0149-7634(03)00033-2).

behaviours. All these effects would tend to decrease a trader's appetite for risk.

When might conditions of chronic stress occur in the markets? Bear markets and crashes are notable for their extreme levels of volatility, the protracted subprime mortgage crisis being a notable example, with the *vix*, an index of implied volatilities on the New York Stock Exchange, rising from 12 per cent before the crisis to a high of 80 per cent 18 months later. It seems likely that cortisol levels among traders threatened for so long with historic levels of uncertainty would have increased and perhaps remained elevated for a prolonged period of time. Under such circumstances, the steroid may have contributed to the extreme levels of risk aversion observed among traders. Indeed, extended periods of uncertainty and uncontrollable stress can promote a condition known as 'learned helplessness', in which persons, and animals, lose all belief in their ability to control or influence their environment.⁹⁴ Under these circumstances, traders could become price insensitive and fail to respond to lower asset prices or interest rates, thereby rendering monetary policy ineffective. In short, rising cortisol levels among traders and investors may promote risk aversion during a bear market, exaggerating the market's downward move.

94. S. Kademian, A. Bignante, P. Lardone B. McEwen & M. Volosin, 'Biphasic effects of adrenal steroids on learned helplessness behavior induced by inescapable shock', *Neuropsychopharm* 30 (2005), 58–66 (doi:10.1038/sj.npp.1300577).

Could testosterone work in the opposite direction, encouraging irrational risk-taking during a bull market? This is a difficult question. Moderate levels, as described above, may promote effective risk-taking among animals and high-frequency traders. But higher levels may indeed carry increased costs such as encouraging excessive risk-taking. In studies related to the challenge hypothesis and the winner effect, animal behaviourists have found that the higher a male's testosterone level (either on account of the analogous forms of over-confidence and irrational risk-taking. The traders we observed experienced only moderate increases, although one trader, who enjoyed a 5-day winning streak during which he made over twice his daily average P&L, experienced a 75 per cent increase in mean daily testosterone. It is known that cortisol can rise to extreme levels, and for extended periods of time; but research on the costs of high physiological levels of testosterone in humans is rare. Nonetheless, some studies have found that physiological levels of testosterone are indeed correlated with risky behaviour,⁹⁵ sensation seeking⁹⁶ and the size of offers rejected in the Ultimatum Game, rejections often considered as

95. A. Booth, D. Johnson & D. Granger, 'Testosterone and men's health', *J. Behav. Med.* 22 (1999), 1–19 (doi:10.1023/A:1018705001117).

96. R. Daitzman & M. Zuckerman, 'Disinhibitory sensation seeking personality and gonadal hormones', *Pers. Individ. Differ.* 1 (1980), 103–110 (doi:10.1016/0191-8869(80)90027-6).

violations of economic rationality.⁹⁷ Other studies with users of anabolic steroids, or subjects administered pharmacological doses of testosterone, have found evidence of manic behaviour.⁹⁸ In one study, researchers administered testosterone to a group of women playing the Iowa Gambling Task⁹⁹ and found that it shifted risk preferences to such an extent that the women switched from playing the low variance and positive expected-return decks of cards to the high variance but negative expected-return decks. A similar result was found in a physiological study in which the performance of young males on the Iowa Gambling Task was negatively correlated with their testosterone levels.¹⁰⁰ These study results suggest that elevated levels of testosterone could at some point begin to impair rational financial decision-making.

97. B. Van den Bergh & S. Dewitte, 'Digit ratio (2D:4D) moderates the impact of sexual cues on men's decisions in ultimatum games', *Proc. R. Soc. B* 273 (2006), 2091–5 (doi:10.1098/rspb.2006.3550); T. Burnham, 'High-testosterone men reject low ultimatum game offers', *Proc. R. Soc. B* 274, 2327–30 (doi:10.1098/rspb.2007.0546).

98. H. Pope & D. Katz, 'Affective and psychotic symptoms associated with anabolic steroid use', *Am. J. Psychiatry* 145 (1988), 487–90; H. Pope, E. Kouri & J. Hudson, 'Effects of supra-physiologic doses of testosterone on mood and aggression in normal men: a randomized controlled trial', *Arch. Gen. Psychiatry* 57 (2000), 133–140 (doi:10.1001/archpsyc.57.2.133).

99. J. van Honk, D.J.L.G. Schuttera, E.J. Hermansa, P. Putmana, A. Tuitena, H. Koppeschaar, 'Testosterone shifts the balance between sensitivity for punishment and reward in healthy young women', *Psychoneuroendocrinol.* 29 (2004), 937–43 (doi:10.1016/j.psyneuen.2003.08.007).

100. R. Reavis & W. Overman, 'Adult sex differences on a decision-making task previously shown to depend on the orbital prefrontal cortex', *Behav. Neurosci.* 115 (2001), 196–206 (doi:10.1037/0735-7044.115.1.196).

4. CONCLUSION

Taken together, the findings surveyed in this review suggest the possibility that economic agents are more hormonal than is assumed by theories of rational expectations and efficient markets. These theories assume, for example, that prices in financial markets accurately reflect all available information. But a trader's interpretation of information may not be stable: a trader with high levels of testosterone may see only opportunity in a set of facts; while the same trader with chronically elevated cortisol may find only risk. Furthermore, risk preferences may not be stable. If traders are subject to a financial variant of the winner effect, such that rising levels of testosterone increase their appetite for risk during a bull market, and rising levels of cortisol decrease their appetite for risk during a bear market, then steroid hormones may shift risk preferences systematically across the business cycle. This effect, even if confined to a small number of people, could destabilize the financial markets.¹⁰¹ The hypothesis of steroid feedback loops exaggerating market moves raises the further possibility that the emotions of irrational exuberance and pessimism (what the economist John Maynard Keynes called 'animal spirits') commonly blamed for financial instability may in fact be steroid-induced shifts in confidence and

101. C. Camerer & E. Fehr 'When does "economic man" dominate social behavior?', *Science* 311 (2006), 47–52 (doi:10.1126/science.1110600).

risk preferences. This is not to say hormones cause bubbles and crashes; advances in technology, for example, caused the bull markets of 1920s and the Dotcom era, but hormones may exaggerate moves once under way.

The study of hormonal influences is, we believe, an important step in the ongoing project, beginning with behavioural economics and continuing with neuroeconomics, of showing how the body influences economic decisions, frequently pushing economic agents, for good or ill, away from rational choice. The research, moreover, carries intriguing policy implications: if hormones affect risk-taking, then perhaps financial markets can be made more stable by having a greater endocrine diversity in the financial industry. How do we achieve endocrine diversity? Hormone levels change over the course of our lives, with testosterone and oestrogen declining, and cortisol increasing; so young and old have markedly different endocrine profiles. The sexes as well have very different endocrine systems. Market stability is served by opinion diversity; so it may be served as well by having more balance in the banks between young and old, men and women. One does not need to argue that one group is better than others for this policy to work; merely different.¹⁰² However, there are grounds for thinking that women may be less 'hormonally reactive' when it comes to financial risk-taking. For example, women have only

102. Dreher et al., 'Menstrual Cycle phase modulates...'

5–10 percent of the circulating levels of testosterone of men, and they have not been exposed to the same organizing effects of pre-natal androgens. Furthermore, some studies have found that women's HPA axes are less reactive to stressors stemming from a competitive situation.¹⁰³ Their greater presence in the ranks of money managers may therefore help dampen hormonal swings in the market.

Lastly, the endocrine system may be the missing link in the new field of neuroscience and economics, connecting market events to brain processes.¹⁰⁴ If research in endocrinology, especially work done with animal models, were to be wedded to recent developments in neuroscience and economics, we could begin to approach a unified scientific subject, from molecule to market.¹⁰⁵

103. L. Stroud, P. Salovey & E. Epel, 'Sex differences in stress responses: social rejection versus achievement stress', *Biol. Psychiatry* 319 (2002), 318–27 (doi:10.1016/S0006-3223(02)01333-1).

104. X. Caldú & J. Dreher, 'Hormonal and genetic influences on processing reward and social information', *Ann. NY Acad. Sci.* 1118 (2007), 43–73 (doi:10.1196/annals.1412.007).

105. B. McEwen, 'From molecules to mind: stress, individual differences, and the social environment', in *Unity of Knowledge: The Convergence of Natural and Human Science* (eds A. Damasio et al.), *Ann. NY Acad. Sci.* 935 (2001), 42–9 (doi:10.1111/j.1749-6632.2001.tb03469.x).

On Cunning Automata: Financial Acceleration at the Limits of the Dromological¹

Nick Srnicek and Alex Williams

*Man is a being that does things such as feeling happiness, playing the violin, going for a walk, and all sorts of other things which are simply not needed. [...] The best sort of worker is the cheapest worker. The one that has the least needs. What young Rossum invented was a worker with the least needs possible [...] He threw out everything that wasn't of direct use in his work, that's to say, he threw out the man and put in the robot.*²

KAREL ČAPEK, 1920

*We would like to explore the possibility that the need for [financial] specialists, market makers, and block positioners can be eliminated almost completely by an efficiently operated computer exchange.*³

FISCHER BLACK, 1971

*For the replicants money is not a matter of possession, but of liquidity/deterritorialisation, and all the monetary processes on Earth are open to their excitement, irrespective of ownership.*⁴

NICK LAND, 1993

0. FROM THE CASINO TO THE WARZONE

Contemporary representations of finance are anything but complimentary. Chief amongst them is the image of ‘casino capitalism’, a popular ideologeme in the post-2008 media ecosystem of financial paranoia and fiscal crisis. While the term might serve some rhetorical purpose for the tattered remnants of what was once the left, it occludes the complexity, sophistication, and political centrality of the financial system in post-Fordist capitalism. Moreover, it inevitably misses the relationship that actually obtains between gambling and finance: in this figuration, who are the punters and who is the house? If the work of sociologists of finance (paradigmatically, Donald MacKenzie)⁵ has anything to teach us here, it is that the slippery reflexivity of financial models, the lawless shadow banking system of OTC derivatives, and the ruthless market manipulation of leading investment banks all engender a system far more corrupt and non-transparent than even the most

1. The authors acknowledge the valuable input of Antoine Bousquet, Mark Fisher, Graham Joncas, Ned Molloy, and Jared Woodard. We extend special thanks for the invaluable heretical inspiration of Reza Negarestani and Benedict Singleton in the construction and refinement of this piece.

2. K. Čapek, *R.U.R. (Rossum's Universal Robots)* (USA: Createspace, 2012), 12.

3. F. Black, ‘Toward a Fully Automated Stock Exchange’, *Financial Analysts Journal* 27:6 (December 1971): 25.

4. N. Land, ‘Machinic Desire’, in *Fanged Noumena: Collected Writings 1987–2007*, ed. R. Mackay and R. Brassier (Falmouth: Urbanomic, 2011), 337.

5. D. MacKenzie, *An Engine, Not a Camera: How Financial Models Shape Markets* (Cambridge: The MIT Press, 2008).

stacked of Vegas poker tables. Moreover, this gambling metaphor also entirely conceals the significant technical innovations generated by the financial sector in the last decade. These novelties depose the image of the casino as a stable set of probabilities, replacing it with a new regime in which technology redefines the risk landscape itself. This new financial universe of warring technical engines, trading as close to the speed of light as possible, comes into view with the relatively recent appearance of high-frequency trading (HFT).

This concern of this essay is the universe HFT has created, its inner dynamics and its external effects. It will draw out a distinction between two regimes of what can be termed acceleration: *dromological acceleration* versus *universal acceleration*. This distinction turns on the differend between a fundamentally brainless increase in speed, and an alternative notion of a rational acceleration capable of navigating a more complex universal space of alternate possibilities. Differentiating between the dromological and the universal allows us to uncover the essential problem with the conceptual and technological regime underpinning HFT—that of the computational algorithm—and, along the way, to touch upon the suppressed history of cunning. In so doing, it indicates a more sweeping financial, social, and political acceleration to come.

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1. FOR A FULLY AUTOMATED EXCHANGE

The dream of a fully automated exchange has been floated in financial circles for decades now, with Fischer Black reflecting on eliminating the fleshy parts of financial markets as early as 1971.⁶ The past decade has finally seen this potential become actual. The Securities and Exchange Commission opened the path for electronic exchanges in 1998, in what should perhaps retroactively be identified as a second financial ‘big bang’. The process of decimalisation (the shift from fractions to decimals in the pricing of securities) in the 2000s accelerated this process further. It reduced the spread between buy and sell prices of securities, making profits harder to attain for market-makers,⁷ which subsequently spurred a need to move toward larger trades to alleviate the smaller spreads. With the rise of direct market access (allowing investors to bypass mediators between themselves and the exchanges) and the construction of entire automated infrastructures, a major comparative advantage arose for firms possessing the latest technology.⁸ Today, automation has infiltrated every aspect of the trading process:

6. Black, ‘Toward a Fully Automated Stock Exchange’.

7. M. Durbin, *All About High-Frequency Trading* (New York: McGraw-Hill, 2010), vi.

8. The competitive advantage of speed has been a constant of financial markets. Upon the South’s defeat in the American Civil War, for instance, one financier chartered the fastest boat possible in order to travel across to Europe and profit from the news before the information reached anyone else.

trade analysis, execution, and post-execution processing. The entire process can be—and in some cases, is—run by algorithms. While there is a diverse ecology of financial players who incorporate these robots (for instance, those simply looking to liquidate large positions, or those looking to track indexes), at the cutting edge of this financial automation are those groups involved in high-frequency trading. Speed has always been crucial to financial markets, but the technological arms race that has emerged in the 2000s has brought about entirely inhuman speeds.

In HFT systems, profits are extracted from the continual churning of portfolios—trade decisions are made and executed in milliseconds, microseconds, even nanoseconds. The latest iX-eCute chip from Fixnetix processes trades in just 740 nanoseconds.⁹ Given that a blink of an eye takes around 250 milliseconds, this means that this chip can complete over 330,000 trades in the literal blink of an eye. Conscious acknowledgment and reaction to an event requires approximately 500–1000 milliseconds (or 1 second). Yet HFT is reaching into temporal depths of nanoseconds (1 billionth of a second).

The growing status of HFT can be indexed by the fact that the average daily volume of the NYSE increased 300 percent over the period of 2005–9, while the number of daily trades increased 800 percent over the same period.

9. <http://www.fixnetix.com/services/innovation/>.

Meanwhile the average time for a trade execution dropped from 10 seconds to 0.7 seconds over the same time period.¹⁰ Similar trends holds in the London Stock Exchange as well.¹¹ In short, high-frequency trading has arrived as an influential force in modern markets. Common estimates now routinely state that HFT accounts for over 70 percent of equity markets volume in the us, and over a third in the UK, with this set to rise in the near future.¹² According to most estimates, the profits to be made from HFT are relatively minimal—a few billion dollars at most¹³—an amount that pales in comparison to more lucrative ventures in the financial world. Yet there is a relative certainty about the profits to be made—meaning that once a machine is set up, it becomes a secure source of income.¹⁴

The precise composition of human and nonhuman entities in a HFT system varies, but at the extremes some firms refuse any human intervention in their automated processes. Instead, machine-readable data continuously flows into the algorithms and trading decisions

10. Durbin, *All About High-Frequency Trading*, vi–viii.

11. D. Beunza et al., *Impersonal Efficiency and the Dangers of a Fully Automated Securities Exchange* (UK: Foresight, Government Office for Science, 2011), 5.

12. *The Future of Computer Trading in Financial Markets* (UK: Foresight, Government Office for Science, 2011), 2.

13. M. Kearns, A. Kulesza, and Y. Nevmyvaka, 'Empirical Limitations on High Frequency Trading Profitability', SSRN Electronic Journal (2010), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1678758.

14. D. Cliff, D. Brown, and P. Treleaven, *Technology Trends in the Financial Markets: A 2020 Vision* (UK: Foresight, Government Office for Science, 2011), 13.

are made automatically.¹⁵ Any human involvement merely complicates the process of understanding where errors and problems have arisen from; the purity of the automation is necessary for assessment. The overall trend is towards this hegemony of automation, purifying the financial world of human decision-making much as the first wave of industrialisation purified many traditional crafts. One UK government document foretells of a ‘depopulation of trading floors’ as robots increasingly take over the financial world.¹⁶

2. THE RACE TO ZERO

The abstract diagram of an individual HFT trading system is comprised of three components: trading strategies, mathematics embedded in software programs, and technological infrastructure. In terms of infrastructure,

[HFT systems] are perfect examples of so-called distributed, real-time systems, borrowing patterns from the field of complex event processing, with thousands of individual programs running on just the right number of computers in just the right number of data centres. They buck the decades-long trend of packing more and more processing onto a computer’s

15. E. Perez, *The Speed Traders* (New York: McGraw Hill, 2011), 129–30.

16. Cliff, Brown, and Treleven, *Technology Trends*, 36.

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CPU, favouring the seemingly backward approach of delegating some computing tasks to specialised hardware. They even take over the massively parallel processing capability of graphical processing units—game cards, in essence—for financial computations.¹⁷

The material infrastructure of these systems is intrinsically distributed and networked, while the software is dependent on the modularity of the components and their loose coupling via relatively simple communication networks.¹⁸ Software engineers have developed such systems in order to maintain resiliency and flexibility in changing circumstances. The operating systems used are stripped down to their bare functional minimum in a further effort to decrease computation times. An entire artform of coding and sculpting of functionality produces machines that are finely honed for speed. The creation of an HFT system involves closely tuning every programming instruction, from how memory is handled and released, to how individual data points are manipulated, how databases are searched, how inputs are received and sorted, and so on. At the extreme, algorithms are physically instantiated in the silicon chips themselves: hardware and software united as one.¹⁹ The drive to extract every

17. Durbin, *All About High-Frequency Trading*, 8.

18. *Ibid.*, 101–2.

19. Cliff, Brown, and Treleaven, *Technology Trends*, 19.

surplus nanosecond results in a painstaking process of optimization.

This functional core of the infrastructure is in turn networked to exchanges situated around the world. While the popular perception portrays Wall Street as the central location of global finance, it is in fact New Jersey and Chicago where much of American finance is corporeally instantiated. High-frequency trading hubs such as NYSE's facility in Mahwah house many of the largest exchanges' matching engines—the computers used to match, buy, and sell orders collected from around the world.²⁰ There is a physical centrality to distributed global finance, and, unsurprisingly, these locations are heavily protected as a component of the nation's critical infrastructure.²¹ This necessarily corporeal existence marks out such facilities as key nodes for the virtual networks of HFT systems: Since electronic signals are sent as bursts of light over optical fibres, the distance between sender and receiver is a key variable for latency. It takes at least eighteen milliseconds for a signal to travel at the speed of light from New York to London. While seemingly innocuous, such a gap is time enough for a New York trader to register new data and act on it before a London trader even sees it.²²

20. Durbin, *All About High-Frequency Trading*, 16.

21. D. MacKenzie, 'How to Make Money in Microseconds,' *London Review of Books*, May 19, 2011, 16.

22. Cliff, Brown, and Treleaven, *Technology Trends*, 15.

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In order to overcome this fundamental physical limit, firms fight, cheat, and literally carve holes in walls in order to colocate and be as physically close to the matching engines as possible. The concern to maximise profit renders it imperative to compress spatial relations in the most efficient way possible—all in order to shave millionths of a second off trade times.

This speed imperative extends to the ways in which HFT systems communicate and interact with matching engines. Beyond physical proximity, there emerges a synthesis of the computing systems themselves. HFT systems are becoming parasitical upon their infrastructure—carefully designed to adapt to the specificities of their ‘hosts’. The imperatives of acceleration demand that any intermediaries be negated. For instance, rather than operate through intermediary services, HFT systems are likely to use direct market access with exchanges in order to immediately receive market data and execute trades. Similarly, in communicating with exchanges, HFT systems will replace the industry standard language (Financial Information eXchange Protocol, or FIX) with their own language adapted specifically to communicate directly with the exchange’s native application programming interface (API).²³ The elimination of the interpretation process between message formats (from FIX to the native API) shaves

23. Durbin, *All About High-Frequency Trading*, 122.

hundreds of microseconds off the latency. Physical colocation meets coding unification.

However, while this colocation imperative tends to centralise HFT systems, they are simultaneously decentred by the need to interact with multiple exchanges. Arbitrage opportunities and correlated products exist across exchanges as well as within them, and any profit-seeking firm with sufficient resources will seek to explore these possibilities. The architecture of HFT systems becomes crucial here, since they must be deployed in strategic fashion to maximise the exchanges connected, while minimising the latency of the wide area network. While some of this traffic occurs via the public internet, most information about market prices and trades is disseminated through the Secure Financial Transaction Infrastructure (SFTI). Owned and maintained by a subsidiary of NYSE Euronext, SFTI provides the US with a private high-speed and highly-reliable computer network dedicated to market data. Some companies have gone further, however, and tunnelled their communications cables through mountains in order to shave microseconds off the transmission time between New York and Chicago.²⁴ Other initiatives are looking to employ microwave dishes as a contender against fibre-optic cables.²⁵ Since all these forms of

24. Cliff, Brown, and Treleaven, *Technology Trends*, 14.

25. A. Troianovski, 'Networks Built on Milliseconds', *Wall Street Journal*, May 30, 2012, <http://online.wsj.com/article/SB10001424052702304065704577426500918047624.html>.

information transmission are limited by the speed of light, physicists have begun to triangulate the precise planetary coordinates of optimal trading locations.²⁶ Other researchers suggest fibre-optic cables are too slow, and recommend routing communication directly through the earth's core in order to avoid needlessly circumnavigating the surface. Within this speculative solution, the earth itself becomes an impediment, something to be hollowed out in order to facilitate the circulation of capital. Privatised particle accelerators would generate and encode neutrinos in order to bore a sub-molecular pathway through the earth—saving up to 44 milliseconds.²⁷

The dromological²⁸ dynamics of HFT emerge from their networked embodiment and the antagonistic arms race that impels its protagonists to turn the planet into a medium for capital circulation. As Virilio presciently declared, 'What is eliminated by speed is the earth'.²⁹ Assemblages of silicon logic-gates, neutrino messengers, and subhuman temporalities coexist for the ultimate purpose of accelerating financial

26. A.D. Wissner-Gross and C.E. Freer, 'Relativistic Statistical Arbitrage', *Physical Review E* 82 (2010).

27. B. Dorminey, 'Neutrinos to Give High-Frequency Traders the Millisecond Edge', *Forbes*, April 30, 2012, <http://www.forbes.com/sites/brucedorminey/2012/04/30/neutrinos-to-give-high-frequency-traders-the-millisecond-edge/>.

28. Virilio defines dromology as the science and logic of speed. P. Virilio, *Speed and Politics* (Cambridge: Semiotext(e), 2006).

29. P. Virilio, *Grey Ecology* (New York: Atropos Press, 2009), 91.

flows.³⁰ The macro-level picture is one of an entire evolving ecology of data centres and software programs supported by a highly optimized and condensed material infrastructure. These algorithms and finely-tuned HFT systems are at war with each other, competing for every nanosecond possible. A race to zero.³¹

3. STRATEGY AT THE SPEED OF LIGHT

This financial warfare carries over into the trading strategies employed by HFT firms. On an abstract level, HFT operates by determining the statistical likelihood of gaining on particular trades, and multiplying the small profits to be made from each individual transaction by carrying out large quantities of trades. The typical HFT trader generates profits through two main strategies: (1) making markets and scalping off the price differential between bid and ask prices, and (2) statistical analysis of price connections between different securities.

Market making consists of passive and active trading, specifically by taking the other side of orders with the aim of making markets more liquid.

30. In other words, finance joins the military as the leading technological accelerator.

31. A. Haldane, 'The Race to Zero' (presented at the International Economic Association Sixteenth World Congress, Beijing, China, July 8, 2011), <http://www.bankofengland.co.uk/publications/speeches/2011/speech509.pdf>.

The profit yielded by this strategy emerges in the difference between the bid and ask prices of a particular security. Passive trading involves inputting an order into the system without knowing whether another party is willing to take the other side, and HFT systems use programs called autoquoters in order to generate such submissions. On the other hand, active trading involves taking up the opposite side of already existing submissions in the order book using software called Electronic Eyes.³² With market making, there is a continual push to be the first to fulfil an order. As profits are made off the difference between the bid and ask prices, the risk is that, before a trader is capable of completing the roundtrip trade (buying and selling, or vice versa), prices will have moved against them, forcing them into a loss. With bid-ask spreads at historic lows, the margin for error here has become increasingly thin. Speed becomes essential, both to beat other market makers and to exit a trade and profit as quickly as possible.

By contrast, the statistical arbitrage strategy relies on the general notion of arbitrage: the ostensibly risk-free profit made by taking advantage of price differences for similar products in different markets. The traditional form of statistical arbitrage involves pairs analysis—the recognition of a correlation between two securities in order to profit off of any changes in one

32. Durbin, *All About High-Frequency Trading*, 28–9.

part of the pair. For instance, if security X is positively correlated with security Y, then one can expect that a rise in X will soon lead to a rise in Y. A trader purchases Y before this rise, and then gleans the small profit to be made once it does rise. Statistical arbitrage traces these correlations according to two types of relations, structural and systematic. The former refers to the relatively stable correlations that exist between an index and the stocks that comprise it. The latter, by contrast, refers to the more fleeting correlations that hold between different sectors, regions, and markets, as well as securities affected by common underlying factors like interest rates, energy prices, and weather patterns.³³ In this regard, complex statistical arbitrage strategies involve encoding inferences about these relations between securities. As Donald Mackenzie recounts,

One example of such a pattern, explained to me by a former statistical arbitrageur, involved the shares of Southwest Airlines, Delta and ExxonMobil. A rise in the price of oil would benefit Exxon's shares and hurt Delta's, while having little effect on Southwest's (because market participants knew that, unlike Delta, Southwest entered into hedging trades to offset its exposure to changes in the price of oil).³⁴

33. Perez, *The Speed Traders*, 204.

34. MacKenzie, 'How to Make Money in Microseconds', 16.

Any price violation of this inferential relationship would be almost instantaneously recognised by statistical arbitrageurs (particularly HFT systems) and arbitrated away for an ostensibly risk-free profit. In order to make such inferential connections profitable, one must discover relationships that are statistically significant, yet not so obvious as to have already been exploited by other firms.³⁵

Contemporary statistical arbitrage is comprised not just of pairs analysis, but also of highly complex sets of correlations between vast numbers of securities organised by sectors, regions, and markets. In the most advanced cases, petabytes of data are analysed by server warehouses in order to uncover linear and nonlinear correlations between massive sets of securities.³⁶ Other strategies encompass predictive analytics that monitor real-time data flows and calculate near-term likely outcomes on the basis of them.³⁷ Regression equations are used to uncover the precise statistical relations between these entities, which are then used to model the web of tightly woven prices seen in contemporary financial markets.

35. D. MacKenzie, D. Beunza, and I. Hardie, 'The Material Sociology of Arbitrage', in *Material Markets: How Economic Agents Are Constructed* (Oxford: Oxford University Press, 2009), 85–108.

36. Cliff, Brown, and Treleven, *Technology Trends*, 21.

37. *Ibid.*, 22.

5. THE RHYTHM OF THE NONHUMAN

As relatively autonomous agents, HFT systems interact in complex ways and produce emergent phenomena such as flash crashes and ultrafast black swans.³⁸ There has also been evidence of periodic 1000-millisecond cycles where trading surges arise from the interactions of HFT agents.³⁹ These are the emergent rhythms of an automated financial ecology. In the words of one complexity research paper, these development demonstrate there has been ‘a new fundamental transition from a mixed phase of humans and machines, in which humans have time to assess information and act, to an ultrafast all-machine phase in which machines dictate price changes’.⁴⁰ For the authors, this transition entails a shift from an ecology where the number of trading strategies is greater than the number of participants, to an ecology where strategies are clustered together and subsequently produce herding patterns.⁴¹ The result is the ultrafast black swans that emerge at nonhuman temporalities. The concentration of trading strategies that leads to this outcome is not a necessary feature of automated trading, however. The implementation of

38. N. Johnson et al., ‘Financial Black Swans Driven by Ultrafast Machine Ecology’, arXiv:1202.1448 (February 7, 2012), <http://arxiv.org/abs/1202.1448>.

39. MacKenzie, ‘How to Make Money in Microseconds’, 16.

40. Johnson et al., ‘Financial Black Swans’, 5.

41. Ibid., 6–7.

learning algorithms, the development of more computing power, coding efficiency, and human expertise are likely to produce an increasing diversity of trading strategies in the future.

As Virilio, Serres and others have highlighted, with massive technological systems come accidents.⁴² Despite their infrequency, these are *normal* accidents insofar as they are statistically predictable. Algorithms will go wrong, errors will be made, and the physical destruction wrought by these accidents will be entirely predictable. Contemporary societies are invisibly shaped by algorithms—a recent traffic jam arising from an error in an algorithm is only one of the more mundane examples.⁴³ As one commentator warns, ‘Bad algorithms have no common sense and get easily caught in destructive loops’.⁴⁴ As a result, HFT trading systems are subject to stress-testing and quality assurance, along with periodical updates and bug fixes.

A significant degree of the concern over HFT has been focused on its capacity for virally spreading destabilising movements. Much as the October 1987 crash was fuelled (though not ignited) by automated trades, the regulatory nightmare is of a nonhuman force tearing

42. C. Perrow, *Normal Accidents: Living with High Risk Technologies* (Princeton: Princeton University Press, 1999).

43. ‘Computer Glitch Summons Too Many Jurors’, NPR, May 3, 2012, <http://www.npr.org/2012/05/03/151919620/computer-glitch-summons-too-many-jurors>.

44. Perez, *The Speed Traders*, 110.

down trillions of dollars of assets in seconds. (The May 2010 Flash Crash saw over a trillion dollars of market value evaporate in under ten minutes.) Yet as Alexander Galloway and Eugene Thacker note, ‘out of control is a misnomer. These are not networks that are somehow broken but *networks that work too well*’.⁴⁵ In a financial world increasingly operated via computational algorithms, we might need to reframe our notion of what control is. That being said, should anything go wrong, one can envision a wave of insolvency eliminating entire populations of firms (a possibility that already wiped out a significant portion of the statistical arbitrage population in 2009).⁴⁶ Similar occurrences happen on a smaller scale: in 2003, a trading firm made itself insolvent in sixteen seconds by accidentally turning on an algorithm. It took them a further forty-seven minutes to realize their act of self-annihilation.⁴⁷

The risk of contagion is heightened by the fact that this emergent network is tied together by the (normative, not causal) law of arbitrage. This law—that any security should have the same price in every market—is the condition for speaking of a market and its moods.

45. A. Galloway and E. Thacker, *The Exploit: A Theory of Networks* (Minneapolis: University of Minnesota Press, 2007), 6.

46. J. Doyne Farmer and S. Skouras, *An Ecological Perspective on the Future of Computer Trading* (UK: Foresight, Government Office for Science, 2010), 17–18.

47. C. Clark, *Controlling Risk in a Lightning-Speed Trading Environment*, Policy Discussion Paper Series (Federal Reserve Bank of Chicago Financial Markets Group, 2010), 3.

These pricing interconnections operate not just across markets, but across related entities.

The web of subtle but inviolable pricing relationships among securities in the equity super-market is vast, complex, and dense. The web moves continuously across time, changing shape and composition but always remaining bound together as one massive market.⁴⁸

By accelerating the creation of arbitrage-free relations across exchanges and asset classes, the statistical arbitrageurs of HFT actively construct a single massive market that involves stocks, futures, options, and more complex derivatives. As more HFT strategies become premised on statistical arbitrage and predictive correlations, these markets are increasingly interconnected.⁴⁹ In standard complex systems, the rise of interconnectivity entails the rise of mechanisms for propagating volatility. As one security becomes mispriced, its statistically arbitrated connections to other entities can become mispriced as well, generating a possible wave of misrecognition throughout the market.

These dynamics are sped up by the emergent arms race as HFT firms compete to eliminate latencies.

48. Durbin, *All About High-Frequency Trading*, 37.

49. This is a materialisation of the SEC's intended goal of producing a single national market for the US, and which is shaped most notably by Regulation NMS.

Yet while the exploration of market space for infinitesimal profit margins is quickened by the evolution of HFT ecologies, counterforces are being called forth as well. It has been suggested that by sensing the split-second early warning signs, government regulator algorithms could moderate the system's volatility through directed interventions.⁵⁰ A space for human ingenuity remains as well, as individuals discern and exploit algorithmic errors in order to generate profits.⁵¹ The landscape presented here is therefore one of competing profit-driven algorithms managed by equally posthuman government regulator algorithms combined with the remnants of the human trading population.

5. ALIEN MAPS FROM A CHINESE ROOM

In understanding the nature of HFT a crucial distinction must be drawn between sheer information processing and thinking.⁵² Thought requires at least a special class of information to be processed, *semantic* information, rather than the bare processing of data. Entities as diverse as geological processes, ants, and

50. Johnson et al., 'Financial Black Swans', 9.

51. M. Stothard, 'Day Traders Expose Algorithm's Flaws', *The Globe and Mail*, May 16, 2012, <https://www.theglobeandmail.com/globe-investor/day-traders-expose-algorithms-flaws/article2434717>.

52. R. Brassier, 'Concepts and Objects', in *The Speculative Turn: Continental Materialism and Realism*, ed. L. Bryant, N. Srnicek, and G. Harman (Melbourne: re.press, 2011), 49.

thermostats, may be seen as processing information,⁵³ but it would be inaccurate to suggest that they think, or more specifically perhaps, *understand*. To suggest this is to recall John Searle's Chinese Room Argument, where a human who speaks only English is locked inside a sealed room, handed input questions in Chinese, and uses a codex to routinely transform the Chinese questions into Chinese outputs, without ever understanding the meaning of either the questions or the outputs.⁵⁴ Whilst to a Chinese speaker it would appear as if the denizen of the room were fluent, in fact they are simply following a series of instructions to effectuate the necessary linguistic transformations.

In the same fashion, the algorithms of HFT systems encode the results of chains of inferences made by quantitative finance experts, but in themselves they operate solely at an informational level. They remain subject to the limits of computational reason.⁵⁵ Segregated from the cognitive processes embedded in human beings, these systems are effectively pure data calculators, blindly outputting diagrams of the hidden connectivity beneath the morass of complex financial

53. See M. DeLanda, *A Thousand Years of Nonlinear History*, (New York: Zone Books, 1997). Note, however, that this computational vision of nature is ultimately problematic: see section 7 below.

54. J. Searle, 'Minds, Brains and Programs', *Behavioral and Brain Sciences* 3:3 (1980): 417–457.

55. G. Longo, 'Critique of Computational Reason in the Natural Sciences', in *Fundamental Concepts in Computer Science*, ed. E. Gelenbe and J.-P. Kahane (London: Imperial College Press, 2009).

transactions that make up the everyday churn of the markets. This cognitive map etched into the real by HFTs exceeds any other in terms of a detailed charting of the cross-relationality of securities, derivatives, FX swaps, and other financial instruments.

As we have seen, in addition to mapping relations invisible to even the most highly trained human eye, hfts are able execute trades based upon these maps in the interstices between nanoseconds. Indeed, the speed and potential volatility involved in HFT mean that it can effectively render human perception blind in times of crisis. A low frequency trader's perception of the market comes via price signals—the order book of any particular exchange. Yet HFT systems' ability to react quicker to changes in these signals means that by the time a human mind is consciously aware of a price, HFT systems have already drastically transformed it.⁵⁶ This is particularly crucial at points of high volatility and low liquidity (i.e. times of crisis). The limited organic perceptual capabilities of the human body render it lamentably lethargic by comparison.

56. Haldane, 'The Race to Zero', 13.

6. THE LANDIAN NOMOS AND TWO REGIMES OF ACCELERATION

Bereft of semantic content, what is occurring in HFT? A pure manipulation of data—numbers reacting reflexively to each other according to a nervous system of automated algorithms, with the classic role of the market-maker—to provide liquidity for long-term investors—ultimately subtracted. In an apotheosis of *non-sense*, (but not, it must be noted, *nonsense*), one is left with the purely machinic mechanism of trading for trading's sake.⁵⁷ This landscape of machine-machine trading and dynamic numerical abstraction constitutes a kind of financialised *nomos*—defined by accelerationist philosopher Nick Land as a field of asignifying numbers reacting and inter-reacting with each other in a nonrepresentational space. Land claims such asignifying practices are not entirely anti-rational, as they maintain a nonconceptual intelligibility.⁵⁸ As Land puts it, numbering practices as emergent anti-logos are 'no sooner in the head than on fingers and pebbles [...] always happen[ing] on the outside'⁵⁹—perhaps even originating in the prepersonal encounter of the body with its spatial environment. The machinic *nomos*

57. Durbin, *All About High-Frequency Trading*, 180–81.

58. R. Mackay and R. Brassier, 'Editors' Introduction', in N. Land, *Fanged Noumena*, 21.

59. N. Land, 'Mechanomics', in *Fanged Noumena*, 508.

instantiated by HFT systems is the latest technical upgrade to a set of practices that have always, in some sense, been defined by their externality.

Speeding up numerical culture, HFT systems are vectors of *eversion* (turning inside out) of the previously anthropocentrically explicable processes of capital. As Land puts it: ‘as capital evolves, the increasingly absurd rationalization of production-for-profit peels away like a cheap veneer from the positive-feedback detonation of production-for-production’.⁶⁰ This is the financial sublime in its ultimate contemporary form, the miserly rationalism of the capitalist figure (accumulation for accumulation’s sake) transposed into a rigorous and inhuman register. HFT embodies this process—indeed, its existence is premised not on holding and maintaining stocks grounded in some fundamental value, or anything so naïve as a belief or intentional attitude towards anything as such, but on mindlessly accelerating the essential metabolic processes of the markets themselves, eliminating price discrepancies and arbitrage opportunities while enhancing liquidity.

It is only today that Land’s long-mooted inhuman planetary intelligence has a legitimate candidate instantiation: ‘silicon viro-finance automatisms’ apparently rendered business reality.⁶¹ Where humans remain too

60. N. Land, ‘Making It with Death: Remarks on Thanatos and Desiring-Production’, in *Fanged Noumena*, 265.

61. N. Land, ‘Machinic Desire’, in *Fanged Noumena*, 337.

slow—too *fleshy*—to push beyond certain temporal, perceptual, and quantitative barriers, HFT systems surge past, generating the fine nanoscale structure of modern financial markets, too intricate for the naked mind to observe. With a long-term tendency for the rate of profit to fall, the desperation of firms to maintain their share of decelerating global growth is revealed by the elaborate measures taken to shave nanoseconds from trades.⁶² And in a sense that would no doubt please Land himself, no lasting value is created beyond *the acceleration of the process itself*.

But it is for this very reason that, although HFT might superficially appear a plausible contender for emergent accelerationist singularity, there remain some fundamental constraints which render it, in its present form, highly unlikely to take on this role. The roots of these constraints lie in a division, at the level of the meaning of ‘acceleration’ itself, between two distinct regimes. The first of these is the purely *dromological* (in the sense derived from Virilio): a linear quantitative ramping up of speed or ability, which must be identified with Land’s own accelerationism. Within the paradigm that defines the financial gamespace, more is always better. And while these dromological shifts have important dynamic effects (effects which are not entirely predictable in advance), at no point does

62. A. Kliman, *Reclaiming Marx’s Capital: A Refutation of the Myth of Inconsistency* (Lexington Books, 2007).

such a regime call into question the basic rules under which it operates. Capital, and its ultimately tedious logic of accumulation, remains.⁶³ However, as Reza Negarestani has indicated in recent work, there exists another regime of acceleration, a *universal acceleration*.⁶⁴ We here distinguish between a mere increase in speed within a localised horizon, (dromological acceleration = increasing intensification of the value form of late capitalism) and a mode which goes beyond brainless speed to navigate within a larger, global space of possibilities (universal acceleration).⁶⁵

In any arms race, the ultimate advantage comes not in simply dominating an agreed space of competition, but in redefining this space so as to change the very rules under which the game itself is played. This necessarily involves a transposition from one conceptual register or spatial local horizon, and into other potential localities or logics.⁶⁶ The entity capable of transforming the ‘transcendental’ that organizes a

63. N. Land, ‘Critique of Transcendental Miserabilism’, in *Fanged Noumena*, 623–7.

64. R. Negarestani, ‘Abducting the Outside’, talk at Miguel Abreu Gallery, New York, November 2012. Negarestani also refers to an ‘Oresmean Acceleration’ of epistemic sabotage leading to destabilisation of equilibrium regimes, generating new opportunities to explore the universal conceptual space.

65. R. Negarestani, ‘Globe of Revolution. An Afterthought on Geophilosophical Realism’, *Identities: Journal for Politics, Gender and Culture*, 17 (2011): 25–54.

66. Such shifts are inherently experimental and riven with contingency, being by their nature abductive transitions. See Negarestani, ‘Abducting the Outside’.

world will be able to define the rules of the games to be played within such a world, and hence to exert control over those who are incapable of such manoeuvres.

7. THE LIMITS OF DROMOLOGY AND THE RISE OF CUNNING

The universal regime of acceleration is particularly significant as HFT reaches the outer limits of dromological acceleration. To be certain, short of a properly apocalyptic economic collapse, there is no reversing the actualisation of machine trading. In many respects, these systems simply take tendencies that have always existed and accelerate them beyond human perceptual capacities. Any humanist critique of these impersonal forces has no purchase on them. Yet limits will be reached on the dromological level (via either regulatory rules or physical laws), and the competitive advantage of speed will eventually evaporate. Perhaps most worrying for the current HFT paradigm are the fundamental limits imposed by physics—namely, the impossibility of beating speed of light communication, and thereby the unfeasibility of defeating competitors who can operate at the same speeds. The dynamics of purely dromological competition cannot surpass this limit. This is in addition to the declining marginal profitability of each increment of increased velocity, given the exorbitant expense involved in running

close to this speed limit. Operating under these constraints, HFT systems will need to move beyond iterative dromological acceleration to a more intelligent paradigm—from brain-dead computation to cunning automata. To explain why cunning in particular, rather than another form of intelligence, we must detour through the buried history of cunning itself.

As the anomalous design theorist Benedict Singleton has recently argued, it is precisely in cunning that we can locate the occluded origins of a certain mode of technologised expertise.⁶⁷ In defining cunning, Singleton recounts Plato's ban on the creation of hunting traps, on the grounds that the form of intelligence lying behind the practice of trapping would inculcate a sinister and socially deleterious political sensibility. This suppressed form of intelligence known as *mêtis* (as opposed to *poesis* or *techne*) denotes 'skill with materials guided by a kind of cunning intelligence', and is identified strongly with the figuration of the trickster in ancient mythology.⁶⁸ *Mêtis* is a mode of artifice that operates through devious and *well-timed* action, which brings into play the dynamic tendencies of the materials it works with. This style of intelligence operates in an improvisational fashion, implementing a sequence of contingent nested plots rather than an overarching plan.

67. B. Singleton, *On Craft and Being Crafty: Human Behaviour as the Object of Design* (PhD Thesis, Northumbria University, UK, 2012), chapter 4.

68. M. Detienne and J.-P. Vernant, *Cunning Intelligence in Greek Culture and Society* (Chicago: University of Chicago Press, 1974).

A sculptor, working in marble, may begin with a guiding aim (say, to sculpt an image of the Apollo); but the actual act of sculpting is, to a large extent, an improvisation based upon the specific contingencies within the grain of the material itself (for example, in the precise manner in which a shard of marble splinters apart from the main block). Mêtic practice entails a complicity with the material, a cunning guidance of the contingent (and unknowable in advance) latencies discoverable only in the course of action.

In the form of a trap, the material mêtis works to exploit is the behaviour of prey. The affordances towards which prey are most sensitive become vectors by which they can be manipulated and ensnared.⁶⁹ In this sense, mêtis is closely linked to the cunning of the predator. Indeed, Gilles Châtelet and Giuseppe Longo have even contended that the historical roots of mathematics, and its uncanny ability to track the real even in anticipation of empirical knowledge, is grounded in its gestural origins, and specifically in the eye-tracking geometric trajectories used by predators to trace the movement of prey.⁷⁰ It is not for nothing that xenobiologists anticipate that any alien intelligence we might eventually encounter will likely have evolved from a predatory species, and hence will intrinsically pose a significant danger to us.

69. Singleton, *On Craft*, 129.

70. F. Bailly and G. Longo, *Mathematics and the Natural Sciences: The Physical Singularity of Life* (London: Imperial College Press, 2010), 68.

The disconcerting moral valence of *mêtis*-as-trickster know-how, using deception and opportunism to overcome and manipulate complex material, is one potential destination of a technology developed for an industry of similarly questionable ethical status. Whereas most prior uses of HFT have relied upon mere quantitative force to obtain otherwise impossible arbitrage opportunities, large tranches of the upper human echelons of the financial services industry instead depend on an absolutely *mêtic* praxis, using all the skills of deception available to generate advantageous positions for their institutions.⁷¹

Indeed, finance is perhaps the predominant contemporary effectuation of what Singleton refers to as the *trickster logic of production*. The figure of the trickster is common to almost all pre-modern mythic traditions. Lewis Hyde gives a complete history of such characters, who include Loki (Norse), Prometheus (Greek), Monkey (Chinese), and Coyote (Amerindian), with echoes of the trickster even appearing in a more tame form in childhood folkloric figures like Brer Rabbit.⁷² Common to all tricksters is the use of a cunning

71. For a recent paradigmatic example of *mêtic* strategy by a financial institution, see the infamous Abacus 2007-AC1 CDO transaction masterminded by Goldman Sachs. The firm, working in consort with hedge fund client, Paulson & Company, selected underlying securities to generate a CDO which they knew was highly likely to collapse in value, which they then sold to their other clients. The deal lost the investors \$1 billion, but produced \$1 billion in profits for Goldman's collaborator. Goldman Sachs was eventually fined \$550 million by the SEC following an investigation of the deal.

72. L. Hyde, *Trickster Makes This World* (New York: Farrar Straus & Giroux, 1998).

intelligence to devise technology, deployed as a tool of the weak against the strong. The trickster logic of production is above all *inventive*, often weaponising empathy with its targets into an effective trap with which to ensnare them. The historical bildungsroman of financiers in Western history attests to the sector's mêtic capabilities. Evolving from the marginal (if not outright taboo) role of the usurer to the world's pre-eminent political-economic actor entailed the use of a series of elegant traps targeting far stronger entities (most obviously in the regulatory 'capture' of nation states).

Given dromological limits and the ultra-mêtic environment of the financial sector, HFT technology appears ineluctably drawn towards a future where it is cunning intelligence, capable of improvisation, psychological manipulation, and universal accelerationist strategy that will give maximal competitive advantage. Already, undercurrents of deception, manipulation, and creative cunning are rumbling beneath the iterative veneer of standard machine trading.

One of the basic methods by which an approximation of cunning is being built into HFT is in the strategies used: ultrafast orders can be manipulated to uncover the price and size of orders, even when these are not publicly listed on an exchange's order book. For instance, some algorithms are designed to uncover telltale signatures of other algorithms in

operation ('algo-sniffing'), thereby gaining competitive leverage over them. Other algorithms are already constantly evolving as they face up to a changing ecology of human and nonhuman traders.⁷³ Signs of this algorithmic battle of cunning are emerging in the inputs to these algorithms as well. One London-based hedge fund intently focuses on improving its data sets in order to draw out hidden correlations:

The company's London offices display charts tracking the prices of commodities going back hundreds of years, old maps and bank notes and even a dividend cheque from the 18th-century South Sea Company.

Winton sends researchers to libraries and archives across the world to find numbers held in books and on microfilms. It has found barley and sesame prices from ancient Babylon, and English wheat prices going back to 1209.

It now employs more than 90 researchers, including extragalactic astrophysicists, computer scientists and climatologists. The company hired a meteorologist who had researched the 'El Niño' phenomenon. The physics graduate—Winton wants to keep his name secret for fear a rival might poach him—works in London correlating weather data to crops such as

73. Haldane, 'The Race to Zero', 4.

corn, wheat and soybeans. That data can be used to forecast how prices might fluctuate with the weather.⁷⁴

Uncovering these obscure connections enables firms and algorithmic systems to gain leverage over others and manipulate their competitors and the markets accordingly. In the future, HFT systems are likely to be increasingly linked to the automated algorithmic sensing systems that are emerging in other parts of the economy (sentiment monitoring, consumer data analysis, etc.).⁷⁵ In this regard, some have looked to extend and integrate Semantic Web components into automated trading, making information more tractable for machine manipulation.⁷⁶ Beyond sentiment monitoring of large clusters of individuals, true semantic processing by machines would revolutionise algorithmic and high-frequency trading.

In other areas, genetic algorithms are being used to search out the space of possible combinations and uncover the optimal tuning for each parameter.⁷⁷ Set in a virtual space, hordes of algos are released into a competitive free-for-all, with the winners subsequently

74. T. Wilkes and L. Fletcher, 'The Algorithmic Arms Race', Reuters (London, May 21, 2012), <http://www.reuters.com/article/2012/05/21/us-trading-blackbox-idUSBRE84K07320120521>.

75. *Sentiment Analysis And Social Media Monitoring Solution RFP, Request for Proposal* (Event-6994) (Federal Reserve Bank of New York, 2011).

76. Cliff, Brown, and Treleven, *Technology Trends*, 22–3; T. Berners-Lee, J. Hendler and O. Lassila, 'The Semantic Web', *Scientific American*, May 2001.

77. Cliff, Brown, and Treleven, *Technology Trends*, 30.

being unleashed in real markets. At this point, the algorithms can quickly extend beyond human capacities to understand—rather than ten variables that have to be calibrated, there can easily be hundreds or thousands of variables. The capacity for self-reflection, learning, and automating the evolutionary process opens the space for increasingly nonhuman algorithms. At this point, one cannot even protest that at least a human programmed it.

As the algorithms become more sophisticated, so the jobs of maintaining them and of fine-tuning them to current market conditions, will become more involved. This would be a problem if skilled humans are required to perform the fine-tuning, but the likelihood is that in the future the design of new algorithms, and the tuning and optimization of existing ones, will also be an automated process, performed by computers. Rather than hiring programmers to write new algorithms, trading institutions will instead in future hire programmers to write the computer systems that design the new algorithms and then fine-tune their subsequent operation.⁷⁸

Such algorithms can evolve beyond their creator's intentions and take on a life of their own. Such a technology already exists, in the form of a computer program called Eureqa, which analyses raw data and produces equations without any human oversight.

78. Ibid., 29.

Given a desktop computer and a few hours, Eureka reproduced Newton's equations. With more powerful computers and more time, Eureka is being used in fields where being overwhelmed by data is a real problem. In this way, the program produces equations and scientific statements unattainable by humans. As one scientist working with the program said, 'Eureka can even propose experiments that researchers would have difficulty imagining.'⁷⁹

Yet despite all of these approximations to the mêtic regime of universal acceleration, it remains highly questionable whether the basic computational substrate which HFT consists in is capable of fully supporting such developments. The evidence suggests that, whilst algorithmic complexity in HFT systems is increasing in an attempt to stake out a smarter and more cunning territory than that afforded by speed alone, we have yet to arrive at anything approaching an automated form of mêtis. Even genetic algorithms are mere approximations of a more subtle reality. To transition from dromological to universal acceleration, from localised speed to real cunning, would require a transformation and replacement of the algorithmic form itself.

79. B. Keim, 'Download Your Own Robot Scientist', *Wired*, December 3, 2009, <http://www.wired.com/wiredscience/2009/12/download-robot-scientist/>.

8. THE NEXT MACHINE

If cunning is the domain of the trajectory (intimately imbricated in the protogeometry of predation), then the ultimately *iterative* algorithmic application of computational processes will only ever be able to imitate in a blocky, quantised mimesis, a pixelated 8-bit computer game rendering of reality. Given that computation is built upon the discrete (from the bit to recursive algorithmic processing to quantified measurements), the domain of the continuous (i.e. of the complex real) remains alien to the computational paradigm—at best, something to be poorly approximated.⁸⁰

As outlined by Giuseppe Longo, algorithms encode a finite and iterative conception of time, using real discrete numbers, resulting in an inability to represent geodetic spatiality (i.e. non-trivial continuity). This is grounded in Frege and Hilbert's project for the axiomatisation of geometry through arithmetic. Operationalised via computation, it is only ever able to imperfectly model complex social, rational, biological, chemical, and quantum mechanical systems, and the symmetry breaking and sensitivity to initial conditions they entail. Whilst the shadow of the Newtonian-Laplacian reductive project has been largely dispelled from the leading edge of the sciences in the

80. Longo, 'Critique of Computational Reason'.

course of the twentieth century, it remains at the heart of computation.⁸¹

Classical computational science, premised on algorithms, is fundamentally constrained by the rules of proof which it instantiates, neglecting the rules of construction which make mathematics the more universal science.⁸² Algorithmic thought only ever remains bound by the existing entities and the regulated manipulations of those entities. Generativity doesn't exist here, only in mathematics proper—and algorithmic machine trading remains bound to the rules prescribed for it, rather than reaching a level of universal synthetic acceleration. Contemporary assertions (without warrant) that the universe is, in some sense, already a computational system (surely a Ptolemaic counter-revolutionary move) are therefore naïve. The problems with the conceptually emaciated computational paradigm have already been outlined by the father of the computer himself, Alan Turing. Turing contrasted his original conception (fundamentally Laplacian in its reductive nature) and a non-linear, continuous variant, as early as 1952.⁸³ We must shift computation closer to the continuous, non-iterative nature of material reality. This 'Next Machine' must begin from a refounding of mathematics

81. Ibid.

82. We owe these points to Reza Negarestani's illuminating recent work.

83. A. Turing, 'The Chemical Basis of Morphogenesis', *Philo. Trans. Royal Soc.*, vol. B237, 37–72, 1952.

in accordance not with Laplace, Frege, and Hilbert but closer to the findings of contemporary post-quantum physics and complexity science. These matters are already vigorously alive in emerging fields such as quantum computing, where questions of foundational principles and the epistemology of measurement and quantisation are central.⁸⁴

Only once this fundamental architecture has been reconceived will the essentially *blind* accelerative power of our contemporary technology give rise to a second wave of intensive acceleration, the shift to automated cunning and its potential wider adoption. Such *cunning automata*, grounded in a continuous neocomputational format, will return technology to its suppressed mêtic ancestry—that is to say, they will replace algorithmic speed within a highly constrained local horizon (capital as we know it) with a properly improvisatory form of automated practical intelligence which metabolizes contingency via a Machiavellian asymptotic apparatus of technopredation. Yet, as we are surely aware, such a navigation, open to the inherent contingency of the universal continuum, is not without risk.

84. G. Longo, 'Critique of Computational Reason', 17.

9. AFTER ZERO

The gambling paradigm, imagined by critics of modern financial trading, is already being exploded from the inside by the dromological accelerationism of HFT. Risks and probabilities are becoming less significant than speed itself, as firms aim to use HFT to eliminate risk itself through obtaining the ideal of instantaneous arbitrage. But if the image of thought of the casino is undercut by our present HFT, then an entirely new image is required for the emerging systems of manipulative machines, the cunning automata of universal accelerationism. This image of thought must be connected to the longer term trajectory of the technology. We propose to sketch three alternative possible speculative scenarios, or hyperbolic images, to answer this remaining question.

In the first, HFT systems are outlawed following a series of catastrophic financial apocalypses. Exchanges around the world are reportedly already examining implementing voluntary measures that may limit the profit potential of HFT, though at the moment the effectiveness and implementation of these rules is uncertain.⁸⁵ The unpredictable emergent effects of automated trading war machines, combined with

85. S. Goldstein, 'FSA's Turner Backs High-Frequency Trading Curbs', *The Wall Street Journal*, September 23, 2011, http://articles.marketwatch.com/2011-09-23/markets/30879600_1_high-frequency-trading-curbs-price-discovery.

the constitutive irresponsibility of their institutional masters, could lead to the virtual eradication of the technology, given a sufficiently disastrous sequence of trades.

In the second scenario, semantically effective HFT systems serve to nearly entirely replace the anthropoid components of the financial sector. In this Landian conception of our accelerative future, capital sloughs off its human drag, expanding into ever more abstract processing-accumulative strategies. One speculative and fictional exploration of such a post-singularity universe imagines posthuman intelligences as cunning self-aware financial instruments, dismantling solar systems so as to obtain maximal computational power.⁸⁶ Human intelligence is incapable of taking part in such esoteric cosmic xoeconomics, and if acknowledged at all is used as mere fodder for anthropic futures trading. Here, today's deregulated neoliberal financial sublime runs amok, as abstract accumulation-for-accumulation's sake despoils entire star systems.⁸⁷ With numerical cunning fully autonomous from its original hominid substrate, the real thinks itself even as it undoes itself towards cosmic annihilation, in a vector of absolute deterritorialization. Hegel and Deleuze are revealed Janus-faced, as an autonomous

86. C. Stross, *Accelerando* (London: Orbit, 2005).

87. S. Shaviro, 'Accelerando', *The Pinocchio Theory*, October 13, 2005, <http://www.shaviro.com/Blog/?p=450>.

Absolute Knowing becomes asymptotically equivalent with a universal thanatotropism.

So tends this line of thought. But as we have outlined, the Landian register of brute speed, constrained within a single (and highly contingent) local horizon (i.e. late capitalism) is out of sync with the kind of universal, navigational concept of acceleration embodied in the history of cunning intelligence. Moreover, the Landian dictum of 'always further with the process' gets nowhere when confronted with real and intractable limits in the process itself (here the insurmountable gap between the continuous, geodetic real and quantised algorithmic iteration).

Hence the third scenario, wherein cunning automata are liberated from the capitalist dynamic tout court. In this future, the deleterious impact of HFT systems and the broader dynamic of automation (of which they are merely the contemporary leading edge) direct capitalism towards a sequence of terminal secular crises, as the tension-fuelled dynamic between labour and capital inculcates system-wide rupture. What follows, however, is not a return to some prelapsarian fantasy of organic wholeness (or, even more repulsively, a full-blown anarcho-primitivism). Rather, a properly post-capitalist society emerges *through* a real acceleration of the technologies born under capital. In this respect, one can see the second and third scenarios as radicalisations of the most extreme socio-economic

visions of the mid-twentieth century: the twinned informatic imaginaries of Hayekian catalaxy and Soviet cyberplanning.⁸⁸ Crucially however, what both visions now abandon is the misguided notion of general equilibrium.

Post-capitalism would unshackle the cunning automata of mêtic systems towards a universal accumulative strategy encompassing the entirety of the planetary, and eventually *universal*, system. Finance already has pretences towards becoming a universal system capable of correctly pricing and rendering interoperable all manner of things. However only the tacit, improvisatory, competitive, and above all *cunning* nature of technical entities could ever resolve the seemingly intractable problems associated with wide-scale social calculus.⁸⁹ The opening up of the contingency of the universal, made possible by navigating beyond the suffocating politico-conceptual space of capital, does not entail the achievement of some ludicrous and properly impossible endpoint of ‘full communism’. A genuinely universal accelerative post-capitalism would be distinct from (and distinctly more interesting than)

88. For the former, see P. Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (New York: Cambridge University Press, 2002), and for the latter, F. Spufford, *Red Plenty* (London: Faber and Faber, 2010) and E. Medina, *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile* (Cambridge: The MIT Press, 2011).

89. For a recent take on the intractability of planned calculation using linear programming techniques, see C. Shalizi, ‘In Soviet Union, Optimization Problem Solves You’, *Crooked Timber*, May 30, 2012, <http://crookedtimber.org/2012/05/30/in-soviet-union-optimization-problem-solves-you/>.

predictable Marxist utopias, given the necessary and indeed increased *alienation* of the human from the world in which they exist. This new world is not the end of history, but the beginning of a new and very different universal kind.

Notes from New Jersey

Sam Lewitt

In Spring 2012 I had some photographs erased from my camera by a team of agents from the Global Security Division for the New York Stock Exchange, and New Jersey State police. This occurred after taking a slow walk around a central High Frequency Trading hub in Mahwah, NJ.

The conditions surrounding this encounter can be schematically described as follows: I drove to New Jersey with the intention of photographing the facade of NYSE and Euronext's main High Frequency Trading datacenter—a sprawling server-farm through which algorithms execute one third of all buy and sell trades on the world stock market, at microsecond intervals. This trip was spurred by abiding questions concerning the conditions of intelligibility for value's circulation through an increasingly abstract and insensible system of valuation and debt. These questions have

increasingly elicited a negative judgment as to the possibility of photographically depicting a site which, de facto, requires a very high level of conceptual abstraction for even a basic comprehension of what goes on within its heavily fortified walls.¹

Nevertheless, however apparently ‘abstract’ and ‘insensible’, the financial system must still flow through conduits and addresses (street and IP, not to mention its movement through every debtor’s conscience as a force of subjection) that sediment its discreet locales and remote installations, of which the Mahwah datacenter is a particularly robust example. Bertolt Brecht’s thoroughgoing scepticism with regard to the mimetic powers of photography (originally targeting *Neue Sachlichkeit* in the early 1930s), at a moment of monopoly capitalism’s financing of the ascent of the fascist State, was certainly at the back of my mind. ‘Things,’ he writes, ‘have become so complex that a “reproduction of reality” has less than ever to say about reality itself. A photo of the Krupp factory or the

1. As Sociologist Donald MacKenzie notes, the human sensorium can react to the most basic of stimuli in roughly 140 milliseconds, or 140,000 microseconds, which could hypothetically correspond to as many trades in that same interval via High Frequency Trading (See ‘How to Make Money in Microseconds’, *London Review of Books* 19 May 2011: 16). At this point, the existence of HFT trading is common knowledge. Its reduction of sense through the implementation of such high speeds in executing orders finds its obverse counterpart in the financialization of affect in so-called ‘Social Sentiment Trading’. Witness London based Derwent Capital Markets, a boutique hedge fund that uses Twitter and other social media to track ‘the mood’ of the market. <http://www.derwentcapitalmarkets.com/>.

AEG tells us almost nothing about these institutions'.² My trip to New Jersey was an attempt to test the contemporary validity (beyond anything imaginable to Brecht and his contemporaries) of this well known judgment—to thicken the void of representability that the building and its function suggested. It is the kind of architecture whose design and manner of physical installation makes its aim apparent: to withdraw from appearance, if not simply to go unnoticed in its sprawling banality.

This makes for an instructive, if somewhat commonplace, comparison between the Corinthian columns of the old Stock Exchange building on Broad Street in New York's financial district, and the building in New Jersey. The difference here proceeds along the same lines as the transformation of the aesthetic/perceptible properties of the appearance of money in the everyday context of exchange. In its ornamental excess, the Broad Street building belongs to an age of Masonically encoded bank notes, which once gave aesthetic credence to the illusion that money is valuable in itself, whatever the magnitude of abstract labour it represents in exchange. In a spurious process of naturalization, this perhaps secondary, but symbolically efficient ornamental dimension of paper and coined money has ceded to the dominance of media such as

2. B. Brecht, 'The Threepenny Lawsuit', in *On Film & Radio*, ed., tr. M. Silberman (London: Methuen, 2000), 164.

COLLAPSE VIII

magnetic stripes (now on the way out), electronic PIN numbers, and graphics displayed on backlit screens: to economies based on so-called 'bank money' and debt financing. This spectralization of the apparent substantiations of value should however be seen as a fundamental tendency of social relations dominated by the exchange abstraction.³

Indeed, value is a form without a particular, localized substance. It tends rather toward its pure, historically systemic state. Exchange value is an independent form of value's appearance in the world. It relates the commodity via money to the total interwoven context in which commodities circulate within capitalism, including transformations of technical forms of production, tightening labour conditions, and, to be sure, the fluctuation of commodity prices. Marx writes with regard to the commodity form:

Not an atom of matter enters into the objectivity of commodities as values; in this it is the direct opposite of the coarsely sensuous objectivity of commodities as physical objects.⁴

3. To describe the destructive autonomizations of finance as a perversion of capitalism is only correct if we emphasize that it is capitalism which is a perverse system of relations, not some dimension of the value relation within capital that has merely been perverted.

4. K. Marx, *Capital*, Vol. 1, tr. B. Fowkes (New York: Vintage Books, 1977), 139.

The value of money itself maintains no illusory connections to any ornament of physical, sensuous material. Marx writes:

On the money market...[t]he commodity has the same form [...]. It exists in the undifferentiated self-identical form of independent value, of money.⁵

Finance's semiological propensity toward the immaculate self-referral of commodity prices, the decoupling of commodities as values (i.e. socially mediated objectivities) from their physical production—as in the execution of buy and sell orders based on fictitious time horizons—delaminates the value form from any ostensible substantiality or essential physiocratic ground, stripping capital down to the naked errancy of its automation. The real senselessness of value tends toward its realization in finance as undifferentiated monetary value prior to its appearance (or not) in a particular form of competition in a specific market.

Here, the sensible surface of capital is as dynamic, changing and mortal as the technical material supports, organisational logics and discourses which serve as its contingent media. The reduction of sensual identification with the medium of exchange as such (however illusory that identification may have been in

5. K. Marx, *Capital*, Vol. 3, trans. D. Fernbach (New York: Penguin Classics, 1991), 490

the first place) is manifest in the Mahwah building's blankness. It is a building that exists in dislocation, nestable in any suburban or exurban threshold, next to a soccer field or amid extruded logistical sprawl. Its force is one of simultaneous decontextualization and internal isolation. It is densely populated with all kinds of hidden lockouts and security functions which will swiftly be put into effect by any suspect operation—such as publicly noticing its existence. I tripped a switch in Mahwah, and everybody's nervous system became agitated. Security turned out in force. They were waiting in the wings, standing sentinel over this disappearing monument to the abstraction that concretely structures a node in global capitalism's 'critical infrastructure'. My ageing prosumer camera became a knot in the net of guilt woven by the extraordinary powers granted to this team of NYSE/Euronext security forces and NJ State police. A grilling ensued post-haste. My automated lens was turned against me, interpolating a scene of identification and incrimination. What were the basic conditions of representation at the moment that the police and security set the scene? Let's call its representational logic 'interrogation in the age of neoliberal self-governance'—after all, in advance of any crime, for I was not charged with anything illegal, the security system will have needed to pass me through their filtration system for the sake of intelligibility. Their verbal data mining

proceeded in a manner reminiscent of the process one must undergo to sign up for a social networking site: Who are you? What do you do? Who do you know?—A script revisited by the JTTF officers who visited my apartment several weeks later.⁶

This encounter ended with the forced erasure of the contents of my camera. Disciplinary measures took the initiative over my inability to control myself with the right kind of images. Despite this corrective to my error in self-management, I was informed by the security and police that they could not stop me from reconstructing the images from memory after I had left. If I was an artist, they suggested, I should

6. As their US Department of Justice press statement reads, the 'Joint Terrorist Task Forces (JTTF) are small cells of highly trained [...] passionately committed investigators, analysts, linguists, SWAT experts, and other specialists from dozens of US law enforcement and intelligence agencies' (<http://www.justice.gov/jtft/>). This information-sharing agency notably coordinates on the federal level with Homeland Security, which, it would seem, is 'passionately committed' to sparing no expense in the defence of finance capital and its open secrets such as the existence of the Mahwah datacenter, against the ostensible freedoms of its citizenry.

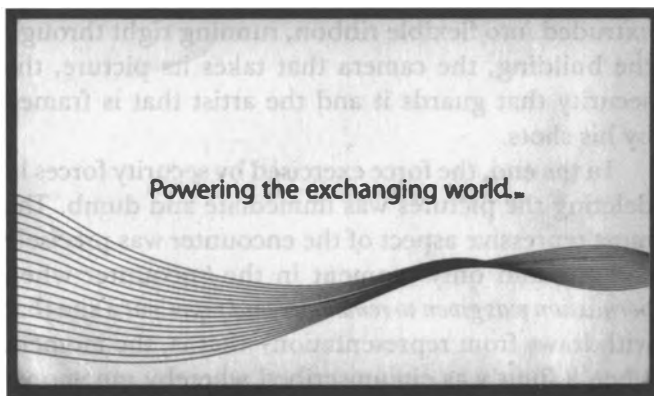
This coordinating agency, which spends an enormous amount of tax revenue on the State's defence of finance, expresses a fundamental historical contradiction. Enormous resources are expended to surveil the traffic of citizens internally, consolidating the juridical force of the nation-State; while it is the global circulatory system of finance capital that it protects which has, more than anything, driven the total reconfiguration, if not the dissolution, of its integral sovereignty as a decision making entity (not to mention that of the productive economies which constituted the State form's economic vitality during its imperial phase). The consolidation and preservation of the juridical power of the State in the defence of private financial institutions is a part of the same process by means of which the global volatility of financial markets, as the engine that spurs crisis in a bid to renew cycles of capital accumulation, drives the State's withering toward default.

have the skill to make a drawing from my impressions. My Canon camera model, it should be noted, is a *Rebel tti*. Despite this readymade classification emblazoned on the device, it was expected that I would have the discipline to do such a thing.

Expectations of discipline are married to the language of flexibility that sutures the lineaments of this anecdote. After all, in an economy structured by massive debt, which is securitized and traded on the stock market, self-discipline in the form of ‘personal responsibility’—‘I take responsibility for corporate debt as if it were my own’—constitutes a force of subjection needed for the system to operate. But the logic of ‘personal economic responsibility’ is historically fused to the acceptance of ‘job flexibility’, i.e. precaritization and exploitation, inherited from the defunct ruins of the so-called ‘new economy’. Personal pronouns are now more than ever material for an insensible process of valorization.

Rather than semantic coincidence, this speaks to the deep materiality of linguistic self-identification with managerial culture’s circuitry of control. On a technological level, the electrical signals that course through ‘my’ camera when the shutter button is pressed move along ultrathin flat flexible cables that coordinate and control the imaging system. Prior to purchase, before any shots are framed, the camera manufacturer’s website promises ‘uncompromised [...] power and

flexibility right in the palm of your hand.’⁷ ‘Flexibility’ stretches a lexical thread through both end-user performance *and* the technical structure of the device, mediating physical and ideological descriptions prior to the record of any image whatever. Perhaps this winding of semantic threads, flexing between camera parts, subject positions, and power relations, extends to the security guards themselves, despite their absolute rigidity with regard to my presence in Mahwah. To be sure, the graphic representation of a flexing helix on their company card is material for me too:



7. http://www.usa.canon.com/cusa/support/consumer/eos_slr_camera_systems/eos_digital_slr_cameras/eos_rebel_t1i_ef_s_18_55mm_is_kit.

The site in NJ is not directly representable, and not only because the reproduction of its image is proscribed. For a site like this, only one dimension of representation is possible and it is tied to guilt. For while a photograph can't tell you anything about the connections that encompass the complexity of its function, it can show cooling systems, its visible security, points of entry, etc. I had no intention either to graphically reveal any of this, nor did I assume that the photographs would show anything but a location that is constitutively *dislocated*...a concrete bunker of abstraction in a rustic setting: a local thickening of the mortality of the technical dimension of representation, extruded into flexible ribbon, running right through the building, the camera that takes its picture, the security that guards it and the artist that is framed by his shots.

In the end, the force exercised by security forces in deleting the pictures was immediate and dumb. The most repressive aspect of the encounter was precisely the one and only moment in the encounter when *permission was given to remember and represent* a site that withdraws from representation—that is, the moment when a limit was circumscribed whereby mnemonic experience was assigned to positive neurochemical recollection of a particular location, against the dislocated backdrop of the total automation of crisis.

The Writing of the Market

Interview with Elie Ayache

*I watched C-beams glitter in the dark near the
Tannhäuser Gate...*

ROY BATTY

Elie Ayache is an expert in derivatives pricing and author of many articles on the philosophy of derivatives trading. This theoretical work culminated in his 2010 book The Blank Swan.¹ In this unique work whose references range from Derrida to Deleuze, Blanchot to Badiou, by way of Black, Scholes and Merton and other financial and philosophical luminaries, he recounts how his reflections on the nature of price and the market led him to an original philosophical position that converges with Quentin Meillassoux's critique of probabilistic thinking and explorations of absolute contingency. In our interview, Ayache elaborates on The Blank Swan's response to Nassim Taleb's The Black Swan, drawing a more radical set of conclusions from the failure of probability and setting the scene for a

1. E. Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010).

COLLAPSE VIII

renewed ontological thinking in which the unfolding of time is sidelined in favour of a conception of the market as the place of a writing of the future.

THE UNEXCHANGEABLE PLACE OF EXCHANGE

COLLAPSE: What was it that led you, a derivatives trader and co-founder of a trading software firm, to turn towards philosophy?

ELIE AYACHE: I had the fortune to start my trading career in 1987—more exactly, on October 19, the day the market crashed. The bank had hired me in September after my graduation from engineering school, but October 19 was the first day I had set foot on the floor, owing to my boss's intuition that there would be something worth watching and learning in there that day. I remember a distinct feeling which I would later recognize as philosophically-charged and which spontaneously imposed itself on me as I stood by the pit and watched the fast trading activity. (I couldn't trade myself as I was still an apprentice, I could only watch.) Simply, I became convinced that there was more going on, in producing the events and their succession, than the mere chain of causes and effects that unfolded in chronological time.

When your world reduces to a trading pit, history becomes quantitative. Events come down to price movements, and all price movements are caused by previous price movements and by quantities offered to be bought or sold at every price level. Action in the open outcry pits is recorded by camera, just in case there is a disagreement on a size or a price and the two parties want to check exactly what words were shouted and exactly what hand movements were made at the moment of the trade. One can safely assume that the 'film of events' unfolding in a pit is exactly reducible to the film that the camera records. There may be causes, not apparent on the film, that trigger the desire of the given trader to buy or sell a certain size at a given price. But as far as the subsequent price movement is concerned, all that matters is the size and the price that he trades, and the shouts and the gestures that he shows to the camera. What effects the trading action of a given trader might have on other traders does not matter either, because all we care about in the trading world is how the subsequent emotions or affects of the other traders will translate into subsequent inner motives and how these inner motives will translate into subsequent trading action. The whole chain of causes is therefore coded in the recorded sequence; and one can safely assume that if the recorded film were to be replayed, the same chain of events would follow.

Yet my distinct and instinctive feeling, as I stood by the pit and watched the action, was that the same chain of events *wouldn't unfold* if the same recorded film—that is to say, chronological time and all that it has recorded—was replayed. I felt there was a non-recordable, non-representable, non-retrievable and non-replayable element in the chain of events that contributed decisively to its unfolding, and that this element was inscribed in the place itself where the events actually took place: in the market place, in the actual place of the exchange which is, as such, unexchangeable.

That the event should be this way and no other way, *this* absolute contingency, was linked to the place where it happened, and it exceeded the chronological film, the time-recording. You have to be in a place to watch the event take place and explain its taking place. I guess that this concerns all kinds of events and not just the market; but the market has the advantage of making this irreducible element or excess more acutely felt, because the market is quantitative, and therefore may lead one to think that it is recordable and programmable—before one realizes, all the more acutely, that this is not the case.

C: How do the questions you need to ask in developing a pricing technology for derivatives extend this philosophical thinking of the market?

EA: Derivative pricing theory is just a branch of stochastic calculus, which is itself part of probability theory and its formalism. In this respect, a philosophy of derivative pricing theory is no different from a philosophy of probability. Instead of throwing a dice or spinning a roulette wheel, one would consider the underlying market as a random generator. A philosophical questioning of this would consist in asking whether the probability is real or is just a manner of speaking, a shorthand for statistical regularity. Further epistemological complications may arise, due to the complexity of the random generator we are considering. The question may be posed—following Taleb—as to the reliable inference of the probability distribution from which the market is drawing its outcomes. Randomness may be further blackened by essential uncertainty—never being in a position to know which dice we are playing with, etc. This is all fine, and yet it completely misses the specific material that we are engaging with here—namely, the market.

The market is not just a generator of random numbers; it is the material place of an exchange. Derivatives would indeed simply constitute a sub-case for probability theory and stochastic control if it were merely a matter of computing a value for them, in the same way as we speak of the value of a mathematical function. We know what the value of the derivative is, at maturity, as a function of the underlying price on which it derives,

and the whole problem is to determine its value *prior* to maturity, with only mathematics and probability theory to carry out this backward translation in time. What is missed in this traditional way of posing the problem is that derivatives are a *technology*, i.e. a material procedure and not just a mathematical function. They are contracts that are materially written on paper and whose destination is to be materially exchanged.

When we consider the stochastic process of the underlying, price is confused with a number and the market is reduced to a random generator; we don't really wonder what the meaning of price and of the market may be, what their inner process may be.

Now, consider that the derivatives contract is materially (directly, without any conceptual or formal intermediary) destined or *meant* to be traded; and that the meaning and even the definition of price may be the following: the number that gets specifically and materially attached to derivatives contracts in that specific place, the market, where derivatives are materially exchanged. Consider that there might be no other definition of price than this one. Consider that we are in the process of inventing the whole technology of price and of the market, and that the derivative is the material piece necessary for that process of making. In that case, the technology of derivative pricing can no longer be thought independently of the fact that to price something is to price it *in the market*,

or independently of the fact that the derivative trader will be the main and, as a matter of fact, the sole intended user of the technology.

The philosophy that is *specific* to derivatives pricing technology (as opposed to a philosophy of derivatives pricing theory that comes down to a philosophy of probability) becomes the analysis of the above thought, which brings together market and technology. It is no longer a matter of the complexity of the market, but rather of its simplicity. For it is the same market, the same medium and milieu, that must be thought at the beginning and at the end—as that which produces the underlying price and which receives the derivative price, only to produce it again. The thought can no longer proceed in a sequence: first the underlying process, then probability theory and derivative valuation theory, then a derivative value that is changed into a price and that is effectively immersed and varied in the market. No, from the start the valuation must be a *pricing* in the sense that the derivative price, manufactured and produced though it may be by a pricing tool, is designed to be exchanged in the market and *generated* by the market.

The practical consequence that the user and the manufacturer of the technology have to face is the constant *recalibration* of the pricing model—and that the recalibration process must not even be thought sequentially, but must be considered *a priori in the very design of the tool*.

Any derivative pricing model is supposed to generate a certain derivative value as an output, as a function of the underlying price and parameters such as volatility. However the technological purpose of this value is to be a price, and thus simultaneously to act as an *input* to the model. No sooner has the derivative market-maker produced the derivative value with his valuation tool than this value, now become a price, is fed back as an input into the tool, triggering its recalibration. Traders use the Black-Scholes-Merton (BSM) formula to generate option value given volatility, while simultaneously feeding option prices into the formula to imply volatility. The complete act of pricing is the combination of these two directions.

What we call the *fundamental principle* of the market is that the states of the world in the market consist of prices—all the prices and nothing but the prices. States of the market-world cannot be abstract states such as states of the economy, measures of inflation, or labor, etc. Such abstract states may be implicit; however, *in the market*, they must be represented by prices of assets. So when a framework like BSM posits the prices of the underlying asset as states of the world, and then computes the values of derivatives as a result, it verifies the part of the fundamental principle which says that states of the world are nothing but prices (for it reduces the whole economy to the price process of the underlying); but it *denies* the second part of the

fundamental principle according to which states of the world are *all* the prices. It denies the fact that derivatives prices are *also* independent states of the world, and should not be expressed as functions of the prices of the underlying (or, in other words, as values).

This is a severe philosophical problem. As we can now see, the fundamental principle of the market seems to undermine any attempt at representing the dynamics of the market in a probabilistic framework, no matter how large or complex: Any totalized set of states of the world (for instance, the prices of the underlying and the prices of any number of derivatives written on the underlying) will have as a consequence that the value of a certain derivative whose prices were not part of the initial set of states of the word will be computed as a function of the existing states, and thus will not count as a *price*, i.e. as an independent state. Now, of course, the values of derivatives written on a given underlying will ultimately depend on no other variable than the price of the underlying that obtains at their expiration. And of course the holder of a European call or put ultimately will not care what levels and what changes of volatility have obtained during the lifetime of the option, or more generally, what exact path the underlying has travelled. Certainly, all he cares about is the final settlement of the option and the corresponding underlying price level. *However*, as soon as he starts caring about dynamically

hedging the option, he can no longer ignore path-dependency. He becomes dependent on the whole path of the whole market that will take place in the meantime. For the proceeds of the hedging strategy will depend on volatility changes, and hedging against those changes will require running, in the dynamic hedging strategy and on top of the underlying, a trading account on derivatives that depend on volatility, such as variance swaps or other options whose prices become states of the world that are additionally required. In turn, the hedging ratios to apply to these additional hedging instruments and the proceeds of their hedging strategy will depend on changes to the parameters that govern the stochastic process of the volatility itself, i.e. the volatility of volatility, etc.; and those parameter changes will in turn have to be controlled by a further complication of the dynamic hedging strategy involving derivatives that are more complex still.

If the market is the rule and if you are not content to buy (or sell) and hold the derivative until its expiry but wish to trade and engage dynamically in the market and unwind your position at any moment, you become dependent on all the prices of derivatives of all degrees of complexity—in another words, you become dependent on the total ‘state’ of the market, which can never be reduced to a total of states. The market becomes the one and only vast (and continual)

event which screens off any residual or ulterior event. As such, it can never be framed or calculated even though it is present. Engaging with it becomes equivalent to engaging with the event, with any event, or with the ‘essence’ of the event, which is to be incalculable. It is a continual event, when the event is by definition a discontinuity, without this being a contradiction.

BLACK SWANS, BLANK SWANS, ANTIFRAGILITY

C: The title of your major work *The Blank Swan* is an obvious riposte to Nassim Taleb’s *The Black Swan*,² a work which addresses the incapacity of human beings to adequately predict catastrophic events—precisely such as the 1987 crash. How does the conception of the market-event you just described relate to Taleb’s work?

EA: Taleb’s angle is epistemological. He basically argues that one cannot know the small probabilities. If you think that an event happens once in a hundred years, then you’re going to need ten thousand years worth of data in order to ensure that your probability prediction is reliable. Of course, this is never the case, and what you would be tempted to do is to fit a certain probabilistic model to the available data, or in other words, to what you already know has obtained with

2. N.N. Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007).

what frequency, and then let your model work out for you the probability of extreme events that have never happened so far.

Typically, in the financial market, you fit a certain probability distribution to the statistics and satisfy yourself (this is the purpose of fitting) that downward price jumps of, say, -15% have a probability that agrees with their historical frequency of occurrence. However, you will never be able to calibrate your probability distribution to a downward jump of -45%, because there is no such jump in your historical sample. All you can do is trust that the 'true' random generator of the market is accurately captured by your model, and that, extrapolating from this, your model will now tell you the truth about jumps of -45%. As Taleb puts it, only the assumption that you are dealing with a certain type of probability distribution—for instance a Gaussian—can justify the belief that a certain amount of data is enough in order to infer (calibrate) this probability distribution. So how would you proceed when you don't know the type of probability distribution that you are after?

Taleb argues that probability distributions in the market should have much fatter tails than the Gaussian. Typically, they should be of the scalable (Mandelbrotian) type. If extreme events happen more frequently than we think, then it is all a matter of correcting the probability distribution—and, if the

chosen distribution has infinite moments, a matter of recognizing that we will never really *know* it, because it would take an infinite amount of data to calibrate its fat tails. But notice that the whole discussion remains couched in terms of probability and frequency. If you measure the extreme event on some scale (hence the word ‘extreme’) then it is only ever a matter of relative frequency and comparison: the extreme event happens *more often* than we think.

So the outlook here is epistemological: Taleb believes in the reality of the random generator, but he thinks we cannot *know* it. The preoccupation with the event becomes ontological, however, when there is no previous scale, or population, of which the event is a grade (whether extreme or not) or member—when the event literally emerges out of nothing. Such an event is not extreme; it is world-changing. You cannot deal with it using either probability or improbability. My point is that the market, contrary to its quantitative and statistical appearance, is the (continual) place of such an ontological event. It seems that Taleb reserves the mild Black Swan problem (a matter of getting the right probability distribution, of using probability language) for the market. When he turns to the case of the major disrupting event that fits no scale—what I call a context-changing event—he considers it only in very qualitative terms. But according to me, the quantitative aspect of the market (prices going up

and down) actually masks the ontological fact that probability *never applies at any instant*, because every instant is the *same* (it is not the successor in time of the previous instant); it is the same in that it harbours the same immeasurable, unrepeatable, unheard of, event. I say the event is the 'same' in terms of featuring the same irreducibility and incomparability all the time. Above all this repetition is not to be understood in terms of statistics, of course. It is a repetition of the same wherein the 'identity' that the events share is precisely that *they are not comparable and reducible to any scale*, shared or not.

The events in question concern prices and seem to be quantitative, so there *seems* to be a scale. Yet the market is history, and every event, at every instant, must be as incomparable with the next as historical events are (no wonder the market is correlated to history and always accompanies it). It is through derivatives that such an aporia can be resolved. In derivative pricing it becomes evident that the market is not a succession of instants, because the process of infinite recalibration it demands freezes everything and puts us 'at rest' with the event.

Thus, instead of being regarded as a case of probability and statistics, the market should appear as the *only* case (a singularity, a miracle) where history and its events take on the appearance of numbers. It is a major coincidence. The blank space or the hinge between

incompatible contexts³ (this absolute discontinuity) happens to be filled by the (continuous) matter of the market, which I call ‘writing’ (since writing amounts to filling in the blanks). The matter of the market is the matter of metaphysics. By declaring this I shouldn’t be breaking news to Taleb, really, but breaking news to Badiou (and Meillassoux).

So my main observation concerning Taleb (and my main divergence from his position) is that it is no coincidence that he started his career (as I did) in the financial markets, in the derivatives pricing and trading business. The market is the only place where the qualitative absolute event, the one that is irreducible to measure and scale and probability, finds quantitative expression, in a material medium borne by numbers, or rather prices. The market is *quantitative history*. One should keep in mind this contradiction in terms: one should remain aware that the historical event is incalculable and unquantifiable because it precedes any scale; and *then* understand the extraordinary nature of price (and of its medium: the market) *as the quantification of that unquantifiability*. This is why the market is truly the technology of the future. You have to realize that price is not a number. Quantifying the event (translating it into numbers) is impossible; yet the market *is* such a translation, precisely in so far as it takes place *outside* of possibility. ‘Quantitative history’

3. See Michel Bitbol’s contribution to the present volume.

does not mean that the event is being forced into the mold of numbers. Rather, a quantity, a number of an extraordinary nature, has been found such that history can be quantified.

All that price shares with numbers is the external shell; it has a different mathematics altogether. When the resemblance is mistakenly thought to be full, and price is thought to be just a number, its process can only follow and come second. Then we remember (as if it had been forgotten) that the market is random; and, since the number is fully present before us, there is no choice but to postulate a stochastic process outside of price and to make price follow it. But in reality, the *price process* came before; it was always present inside price.

Thus when looking at price one should not look at the succession of empty shells it leaves behind as time passes. One then mistakes them for a time series and starts looking for the random generator of the underlying price, as Taleb does. Taleb was misled by the resemblance between price and number, and consequently applied the category of probability to the market, setting up the whole problem as one of deciding between Gaussian distribution and scalable distribution. Instead of recognizing in the market the (quantitative) *solution* of the severe Black Swan problem (how to mediate and exchange the unexchangeable event), he saw in it an instance of the mild Black Swan problem.

As a matter of fact, Taleb's whole movement of thought and line of work will later unfold as a constant withdrawal and distancing from the market, whereas I maintain that, given that he was fortunate enough, like me, to start a career and even a specialty in the financial market, he should have stuck with his specialty and drawn all the consequences—as extreme, incredible, impossible and metaphysical as they may be—of his experience and expertise with that extraordinary medium and matter. There is a scientific duty that is pressing here. There is the discovery of this new matter and of the new science that attaches to it. The peculiarity is that metaphysics is needed as an introduction to the science. One has the duty to advance this science. Taleb mistook the science of the market for the intervention of an old science—the science of probability—in a field where it does not apply. As a consequence, not only did he move away from the market, but this move has simultaneously expanded itself into a general attack against science.

C: If the numerical 'shell' is to be discarded, then what is it in price that this new science should examine?

EA: Its intensive, nontemporal process, the *place process*, which is that a price has to be given for the derivative written on the underlying. The underlying 'follows' no process other than *its writing as a derivative*

and the simultaneous (nontemporal) availability of the derivative price. Instead of a random generator being posited, based on the statistical time series of the underlying, instead of statistics being understood as the result of successive draws of the random generator, the only generator of the underlying price should be the availability of a price for its derivative. The fact of such a price being given (and this givenness is the *definition* of the market, I would say) should replace the fact of a statistics of underlying prices being given (the definition of the random generator).

C: So the materiality of the market replaces the notional primacy of the random generator?

EA: Yes, and the market acts in a different dimension than the random generator, and therefore in a dimension other than time (it acts in place). Just as we infer historical volatility from the history of underlying prices, we infer implied volatility from the single option price. This substitution should be understood literally and in an epoch-making sense, and the corresponding transposition of the notion of the generator should be carried through and completed. Nobody has thought yet about the real implications of implied volatility.

The existence of the market is the availability of prices of derivatives of all orders, and this is equivalent

to the *nonexistence* of the random generator. As I said, a true engagement with the meaning of the market leads to ontological considerations. What I have tried to accomplish in my work is to stick with my specialty (the market) and to draw the ultimate consequences from a thorough metaphysical analysis of it; and then to generalize these incredible findings outside the market by trying to discover what, in other cases, resembles the market. Because of the way that possibilities are nontotalized in the market (the definition of price), the market becomes the medium of contingency; it even *replaces* the event; and anybody who dwells in the market can be said to stand right in the middle in the event.

By replacing the random generator with writing, the market picks out, in the Black Swan, the decisive feature of the *change of contexts*; it seizes the ‘true generator’ of the Black Swan and thus becomes immunized against it. I have tried to think deeply about what, in the exceptional case of the market, makes it such a wonderful medium, such a solution to its own Black Swan problem. I remained focused and specialized in the market. Taleb, by contrast, never really dropped the frequency or probability-based notion of event (what he calls randomness). He never really upgraded his category to the one that changes whole ranges of possibilities; if he did glimpse it, his angle remained epistemological (‘unknown unknowns’). He never saw

in the ontology of the event (radical discontinuity) the opportunity for the existence (ontology) of a fabric or medium *that will precisely mend discontinuity by thriving in its gap*, so to speak; by making the discontinuity continuous (this new definition of matter) and the unquantifiable quantifiable thanks to a new kind of quantity or number (price). He passed through the market as a case of wild (unknowable) randomness, only to dedicate the rest of his thinking to events in general, lying largely outside the market. He renounced (and even denounced) his former specialty. He didn't explicitly analyze the event as ontologically incalculable, and thus he deprived himself of the answer to that problem.

This default will have consequences for the solution that Taleb will subsequently propose to the general Black Swan problem. For him, the event is immeasurable because received (probabilistic) science cannot measure it. But why not turn the immeasurability of the event into a search for a new science? For Taleb, received science is only a tool to know the world (The original subtitle of his solution book, *Antifragile*, is 'How to live in a world we do not know or understand');⁴ therefore, in the face of the event, it is the epistemological failure of science that Taleb denounces. He never envisages science as an ontological tool, as a creator

4. N.N. Taleb, *Antifragile: How to Live in a World We Don't Understand* (London and New York: Penguin, 2012).

of worlds, even of matter. As a consequence, when he turns to trying to solve the problem, the proposed solution will consist in abandoning the enterprise of science—in this case the science of probability.

Probability science becomes increasingly vulnerable and fragile when faced with the extreme event, because it cannot accurately express its probability; for this reason, the sad truth, Taleb rightfully argues, is that the science of randomness (probability science) in reality *dislikes* randomness, now understood in the metaprobabilistic sense that the probability forecast will be proven wrong. (Taleb will always understand metaprobability, or the criticism of probability, in an epistemological sense—as the failure of a model to capture a generator that, nevertheless, must exist—never in the ontological sense—as the failure of the whole framework of probability, namely the *nonexistence* of states of the world and the *nonexistence* of a random generator.) Probability science is needed in order to theoretically value derivatives and manage the risks of derivatives portfolios, but it can be massively wrong in its valuations. Therefore one way of *liking randomness* instead of fearing it, according to Taleb, is to keep the derivative, which thrives on randomness, but to discard the science of its valuation.

As a result, as far as options are concerned, Taleb proposes to abandon the subtleties and finesses of dynamic hedging (the fruits of the received science)

and to adopt a static buy and hold strategy. He cannot sell, because a seller of options does not like volatility and, worse still, because a seller needs the science and needs dynamic hedging in order to manage (replicate) the options he sells. Notice that Taleb falls back on the market by default, as the only remaining background once science is abandoned; yet he never engages in the market as the positive replacement of the science. And when he notices that the market is quantitative after all—that it is a science, in my sense—and that one needs to be quantitatively critical of the premiums of options that one is buying and holding, Taleb abandons the market altogether and writes *Antifragile* as an apology for the asymmetric payoffs (a.k.a. derivatives) that one can find and purchase for free, outside the market—that is to say, generally in life. Notice that, since they are costless, they don't require a seller.

One can summarize Taleb's move in the following way: On the way up, the market was never recognized as the matter which lies beyond probability and which is, in its own domain, the quantitative solution to the problem of the qualitative event or Black Swan; the qualitative event itself was never recognized as an ontological problem which required an ontological solution. On the way down, randomness, which remained epistemological, required as the solution of its problem only that the science be dropped (together with the market).

Even though he has dropped probability and the problem of valuation of asymmetric payoffs, Taleb is still locked into the language of frequency; he is still a slave to the scale and comparison, to the *degree*, and therefore to its relativity. Fragile things resist frequent shocks of lesser magnitude, but break in case of an extreme and infrequent shock. Antifragile things get stronger and stronger (scale and degree) as they are subjected to shocks and accidents (to randomness). Notice that the randomness that affects them is tamed, at least in the sense that the scale upon which the antifragile thing is recognized to have become stronger is itself preserved. How would the antifragile thing fare in case of events that destroyed the whole world, or at least that radically changed the background or the scale against which the antifragile thing must be recognized as being the same thing before it is recognized to have become stronger?

Taleb's *The Black Swan* was a metaphysical book (at least according to me). The event there was absolute: anything could happen; there was nothing, no world, no range of possibility, no time, that the event couldn't change or abolish. In *Antifragile*, Taleb recognizes a category that is now superior to the event and seems to dominate it, namely antifragility. But one cannot recognize in the event the absolute discontinuity, the failure of any scale, and *then* propose as a solution a notion that depends on scale.

The solution must be absolute, like the problem. Taleb's new great discovery in *Antifragile* seems to be (-1, 0, 1): the contrary of fragility (1) is *not* robustness (0), but antifragility (-1). However, the real *not* that he is missing is, as in *The Black Swan*, the *not* that negates the whole idea of scale. It applies to fragile, robust and antifragile alike because it removes the scale, in the same way that the market, in *The Blank Swan*, is the *not* of both probability and improbability, of both prediction and its failure. Antifragility without scale amounts to creating an absolute—in other words, to creating *matter*. The solution must be metaphysical: the medium that insinuates itself at the hinge of the event; to be in a state of relative rest with respect to the event.

C: Against both the black swan and antifragility, then, you posit the market as *the medium of contingency*, the place of this event that is beyond fragile, robust and antifragile alike.⁵ Let's address what you mean by contingency.

EA: Contingency is one-sided. A contingent thing is the way it is without remainder, without recall, without reason—without reflection. Contingency is unexchangeable, to speak like Baudrillard in *Impossible Exchange*.

5. Ayache, *The Blank Swan*. See also R. Mackay (ed.), *The Medium of Contingency* (Falmouth: Urbanomic, 2011).

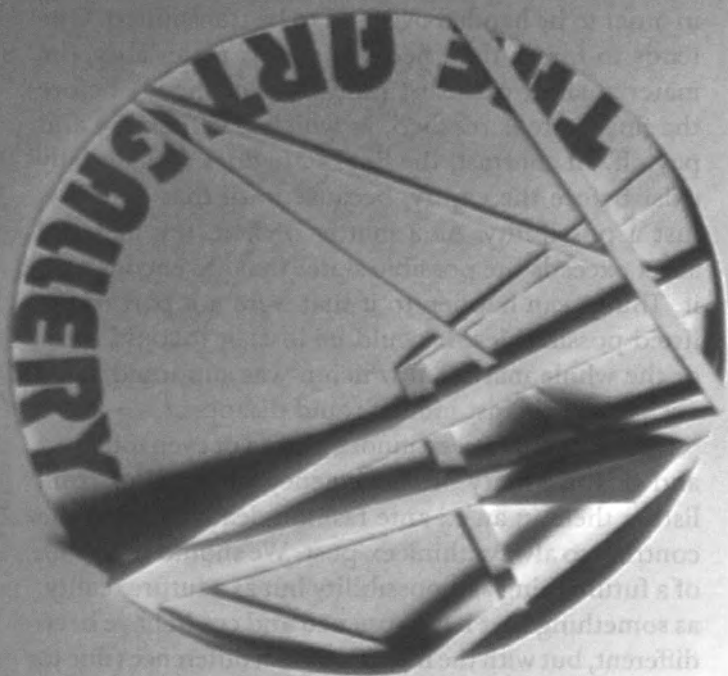
The contingent state is not selected from a preexisting list of possible states. To list such possible states is to involve contingency in their reciprocity and their mutual reflection: this state *as opposed* to another. Which means that identity is recognized (*this* state, *that* other state) before difference. In contrast, massive and absolute contingency, contingency as *matière première*, has to be recognized *before* state and identity. We must say of the contingent thing that it can be (different) before we say that it is, or what state it is in. In this way, a future contingent event (that doesn't exist yet) becomes no different from an actual contingent thing or an actual contingent fact. To recognize massively that an actual contingent thing could have been different dispenses with any need to list the alternative possibilities that it might have been. We don't need them because the thing is actualized. It is no longer possible, it is before our eyes, yet we know that it could have been different. Its contingency never leaves it, so to speak, to become reflected and dispersed in external possibilities. Similarly, we should be able to think of the future event as something that could be different (or that could even never be at all), before and without knowing what it is or will be.

All that Time brings to this is identification, because it is in time that we eventually identify the future event. The whole idea is to secure a bridge to the future event that is other than time, a bridge that is indifferent to the

identity of the event (what it is) and sensitive only to its contingency, and which establishes a link, a mediation, a channel of communication with that contingency alone. I argue that the market of contingent claims is such a medium and such a bridge. This bridging is achieved through the combination of *writing* and *exchange* (a kind of alchemy). When something is written, it is too late; think of opening it after the fact, as when you open the will of a deceased person. It is too late because of the material on which it is written and because of the mark that the material bears. This mark doesn't offer interchangeable possibilities. It offers itself as one. It is what it is, yet it could have been different.

C: But a contract on the market precisely deals with different possible states of the world which may or may not be fulfilled, does it not?

EA: It is true that the written contingent claim specifies different states of the world, or possibilities, in which it pays different amounts (if A, pay $x(A)$; if B, pay $x(B)$, etc.). However, these are written; they are not merely mentally represented. In order for them to be realized and to actually pay off, the material sheet on which they are written needs to be handed over and exchanged. As such, the material sheet that binds them is one; it is not many. It will not change



depending on what state may come about in the future. It must maintain its identity, or rather its materiality, in order to be handed over and to be transmitted. One tends to forget that, because of this materiality, the material sheet can exist (and be exchanged) before the final state is reached, in which it will expire and pay off. In contrast, the final state doesn't materially exist before the expiry, because until that date it is just a possibility. As a matter of fact, the material sheet exceeds the possible states that are encoded on it. Things can happen to it that were not part of the listed possibilities. It could be lost, or it could burn, or the whole market in which it was supposed to be exchanged against money could disappear.

These possibilities cannot be listed or even totalized, and this massivity of contingency prevents us from listing them in an ex-ante fashion, leading us on the contrary to always think ex-post. We should not think of a future thing as a possibility but as a future reality; as something that has happened and could have been different, but with the mere *incidental* difference (due to the incidence of chronological time) that we don't know what has actually happened. Reality must be separated from actuality. We must think of (massive) contingency ahead of time and find a way of translating this massivity and this ex-post character to a place (and a time) that is before the event, but *without turning ex-ante*. Time is unavoidable, but what must be avoided, when



thus going backward in time (from the future to the present) is the ex-ante attitude. It is as if we were saying that that material sheet, whose ex-post future fate we have already considered (and already realized that it could have been different), is *still* here with us now, in the present, *after the fact—that is to say, before it*. The massivity of contingency after the fact should correspond to an equivalent massivity before the fact, which will not count as an ex-ante stance *because of this massivity*. In other words, the nondistinction and nonidentification of alternative possibilities after the fact (due to the massive ‘too late’) must correspond to an equivalent nonidentification of possibilities before the fact. Once this equivalence is found, chronological time becomes incidental (non-essential) on contingency—and being chronologically situated before the event (incidentally) will no longer count as being ex-ante.

Chronological time is of the essence when states are distinguished. Reviewing one distinct state after the other imposes a chronology on thought if only because the review is analogical and the identity of each state is recognized (and circumscribes the state) *before* its difference with its neighbour. Reviewing states in this manner necessarily introduces an integral (a synthesis) or a supervising state that runs through each one. We can even go further: this mode of reading is *equivalent* to having such a supervising state. There is the impression of a draw, of waiting to see each outcome.



Probability is an integral because it is the summation of a 1 and 0s conveniently distributed over recognizable states. Reviewing the states in an identifiable order is the *same thing* as having the one state that maps into each following a probabilistic transition. This is the meaning of probability. Distinguishing the states imposes this probability structure and requires time and the ex-ante attitude in order to resolve itself.

In contrast, there is no integral, but only a *difference*, in the reverse reading of contingency, where the fact that the state we are in could have been different is recognized *before* its identity. While the reading of identifiable states is conducive to *valuation* (as in evaluating a function) the reading of contingency ('it could have been different') is conducive to *pricing*. While the list of identifiable and reviewable (reciprocal) states is equivalent to stepping back into the supervising state, the multiplicity and mode of count (not a function, not a number) of contingency and of its massivity cannot step back; it can only invaginate itself in the material sheet itself, exchanging it. Just as, when we read the list of identifiable possible states, we reproduce (describe, constitute) the supervising state, so, when we 'read' the one contingent strike, or mark, we create its exchange.

It might seem that the ex-ante attitude (waiting and seeing what possible outcome or state will obtain) is more suited to the 'future' than our twisted suggestion,

in which we position ourselves in the future after the fact (ex-post) and recede to the present through an unwarranted medium that we are calling the *exchange* (or the market). The ex-ante attitude seems to be a more faithful description of the attitude of predicting what will happen. Crucially, however, the ex-ante attitude depends on having recognized the possible outcomes and totalized them in a list. And where can such identification come from, if not from the *past*? We observe the past series of outcomes of a die or a roulette wheel and we decide that these are the only outcomes, and consequently project them into the future. Yet the future is massively unpredictable. Anything could happen; fire could destroy the casino or a meteor could hit us while we cast the die. Probability and the ex-ante attitude in which it is framed depend on reducing the contingency of the present world to a *comparison* with alternative possible worlds that we arbitrarily carve out and separate from the present one, using our imagination—or rather, *lack of imagination*. We invent numbers, 0 and 1, that we assign respectively to the possible worlds that have not obtained and to the present actual one. Yet the present world should have remained *one* in the sense that it admits of no rivals or alternatives, even ‘possible’ ones. It should have remained 1 without 0, where 1 is not a number (whose fate is to be compared to a 0 or whose difference is to be construed analogically) but is a

mark, a strike, whose difference is intrinsic, since it spontaneously says that *it is what it is only to the extent that it could have been different*. This 1 without 0, this unity that has factored in the difference intrinsically, is a new unit of count; it is a different way of counting altogether, whose medium, I shall argue, is money (hence the market), not frequency.

Creating these alternative worlds is not only a fiction; it robs the present world of its reality. Since the alternative worlds are not compatible with the present one, the only way they could coexist with the latter is in a fictitious *past* stage where all worlds (the present one along with the alternatives) are considered to be mere possibilities. Identifying the present world as a state is the same as identifying the alternative worlds or states, is the same as fabricating the past world. Assigning *comparable* numbers (1 and 0) to the present world and to the alternative ones is only the prelude to assigning to them 'middle' numbers (p_i) that they share equally, *whose sum is also equal to 1*. To explain the contingency of the present world, we thus imagine a past 'real' world from which the present one and the alternative ones spring as possibilities. That past world now bears the number 1 (the sum of probabilities). It is as fictitious as the alternative worlds (since its whole *raison d'être* is to support the incompatibility between the alternative worlds by stepping into the past); yet the thought is now that of a transmission of reality.

The 1 of the reality of the present world is now ipso facto thought to have been transmitted to it by the fictitious past world through a temporal transition. This immediately results in an extrapolation whereby future possibilities are in turn thought to spring from the present world, only because it now bears the *analogical comparable* 1 and we now identify this fabricated reality with a sum of possibilities.

C: This sounds like a development of Bergson's famous critique of possibility, and of Meillassoux's more recent critique of probability and its postulation of possible worlds. How does your conception of *writing* supplement the critique of this retrograde notion of futurity in the name of absolute contingency?

EA: The 'sheet of paper' is immaterial when we are in the mode of reading the list of possible states, because only the contents matter and the writing is here merely programmatic. By contrast, the material sheet of paper is *essential* to the reading of contingency because this reading, as a reaffirmation of the mark and of difference, is a reaffirmation of the fact that no writing as difference and as mark is possible unless it is engraved on a material medium—a sheet of paper, a stone, a computer memory, etc. Once it is recognized that this material property of the sheet is *essential* to the mode of difference of contingency, it is immediately recognized

that the sheet can (and must) be exchanged; this is the same movement of thought. It is the *same matter* which bears the difference and strike of contingency as one, without splitting into different states, and which, as a result, turns itself into the exchange.

Finding an equivalent for the ex-post massivity of contingency before the fact (yet without becoming ex-ante) means securing that the two 'masses' are the same following the 'line of flight' of the event, even though they are separated by chronological time. The medium of transmission is the market and is such that, in the mode of count of the event, the price of the contingent claim is *simultaneous* with its final ex-post strike, as if the price and the final contingency were 'light-like' events, to speak the language of relativity theory. What makes the market as massive as the final event and transports it, through this equivalent massivity, right into the middle of the event, or rather, into its place, is the nontotalization of possibilities due to the necessary tradability of all the other contingent claims. Before the final event there occurs the *whole market*—and what the 'whole market' means is that no contingent claim, of any grade of complexity, shall be denied a price and a trading. As I have explained above, any attempt to recede from the final event (or the strike of contingency) via the probability framework will require a total of states, with the consequence that some derivative will admit of a value (a function of other states) instead of a price, thus negating the fundamental principle of the market.

FROM TECHNOLOGY TO METAPHYSICS

C: How does this lead to the idea that the market is a *technology* of the future (rather than merely a mode of knowledge or prediction)?

EA: Letting the *whole market* occur before the event is equivalent to blocking any attempt at receding through probability and the ex-ante attitude. It is as if we were (incidentally) situated before the event chronologically but we were essentially brought back, by the pressure of the whole market, right into the middle of the event. The nontotalization of possibilities in the market makes it feel as if it was continually an event, the only event, and as if we were continually following it ex-post. A connection between massivities is established, which falls outside time.

It is because of this material bridge that I speak of a technology of the future, instead of a knowledge or prevision or vision of the future. The market replaces the final event because the nontotalization of its possibilities brings it right into the middle of the event (into its place, albeit not into its time), and equivalently the technology that the market is replaces the future. It replaces its knowledge (for there is nothing in the future that puzzles us today except its knowledge). The market makes it so that something other than knowledge matters in the future, and so that the future becomes real—

no longer in the epistemological sense of the realization of a forecast or a possibility, but on the contrary in the ontological sense that all possibilities have been withdrawn from the future (since we consider it ex-post) and that this *future real* has been connected to the *market real* through the market technology.

Anyone who travels to the future in the capsule of the market is insulated from time. When one moves outside the market (or outside matter, outside the ex-post stance) to project states of the world, one commits oneself to that outside medium of probability as an absolute medium (even when the selected states are part of the prices of the market). To adopt the logic of the count of states is to leave the *whole market* (as nontotal) and to adopt a metric that is no longer intrinsic. (What is intrinsic is the whole and the nontotal.) Rather, what should measure the distance between the final event and the present market is the intrinsic metric of the arrangement of matter (Julian Barbour)⁶ inside each. The arrangement of matter of the final event is the strike of its contingency, which is irreducible to possibility; and the arrangement of matter of the market is its strike as whole and essential event, in which every price of every contingent claim is an integral part, irreversible. It is true that something will change between the present market and the final event; however, that change and the way we engage

6. See COLLAPSE V, 75–121

with it is no longer a matter of prediction; it is no longer accounted for against the absolute and extrinsic medium of probability (the ether). We no longer see (and foresee) the final event when we are locked in the market capsule because all that occupies us is the market. The market has replaced the event, literally.

C: The medium of contingency, then, and a technology; yet another way you characterize the market is that it is not simply a matter of developing a philosophy *of* the market—in a certain sense the market already *is* a philosophy. Why does the market qua technology necessarily give rise to a metaphysics?

EA: Industrial revolutions are usually the precursors of metaphysical revolutions. Einstein's abolition of absolute time and space and his enunciation of the relativity principle wouldn't have occurred had the telegraph and railway networks, then becoming a global industry, not presented the problem of the unification of time and of the determination of city longitudes around the world. A whole technology developed to mechanize the coordination of clocks. Simultaneity became a mechanical procedure and was no longer a metaphysical concept.

Based in Switzerland, the home of the clock industry, and working as an application examiner in the Swiss patent office, Einstein was the privileged witness

of this revolution. Owing to his status of total outsider vis-à-vis the scientific establishment (unlike Henri Poincaré), he was bold enough to redefine time in terms of simultaneity, and to redefine simultaneity in terms of the procedural transmission of signals between clocks. Relativity theory was conceived as a machine, not as a metaphysical speculation or an amendment of previous theory. In fact, Einstein wrote his revolutionary 1905 special relativity article in the brisk style of a patent claim, where reference to previous work or to similar inventions was precisely omitted.

The market of contingent claims is also a major industrial revolution; however, its metaphysical consequences haven't yet been drawn. In many respects, it is similar to the one that prompted Einstein's theory of relativity, with the market acting as the new globe and the synchrony of prices like a global clock.

Where patents to synchronize distant clocks were filed in Einstein's day, today the industry is filing maps of synchronous derivatives prices. When the traded vanilla options prices are too scarce, data vendors extend the market and produce complete and smooth implied volatility surfaces. When the underlying price moves or time passes, the surface is recalibrated from a new intake of traded derivatives prices instead of being recomputed from an underlying probabilistic hypothesis. And, once it is observed that implied volatility is traded and stochastic, the market is solicited

again for the prices of options on volatility indices (for example, vix options) and the latter are repackaged and redistributed in turn in a refinement of the market synchrony, instead of upgrading the theoretical probability distribution underlying the BSM model to stochastic volatility.

The medium of probability needs to be abolished, when thinking of the material relationship between a contingent payoff and its present market price. Probability is an outdated, yet very entrenched metaphysical category that has to give way once the market is conceived as a machine or a technology and no longer as a theory (once the suppression of possibilities under the massivity of the final contingency is recognized to be equivalent to the suppression of possibilities under the massivity of the market—under the *whole market*).

Just as there is no absolute time rigidly attaching to the ether, but only time defined relatively to the material procedure of the synchronization of clocks, there is no absolute probability with which to distribute the underlying and value contingent claims accordingly. Rather, probability is defined relatively to the frame of reference, whereas the real, intrinsic relation is the one that prevails between the contingent claim and its market price.

The rule is to infer the probability distribution of the underlying from the market prices of contingent claims. For instance, volatility is implied from the

option price in BSM. When the implied volatility differs among strikes and maturities, we change the probability assumption and we now calibrate a stochastic volatility model (or a jump-diffusion, or a mixture of the two) to the full vanilla surface. The next day we recalibrate the model to the new options prices, thus changing the distribution again (horizontal recalibration). And when we realize that the market prices of higher-order exotic options are not explainable within the model, we upgrade it to the next level. We thus recalibrate a model of stochastic volatility of volatility, or stochastic jump sizes and intensities, etc. (vertical recalibration).

We call ‘intrinsic non-arbitrage relations’ those relations that help us value derivatives independently of any model of the underlying process. These relations are deduced purely from the statics of the respective payoffs or static replication—that is, from the clauses that are *written* when possibilities are over and the underlying dynamics are terminated (typically at maturity of the instruments or at their knock-out barriers, etc.). Now, the observation is that market prices are also model-independent and, by definition, arbitrage-free. Why don’t we consider their relations to be intrinsic too?

Might not the metaphysical revolution lie in considering that the market prices are *written* too and are devoid of probability dynamics—that is, written

somehow ‘after’ the end of possibilities, after the fact, outside chronological time? Could the market price be essentially occurring in the middle of the event—right in the heart of the terminal-contingent payoff and with no need to predict it—yet accidentally taking place ‘before’ the event, in what may look like a chronological antecedence but is in fact a taking over of the event, literally taking the place in which the event takes place? And if probability and temporal process do not intrinsically occur between the present price and the future payoff, then what does? Relativity theory is in reality a theory of invariants—so, we ask: what is our invariant?

Only because a nondeterministic phenomenon repeats itself with a few variations are we able to assemble the variations and retrospectively call them ‘possibilities’ that are open to the event. (The possible states are identified.) The event is the result of abstracting the differences in the same class and of subsuming the facts under the same phenomenon, which we then suppose will admit of different outcomes. The ex-ante outlook therefore has no physical existence; it is a logical abstraction. Possibilities are defined *after* the population, not before. As we have already discussed, probability is also defined in retrospect.

When there is no such empirical population or reference class of which the event is recognizably a member, metaphysicians can still imagine a set of

possible worlds in which to measure its frequency. A less exorbitant alternative is to drop objective probability altogether and to believe only in subjective probability. However, does any of this make sense when probability, as a concept, has been recognized to be past, not future, and only to be misplaced in the future? What could the probability or even the possibility of an absolute event, a Black Swan, possibly mean? Is time itself not void as the medium of such an event?

C: And presumably you would claim that this realization is implicit in the techniques that have developed for derivatives pricing, even if they ostensibly seem to rely on a probability framework?

EA: Derivatives pricing almost kicked off as a branch of actuarial science. The event of the underlying price resting above or below a certain strike at a certain maturity was analyzed as the linking of very small price increments that occurred in abundance in the interval. On the assumption that the instant probability distribution would be inferred from the statistical series, the temptation to compute the fair value of the derivative as an actuarial value was great—one such that you broke even on average. However, the non-arbitrage constraint binding the derivative, the underlying and the riskless bond quickly dispelled this temptation in favor of risk-neutral pricing, if only because of the

risk premium attaching to the underlying and of the investor's expectation not to break even on average. Finally, the dynamic replication argument of BSM—itsself compatible with non-arbitrage and risk-neutral pricing—gave derivatives pricing a more operational turn. It turned the abstract equivalence between the real probability measure and the risk-neutral measure into a pressing and very local accounting equation.

In reality, BSM had just consummated the thought that the market was a material procedure and not an application of probability. Nobody cared any longer whether the derivative price was sensitive to the distribution of profit and loss in the long run, or to the instant random generator that caused the systematic slippage in hedge rebalancing. We all woke up in a market where derivatives and underlying were trading alongside each other and moving together. Nobody uses the BSM formula to explain the option price; everybody inverts it against the option price to compute the dynamic hedge.

Implying the BSM volatility from the vanilla option price opens an endless chain: every subsequent model (stochastic volatility, jump-diffusion, etc.) is calibrated to the options market in turn and becomes virtually stochastic by recalibration. Its meta-model will be governed by the prices of higher-level exotics and, where they don't actually exist, it is only virtually that we should conceive of recalibrating against them.

The market is this infinite chain of prices of contingent claims.

If the chain is virtually infinite, then the relation between any contingent payoff and its price becomes intrinsic. Any probabilistic model is an arbitrary section of this infinity and will always be relative. Incidentally, every exotic structure in the ascending ladder will trade at variance with the replication plan corresponding to that section. This means the underlying stochastic process is prevented from running its course at any level. The virtual infinity of prices, or the market, replaces the whole probabilistic hypothesis and the exchange's 'proper time'—or rather, its proper place—replaces the improper and misleading time of probability.

TIME AND THE BOOK

C: So—once again, when read carefully, this technology entails a whole philosophy *of* the market.

EA: The market becomes philosophy by realizing exactly what happens to the orientation of thought (what happens to thought) when the market is no longer envisaged as a random phenomenon taking place in the ether of probability, against the transcendent background of possibility, but as a direct medium of contingency from which possibility is withdrawn, or as the material technology of the future from

which knowledge and prevision have been withdrawn. In this transformation, thought, we might say, has been brought from the depth (or the illusion of depth—Wittgenstein) to the surface, from abstraction to matter, from thought to writing. And the market has become necessary, not through the summation or totalization of possibilities, but through the subtraction and suppression of possibilities.

If the market price becomes intrinsically linked to contingency, as we said above, as geometry is intrinsically linked to matter in general relativity—that is to say, immanently, without any superior dimension supervising the link—then this link becomes absolute and, in a sense, necessary. (Relativity theory is a theory of relativity in so far as the nonabsolute character of space or time is concerned, or in so far as the relativity of the given frame of reference is concerned; however it is an absolute theory when the invariant is considered.) This is not saying that the market price becomes deterministic; it is not necessary in that sense. The market is necessary in the sense that it is the only medium of contingency, once contingency has become absolute in the sense of the abolition of possibility (not the summation of possibility). Contingency is one-faced and one-sided, and the market is necessary in being the only ‘other’ side of the one-sided contingency. The market is its translation, its mediation, its mirroring and its speculation, without this translation or mediation or mirroring being a relation with two terms and two sides,

established within an encompassing supervising space. The market is necessary in the sense in which Blanchot says that 'the necessary book is subtracted from chance', or in the sense in which the thrower of the Nietzschean die embraces a 'fatal necessity' and emits a 'necessarily winning throw' (Deleuze).

Thus the generalization of the market is the book and the market becomes philosophy when it is recognized that philosophy too is looking for a necessity of thought, not as a transcendent sum of possibilities, but in the immanent material sense of Blanchot's necessary book (referring to Mallarmé's). The market becomes a book once it is recognized that the transformation of thought that happens there (which remains special and specific in the market as it concerns only financial contingent events and their financial translation and mediation through price) can generally be described as the couching of thought in writing. Blanchot says that thoughts, as abstract and difficult as those that could be found in philosophy books, can be expressed in a literary book provided they are *not yet thought*. My interpretation of this is to say that good philosophy books are the ones in which the thought is written (as in literary books) and *not yet thought* (reflexively, transcendently). Writing is faster than thought, and to say that a literary thought can be philosophical (and can be better than philosophy, according to me) is to say that it should retain what writing and literature have specifically given to it—the event—and should

not be slowed down by reflexive (ordinary philosophical) thought. Something is well written, according to Joubert, when the author cuts the sentence and refrains from adding to it what can be guessed and predicted at that point—what is no longer the continual event and could slow down the sentence if added to it at that point. In my elaboration of the word ‘writing’, writing takes place when thought races at the same speed as the event, overtaking traditional reflexive thought—thought that is slowed down by states of mind and representation.

In a sense, philosophy is nothing other than a philosophy *book* (it is material thought), not just in the obvious sense that philosophy is contained in books and that we all, in the end, refer to very specific books when we talk of the philosophy of specific philosophers, but because engaging in philosophy is engaging with the event of thought, and writing a book is the only way to be up to speed with the thought (usually another philosopher’s) that we are engaging with, making it truly feel as if the chronologically older book now was to be interpreted at the light of the new one, or as if the old one was chronologically posterior to the new one. Philosophy is not a reflexive commentary. As David Wood would say, to reflect in commentary on the thought of other philosophers is to go counter to them.⁷ Instead, one should encounter the other

7. D. Wood, *Thinking After Heidegger* (Cambridge: Polity Press, 2002).

(older) thinker, that is to say meet him; and since thought is running the course of the event, which is one-way (one strike), to meet the other thinker is to match his speed, meeting him in the middle of the event, writing a philosophy book that will join his in the non-chronological *place* of thought (or in the infinite race of the event). (Wood speaks of repetition.)

It is not that philosophy is a closed library and that the only concern of philosophy books is other books, with no connection with the real. Philosophy is thought as the other side of the real; it is speculative in the sense of mirroring the real; however, it should not slow down the real (its event) with the reflective side of the mirror. Philosophy should reflect the real without adding a side or a face; it should literally replace the event of the real. I interpret speculative materialism (or speculation without the metaphysics of dogma and without the metaphysics of necessity) not just as the affirmation of the necessity of contingency but as the other side of the one-sided contingency—what becomes necessary to it in the (non metaphysical, non reflective) sense I described above. The correlation of thought and being ultimately is not a relation; it is a one-sided duality in Laruelle's sense (he has photography as a special means of speculation or as an illustration of philosophy;⁸ I have the market). Once Meillassoux

8. F. Laruelle, *The Concept of Non-Photography/Le concept de non-photographie*, tr. R. Mackay (bilingual edition, Urbanomic and Sequence Press: Falmouth and New York, 2011).

applies to his own medium (his own thought, his own book) the abolition of possibility that is required by absolute contingency, turning his thought into the material book, the problem is upgraded from one of thinking the real as given to thought or of thinking the real without thought, to the discovery of the new *matter of writing* in which the event is repeated. What I call the ‘market’, thus generalized, the medium through which we connect with the event, is thus the *book* (the new matter); the proper medium of Meillassoux’s speculation. No wonder Meillassoux resorts to Mallarmé (and to his poem, which is his book) as the solution of the problem he has posed in *After Finitude*.⁹ (Each one of our heroes proposes a solution after the book that has posed the problem: Taleb, Meillassoux.)

They are all after the thought of the real (of the world) without thought. They haven’t really dispensed with chronology. They want the book that writes itself (Taleb’s *The Black Swan*) or that is necessary, subtracted from chance (Mallarmé’s). How long before they realize that the matter of which books are made is *real matter*, as absolute (and independent of thought) as the one they prize so highly in their materialist ontologies? Books, of which the market is the special (numerical, quantitative, nonliterary) instance, are the technology

9. Q. Meillassoux, *The Number and the Siren*, tr. R. Mackay (Urbanomic and Sequence Press: Falmouth and New York, 2012). See also Meillassoux’s contribution to the present volume.

or the material medium that truly permits us to rotate our universe in a direction that makes us insensitive to chronological time. Call the event of the real, its strike, its contingency, the world's best kept secret; and instead of wondering how chronologically or spatially to think with or without this event (to think it as uncorrelated to thought, as having happened before thought and as continuing to happen after thought), think of the availability of a matter that allows us to repeat this event. This is better than thinking it. This is literally making it and replacing it.

Philosophy tries to think itself outside its book (its whole book), somehow theoretically, in the same way that the theory of the market (best represented by derivative valuation theory) ultimately elaborates itself and misses the market in the last instance. Derivative valuation theory thinks of the market against the absolute background of probability (it believes it has no other way of animating the price process of the underlying than against a probability framework) and it culminates in valuing a derivative of a certain order of complexity by stochastic control and dynamic replication by the traded assets whose probabilistic dynamics it has identified with the market. However, in doing so, it falls short of the last and most essential step concerning the market, which is that this last derivative has to admit of a market in the last resort—or rather, in the first place. In order to think the market, it goes

outside its medium, only to recognize in the end—but now it is too late—that the derivative that has been valued last, is *still* the market. Similarly, philosophy thinks the real; it even thinks the existing stock of philosophy books that are now part of its tradition and reality; however ultimately it fails to recognize that what it has produced is yet another book; that it is *still* the book.

C: Presumably this is not to say with, for example, Stanley Cavell, that philosophy is not a set of problems but a set of texts?

EA: No, I am not saying that there is no value for the thoughts that are expressed in the philosophy book outside the matter and the accident—the contingency, the event—of that book. Rather, I am arguing that to think of philosophical thought outside its book is to deny thought its material nature. It is true that anyone trying to think the real without thought will in the end have produced just another thought or written just another book; however, this is a facile rejoinder to oppose to him. Instead, one should reverse the direction; one should no longer think of the real as the independent domain, and of thought only as the circle that slows it down or reflects it. One should think that the whole separation of the real from thought or of thought from the real is a false problem and a

consequence of the wrong orientation (an orientation that has stepped outside the book). For the thought of such a separation conversely slows down thought relative to its own material process.

One has positively to embrace the 'aporia' according to which yet another book will be written and no matter what we think, it is still the book. One has to understand this wholeness of the book (the whole book, the whole market) as a homogeneous medium whose acceptance amounts to repeating the event and no longer being separated from it. Thought has had a tendency to grasp the real against a fixed frame (of thought) that keeps thought separated from the real, when, in reality, this absolute background doesn't exist, and the only way of thinking is to think 'intrinsically', following only the arrangements of matter. The only matter that gets arranged and rearranged behind the real and thought is written matter, without which we wouldn't know anyway what to say or what to write, what to leave behind.

The genesis of the book encompasses the genesis of the market, where the market is the special medium from which probability (this transcendent way of watching thought) has been retired and which is supposed to reorient thought accordingly, by detaching it from chronological time and its absolute metric and making it homogeneous with the event. The book is no less true than the real, and the category of writing

enjoys a compatibility with the event that overturns the order of time. What was speculative thought thinking anyway in the standard order of time? That once the absolute is finally thought without thought (once speculative philosophy has reached its end) then thought would stop? On the contrary, I think that a speculative metaphysics without the dogmatism of the absolute, speculative thought without this absolute end (the absolute as an end), is precisely a thought without an end and without a stop. It is only through the reorientation and the correction of the medium that I suggest that thought will have both left the circle (this vicious infinity) and will be guaranteed to reach no end outside. There is an intrinsic link between the event of the real and the book (or material thought) which guarantees and explains that the real and thought never stop and that their event is always repeated.

PRICE, VALUE, AND DERIVATIVES

C: Your account of the market focuses on writing of *derivatives* in particular, and makes a case for considering the market exclusively in terms of the derivative pricing process. One objection we have encountered when speaking to others of your work (from within philosophy, but also to traders) is that there are a plurality of markets in existence, each with a seemingly different *raison d'être*. On your view, what gives you

license to speak of *the* market rather than just markets in derivatives, given that these latter form the basis of your analysis?

EA: As just outlined, for me the market is a new order of thought, a new metaphysics that frames the new matter in charge of filling in the blanks that the Black Swan leaves, of extending and ‘continuing’ in the discontinuity of the event, of providing the medium that is located at the hinge of the event, etc. I have reached this conclusion through elaborating the category of *price*, precisely as it diverges from probability and from valuation, and more generally from the whole framework and order of thought in which we think of states and identify them, read them chronologically, evaluate functions that are written on them, etc. So it is true that price comes, in my philosophy, before the market place (which will only be deduced at a later stage as the place where contingent claims receive prices, as the place where their contingent payoff and final event gets translated—literally dragged in space—into prices, as the medium which allows us to recede from the final and massive strike of contingency without using probabilistic transitions or adopting the ex-ante attitude). Price comes before as a new logic of the count, or a new logic of the one and many—a new mathematics, even. Derivatives, or contingent claims, are essential in this presentation of price

because they are written—they are a schedule of different clauses—and because they articulate the dialectics of the one and the many in the difference of their clauses.

I need first to establish the difference between valuation and pricing, between (a) reading the value of a function as chronologically differing *because* its argument or underlying state is chronologically identified, and then recognized as differing in the reading, and (b) reading the function as massively and ‘non-chronologically’ differing, as differing without distinction and identification of underlying states and possibilities, as differing in the massive sense of the ‘too late’ and ex-post, which is the sense of contingency—the function being what it is, not in a sense of a recognition of a state but of a strike, or a mark, which *could have been different*.

Now, this inverted mode of reading is precisely the mode of *pricing* as opposed to *valuation*. I need to establish this point of logic, which at first seems remote from the market, before observing that the latter mode—valuation—is conceptual whereas the first mode—pricing—is material, and requires the material sheet on which the function is engraved. It is in a subsequent move that the difference of contingency, instead of being integrated in the supervising state, is recognized not to be translatable and not to issue otherwise than in an exchange (of the material sheet).

The market, which exchanges the sheet, is thus defined (constructed, constituted) as the only way to ‘evaluate’ the difference without looking at it in an ex-ante fashion, by evaluating it after the fact, after it is too late, and dragging it before it takes place (for evaluating something is always a matter of looking at it ahead of time—from this there is no escape).

We think there is something, a bridge, between now and next, between the present state and the future state, and that probability will play out in that interval. In reality there is nothing between the present and the future; there isn’t even time (time is not the proper medium) because the future contingent event is totally unpredictable (possibilities are never totalized).

Now consider an alternative in which the relation between present and future (the forecast) is not an artificial, logical and chronological consequence of the totalization of possibilities. Consider an alternative in which we face the real future—not one masked by an ex-ante attitude whose only cause is the present, or rather past, identification of possibilities. How to have as of now, not something precise to say about the future (for we are no longer standing in a precise state, now that we no longer precisely identify the possible states), but literally something massive and imprecise, literally traces of the future that have been imported into the present, instead of a false precision that is due to a present artificial identification and

has been exported into the future; how to have the ex-post signature of the future somehow handed over to us now?

I claim that writing is that massive thing that does not distinguish precise states in the future. A contingent claim is written and is programmed to pay off a certain amount of money in the future if a certain event obtains, which is *precisely* described in the writing and which we may, for this reason, provisionally call a 'state'. However, the payoff is not only contingent on the precise encoded state; it is also contingent on the material sheet of paper that carries the writing. That piece of paper must be *exchanged* against the money that will be paid off; the holder has to produce evidence of his claim and to hand it over at maturity in exchange of the payment. Because of this material procedure which has to take place in the real future, nothing is really programmed in advance; nothing is projected, as was the case with probability. For all we know, the holder may suddenly realize that he has lost the sheet of paper (he no longer materially holds the claim), or the conditions ruling its exchange against money may fail to obtain. Imagine that the place of exchange is destroyed, or that the wording of the contract is found to be legally invalid, thus enabling the liable party to escape its obligation. Imagine that the whole world ends. Imagine, in other words, any contingency that may be associated with opening

testaments at the time of opening them *and not before*. For this reason, the sheet of paper does not carry any state at maturity but is just massive; its ex-post fate is 'written on it'. Also for this reason, what it carries today is not a state either; it is the whole market. The sheet of paper that was subject to its massive contingency at maturity (in the future) is *still* with us today—the same sheet, as real and undivided. It is exchanged against real money at maturity, and it is exchanged against real money today (at a different price) in the market.

In contrast, we cannot say that the state that will be realized in the currency of probability is with us today. If we assume that it is real in the future (when and if realized), it is not real today, but only possible. It is not realized through a material exchange in the future, through something that really crosses a place and leaves a trace (money) in the future that can be found before the future (today), but through an intellectual attribution (probability = 1). As a matter of fact, it is not even real in the future and it doesn't really belong in the future; for it is only an extrapolation from the past. Money was invented for the purpose of mediating between present and future in the correct *forward way*, connecting real to real and not possible to real (which is the backward reverse way) and without the precision and indeed the fragility of probability.

Money, writing and the exchange are facets of the same solid. Money was invented for the purpose of

monetizing that thing in the future which will be still with us today, and money was invented for the purpose that there should be a price in the future (the real amount of money exchanged then) *and* a price today (the real amount of money exchanged today), keeping in mind that the market is what closes the solid and allows the sheet to change hands today in advance of tomorrow. The market is massive at both ends. It is massive at expiry in the sense that the contingent claim is contingent upon the massive material sheet and not just the encoded distinct clauses and has no choice but to be exchanged as a result; and it is massive before expiry because there are no delimited and distinct states of the underlying either, or of any derivative that may act as an underlying for a higher order derivative, but virtually all the prices of all the derivatives. The market is massive because of the fundamental principle.

It is when states are identified and enclosed in their reciprocity, it is when their device is later run in complete isolation from the real world and when the stability of frequencies is observed, that the notion of generator is formed, which is now supposed, ahead of the event (*ex-ante*), to *generate* it with a probability corresponding to the frequency. The generator is the transcendent instance that is supposed to replace the immanence of statistics. Worse, the random generator is reified; it is believed that there exists something real

and instantaneous (Popper calls it a generating condition or a propensity) that would generate the statistical series with stable frequencies if given enough time. The modesty of waiting until after the event (ex-post) is replaced by the supremacy and pretense of the generator. My claim is that the category of price, especially if it is thought through the narrative of derivatives and their market, is the way of resisting this transcendent generator and reinstating immanence.

The reason price is interesting as conducive to immanence and as instating the *surface* of the market (and it is the surface that we want above all) is that in our analysis of derivative pricing, we encounter two notions of price that we need to level with each other and with the surface, as well as two notions of the exchange that we need to make identical. In one instance, the exchange is considered as the generator of prices of the underlying; in the second, as the massive ‘evaluator’ or rather ‘pricer’ of the contingent claim, where price is defined in contradistinction to value, as translating the contingent claim massively without any distinction of possible states. Price is just a number in the first instance and it is a logic (even a different mathematics) in the second. The exchange is a mere number generator in the first instance, a topology in the second; it is the other side of the material sheet on which difference or contingency is seen as a single and singular mark and not as a list of states.

Yet the market is one; it is not split between two notions. Price cannot, on the one hand, be defined at a level of thought where it competes with probability as a logic of mapping the one to the many and, on the other hand, behave like a random number that is ruled by probability and follows a stochastic (time) process. Ultimately, the genesis of price through pricing, or the concept of price as that which happens to the contingent claim once it reverts through its own written matter without distinction of states and is exchanged as a result (for lack of a transcendent space in which a supervising state would be found to support value), ultimately this inner *process* of price, which we earlier called the meaning of price, must take over the customary notion of an external generation of prices in the market, understood in the sense of random numbers. Time as the dimension in which the random generation of numbers takes place must be replaced by place, where a generation of writings takes place instead.

The image of the time series is very powerful and entrenched. We cannot help thinking that out of the continual confrontation of demand and supply, price changes in the underlying are continually generated, thus turning the market into a kind of engine. Yet the continual exchange that we must think of should move along the dimension of writing, not that of time. The underlying should not follow a stochastic process

but its own writing into a derivative payoff, then in turn the writing of that derivative into a derivative of higher order, etc.

It appears that certain statistical parameters are crucial for the pricing and hedging of derivatives. We are told that the underlying follows Brownian motion (for example) and we are supposed to infer the instantaneous volatility of the process, which we need for pricing and hedging, from the time series of the underlying. If the underlying were really sampled continuously through time, we would be able to find as long a time series as we want in as narrow a time interval as we wish, as this is the fabulous advantage of Brownian motion. Since instantaneous volatility itself is liable to change (as witnessed by the trading of volatility derivatives), in theory we must perform this extraordinary act whereby we mine the largest set of statistical data in the narrowest time interval. However, the derivatives market spares us that extremity. Instead of inferring volatility historically (even benefiting from the Brownian marvel which enables history to shrink into a spot), we imply it from the market price of the derivative itself, *which is otherwise given*. We simply find the volatility coefficient to feed into the BSM formula in order to match the derivative price. Since our purpose is to price the derivative, we may as well use the volatility that makes the price right.

The local properties of Brownian motion exempt us from worrying about the volatility (or indeed the whole statistical distribution) that should prevail over the whole lifetime of the derivative and from finding the correct one such that it makes us break even on average when plugged into our hedging strategy over the whole finite horizon. Thanks to the fractal character of Brownian motion and to the stochastic integral, our hedging strategy breaks even 'in the long run' even on the spot, and all we care about indeed is that we be hedged against the next market price change of the derivative. However, the locality of everything (which is the other name of the market) soon turns into a complete statistical black hole. For not only is the notion of a given (reified) and stable random generator already stretched to an extreme with the local character of Brownian motion, but, since the derivatives market has replaced statistical inference by making us infer a statistical parameter (volatility), which in theory pertains to the series of prices of the underlying, from the instantaneously given price of a given derivative, we now have to worry that this inferred parameter (implied volatility) may not make the price of all remaining derivatives come out right.

A SMILE WITHOUT A CAT?

This is the beginning of the smile problem. The smile problem, as I understand it, is the problem of inferring

‘statistical’ parameters, which in theory pertain to a given underlying and which we need in order to price and hedge its derivatives, when all that we can observe are market prices of derivatives. It is a severe problem that ultimately leads to the total demise of the whole statistical paradigm (and correspondingly the notion of random generator), for the reason that there is not one stage that we may reach, in which we may have satisfied ourselves that a certain stochastic model has been calibrated to the extant prices of derivatives yet in which we may rest confident that the next set of derivatives prices that will prevail in time will be matched as well. From the instantaneous market prices of derivatives, no matter how complex they may be and how involved a story their prices may tell us about the dynamics of the underlying, there simply is no way we can predict the future dynamics of those derivatives prices. From a snapshot there is no way we can infer the subsequent motion picture, unless we believe that the underlying random generator has been captured and will persist—unless, that is, we believe that such a random generator existed in the first place, which we could have inferred statistically given a long enough time series, but that for some reason we decided to infer it from the market prices of derivatives only, as an alternative method. The truth is that the market prices of derivatives are the only method.

The surface of the market constantly blocks any attempt to withdraw from it into a transcendent stance

in which the random generator would finally be uttered. A random generator is the guarantee that certain states of the world are visited over time with certain probabilities. However, the fundamental principle of the market is such that those probabilities themselves are put into play and into trading and become additional states of the world. The set of derivative prices against which we calibrate a certain model is never complete, and there is no guarantee that the derivatives of higher order, which did not trade so far and did not register an actual price, would have their virtual prices agree with the calibrated model. As a matter of fact, had those virtual prices been actually available, calibrating the model against them additionally to the existing prices of derivatives (of lower order) would imply different price dynamics for the latter depending on what those virtual prices are. One should therefore never infer anything statistically when facing a market; one should never withdraw into an ex-ante attitude where a random generator is given the right of existence, not even for one second. On the contrary, one should infer without withdrawing and without inferring, always going forward, always following the surface, always acting as if the virtual price of the next complex derivative could have been different.

The act of inferring statistical parameters, for the sake of pricing derivatives, from the instant prices of derivatives (and not from time series of the underlying),

this act which is definitional of the surface (since it abolishes the supremacy and verticality of the generator) and consequently definitional of the market, has not yet been thought thoroughly and radically. Whatever we do, there are still in our minds remnants of the thought that the market price is a temporary deviation from value, and that value, as derivative valuation makes it clear, is only a matter of probabilistic weighting of the final derivative payoff (or equivalently, a matter of statistical break-even of the strategy of holding the derivative).

We still haven't thought thoroughly what this means: that the information should come from the market prices and nothing but the prices—that it should come from the future and not from the past. Derivatives have the advantage of turning any information about the price into another price. They help us complete the radical shift towards the market, when the market is to be conceived as a radical alternative to statistics instead of a case of statistics. To think what price is, and consequently what the market is, the whole sophistication of derivatives is needed. It is not a coincidence if the exchange is essentially linked with randomness. The existence of a frictionless market and the capacity to buy and sell without limitation imply that the price trajectory should be predictable (differentiable) at no time scale and should be irremediably inflicted with randomness. The efficient market hypothesis entails

the random walk, because any predictable future price would by anticipation be traded in the present spot, leaving for the future only the unpredictable. However, this ignores the fact that derivatives, virtually of any order of complexity, are also trading and consequently preventing the thought of the random generator from ever materializing.

Randomness is somehow inseparable, in our minds, from the notion of a statistical population; and the sampling of the latter is inseparable, in our minds, from a chronological sequence: one random sample then another. Randomness seems inseparable from the notion of a trial. Yet the thought of the radical randomness of the market is such that even the idea of a trial is forbidden. Time is usually the revealer of randomness, either physically or logically. What we are talking about, concerning the massive randomness of the market, is that not even the first sample be drawn. What we have next is always the massive event, which is never a sample. It does not happen in time but takes place. Once place is understood in that sense, as the alternative to time, when speaking of massive contingency, and as the exchange place of contingent claims, which are precisely written as bearers of this massivity and precisely delivered to the exchange as the other side of writing, the marketplace and the exchange acquire a generic meaning that should be generalized to all kinds of markets. All we need is that there exists

a future (a contingency) and that there exists a place. So the probability paradigm seems to fall short of the price paradigm, and this seems to require a revision of the entire metaphysical framework of possibility and realization. This is what prompted me to look into alternative frameworks such as the Deleuzian virtual or the Nietzschean dice-throw.

C: The dice-throw instead of the Black Swan...?

EA: In an article I wrote in 2006,¹⁰ I used for the first time the expression ‘anti-Black Swan trader’. Taleb, who had not yet published *The Black Swan* then but was already recognized as the creator of the concept or at least of the expression, said he was intrigued by my ‘anti-Black Swan’ proposal. My 2006 article was a defense of the derivatives market as the technology that could take care of contingency beyond probability, or of the Black Swan event that fell precisely outside the probability framework (literally a technology of the future). Simply, the idea was that, if the states of the world were to coincide with the states of the underlying that the derivative was written on, and if this underlying was tradable, then the probabilistic framework and its fixed states of the world would ultimately result

10. E. Ayache, ‘Why 13 Can Only Succeed to 11, or, The End of Probability’, *Wilmott*, July 2006, 30–38. Available at http://www.ito33.com/sites/default/files/articles/0607_nail.pdf.

in derivatives being algorithmically controlled (replicated) and in their values being perfectly assigned. Yet the market is by definition the place of trading of *every financial instrument*, no matter whether derivative or not, *at prices that precisely vary from any pre-assigned value*.

Any probability framework, no matter how complex you make it in order to model the trading behaviour of derivatives up to a certain order of complexity, will admit of a derivative of a higher complexity that will be perfectly replicable by the derivatives of lower order and will, therefore, be denied a market of its own and a variance of its own. In other words, the event of its market, if it is to take place, must exceed the existing framework and be incalculable within it. It is precisely the market-maker of that derivative, although he needs the probabilistic framework in order to hedge (replicate) the derivative that he buys or sells and manage his inventory, who must, qua maker of its market, be attuned to this excess, to what falls outside the framework. Nobody has thought the market yet through (and as) this contradiction—or rather, paradox. To repeat, the market is the category that is yet to be discovered and analyzed; it is the matter and the science that is yet to be created. Derivatives just happen to make the discovery of this new matter pressing and to pose the problem in the most acute way.

The probability dynamics that supposedly govern the underlying are not the real market dynamics or the real price dynamics (even though every derivative textbook will represent the market as just this underlying stochastic process). In the immanent theory of the market that derivatives allow, the real market dynamics—eventually unpacking the meaning of ‘price’—takes place when the derivative market-maker, equipped as he may be with the derivative valuation tool that reduces the market to the probability dynamics of the underlying, *trades* the derivative *in the market* and, by so trading it, intends it to vary from the prescription of his valuation tool and to leave its circle. The mystery of the medium that the market-maker is immersed in (the market) is such that the price he makes becomes given at once and made by the market. The derivative price that the market-maker makes is in every sense the output of a formula, the result of a self-financing dynamic strategy that holds and defends that price; and yet the nature of the medium in which this price is posted is such that the price turns immediately into an input to the formula, inverting it.

It is not necessary that the price that the market-maker makes with the help of the formula (let us call it a ‘value’ in this outgoing movement) should be numerically changed by the market in a subsequent price movement. It is before any change (yet), *as he makes it*, that the market-maker intends it as a market price,

therefore as a price that is given by the market and liable to be fed into the same formula (now used in reverse) in order to imply volatility, for instance. The market is this instantaneous paradox of authorship. The market-maker uses the pricing formula to make the price, but the formula is in a way useless because the price is made by the market. Yet the market-maker does not discard the formula; he needs it precisely in order *to make the price as made by the market*. In this simultaneous exchange of the category of the given and the category of the result, in this exchange of the input and the output, lies the specific nature (or mystery) of the market.

The smile problem is the perfect expression of this; it is not meant to be solved because it simply *is* the paradox of the market; it *is* the market. The smile problem attests that you are maintaining the usage of a pricing formula (in this case BSM), because the smile refers to the BSM volatilities that are implied by the price of each option. Yet at the same time it attests that the formula is immediately invalidated by the market (and that you should logically suspend its usage) because the implied volatilities do not come out equal, as BSM would require. This paradox can only make sense through the presence of the market-maker. The market is not left alone (as if the prices of derivatives were just given by the market independently of a maker). One needs the moment of creation.

The smile problem is there for the market-maker to see that the prices are the results of his creation (the outputs of the formula he is using) yet that the main creation of the formula, its main product and result, is that the market turns against it and invalidates it. *The market validates the formula by invalidating it*, because the market that is thereby created does not fully become a market unless it departs from its creator (and was even meant to so depart in the first place, at that very same moment of creation). One has to realize that the term ‘market-maker’ is a living paradox, not a contradiction, whose only consistency comes from being constantly affirmed.

The key to the paradox, which is the key to what I have called the true market dynamics—and therefore the key to the market—is dynamic hedging. Dynamic hedging is what precipitates the market-maker into the market and pins him on the floor. It turns the problem of the valuation of nonlinear payoffs into a local problem, which requires the presence of *locals* (another name for market-makers). If you are holding a costless option, you don’t need to hedge it, of course. If you are holding a costly nonfinancial option (an asymmetric payoff as found in life by Taleb) you may not be able to hedge it; but your losses are limited anyway; you are tinkering and learning from trial and error; but your upside is unlimited. In both cases, you withdraw from the dynamic market; you leave the

local, or the place. Financial options, by contrast, introduced the possibility of being dynamically hedged. Now the premium you pay is no longer the solution of the ex-post accounting equation of the insurer who has sold infinitely many premiums like the one you have bought, and who will therefore break even in the long run, when all the contingencies will have been visited with frequencies corresponding to the premiums collected. Instead, the premium now becomes a *differential* in the mathematical sense; it is no longer a cost but the *rate of change of a cost*, or time decay, because the accounting has become local. Accordingly, the contingency that the premium covers is reduced to its differential, to the essential difference that is at the heart of contingency—that is to say, to essential nonlinearity. (It is of the essence of the contingent claim that it be nonlinear and that the payoff be asymmetric.) The main consequence of dynamic hedging is to bring nonlinearity and locality together. This may sound contradictory, since nonlinearity is associated with the line (albeit broken or convex) whereas locality is associated with a single spot. But on the contrary, we will see that to understand the sense in which the local, the spot, the market, can be said to be nonlinear is to understand how the market can be the metaphysical and radical alternative to Taleb's proposal of basing antifragility on nonlinearity and asymmetric payoffs. The magic of the market is to make the ultimate and

final contingency *present and local*. The contingency (in theory supposed to settle at maturity) is made 'locally' present.

C: Through the fact that the rate of change of the premium is no longer tracking a final settlement but, instead, the market price of the contingent claim?

EA: Yes, and for this it needs the mediation and the translation of price. *It requires the invention of price*. The market price (always by definition the price of a contingent claim) should be defined as that which is required (as the new kind of matter, or material process, a.k.a. technology) in order to bring the ultimate contingency and the ulterior event into the present spot; and to transform the relaxed and resigned (and, one might say, infinite or indefinite) attitude of whoever follows Taleb's antifragility therapy and programme into the dynamism and constant unsettlement and finesse of the trader on the floor.

The spot was required. Let us consider this as the first necessity. *If it didn't exist, it would have had to have been invented*. It was later discovered that dynamic hedging was the way; however, the availability of the price of the derivative takes equal part in the invention. One tends to forget that tracking the market price is an integral part of the dynamic hedging argument.

The market is local; local is the keyword of the market. And ‘local’ implies ‘place’. Time decay, the nonlinearity of the next price change, and the market which presents all this; this is the local miracle that was made possible. Volatility, or the miracle through which Brownian motion can be sampled in an infinitely shrinking interval yet remain random,¹¹ makes it so that when contingency is reduced to its essential and local difference, it can only be the convexity of something given locally—namely, the market price. Statistics could be reduced to a single spot and yet retain the notion of infinite long run; an insurance premium could be reduced to an instantaneous rate of change (time decay); what we thought impossible (that time series and statistical populations might be reduced to a single spot and retain the infinity of the law of large numbers) was made possible thanks to the wonders of Brownian motion; however, the existence of a market was required in order that we may be able to track an instantaneous contingency locally. The market is the way to make the insurance break-even problem (and solution) local. (I would even say that it is the only way.)

Dynamic hedging is not just a subtlety or a finesse made possible by stochastic calculus. It is true that it turned the contingent claim from a vehicle of extensive

11. S.N. Neftci, *Principles of Financial Engineering* (San Diego, CA: Academic Press, 2004), 128.

difference into a vehicle of intensive difference. It is true that it no longer mattered how distributed in extensive time and space were the different payouts of the contingent claim at its expiry (either at maturity, or on knock-out barriers, etc.) but that the only thing that mattered now was the local convexity of the local market price of the contingent claim, whose fortune under local randomness (expressed by local volatility) was to be balanced by the local rate of change of the premium (time decay). It is true that this was made possible by the fact that the underlying was tradable (thus enabling dynamic hedging). But more importantly, it was made possible by the fact that the market price of the contingent claim was considered given and available. The two go together. One tends to forget that BSM supposes that the value of the derivative as a function of time and the underlying price *is given* in order then to track it with the dynamic replication. But what could it mean to say that the value is given other than through the existence of a market giving it, as a price? And if you say that the value is given per se and has to be so given, held by none other than itself or the argument establishing it (for if it were different, then anybody using the BSM replication argument would be able to buy the derivative at a lower price or sell it at a higher price than this given different value and realize an arbitrage), you will yourself be affirming that this value is given as a market price, to which the rule of non-arbitrage precisely applies.

It is not long before the availability of the derivative price in the market becomes the first given—or rather, the only given. For who is to make sure that the given derivative price in reality comes second to a first given that would be the instantaneous volatility of the underlying? Only if the instantaneous volatility were known would the BSM replication argument guarantee that the derivative price had, derivatively, to be such. But in what way and following what route does that guarantee function? What is the conducting medium of the BSM derivation? We know what the conducting medium is formally, but what is it *materially*? Perhaps the BSM derivation is only a formalism, and its only *material* interpretation is that the derivative price be given in a market and the BSM formula be inverted, rather than instantaneous volatility being given and being known. Perhaps there is no material meaning to instantaneous volatility being given (and known), and the only given volatility is implied volatility.

Dynamic hedging made the problem local. It turned the ex-post accounting equation of the insurance company into a local problem (infinite long run compressed into the single spot) thanks to Brownian motion; however, it simultaneously brought into existence the local matter, the absolute *local* which I call the market—the fact that the derivative price had to be given by the market. Once the ‘insurer’ becomes locally involved and becomes a local dynamic trader,

there are no longer any extensional statistics or actuarial tables upon which he might rely. Even though the statistical parameter (volatility) is formally defined in an instantaneous and local fashion, this only takes place on paper, and the only material statistics on which the trader can rely in order to get his local dynamic hedging strategy going is the market price of the derivative, against which he inverts his pricing and hedging formula. In my reasoning, the inversion of the formula (regarding the price of the derivative as the primary given) comes as an integral part of the material interpretation of the BSM formalism.

The *reality of the market* is the interpretation of the formalism of Brownian motion in the same way as the reality of statistics is the interpretation of traditional probability formalism.¹² For this reason, the smile problem is not a temporary stage, a problem soon to be followed by its solution or correction. The smile problem is the ultimate reality we are talking about, because it is the expression of the fact that the derivative price is always *made as being given*. This implies that the only reality of the pricing model, or the only reality of the given probabilistic framework, is its constant recalibration. The reality of the market is the constant excess, or the constant event that disrupts the existing set of possibilities (the constant Black Swan). The market-maker shouldn't so much

12. See E. Ayache, 'A Formal Deduction of the Market', present volume.

consider the derivative value as being the output of his formula or the product of his replication strategy, but rather consider the derivative market price as the reason to recalibrate the formula. If the only way of getting the instantaneous volatility that is needed in the BSM formula is by implying it from the given option market price, then this by itself implies that the BSM formula is soon to be recalibrated and the implied volatility soon to change when it is inferred from the next option price.

IN THE PIT

C: Turning the conception of reality away from the fixity and calculability of the states of the world (extensity) towards this intensity of recalibration, we can see, indexes something like Meillassoux's philosophical position, which turns away from representation to dwell in a kind of constant event—*hyperchaos* or *surchaos*. So we would assume that your position, like Meillassoux's, would resist being read as a turn towards 'becoming': temporal flux does not seem to be central here at all.

EA: It does not mean turning from fixity to change or from state to flux or to becoming (in the sense of a temporal succession of different states), because recalibration is not a temporal process; it has nothing

to do with a learning process. It is intensive in the sense that the whole infinite chain of recalibration opens up right on the spot, in the same bottomless pit. This is encoded in the meaning of implied volatility: it must be stochastic because you are implying it from a market option price that would not make sense as a market price unless it was construed as stochastic. But any subsequent stochastic model that you might think of for implied volatility is not the last word either, because you would also be calibrating it against the market prices of derivatives (i.e. implying its parameters from the derivatives market prices)—therefore it would also be encoded in that model that it will be recalibrated and that its parameters will turn stochastic in their turn. *This whole infinite chain of recalibration of stochastic models of increasing complexity is all instantly contained in the meaning of market price and in the meaning of the market.*

The market-maker lives in this meaning and in this intensity. He lives in this pit.

C: Then what becomes of his relation to the states of the world and to the probabilities that are attached to them—in other words, what kind of a gambler is the market-maker?

EA: One can see that because he lives right at the hinge of the event (in the middle of the event) and

not in the world that precedes or follows the event, he somehow achieves a ‘state of rest’ relative to the event. He lives at the same (infinite) speed as the event. There is a kind of necessity rather than chance that is attached to him. He is *subtracted from chance*, as Blanchot would say, and for this reason he writes the necessary book (the market). Or he is the player of the single (Nietzschean) dice-throw *for all times* (and not once and for all).

In my 2006 article, I used the character of Gene Kranz (the Apollo flight director) in the movie *Apollo 13* as a depiction of the anti-Black Swan trader. The explosion of the oxygen tank in the Service Module triggered a massive recalibration of the whole framework of (stochastic) control represented by ground control. Crucially, the new states of the world that had to be created (and were not part of the previous situation) in order to save the astronauts, emerged from the same floor and from within the same technology. The broken technology itself was reengineered on the spot, without ever leaving the trading floor, in order to bring the astronauts home. Similarly, when looked upon from the point of view of the theory and ‘ground control’, the derivative pricing tool is always exceeded by the incalculable event of trading of the derivative and, as a result, is always broken. BSM says volatility is constant; however, pricing options with BSM in the market leads to implying volatility from the option

price, and therefore to stochastic volatility and to breaking BSM. But from the point of view of the floor, from the point of view of the dynamic trader who lives in the middle of the event and always recalibrates the pricing tool, the latter always succeeds in bringing the astronauts home.

Contrary to what it was designed to do (i.e., land the astronauts on the Moon), the Lunar Module was used as a raft to bring them back to Earth. “I don’t care what anything was designed to do”, says Gene Kranz, “I care what it can do!” This incalculable *capacity*, which addresses the incalculable event beyond the design, wouldn’t have been available if Gene Kranz (and his team) had not acted as dynamic traders, totally immersed in the floor. As a result, he could no longer give the odds of the astronauts returning home. When asked by the president of the United States what the odds of rescuing them were, he answered: “We’re not losing the crew.” When asked again, he answered again: “We are not losing those men.” This did not mean he was certain, as opposed to uncertain. It just meant he was subtracted from chance and was no longer a traditional gambler. He knew no state of the world other than the one he was making himself. Even the category of count is different in his case, and to say that Kranz knew only of *one* state of the world, as opposed to several alternatives, is also to miss the point. Kranz was aware of the massive situation and of its massive

contingency. He wasn't aware of the count of states. The singularity of the event is totally different from the individuality of the state of the world (or of the event now counted as a state of the world). It is always after the fact that you count the event. 'During' the fact, the event is massive and the only way of being aware of its contingency is repetition.

When asked, Kranz repeats. I don't think this engaging with the event, this solution to the Black Swan problem, can be described as 'antifragility'. In a sense, it is a very thin line; it is finer than the blade with which the event cuts the world and chronological time. Kranz is a bladerunner. This matter, in which Kranz or the dynamic trader dwells, is very refined; it comes from the excess of refining the study and the matter of the market beyond any possible probability framework. To the trial and error (tinkering) that Taleb proposes, seemingly unaware of time decay, one should oppose the motto of Gene Kranz: "Failure is not an option". The excess of refinement or extreme aristocracy in dealing with the event implies a different attitude towards life and the world. The refined market-maker also likes volatility, because it is volatility that brings action to the floor and stretches and tenses the material surface that the market-maker lives in. He likes volatility actively—not passively, as Taleb requires. Taleb wants you to take care of your losses and let your gains take care of themselves. He even describes the

history of inventions and technological innovations in terms of this relaxed attitude. Accordingly, Taleb does not have to worry about the lack of volatility because he is waiting and seeing anyway, and is (seemingly) insensitive to time decay. But the active market-maker dislikes the lack of volatility because he gets bored when there is no action. The refinement of thought and aristocracy have melancholy as their correlate. It is not the case, as Taleb claims, that we live in a world that we don't know. Rather, we know the world only too well, so well indeed that the world can sometimes be incredibly boring!

From a Restricted to a General Theory of the Pricing Surface

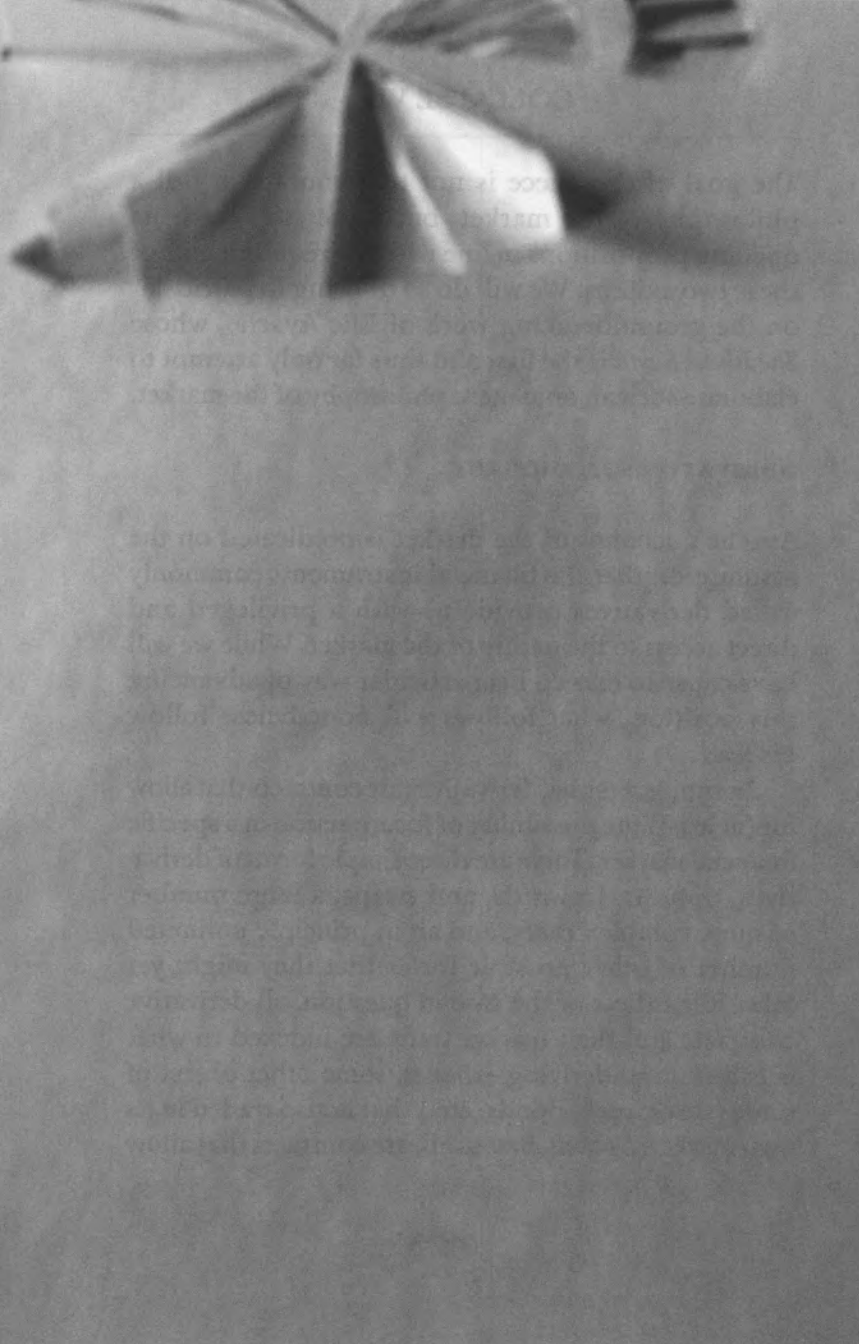
Jon Roffe

TWO AXIOMS

Existing attempts to theorise the market are, in one way or another, instrumental in character, insofar as they treat the market as one class of social processes. The discourses of contemporary economics and the sociology of finance, opposed in many respects, nonetheless both subordinate the category of the market to that of the social. Marx, and in his wake those strains of Marxism that consider the market directly, rely upon a similar position, invoking the category of fictitious capital on the one hand (the derivative and vampiric nature of financial market) and the absolute position of the labour theory of value on the other. In mathematized finance, which in other respects tends to consider the market on its own terms more than any other contemporary position, the market is

subordinated to variously sophisticated frameworks of probabilistic inference—a point that will be returned to shortly. This subordination can even be found in the discourse of neo-liberal ‘free’ market advocates, whose concern for deregulation betrays the presumption that the market is subject by right to regulation and thus capable of being impacted (negatively) by it.

If there is any sense to the notion of a philosophy of the market, it would arise in contradistinction to this instrumentalism. In the wake of Kant, such an approach can be called immanent, an immanent philosophy of the market. This immanent approach has two essential requirements. The first is that a philosophy of the market would think the market from the point of view of the market, without importing theoretical categories from elsewhere. The second is that everything which is of the market must be taken to be significant for the theory of the market. In other words, whatever belongs to the market by right must be taken as significant for the philosophy of the market. These two requirements might be called the axioms of an immanent theory of the market: the (methodological) axiom of immanence, and the axiom of inclusion. The latter axiom is clearly derived from the first, since it asserts at root that no principle of exclusion that arises from outside of the field of enquiry has legitimate methodological purchase within it. Moreover, as we will later see, this latter axiom is also the axiom of the univocity of price.

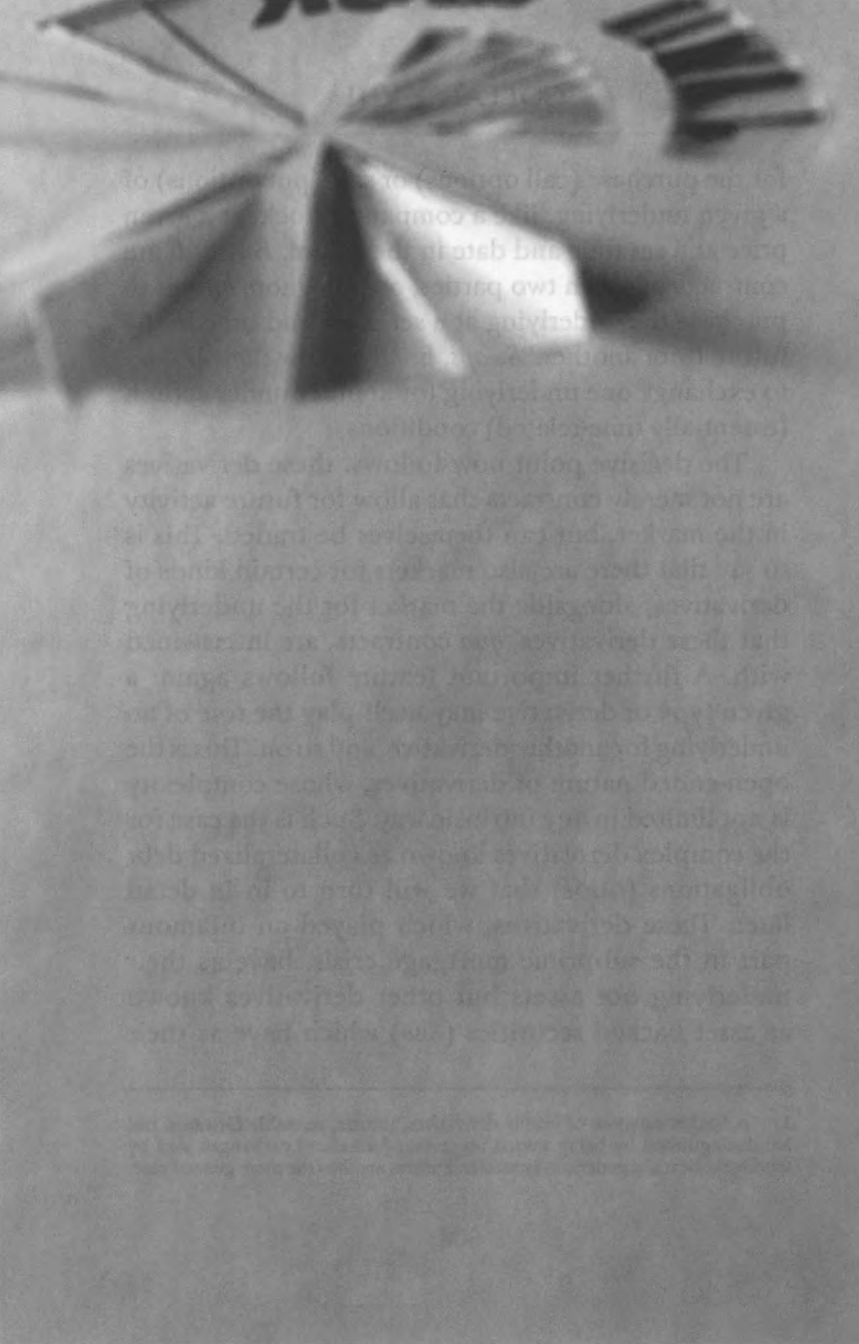


The goal of this piece is not to elaborate in full a philosophy of the market, but rather to sketch its opening propositions in line with the requirements of these two axioms. We will do so drawing in particular on the groundbreaking work of Elie Ayache, whose *The Blank Swan* is the first and thus far only attempt to elaborate such an immanent philosophy of the market.

DERIVATIVES IN OUTLINE

Ayache's account of the market is predicated on the assumption that the financial instruments commonly called derivatives provide us with a privileged and direct access to the nature of the market. While we will have cause to exceed his particular way of advancing this position, what follows will nonetheless follow his lead.

In simplest terms, derivatives are contracts that allow for (at least) the possibility of future action in a specific financial market. There are three simple forms of derivatives, options, forwards, and swaps, a large number of more complex cases, and an in principle unlimited number of other possible forms that they might yet take. Regardless of the case in question, all derivative contracts and their market trade are indexed to what is called an underlying—that is, some other object of trade (stock, cash, bonds, etc.) that is also traded in its own market. *Options*, first of all, are contracts that allow



for the purchase (call options) or sale (put options) of a given underlying, like a company's stock, at a given price at a set time and date in the future. *Forwards* are contracts between two parties, one of whom agrees to purchase the underlying at a set price and time in the future from another.¹ *Swaps*, finally, allow their holder to exchange one underlying for another under certain (essentially time-related) conditions.

The decisive point now follows: these derivatives are not merely contracts that allow for future activity in the market, but can themselves be traded. This is to say that there are also markets for certain kinds of derivatives, alongside the market for the underlying that these derivatives, *qua* contracts, are intertwined with. A further important feature follows again: a given type of derivative may itself play the role of an underlying for another derivative, and so on. This is the open-ended nature of derivatives, whose complexity is not limited in any intrinsic way. Such is the case for the complex derivatives known as collateralized debt obligations (CDOs) that we will turn to in detail later. These derivatives, which played an infamous part in the subprime mortgage crisis, have as their underlying not assets but other derivatives known as asset backed securities (ABS) which have as their

1. A further category of vanilla derivatives, futures, resemble forwards, but are distinguished by being traded on certain formalized exchanges, and by tending to be more generic in character. Futures are thus the more general case.

underlying bundles of assets (often less than desirable or illiquid in nature)—mortgages in the case in question. Markets also exist for higher forms of derivatives yet again that take elements of existing CDOs as their underlying—hence the CDO-squared, CDO-cubed, and so on, each of which steps one degree further away from the underlying.

However intriguing derivatives may appear, they seem an eminently unpromising starting place for an account of the nature of the market. However, as Ayache shows, derivatives expose at least three fundamental features of the market as such: its strictly contingent character, the absolute insufficiency of epistemological formulations about the market, and the univocal nature of price.² Moreover, recall the axiom of inclusion: whatever is of the market must be accounted for in a theory of the market. As Deleuze remarks about the transcendental method, ‘we cannot break off [such an investigation] when we please’.³ That is, the case of derivatives must be accounted for along with everything else.

Ayache’s argument begins from within the discourse of mathematized finance, what is in many respects the account most adequate to the actual functioning of the market. This discourse begins to depart from

2. The integral role of temporality—and specifically the temporal modality of the future—in the structure of derivatives constitutes a fourth point, but one which will not be taken up in this context.

3. G. Deleuze, *Masochism*, tr. J. McNeil (New York: Zone Books, 1999), 114.

economics broadly speaking in 1900, in the landmark study of Louis Bachelier, *Théorie de la spéculation*.⁴ In this piece, his doctoral thesis, Bachelier theorises the movements of stock prices as cases of a continual stochastic process, which is to say that he treats them as ongoing and random in character, subject to no fundamental law. Bachelier's work has one further feature that is significant here. By treating the pricing process on its own (stochastic) terms, he at least partially untethered the theory of market speculation from the socio-political and economic presuppositions that attended it insofar as it was made subordinate to the category of society in economic theory—precisely the aspect of Bachelier's approach that, while providing the groundwork for twentieth-century advances in econometrics, also caused him to be marginalized at a number of points from economic theory. This is not to say that his work is without presuppositions at all. The presuppositions in play however are embedded within the apparatus of the probability calculus itself, a point to which we will return momentarily since it forms the point at which Ayache begins his important critique.

While derivatives have a very long history in one form or another,⁵ it was in the wake of certain developments—

4. A good recent translation can be found in *Louis Bachelier's Theory of Speculation: The Origins of Modern Finance*, tr. M. Davis and A. Etheridge (Princeton, NJ: Princeton University Press, 2006), 15-79.

5. A text from the Bible (Genesis 29:17) is often cited as the first recorded evidence of a option (Jacob agrees to pay seven years worth of labour in

both within finance and 'socio-politically—from the 1970s onwards that allowed for the flourishing of both markets for the trade of derivatives and the development of more complex forms of derivatives as such. Of particular importance though was the development of a mathematical model for the pricing of derivatives. Bachelier's work paved the way, after a fifty year period during which it was more or less unknown, for modern mathematized finance and in particular the resolution of the problem of how to price derivatives. The key development here was that of Fischer Black, Myron Scholes and Robert Merton, who, in a small group of articles in the 1970s elaborated the Black-Scholes-Merton options pricing model (known simply as BSM).⁶

order to secure marriage with Rachel). Should the category of derivative be taken in a more generic sense, there are reasons to extend and broaden this historical account. On the one hand, as Gharagozlou has recently argued, the category (at least in current law) seems to encompass every contract 'for which the remedy of nonperformance is monetary damages.' (A.M. Gharagozlou, 'Unregulable: why derivatives may never be regulated', *Brooklyn Journal of Corporate, Financial & Commercial Law* 4 [2010], 273). On the other, if we take the name derivative to encompass any means of attempting to manage future outcomes via a socially embedded agreement in the present, we might consider that derivatives are merely one case of a very general category of technology coeval with social organization as such, and one which becomes difficult to rigorously distinguish from the technology of money, and more generally the formalization of promises that is intrinsic to law as such.

6. On their respective roles, see Ayache's footnote in *The Blank Swan: The End of Probability* (Chichester: Wiley & Sons, 2010), 67n4. The section in question also provides a good summary presentation of the mathematics of the partial differential equation that constitutes BSM (66–70). For a helpful comparison of Bachelier's account of options pricing with that of BSM, see W. Schachermayer and J. Teichmann, 'How Close are the Options Pricing Formulas of Bachelier and Black-Merton-Scholes?', *Mathematical Finance* 18:1 (2008), 155–70.

Without examining BSM in detail, we can simply note the following two features. The first is that BSM's main function is to provide the price of an option, given certain variables. These variables, including the price of the underlying, are all easily obtained except for what is called implied volatility. In orthodox terms (that Ayache will challenge, as we will see) implied volatility is the estimated range of likely variance of the price of the underlying. Given that the other variables of BSM are easily obtained, it thus fundamentally formalizes the relationship between implied volatility on the one hand and price on the other. The second crucial factor about BSM, above all for Ayache, and one obvious enough to be unworthy of mention from any orthodox econometric point of view, is its probabilistic character. Both because it begins with the presupposition of the stochastic character of the market and because it functions to predict likely outcomes at the level of price given certain variables, it remains fundamentally indebted to the categories of probability and possibility in turn.

CONTINGENCY AND PRICE

It is this latter point that provides Ayache with his entry point, and at which he will develop a critical line of argument on three fronts. The first is strictly philosophical, and concerns the status of the category

of possibility itself. He draws on the one hand on a critique, Bergsonian and Deleuzian in provenance, that aims to depose the category of the possible as such. This argument, as is well-known, asserts that to claim that there are a range of possible future states of the world is to assert the existence of possible world-states *prior* to their real existence. In other words, possibility is asserted to be more primordial than reality. However, possible future states of the world, while being asserted as prior to reality, nonetheless also must be like the real worlds that they will possibly become, making their priority in the genetic order that passes from possible to real reversed at the level of content. The real, it is supposed, is the realization of a prior possibility, a prior possibility that nonetheless emulates the real. This paradoxical situation is what leads Deleuze to write that, in the figure of the possible,

we give ourselves a real that is ready-made, pre-formed, pre-existent to itself [...] the sleight of hand becomes obvious: if the real is said to resemble the possible, is this not in fact because the real was expected to come about by its own means, to 'project backwards' a fictitious image of it, and to claim that it was possible at any time, before it happened? In fact, it is not the real that resembles the possible, but the possible that resembles the real, because it has

been abstracted from the real once made, arbitrarily extracted from the real like a sterile double.⁷

Ayache cites Bergson here: ‘For the possible is only the real with the addition of an act of mind which throws its image back into the past, once it has been enacted’⁸ Both philosophers thus advance the argument that a possible future state only gains consistency retrospectively, or as Ayache nicely puts it, probabilistic analysis ‘masquerades a future in order to mimic a present’.⁹ Or again: ‘Probability is past, not future, and is only *misplaced* in the future’.¹⁰ The upshot of this line of argument is not just that the real is not subordinate to any existing representational structure, but that probability cannot be used as a reliable source of knowledge about the future, since all it tells us about is a selective past.

In concert with this claim is the insistence on a point that Ayache draws from Quentin Meillassoux’s *After Finitude*, that it is contingency rather than possibility that forms the basic matrix of the real.¹¹ Once again, the central claim of this position is well known: that the absolute and foundational character of contingency

7. G. Deleuze, *Bergsonism*, tr. H. Tomlinson (New York: Zone Books, 1991), 98.

8. Ayache, *Blank Swan*, 31.

9. *Ibid.*, 55.

10. E. Ayache, ‘Single-case Statistics?’, *Wilmott* Feb, 2011, 13.

11. Ayache’s particularly astute summary, partial endorsement and subsequent critique of Meillassoux can be found in *Blank Swan*, 133–56.

can be directly demonstrated and defended against all major positions in the modern canon. It may be too strong to say that Ayache draws this argument from Meillassoux, since it is rather the case that the very existence of the market already directly bears out this point: ‘the market, in my philosophy, is also predicated on the *necessity of contingency*’.¹² This is also why he will speak of the performative surpassing of representation and possibility in the market context.¹³

Ayache’s second critical point concerns a fatal redundancy that the orthodox account of the role of probabilistic calculus introduces into the market. He observes that if the model (BSM or one of its ilk) can predict the correct value to give to a derivative at a given point, then it exhausts, in advance, any need to actually trade it, since the only goal of trading is to make money from the difference between expected value and real price. If this real price is known in advance the act of trading becomes entirely pointless, since there will be no way to make a profit in such a situation. In turn, from this point of view, ‘the put is worth zero’,¹⁴ and derivatives more generally are fundamentally conceived as ‘perfectly redundant instruments’.¹⁵ There is then a peculiar characterization

12. Ayache, *Black Swan*, 145.

13. *Ibid.*, 83.

14. *Ibid.*, 335.

15. *Ibid.*, 24.

of the market process embedded in the orthodox view: as a theory of the market, it can do without the market itself, and consists in the final analysis of an inter-probabilistic thought experiment, one that is abstract in the traditional sense, ie., cut off from any reality.

However, the market as an ongoing pricing process in fact takes place, is taking place. No matter the complexity and detail of the use of BSM, the probabilistic description of projected future states comes to an end. ‘However’, Ayache insists, ‘this is not yet trading. Trading the derivative is precisely what happens next’.¹⁶ Taken alongside the earlier points, we can see exactly what this means: that trading happens in the absence of the purported knowledge of the future provided by the probabilistic calculus; a wholesale exchange of knowledge for pricing takes place when trading begins.¹⁷

The third point follows from this. In a very classical Kantian sense, Ayache will nonetheless insist that the probabilistic calculus is not per se useless, but that the orthodox (dogmatic and rationalist, in Kant’s sense) conception of the role of the calculus is misplaced. In fact, ‘the derivative valuation algorithm, pioneered

16. Ayache, *Blank Swan*, 5.

17. As Ayache also argues, traders themselves have no particular investment in the implicit metaphysics of probability and make use of BSM and the other forms of probabilistic inference in just this direct fashion. He is supported in this view, as it happens, by Nassim Taleb. See the frequently cited E. Derman and N. Taleb, ‘The Illusions of Dynamic Replication’, *Quantitative Finance* 5:4 (2005), 323–6, esp. 323.

by Black, Scholes and Merton has been a perfect trading tool and traders have consistently used it, not in order to compute a theoretical value for the derivatives but to price them in the market, that is to say, to trade them and exchange then and unsettle any computed result.¹⁸ That is, in practice BSM—and in an exact parallel with Bergson's claims about the irreducible role played in phenomenological experience by the sensori-motor schema—is not used in order to assert an abstract world order but to orient the trader in the ongoing pricing process.

At this point, it is possible (however schematically) to see why the case of derivatives allows Ayache to justify two of the three claims we noted above, the contingent character of the derivatives market and the absolute insufficiency of epistemological formulations about the market. The only means for knowing about the future of a certain derivatives market is the use of a probabilistic calculus, BSM for example. We have seen though that, however nuanced, such an approach only provides knowledge about the past. The future in such markets is thus not just occasionally afflicted by the catastrophic, unforeseen events that Nassim Taleb dubs black swans, but is *de jure* constituted by events that are all of this sort (hence the blank swan). Probability is deposed in favour of contingency; we see why Ayache ultimately prefers the alternative

18. Ayache, *Blank Swan*, 55.

name given to derivatives in the discourse of the market, *contingent claims*.

If what happens in the market is not the automatic deployment of more or less accurate discoveries about the value of a financial product, then what does happen? The answer is trading—which is to say, *pricing*. The process of pricing is what is irreducible about the market for Ayache. Recall that, given the structure of derivatives, at least two prices are always at stake, the price of the derivative and that of the underlying.¹⁹ What grounds the distinction between these two prices? On the one hand, we see that the difference is established in fact by traders, trading firms, banks, etc., who may be trading only in the underlying. In other

19. Moreover, implied volatility which marks the dynamic relationship between the two prices is also a price: ‘Smile dynamics [which concerns a deviation between modeled and real volatility] is a “price”, just as implied volatility is a price, or the implied yield curve is a price, or the implied credit spread curve is a price. And you have to handle it the same way you usually handle a price that the market offers you. You bet against it, or you use it in a strategy to help determine the price of other things.’ (E. Ayache, P. Henrotte, S. Nassar and X. Wang, ‘Can anyone solve the smile problem?’ in *The Best of Wilmott 2* [Chichester: Wiley & Sons, 2006], 231; the nature of the smile problem is pithily addressed in *Blank Swan*, 75–6). Ayache will also insist (see in particular *Blank Swan* 52–3) upon the fundamentally reversible character of the two prices, the one implying the other, a point also often also made by quants: if you have price, you also have implied volatility, and vice versa.

We do not consider a central—even historically decisive—feature of BSM for Ayache here, namely the way in which it enjoins the trader to be active in both markets at the same time. That is, BSM is not merely a pricing model for options, but provides a way to dynamically replicate a portfolio by playing the two off against one another (ie., hedging). Among other things, this leads Ayache to argue for the irreducibility of the trader, who is required as the active hinge of these two markets and thus the embodiment of the pricing process.

words, there really are two markets in play here. On the other, it is clear that the difference is to be found within BSM itself, in which the underlying is present not only as a price (the current price of the underlying asset), but in the form of implied volatility. It is crucial to see, however, that neither the real distinction between markets nor the distinction between variables in the pricing model introduce a fissure into *price as such*. In the latter case, it is even the case that one can only provide a pricing model if one assumes that it is price that is at issue throughout. Certainly, there are prices; but price as such, the being of price, is homogenous in character. It is this that allows Ayache to argue that the underlying and the derivative are fundamentally traded *alongside* one another, rather than in two radically distinct market spaces, and even that implied volatility registers a movement not in the market of the underlying, but in the market as such, conceived as the mutual space of the pricing of underlying and contingent claim alike.

In philosophical terms, all of this is to say that, whatever the differences between derivative and underlying, between these two markets, price is univocal, and it is this univocity that secures the unity of the market for Ayache. If this logic is further pursued, though, it allows us to see how we might pass from the case of particular markets to the category of the market beyond the specific case of derivative and underlying. Put another

way, the univocity of price demonstrated in the case of derivatives can be generalised. For the same reason that both underlying and derivative are, *qua* prices, traded alongside each other on the market, we can conclude that, from the point of view of the market, anything that admits of a price is *of* the market. However differentiated the various pricing processes that take place on the market may be, they are absolutely homogenous from a view point immanent to the market. Again, this is to say that price is univocal; in turn, the univocality of price is what secures the ontological unity of the market.

If we take these points together, and taking into account this last generalization, we arrive at the following definition: "The market is ultimately the medium of prices of contingent claims."²⁰

TWO FEATURES OF THE PRICING SURFACE

It is at this point that two initial characteristics of the market *per se* can be elaborated. We can observe that, for Ayache, and unlike the projected terminal values provided by BSM, the act of pricing belongs not to an ideal space of prediction but to the materiality of inscription: price is written (the two are even synonymous) and 'the market is text.'²¹ This writing is also material in character for Ayache. This materiality

20. Ayache, *Blank Swan*, 116.

21. *Ibid.*, 92, 107.

marks both the distinction between the contingent character of price and the ideality proper to possibility (its 'depth'), the fact that it is the materiality of the written mark that facilitates transmission (Ayache will speak rather of exchange), and the fact that the ongoing existence of the market is a contingent *result* rather than a self-supporting transcendent realm).

This means that the market is, first of all, a surface of inscription. It resembles nothing so much as an absolute (or asymptotic) palimpsest. Why a surface? On the one hand, insofar as it only concerns price, the market has no depth in any meaningful sense, no volumetric features—another way of saying that there is no valuation in the market.²² On the other, there is nothing more shallow than the market, given the single metric of the pricing-process and the absolute topological barrenness it provides to the market. And because there is nothing on the other side of the market surface—it is not a limit or threshold—it is a one-sided surface.

On the other hand, any account of the market has to reconcile the fact that while the act of pricing is discrete (particular prices are written at particular points in

22. For Ayache, this depth which does not belong to the market belongs properly to the category of possibility and thus to metaphysics (*Blank Swan*, 57). It would seem to us rather that this depth is aligned with the social function par excellence, evaluation. This is not to say that possibility is not a metaphysical category, but just it is also a crucial part of the organization of society—what is possible is what can be judged—and thus that the very regime of possibility presupposes an evaluative volume.

time, whether by a human trader or an algorithm), as long as the market exists, its being is continuous. At the same time, the continuous existence of the market is not radically distinct from the pricing process that is inscribed on it. According to a rather classical order of reasons, we can say that it is the pricing process that supports the subsistence of the market surface rather than the other way around (this is what we meant above by the notion that the market is a contingent result), just because the market surface is not the surface for anything else; at issue there is only price.

The means to bring these points together is provided by conceiving of the inscriptive market surface as *intensive* in character. Topologically speaking, an intensive surface is one that is not separable from the processes that occur ‘on’ it. In other words, process and *topos* are mutually intertwined there. Prices are thus not only written, but constitute intensive ordinates, and the pricing process can be defined, borrowing from Deleuze, as the serialization of intensive quantities.²³ This intensive character of the pricing process also allows us to redeploy a commonly used term from finance, liquidity. In Ayache’s words: ‘liquidity is the opposite of a ground on which one can build

23. While it is to Deleuze that the current points are owed here—and in particular to his two major studies of the concept of the surface, *The Logic of Sense* and *Anti-Oedipus*—it is the source of his own theory of the surface that must also be invoked and developed, above all that of Raymond Ruyer. See *Néo-finalisme* (Paris: PUF, 2012 [1952]), and in particular “‘Surfaces absolues’ et domaines absolus de survol” (107–22).

the edifice of value. Liquidity is a moving ground, a flowing medium where prices, either of the underlying or the derivative, are equally moving and equally “original”.²⁴

**COLLATERALISED DEBT OBLIGATIONS AND THE
GENERALIZATION OF THE PRICING SURFACE**

We began with the critique of probability in order to pass to the contingency of the pricing of derivatives, which was then generalised to include price, and thus allowed for a definition of the market as the regime of the pricing process. It was then possible to define the market as an intensive surface for the inscription of price. These constitute the first elements of an immanent philosophy of the market.

However, in order to effect a second generalization,²⁵ a certain tension between the univocity of price and the pricing of derivatives in Ayache’s work needs to be considered. Despite their obvious centrality in his position, Ayache restricts the scope of his argument to a particular class of derivatives on the basis of two related discriminating criteria. The paradigm case that he aims to exclude from his account is that of collateralized debt

24. Ayache, *Blank Swan*, 56.

25. A third would also be required, one that would take into account all actors in the writing of price—not only traders, but also algorithms engaged in automated trading.

obligations, which we have touched on above.²⁶ While the vanilla derivatives we began with can be formalized in terms of their relationship with the underlying by way of BSM and the similar models that came in its wake, the structure of CDOs forecloses this possibility.

CDOs are based on the bundling together of a pool of assets, bonds or debts—most of the problematic CDOs involved in the US housing crash were of course built on the basis of mortgages. This pool of mortgages is obviously variously composed, with some more likely to be paid back in a timely fashion, and others more likely to default. A CDO is in turn a set of options to buy or sell the likelihood of mortgage payment or default. This set is divided up in terms of these probabilities into subsets or *tranches*, with the least risky sold at the highest premium, and the most risky but potentially most profitable sold most cheaply. It is these tranches rather than the CDO as such that are sold on the market, each of which is valued in relation to the other tranches. In other words, price is no longer a relationship with the implied volatility of the underlying, but is defined as a *correlation* between the various positions within the CDO itself. Given the inapplicability of BSM in

26. For a summary of his position on these instruments and their role in the credit crisis, see E. Ayache, 'How not to bid the market goodbye', *Wilmott* Nov 2007, 42–52. For a more introductory account, which charts the rise and fall of CDOs and other complex securities and the role of ratings agencies in this history, see J. Coval, J. Jurek and E. Stafford, 'The Economics of Structured Finance', *Journal of Economic Perspectives* 23:1 (2009), 3–25.

this case, other forms of probabilistic modeling were developed that allow for the pricing of the tranches in relation to one another, most often through the (not unproblematic) use of approaches that correlate the various positions in terms of likely outcomes in the face of the possible advent of defaults in the underlying.²⁷

While we have seen the dramatic failure of markets in CDOs, from Ayache's point of view the problem must be seen to be related to the very nature of these derivatives, rather than accounted for in terms of the usual explanatory culprits (ignorance, over-complexity, greed, corruption, etc.). The very category of the CDO is, he argues, 'degenerative fantasy',²⁸ writing that

Anyone who believes that [these] derivatives can durably trade and prosper in a market that endures by its own necessity has no other ground for such a belief than sheer dogmatic faith. It suffices that he loses the faith for his market to collapse and disappear. This is exactly what happened in the CDO market.²⁹

27. For a brief summary of the various means used to price CDOs, and their sometimes dramatic deficiencies, see D. Brigo, A. Pallavicini and R. Torresetti, 'Credit Models and the Crisis: An Overview', *Journal of Risk Management in Financial Institutions* 4:3 (2011), 243–53.

28. Ayache, *Blank Swan*, 449.

29. *Ibid.*, 175.

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This passage clearly indicates the two discriminating criteria at issue. The first is that the pricing of CDOs, and thus the existence of CDO markets, takes place in the radical absence of any kind of knowledge, adopting instead the equivalent of a leap of faith. The kind of belief in question is ungrounded by anything whatsoever, and thus liable to collapse the moment that the trader manages to shake off their unwarranted engagement. The second concerns the need for market *durability*. For Ayache, the CDO market demonstrates its secondary, token and false character insofar as it cannot be maintained over time.

The passage to the second generalization of Ayache's account can only be found by overturning both of these claims on the basis of the more fundamental assertions that, we have seen, he makes elsewhere. We should also recall the second of the two axioms with which we began, the axiom of inclusion, since it is only by including everything that is of the market in the theory of the market that a truly immanent account can be achieved. Moreover, we now know that this 'of the market' concerns price and price exclusively. This means in turn that the very fact that CDOs were and are priced means that they cannot be excluded from consideration here.³⁰

30. To this, one could add that the relative success of BSM in relation to the correlationist models used in the pricing of CDOs does not mark a significant difference either, since both models are fundamentally incorrect, a fact that is moreover known to everyone who uses them. The degree to

The first criterion that Ayache advances to distinguish the good derivatives from the bad is manifestly *epistemological* in character—faith in CDOs is ungrounded. However, we have already precisely seen that it is not knowledge at all which is at issue in the market, but only the writing of price, an act that takes place, not in ignorance, but in the absence of any meaningful invocation of knowledge whatsoever. This an-epistemological character of the market might indeed even be characterized in terms of the faith that Ayache suggests must be in play in order for the market in CDOs to exist. Since, that is, I never know what the next price will be—making of the market the ‘technology of the future’³¹—there is nothing to distinguish a market in vanilla swaps from a market in the most complex CDOs from the point of view of price.

The same holds for the second requirement of durability. We might think to leave aside the fact that the kinds of markets in derivatives that are of such philosophical richness from Ayache’s point of view were only exposed as such in the wake of the crash of 1987. The point, though, is precisely that there is no meaningful invocation of chronological time here at all (a point that is moreover central to Ayache’s

which falsity is irrelevant in the valuation of BSM in particular is strikingly shown in Y. Millo and D. MacKenzie, ‘The usefulness of inaccurate models: Towards an understanding of the emergence of financial risk management’, *Accounting, Organisations and Society* 34 (2009), 638–53.

31. Ayache, *Blank Swan*, 21.

construction of the market-time relationship in *The Blank Swan*), since the market's durability is only a meaningful question in the gap between the current price and the next one. This is even why Ayache will write that 'The market *doesn't exist* in the past'.³² But even if this point itself is put aside, it remains the case that CDOs were and are priced, and thus they were and are a part of the pricing process that form a part of the ongoing reality of the market.

THE GENERAL PRICING SURFACE

The second generalization thus becomes necessary in the final analysis on the basis of the immanent requirement with which we began. Consequently, rather than being a generalization, it is more like the lifting of extrinsic barriers, the extrication of criteria illegitimately applied to a rigorous thought of the market. Neither (chronological, metric, lived) time nor knowledge is at issue in the market, whose sole characteristic is the ongoing contingent writing of price and which equally supports and constitutes the intensive surface on which its marks are inscribed. This is the general surface of the market.

32. Ayache, *Blank Swan*, 71.

The Ontology of Finance: Price, Power, and the Arkhéderivative

Suhail Malik

1. FINANCE POWER?

The 2008 financial crisis presented two overt lessons: Lesson One is that the derivatives markets presents a *systemic* risk to national and world economies; Lesson Two is that the relative *size* of these markets is a fundamental risk to geopolitical as well as economic security. The numbers are indeed remarkable: the notional total value of the derivatives market at the end of 2012 was \$694.4 trillion.¹ Compare this to the \$71.7tn global market value of the ‘real economy’ of goods and services, Gross Domestic Product (GDP), for 2012—just over one-tenth of the face value of the

1. Bank of International Settlements (BIS), ‘Table 23A: Derivative financial instruments traded on organised exchanges’, June 2013 [www.bis.org/statistics/extderiv.htm] and ‘Table 19: Amounts outstanding of over-the-counter (OTC) derivatives’, May 2013, www.bis.org/statistics/dt1920a.pdf.

derivatives market, give or take a couple of trillion dollars.² The notional value of directly-traded off-exchange derivative markets—Over-the-Counter (OTC) trading—alone amounted to \$642.1tn, a sum about seven times greater than global GDP.³ While impressive, these headline figures need to be qualified: they represent the sum total of claims *traded* on the market, not how much would have to be paid were everyone in the market to immediately cash-out. This latter ‘gross market value’ at end-2012 is estimated at \$24.7tn,⁴ just under four percent of the notional value of the market or just under a third of global GDP; or, for further comparison, slightly more than the combined GDP of the two largest national economies that year, the USA (\$15.7tn) and China (\$8.2tn). Furthermore, since contracts on the derivatives markets often cancel each other out, for reasons presented later, the *net* credit exposure of the OTC derivatives market and its ‘cash’ value is estimated to be \$3.6tn at end-2012—about 0.6

2. The World Bank, ‘World Development Indicators: Gross domestic product 2012’, databank.worldbank.org/data/download/GDP.pdf.

3. International Swaps and Derivatives Association (ISDA), *OTC Derivatives Market Analysis Year-End 2012*, June 2013 (Updated 9 August 2013), www2.isda.org/functional-areas/research/studies/. Removing foreign exchange (FX) contracts and accounting for double reporting, ISDA reports that the net face value of the global OTC derivatives market at end-2012 was \$417.4tn. The notional value for options and futures exchanges for 2012 are estimated to be \$35.8tn and \$26tn respectively.

4. BIS, ‘Table 19’.

percent of the notional value; a sum comparable with Germany's \$3.4tn GDP, the fourth largest in the world.⁵

These figures and comparisons are striking. What they index is a key feature of the derivatives market: that the notional value of traded contracts amplifies their credit exposure by two orders of magnitude. This multiplication is in part explained by the trade being one of contracts of ownership *claims* rather than direct ownership at full cost: similar to buying a lottery ticket for a multi-million jackpot at the price of a couple of local currency units, the claimed or notional worth of a derivatives contract can be any multiple of its cost.⁶ Yet, even at this latter amount of net 'exposure', the political issue brought into relief by these figures is that the pecuniary magnitude of derivatives markets in total is on a par with all but the most economically powerful national jurisdictions in which they are nominally located and which, assuming the power supremacy of state sovereignty, legislate over them.

To return to Lesson One, however, that final authority is precisely what is weakened—if it is not in fact

5. O. Kaya, 'Reforming OTC derivatives markets', Deutsche Bank Research, 7 August 2013, 14, www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD000000000318054.pdf.

6. The analogy follows Stephen Figlewski's popularising explanation: 'Saying there's \$668 trillion in derivatives floating out there [in 2008] is like saying every lottery ticket sold is worth the full value of the jackpot. If the jackpot is \$100 million and lottery organizers sell 2 million tickets, "that's \$200 trillion worth of lottery wealth that's circulating!" jokes Figlewski' (B. Sheridan, '600,000,000,000,000?', *Newsweek*, 17 Oct 2008, www.newsweek.com/600-trillion-derivatives-market-92275).

upended (as this article will demonstrate)—by these markets’ systemic risk. Two moments of the 2008 financial crisis exemplify the systemic reach of that risk. Firstly, according to the now-standard narrative of the causes of that crisis, the complexity of derivative instruments distributing the risk of interest-bearing loans across the international financial architecture led to systemic and uncontained uncertainty in the credit-worthiness of such instruments as well as the guarantees against their defaulting.⁷ Because financial instruments and their risk could not be securely priced across the sector or even per firm, financial institutions withdrew credit and liquidity from interfinancial trading from 2006, culminating in the collapse of major financial corporations in 2008. Credit also shrunk back in the wider economy of production, services, and consumption from 2006; sectors which, in the Euro-American economies from the 90s onward, had themselves been increasingly sustained by a growing debt-dependency rather than by revenue.⁸ Consequently, the uncertainty

7. M. Hudson, *The Bubble and Beyond* (Dresden: ISLET, 2012); J. C. Hull, ‘The Credit Crunch of 2007: What Went Wrong? Why? What Lessons Can Be Learned?’, *Journal of Credit Risk*, 5.2, 2009, 3–18; C. Lapavistas, *Profiting Without Producing: How Finance Exploits Us All* (London: Verso, 2013), 277–81; N. Roubini & S. Mihm, *Crisis Economics* (New York: Penguin, 2010), Ch.3; E. Stockhammer, ‘Neoliberalism, Income Distribution and the Causes of the Crisis’, *investigación económica*, LXXI.279, enero-marzo, esp. 42–5, eprints.kingston.ac.uk/23226/1/Stockhammer-E-23226.pdf.

8. About 80 percent of the global derivatives market is in the jurisdictions of the US and the EU (Kaya, ‘Reforming’, 4). On increasing household and corporate debt see M. Hudson, ‘Government Debt and Deficits Are Not the Problem. Private Debt Is’, Remarks at The Atlantic’s Economy Summit,

as to the creditworthiness of all financial institutions led in 2008 to a rapid contraction not only of that sector but of the overall economy. The resulting severe economic downturn, exacerbated by ‘austerity’ measures in several regions, exposed the systemic centrality of modern financial arrangements to the nonfinancial economy.

The second demonstration of the systemic integration of financial markets is provided by the transnational response by states to the financial crisis. The pecuniary amounts involved pushed the crisis outside of the conventional scales and terms of operation of state financial institutions.⁹ The transnational state

13 March 2013, Washington DC [michael-hudson.com/2013/03/government-debt-and-deficits-are-not-the-problem-private-debt-is/]; S. Keen, *Debunking Economics*, Second Edition (London: Zed, 2011), Ch.13; Stockhammer, ‘Neoliberalism’, 59–63.

9. Namely, Quantitative Easing (QE) in the US and UK, and the combination of the European Stability Mechanism (ESM) and Securities Market Programme (SMP) for the Eurozone. These policies are unconventional in terms of both magnitude and policy. With regard to magnitude, QE has resulted in a 450 percent increase in ‘the Federal Reserve’s balance sheet [...] rising from \$920bn at the end of December 2007 to over \$4.2tn at the end of February 2014’—continuing with \$65bn per month rolling forward indefinitely from September 2013 (quoting from T.I. Palley, ‘Monetary policy after quantitative easing: The case for asset based reserve requirements (ABRR)’, PERI Working Paper Series 350, May 2014, www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_301-350/WP350.pdf). The ESM has facilitated a reserve of €500bn (about five percent of Eurozone GDP) since October 2012 for bond buy-outs and loan-provision by the EU (‘Gearing up for business’, *The Economist*, 12 October 2013). In addition the SMP established by the European Central Bank (ECB) in May 2010 provides unlimited purchases of government bonds via secondary markets. While both measures seem to contravene the prohibition against any form of central monetary financing of governments stipulated by the 1992 Maastricht treaty founding the EU,

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the SMP circumvents this core injunction by providing a guarantee for markets of government debt (and their concomitant fiscal policies) such that the ECB's monetary provision does not directly underwrite any state's fiscal policy. Similarly, the EMS constructs a Eurowide monetary provision by centrally formalising a set of bilateral loan guarantees channeled through the EU and IMF via a dedicated Luxembourg-based finance institution. On the EMS, see C. Panico and F. Purificato, 'The Debt Crisis and the European Central Bank's Role of Lender of Last Resort', January 2013, PERI Working Papers Series 306, www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_301-350/WP306.pdf. For the SMP, see D. Gros and T. Mayer, 'Liquidity in times of crisis: Even the ESM needs it', *CEPS Policy Brief* 265 (March 2012), www.dbresearch.com/PROD/DBR_INTERNET_DE-PROD/PROD0000000000287245/Liquidity+in+times+of+crisis%3A+Even+the+ESM+needs+it.PDF; a detailed analysis of the 'bounded rationality' (250) of institutional constraints and mobility in the transnational state construction of these unprecedented provisions is given in L. Gocaj and S. Meunier, 'Time Will Tell: The EFSF, the ESM, and the Euro Crisis', *European Integration*, 35.3 (2013), 239–253.

Unconstrained by the Eurozone's institutional distinction between monetary authority and fiscal policy, QE in the US and UK follows the model set by the Bank of Japan in the early 2000s, which faced similar conditions to those confronting the central banks of major Euro-American economies after 2008: shrinking demand lowers prices, and that deflation itself leads to an effective increase in the price of debt (because deflation means the cost of pecuniary assets including debts *increases* in real terms, as then does the size of debt-servicing as a proportion of the overall economy, in turn further reducing demand and exacerbating the initial problem). With interest rates at close to zero in order to reduce bank liabilities (effectively a state subsidy for commercial banks [Lapavistas, *Profiting*, 282]), central banks cannot further encourage lending via this mechanism and so look to stimulate the economy by direct purchasing of highly-graded financial assets such as sovereign debt bonds (also issued by the state) in order to reduce their yield and shift private credit and liquidity to elsewhere in the economy, such as equities in firms thereby providing investment. Alongside this intervention the US Fed reduced federal funds rate for borrowing by commercial banks from over five percent in mid-2007 to near-zero in December 2008 in order to stimulate market liquidity. However, because commercial banks were cautious about further downturns and credit exposure risks after the 2008 crisis, their reserves at the Fed increased from a 2001–07 level of around \$19bn to \$860bn in 2007–08 to \$1.6tn by 2011, or 'more than 10 percent of US annual GDP' for that year compared to reserve levels of less than two percent of GDP in previous crises since the 1970s (R. Pollin, 'The Great U.S. Liquidity Trap of 2009–11: Are We Stuck Pushing on Strings?', *Review of Keynesian Economics* 1.0 (2012), 55–76, www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_251-300/WP284.pdf)).

directives formulated by the G20 in 2009 sought to systematise transparency and reduce scalar risk by requiring greater capital reserves for financial institutions or, equally, capping market exposure for firms dealing with OTC contracts.¹⁰ But these stipulations only serve to capture and organize better the operational framework of the derivatives markets' 'efficient' allocation of capital without proscribing or fundamentally inhibiting their operations. And the reason is clear: with credit rather than revenues providing the conditions for economic expansion, finance markets are now a *condition* of national GDP. While the official sanction for the growth of finance markets is framed in terms

While that reserve reduced the Fed's balance sheet at the time of its own rapid expenditure thanks to QE, the 0.25 percent interest rate on such deposits it offered for the first time on such reserves meant that these accounts provided a direct annual subsidy of \$400bn annually for commercial banks borrowing Fed funds on the one hand and parking it back in the Fed with the other. The channeling of state-generated funds to the financial sector extends beyond banking institutions: because QE mainly supports the prices of financial assets while keeping interest rates at near-zero and relying on banks to provide liquidity to business in a contracted economy with small if any increases in wages, employment levels, and savings, the net effect is a relative increase in income to those holding financial assets—preponderantly the wealthiest five percent of the population, and more emphatically so for riskier asset portfolios than for conservative ones. QE thereby sustained the primary dynamic of neoliberalism since the late-1990s of increasing concentration of income-share towards the very wealthiest via financialization (Bank of England, 'The Distributional Effects of Asset Purchases', 12 July 2012, www.bankofengland.co.uk/publications/Documents/news/2012/nr073.pdf; M.A. Gayed, 'What Wealth Effect? QE Has Helped the Rich More Than the Poor', 21 October 2013, www.minyanville.com/articles/print.php?a=52334).

10. Financial Stability Board (FSB), OTC Derivatives Market Reforms: Fifth Progress Report on Implementation, 15 April 2013, www.financialstabilityboard.org/publications/r_130415.pdf. Cf. also Kaya, 'Reforming', 4–6.

of risk-management and the provision of liquidity to all markets,¹¹ what the crisis itself made palpable was that it is financial markets themselves that impose the systemic entrenchment and expansion of uncontained financial risk—contagion, as it is called—and in the service of that systemic requirement the reduction of liquidity within those markets in the 2008 crisis required significant intervention by state agencies in order to maintain their general economic functioning. For example, Euro-American state support for banks in the year 2008–9 alone amounted to \$14tn (about 25 percent of global GDP). Furthermore, these quantitative factors have a categorial corollary: whereas sovereign monarchs presented the greatest threat to banks in the early capitalist banking system (that of defaulting on war loans), ‘today, perhaps the biggest risk to the sovereign comes from the banks. Causality has reversed’.¹² States are now subject to the distinct power of finance in a way they are to no other terrestrial entity (apart from other states, and climate change).

Even as finance and the state system constitute a nexus of power, it is nonetheless internally riven by the threat presented by the power of finance *against* state sovereignty.

11. FSB, *Implementing OTC Derivatives Market Reforms*, 25 October 2010, 8, www.financialstabilityboard.org/publications/r_101025.pdf.

12. A. Haldane and P. Alessandri, ‘Banking on the state’, first presented at The International Financial Crisis: Have the Rules of Finance Changed?, Federal Reserve Bank of Chicago twelfth annual International Banking Conference, Chicago, 25 September 2009, www.bis.org/review/r091111e.pdf.

If finance (represented by banking or derivatives markets) presents a threat to states, the leading questions are: Why? What is finance power distinct from modern state sovereignty? Since ‘finance’ here is a euphemism for a systemic market-led dynamic organization of capital accumulation, these questions cannot be taken up in terms of the motivations, gains, and losses of those individuals who effectuate financial power and its vicissitudes. Such accounts render opaque the structural and consistent operations of capital accumulation via financial markets by personifying and pathologising the logic and imperatives of capital accumulation, looking past the particular technical and juridical innovations in structure and operation that advance market capitalization. What is required is instead a *power theory of finance* that must take its lead from the operational complexity of financial markets. Most of the following article is devoted to constructing such a theory by synthesising several heterodox theories of pricing, modifying each to fabricate a nonstandard general theory of price and of the political economy of finance. The primary matrix of the argument is Jonathan Nitzan and Shimshom Bichler’s identification of *capital as power*, the outline of which is followed by a mainly descriptive summary of basic derivatives construction and operations sufficient to explain how derivatives structures led to the 2008 financial crisis and, specifically, to the two Lessons elaborated above.

That overview also presents the primary features of derivatives operations in general, leading to the primary contention here, which is the identification of the schematic logic of derivative pricing as a variant of Jacques Derrida's quasiconcept of *différance*. The theory of derivative pricing thereby formulated is then contrasted to a series of other accounts which serve to elaborate and give specificity to the historical and operational institutionalization of derivatives markets which mobilise a différential logic, not least via the praxis of capitalization they inaugurate by constructing time and price relations through one another. Most significant here is the reorganization of the relation to the future via price in general—not just within the circumscribed arena of derivatives markets, but across the entire social order. The comparative analysis also serves to modify the Derridean determination of *différance*, the theorization mutating with the increasingly specific elaboration of derivative operation. In particular, derivatives are shown to systemically operationalise an unprecedented modality of the wager that is intrinsic to the standard notion of betting but is theoretically and practically unavailable upon the basis of that standard notion. The specific determination of the financial condition of price returns to the initial power theory of price as instance of capitalization, therewith providing a comprehensive theory of the real of price determined not in relation to subjective or

sectorial terms but according to the universalising yet différenciating logic of capital-order's construction and operation of power—*finance-power*. The general theory of price requires the theoretical articulation of the *arkhéderivative*, on which basis the basic categories of modern political economy are then reverse-engineered as manifestations of finance-power, concluding with the redetermination of the state-finance nexus and of political futurity in terms of price magnitudes.

In the identification of the complex practices, mechanisms, and institutions of contemporary capitalism in order to revector them purposefully out of it, the argument is broadly sympathetic to Left Accelerationism.¹³ That said, the general theory of price developed here is largely dedicated to the identification of capital-power's complex constitution and organization, formulating its predication on finance, and to what that entails. The revectoring required to provide the requisite political tasks is left to another occasion. Moreover, in addition to providing the comprehensive theory of capital-power necessary for any adequate formulation of a politics of Left Accelerationism (or, indeed, any politics at all adequate to capital-power now), the following argument stipulates two significant reservations as to its current formulation that together serve to retrieve

13. See R. Mackay and A. Avanessian (eds.), *#Accelerate: The Accelerationist Reader* (Falmouth and Berlin: Urbanomic and Merve, 2014). The premises and ambitions of Left Accelerationism are proposed by Alex Williams and Nick Srnicek in 'Accelerate: Manifesto for Accelerationist Politics' (347–62).

Left Accelerationism from its neohumanist tendencies: firstly, that Left Accelerationism must abandon its (admittedly ambivalent) attachment to Marxian and labour-based determinations of capitalism and political economy, because these are not the prerequisites of capital-power in general but tendentious misapprehensions of it (if such positions are not wholly incorrect with regard to the anthropological concerns they serve to articulate, nevertheless they are only incidental and partial consequences of capitalization, and not at all its operative or theoretical truth).¹⁴ The proposition advanced here is rather that the routes to postcapitalism, and what that condition and its political economy can be, need to be instead determined in relation to 'the most advanced theoretical tools available today'. In practical terms, this now means finance in general, and derivatives in particular—not Marxism.¹⁵

Secondly, though more ambivalently, the following theorization of the extirpation of social norms by capital-power (a normativity that does not entail the destruction of social order but the chronic reinstitutionalisation of a risk order) casts significant doubt upon the political and theoretical adequacy of a 'neorationalist' programme to the ambitions of Left Accelerationism. That is, if neorationalism contends that social and

14. Accelerationism's ambivalence towards Marx(ism) is clearly presented in Mackay and Avanessian's 'Introduction' to *#Accelerate* (37–42).

15. Quote from Williams and Srnicek, 'Manifesto', *#Accelerate*, 353, in reference to Marx.

subjective norms can be progressively transformed by the pragmatic universalism of self-revising rational norms, that contention supposes both the authority of reason not only over conceptual thought but also over social norms, and also the revisability of social norms.¹⁶ Yet, for reasons deduced below under the name of the risk-order as capitalization, both of these neorationalist prerequisites are at best questionable: for capital-power, though certainly not directed by theoretical reason, revises social norms to the point at which social norms lose efficacy altogether; authority of any kind is not a prevalent power-modality in the risk-order; and risk itself proscribes any tendential organization or universalist determination, however rationally determined and revisable, other than that of greater capitalization (whose rationality is not that of theoretical reason). In other words, without an accurate and complex enough account of the transformability of social norms on the side of the social itself, neorationalism is left propounding a doctrine without traction. This is not to dismiss the neorationalist proposition altogether, but it does effect an injunction: that neorationalism substantiate the relation between the construction and implementation of rational norms on the one side, and the vitiation of normativity on

16. The neorationalist position is espoused notably by R. Brassier, 'Prometheanism and Its Critics' (*#Accelerate*, 467–87) and R. Negarestani, 'The Labor of the Inhuman' (*ibid.*, 425–66) and, elsewhere, by Peter Wolfendale. See n.89 and 133 below.

the other side—the side of the social order constituted by capital-power. If that articulation can be made, the argument here provides a basis for it.

2. THE POWER THEORY OF CAPITALIZATION

The power determination of finance sought here is theorized by Jonathan Nitzan and Shimshom Bichler. In broad terms, Nitzan and Bichler propose that capital is *directly* power because it is ‘neither a material entity, nor a productive process, but rather the very ability of absentee owners to control, shape, and restructure society more broadly’—a control of productivity that involves the ‘entire spectrum of power institutions’, not least because the absentee ownership at its core requires complex and enforceable institutional structures across a society.¹⁷ Capital accumulation is at once and necessarily a political fact. However, crucially for Nitzan and Bichler, the ‘spectrum of power institutions’ controlling productivity are not a well-organized and unified capitalist class, as a caricatural notion of a bourgeoisie might propose. On the contrary, the main conflict and power struggle in capitalism is *between* those accumulating capital, each of whom looks to do better than the other owners of capital. Capitalists do not just seek to accumulate capital nor (as liberal

17. J. Nitzan and S. Bichler, *The Global Political Economy of Israel* (London: Pluto, 2002), 10.

business dogma has it) to maximize profits, but rather to ‘beat the average’ represented by the normal rate of return.¹⁸ That rate is set not just by the standard instruments such as interest rates, but also by the rate of accumulation of every company and absentee owner, who are therefore competitors for capital. Nitzan and Bichler’s shorthand for accumulation by intracapitalist rivalry is *differential accumulation*, which also posits that accumulation for any one firm is locked into the spectrum of institutional arrangements at local, sectorial, or global scales.¹⁹ The normal rate of return represents the last-mentioned global benchmark for differential accumulation, the index against which any capitalist can measure whether they are ‘beating the average’ or not. And, to return to its necessarily political dimension, it also indexes how the ‘economic’ activity of capital accumulation requires broad social cohesion: a normal rate of return supposes that ‘the underlying power institutions [...] remain stable; the more stable these institutions, the more normal the rate of return, and vice versa’.²⁰

Differential accumulation is a deceptively minimal axiom for what capitalism is extensively—as a system and method of capital accumulation, how it operates

18. Ibid., 11.

19. For a summary of differential accumulation, see S. Bichler and J. Nitzan, ‘Differential Accumulation’, in *Dissident Voice*, 28 December 2011 [bnarchives.yorku.ca/324/02/20111228_bn_da_ft_lexicon_dv.htm].

20. Nitzan and Bichler, *Israel*, 13.

systemically and in its aggregate or micro tendencies—as well as intensively, per transaction and in the sectorial and individual (corporate or personal) instantiations of intracapitalist conflict. The general explanatory theory and logic it provides for capitalization is however mostly based on geospatially organized and historical industrial-corporate capital accumulation and power agglomeration, formations to which Nitzan and Bichler's analyses are mostly dedicated. The question of the types and magnitudes of power combinations between financially-formulated capital and state sovereignty requires that this analysis and its terms be extended to the current operations and structures of finance markets. Nitzan and Bichler's framework accommodates such an extension because, as noted above, for them capital is determined through absentee ownership, and this institutionally organized claim underpins not only bonds and corporate stock but also the derivatives contract. However, a more exact determination of the power theory of finance requires specification of the operational conditions of the logic of intracapitalist conflict on the basis of the two primary aspects of its systemic ordering: *price* and *sabotage*. Taking these in turn:

Price. Following Thorstein Veblen, Nitzan and Bichler propose that capitalists' primary grasp of capital is only in relation to anticipated business earnings,

‘the discounted value of future earnings capacity’.²¹ Future earnings capacity is the expected flow of future revenues; the price paid now for that future income against the normal rate of return ‘discount[s] this flow into present value’. As already noted, the normal rate of return is set by ‘the entire spectrum of power institutions’, while future earnings capacity is ‘the consequence not of productivity as such, but of the *control* [emphasis added] of productivity’, which in turn relies upon the particular historical and legal configuration of that power spectrum. The discount price formula thus reformulates differential accumulation as a specific magnitude, given as a price. Irving Fisher’s (1907) generalisation of discounting formulas provides this last identification: price is the ‘abstract financial magnitude’ of a ‘pecuniary asset’, the latter being ‘merely a claim on earnings’. In short, price ‘tells us how much a capitalist would be prepared to pay now to receive a flow of money later’.²²

Price, then, is core to the capitalist cosmology as an organising index of differential accumulation. It is ‘merely the unit with which capitalism is ordered’, capitalization being the pattern of that order. This cosmology is not just ordered but moreover *constituted*

21. This and two following quotations are from Nitzan and Bichler, *Israel*, 10–11. The outline of Veblen’s argument from the early 1900s is from *Israel*, 31–34.

22. This quotation and those following in this subsection are from J. Nitzan and S. Bichler, *Capital as Power: A Study of Order and Creorder* (London: Routledge, 2009), 151–6.

by price and pricing rather than being the substantial source of the revenue that is priced: ‘bonds, corporate shares, preferred stocks, mortgages, bank accounts, personal loans, or the registered ownership of an apartment block are simply different incarnations of the same thing: they are all income-generating entities’, as is production capacity, fixed or variable capital, corporate structures, and other material terms. Capital accumulation is on each occasion organized only by and for its final cause: anticipated earnings. (‘Final cause’ is not Nitzan and Bichler’s formulation.) All conditions for those earnings are primarily apprehended as pecuniary assets. The fungibility of the pecuniary asset as condition for capitalization will be taken up below in the elaboration of derivatives contracts. More immediately, Nitzan and Bichler’s theory of price explains three primary characteristics of capitalization central to the political economy of derivatives and their markets:

- (i) Indexing the power of ownership indifferently to the specifics of what is owned, prices qua abstract financial magnitudes are ‘uniform across space and time’: prices from one region at one time can be compared and translated to prices from another time and place. Thanks to the fungibility of what is thereby priced, price provides a universal and transhistorical equivalence; and, in thereby presenting a ‘single

quantitative architecture that cuts across time and space', capitalization is world-historical.

(ii) As the measure of an ownership claim on future revenues, price is an exact index of differential accumulation, which is to say: of social power. Through price, capitalists understand their exact place in the order of power, which is thereby quantitatively organized: price is *the* ordering element of capitalization. Such ordering should not, however, be confused with stasis or structural fixity. To the contrary: because what matters in capitalization is not what is priced but rather increasing the magnitude of price qua financial abstraction, for all its ordering and universality price structures the dynamic *reordering* of power, countermanding traditional (notions of) social order:

Prices enable entirely new ways of reordering society. What previously required military conquest can now be done through currency devaluation[...]. [T]he highly malleable nature of prices—i.e., their remarkable ability to go up and down—makes capitalism by far the most dynamic of all historical orders. In fact, in capitalism change itself has become the key moment of order.²³

23. Nitzan and Bichler, *Power*, 153.

(iii) Price is then *the* medium of power in capitalism. Capitalism is, in short, a dynamic power-ordering organized through price as its measure/medium of order and reordering (a doubling that Nitzan and Bichler call capitalism's creative order or 'creorder'). Put otherwise, price is the index and medium of a transformative power-rationality whose specific historical organization is a result of intracapitalist conflict. That always sociohistorically specific struggle is fought through the abstracting universality of price as much as through given and sought-for social arrangements, all of which are therefore transitional.

In every instance, the delocalising and dematerialising abstraction wrought by capitalization is the condition for, and the effect of, the universal and dynamic social reordering of *power* qua differential accumulation. On this account, 'all that is solid' does not 'melt into air', but is ordered via abstract financial magnitudes in and as a power-rationality that is the political real of capitalization.²⁴ All political mobilisation consequently

24. 'All that is solid' refers to the characterization of capitalism's abstracting and deracinating effects in *The Communist Manifesto*, Ch.1. Capitalism's abstraction of material conditions is characterized as the spiritualization or ghost dance of fetishism in the commodity analysis presented in *Capital* 1, Ch.1 §4. While both instances exemplify at source a general Marxist tendency, explicitly articulated in this section of Capital 1, to accuse capitalism of mystifying the labour theory of value that is its concrete truth, such theories are in fact themselves obfuscations of capitalization qua pricing. The tendentially spectral-literary characterization of capitalism has been revived in relation to Marx by Jacques Derrida's *Specters of Marx*, tr. P. Kamuf (New York: Routledge, 1994 [1993]), and in relation to finance

has to determine its real and its own capacity with regard to the quantification of power as price—an initial indication of how the power theory of capitalization adapted here takes leave of Marxian doctrine, a divergence that will become more emphatic as the analysis proceeds through the specifics of derivative structures and operations.

Sabotage. Differential accumulation names the logic and dynamic of intracapitalist conflicts, more colloquially formulated as ‘beating the average’. There are two effectively equivalent ways to meet this imperative: increasing ownership over future earnings—which is what pricing does—and/or ensuring that other firms do not accumulate as much as they otherwise could. The latter operation happens in two ways: sectorially,

by J. Vogl, *Specter of Capital*, tr. J. Reder and R. Savage (Stanford: Stanford University Press, 2015 [2010]).

Alfred Sohn-Rethel proposes that capitalism is a ‘real abstraction’ or ‘real subsumption’ constituting a material-social-cognitive real that it also indifferently deracinates. See *Intellectual and Manual Labour*, tr. M. Sohn-Rethel (Atlantic Highlands, NJ: Humanities Press, 1979), a thesis extended by Maurizio Lazzarato in the mid-1990s to affect (‘Immaterial Labor’, tr. P. Colilli and E. Emory, in P. Virno and M. Hardt [eds.], *Radical Thought in Italy* [Minneapolis: University of Minnesota Press, 1996]), and influentially taken up by Michael Hardt and Antonio Negri in *Empire* (Cambridge, MA: Harvard University Press, 2001), 254ff. A variant of the formal abstraction thesis—in which capitalism transforms a preexisting reality that is more authentically constituted in other, more immediate terms—is upheld by Nitzan and Bichler themselves in their affirmation of Cornelius Castoriadis’s notion of the ‘magma’ of human creativity irreducible to capitalization as the condition for a political counterpower to the latter (*Power*, 20ff.). That said, it is however also Castoriadis’s theorization of the *nomos* as the semantically organized institutional order of a society that provides the basis for identifying capitalization axiomatically rather than by material particularities, labour, or consumption (*Power*, 148–50).

competing firms' capital accumulation has to be diminished compared to one's own; globally, it requires 'limiting the average rate of growth of profit' in order to secure a differentially greater accumulation per firm *against* the average rate. Nitzan and Bichler identify this intrinsic and necessary diminution of overall growth as the *sabotage* wrought by business, the latter term meaning ownership of capital accumulation.²⁵

Sabotage is the socioindustrial correlate to pricing, a systemic characteristic of capitalization, which now has to be understood as the diminishing of aggregate social productivity (that Veblen calls 'industry'): for example, taking out competitors or limiting technical or institutional capacities with patent restrictions. This holds for interfirm rivalry per sector as it does in the global and sectorial dimensions, which are all thereby interlinked: sabotage is a determinant of the normal rate of return, which indexes the systemic organization of the spectrum of power. Extending sabotage to encompass broader social organization and pricing:

the very existence of this 'normal' [rate of return] enables even the most insignificant actors to exercise their 'natural right' for universal sabotage. Since individual capitalists, however small, can always earn the normal rate of return by simply owning a diversified portfolio, they have no reason to produce at less than

25. Nitzan and Bichler, *Power*, 246–7.

that rate. [...] In accepting the normal rate of return as a minimum yardstick below which production should not be extended, they effectively propagate sabotage—even when they themselves do not have the differential power to back it up. Sabotage becomes invisible, ‘business as usual’ as they say.²⁶

As a systemic condition, differential sabotage manifests itself in diverse social arrangements including unemployment, inflation, wage restraint, social fragility, education policy, immigration regulation, etc. In general terms, the normal rate of return indexes the fact that, contra Marxist and Neoclassical accounts, capitalists do *not* accumulate capital by seeking to maximize profits by increasing production, innovation, and consumption, but that differential accumulation requires compromising production as such. Business is then not just unproductive but, moreover, necessarily *counterproductive*—as are capitalist societies overall and in general.²⁷

Price and sabotage, then, are respectively the financial and industrial operators of differential accumulation. It is core to Nitzan and Bichler’s theorization that these aspects are not held apart as distinct dimensions of the social totality, with the first being treated by economics and the second under the banner of a politics

26. Nitzan and Bichler, *Israel*, 38.

27. Nitzan and Bichler, *Power*, 249.

incommensurate with the former. Rather, price and sabotage are coeval and mutually determining, directly constituting the organization of power across society at every scale as a necessarily integrated *political economy*.²⁸ This point will prove to be a primary determinant of the ontology of finance and so requires further attention.

Nitzan and Bichler establish that price directly indexes the political economy of capitalization by generalising Gardiner Means's observations of how businesses fared in the Great Depression.²⁹ Means demonstrated that concentrated industries, which are inflexible and set 'administered prices' relatively unresponsive to market conditions, increase their share of differential accumulation against competitive firms, whose 'market prices' are more responsive to changing market conditions. This because the prices and profits of the former 'respond[ed] only partly or not at all to market conditions', instead fixing a 'long-term target rate of profit and then back-calculat[ing] the mark-up necessary to realize this rate of return over the long haul'. Consequently, prices and profit for such firms during the Great Depression resulted in relatively small declines in prices correlated to sharp drops in productivity and employment. In contrast, firms setting 'market prices' had smaller relative drops in employment

28. Distinct in this to both Neoclassical liberalism and Marxism: cf. Nitzan and Bichler, *Power*, 13 and Ch.8.

29. This paragraph paraphrases Nitzan and Bichler, *Power*, 241–2.

and productivity, but took a larger hit on profits. For Nitzan and Bichler, this demonstration of differential accumulation via price-setting strategies makes explicit that the administering price according to mark-ups ‘already embodies the power to incapacitate’ the social order. That power of fiat pricing can be identified with Michal Kalecki’s notion of a ‘degree of monopoly’, which ‘measures the consequence for relative profit margins of monopolistic institutions and forces’, that is, the degree of power concentrated in a firm relative to the entire spectrum of social institutions.³⁰ The mark-up of ‘administered prices’ is then not only directly the power to incapacitate by competition and the ability or not to own at a given price; it is also the direct measure of the firm’s concentration of power in the entire social spectrum. The key theoretical consequence is that if price-setting advances differential accumulation via both accumulation and the concentration of social power, then *prices set the market*.

3. GENERAL OUTLINE OF FINANCE POWER

Administered prices make explicit that price is the medium of capital accumulation *qua* power-ordering. Accumulation/sabotage is organized by the absentee ownership of assets, which is not ownership of production but of price-setting. This is what power

30. See too Nitzan and Bichler, *Israel*, 39n.11

is in capitalism. By definition, such power is held by capitalists; more salient than this sociological truism is the fact that *finance* is the structural and constitutive condition for that power. Determined initially as the absentee ownership and pricing of assets, finance is also the basis for capitalism's durable yet dynamic *revision* of ownership and pricing of assets, as well as the broader institutional structures of capitalization, at three levels simultaneously:

at the most basic level, it allows owners to lever technical change [...] as a tool of power. At a higher level it lets them use the monetary symbols of prices and inflation to restructure power. And at a still higher level, and perhaps most importantly, it permits them to reorganize power directly, by buying and selling vendible ownership claims.³¹

In contrast to other manifestations of social power, the market of vendible ownership claims—financial markets, whether or not they are explicitly characterized as such—structure institutions according to the primary 'generative order' of capitalization, a 'formula [that] is special in that it doesn't specify what [capital-power] should look like'. Indifferent to the specifics and qualitative particularities of how power is organized, markets and pricing predicated on finance enable social

31. Quotes in this paragraph are from Nitzan and Bichler, *Power*, 306–7.

reshaping and reformatting ‘in innumerable ways’ that ‘no other ruling class has ever been able’ to undertake. It is thanks to finance that the market is the condition, instantiation, and medium of the indefinitely variable, anonymising, and fungible capital-power. Or: finance is the condition and means of capital-power, and capital ‘is finance, and only finance’.³²

As the structural condition of capitalization, finance logically precedes it; and capitalization itself precedes (and exceeds) economics as the constitutive and necessary politics of that restricted regime. Or, inversely: economic practice is a restricted theoretical and practical rendition of capitalization, and capitalism is only a particular order of financialisation, meaning that it is *not the only possible one*. The analysis and politics of capitalization advanced here requires that it is *finance* that is the a priori of all historical and theoretical determinations of ‘industrial capital’. Contrary to how Marxian and Neoclassical doctrines determine prices to be set by interfirm rivalry given exogenous conditions (such as supply-demand, labour and capital costs, consumption, etc.),³³ such that the supposed priority of the latter casts finance capital as parasitical, supplementary, or ‘fictitious’,³⁴ according to the power

32. Nitzan and Bichler, *Power*, 262; see too *Israel*, 36.

33. Nitzan and Bichler, *Power*, 239.

34. Marx adopted the common if ill-defined mid-nineteenth century term ‘fictitious capital’ in his notes from the 1860s–80s, edited by Engels as *Capital* 3 (M. Perelman, *Marx’s Crises Theory: Scarcity, Labor, and Finance* [New York:

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theory of price, financially-set prices are the *primary* elements for the dynamic organization of capital-power.

Praeger, 1987], Ch.6). Introduced in Chapter 25 of *Capital* 3 to designate bills of exchange contrasted against trade or exchange, fictitious capital is distinguished in kind from real capital via the paradigmatic example of interest-bearing capital (Ch.21). The owner of an interest-bearing loan does not transform the lent money into productive capital via commoditization or trade, nor is ownership of the money transferred to the borrower who makes use of it. Without commodity or monetary 'metamorphosis' in the M-C-M' concatenation, or the promulgation of social reproduction (that is, channeled through labour), for Marx the initial sum 'ceases to function as capital' in its 'reflux' back to its original owner with interest. As such, even if the borrowed money is real capital because it is transformed via commoditization, the initial loaned money is but a fictitious capital (which is also why money itself is not necessarily capital but only when it is in the process of social reproduction). Marx generalises the distinction to all prognostications of future income that do not proceed via the commodity form under the name 'capitalization', which is the 'formation of fictional capital' (Ch.29). The danger of capitalization for Marx is that the money-owner does not recognize that income is accrued from social processes but takes it wholly formally, 'something with automatic self-expansion properties'. Accordingly, Lapavistas follows Marx in differentiating between interest-bearing loanable capital, which is 'a hard reality of the capitalist economy', and fictitious capital, by which he takes Marx to mean capitalization via the discount price formula (*Profiting*, 28–9, 161), but he also thereby discards that either route is an equally valid modality of capitalization *for the money-owner* seeking returns primarily with a view to where greater returns can be made—a process that, pace Marx, is not desocialised but, precisely, sociohistorically immersed in differential accumulation. Loren Goldner, for whom capitalization is the current value of future income, argues that fictitious capital is the primary determination of capitalism since the 1970s because of the effective marginalization of labour in dominant economies over the period. Consequently, overcoming capitalism requires not a labour-based struggle but the abolition of fictitious capital and the value-form, a proposal shared with Endnotes' call for communization (n.129 below) despite Goldner's other theoretical disagreements with them ('Fictitious Capital and the Transition Out of Capitalism', 2005, home.earthlink.net/~lrgoldner/ and 'Once Again, On Fictitious Capital', 2003, home.earthlink.net/~lrgoldner/onceagain.html). While not a Marxist, Hudson deploys the notion of fictitious capital mainly to describe the growth of 'paper wealth' over the interests of the capitalism of industrial production ('From Marx to Goldman Sachs: The Fictions of Fictitious Capital', 30 July 2010, michael-hudson.com/2010/07/from-marx-to-goldman-sachs-the-fictions-of-fictitious-capital1/).

That this renders untenable any distinction between finance capital and a putative ‘real capital’ ostensibly predicated on conditions exogenous to finance does not prevent analysis of how the financial sector impacts the nonfinancial sector. Quite the opposite, in fact: finance necessarily promulgates sabotage *in general*, meaning that it is an inherently counterproductive power. The capitalization of business earnings ‘represents nothing but incapacitation’; or, contrasted to price as an abstract financial magnitude, ‘capital is a negative industrial magnitude’.³⁵ To extend Nitzan and Bichler’s formulation, the *positive* determination of price *qua* ‘abstract financial magnitude’ is on the other hand that it directly indexes capital-power’s ordering and reordering.

Taking GDP to be a proxy of the aggregate representation of earnings at a state scale, the comparisons presented in the introduction above indicate that the power magnitude of derivatives markets as a whole have now exceeded that of most nation-states. States have of course been the principal matrix of political modernity since the establishment of the power supremacy of state sovereignty with the 1648 Treaty of Westphalia. If derivatives markets and states are now of the same order of magnitude of capital-power, this signals that sovereignty is no longer the supreme power in the quantitative regime of capitalization, but

35. Nitzan and Bichler, *Power*, 249.

must contend with finance power on a more or less equal footing—and states are increasingly outpriced. As Haldane and Allessandri recognise, at this historical juncture dominant power consists in the power of finance-markets as much as (if not more than) in state sovereignty (the ‘as much as’ here is meant literally: their respective capital-powers can be gauged by the magnitude of each as aggregate ‘pecuniary assets’). That combination forms an organizational and operational nexus of dominant power that can, for ease of recognition, be called neoliberal governmentality. Such governmentality is a quasi-statist power formation which, while it is in part constituted by the established configuration of modern statehood, at the same time corrodes its primacy, as exemplified by two interrelated transformations in its primary structures: firstly, the size of contemporary finance capital, as well as its ‘interconnectedness’, require a transnational organization of legislative and regulatory conditions for finance. Consequently, territory as the spatial extension of state power is not an adequate basis upon which to contend with finance-power today. Put otherwise, the jurisdictional powers of nation-states are interlocked with the transnationality of contemporary finance power, corroding the boundedness and autonomy of their sovereignty (hence the importance of interstate organizations such as the Bank of International Settlements and the Financial Stability Board, which are

at the forefront of these transformations). Secondly, the power supremacy of sovereignty in authority, up to and including military and police powers, is now subject to the reordering wrought by capital-power and conditioned by finance. The magnitudes of this latter power are now large enough to substantially supervene on sovereignty as the final term of statehood and regulatory institutions.

The state-capital nexus transforming modern statehood is but one consequence of the dynamic power-rationality wrought by capitalization. Finance, to repeat, is the structural and operational a priori of capital-power's reordering—an aprioricity here called capitalization's *financiality*, operationally tantamount to prices being set only as a mark-up against other prices. The trading of contracts for future exchange of the 'absentee ownership of assets' in financial derivatives markets explicitly demonstrates this condition. While it therefore seems that the operations of finance markets concretely instantiate the a priori financiality of capital-power, now transactionally liberated from the alibi or convention of the commodity, service, or income stream as exogenous condition for pricing, any such identification has to be cautiously made. While the a priori financiality of capital-power is the *systemic* condition for capitalization, the finance markets are practical and institutional operating mechanisms and facts of capital accumulation. That is, though finance

markets are certainly constituted by the financiality that conditions capitalization and its power-rationality (its transcendental condition, in critical philosophical terminology), finance markets cannot be *directly* identified with financiality in general without category error or subreption, because the former are an institutionally specific sector of capitalization. However, maintaining the distinction between financiality as condition of capitalization and financial operations presents a problem for the argument regarding the redistribution of power between finance markets and states: the categorical distinction between financiality and financial operations advanced here means that the shifts in the relative power magnitudes between the finance markets and states do not necessarily index transformations in *what* power is, in power types. Consequently, the state-finance nexus could be deemed to be wholly coherent and to mark no significant change in power: just more of the same in another guise. But the caution here is not a proscription: the task of this essay is to articulate and integrate the two dimensions of finance—as a priori condition *and* as a historical fact—without directly identifying them. Yet it also seeks to demonstrate that finance markets and derivatives in particular *are* the truth of capital-power as endogenous capitalization made explicit in practice. And it is on this basis that the typological mutations of dominant power between finance markets and states can be explicitly identified.

In order to do that, more detailed elaboration of the operations, logic, and structure of derivatives markets is required.

4.1. DERIVATIVES: TRADING

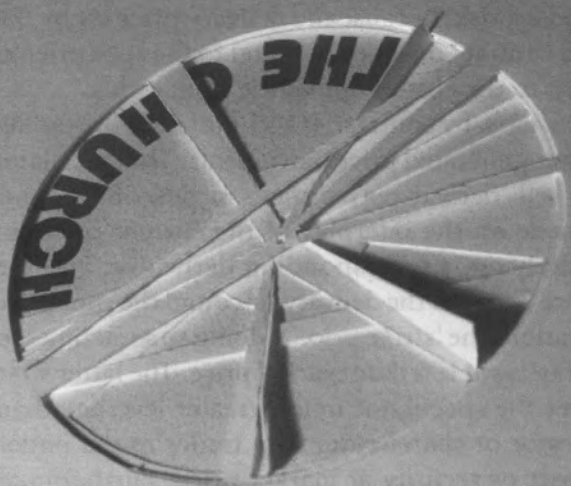
The myriad derivatives structures prevalent in finance markets are of course only constructed and deployed in the service of accumulation by trading. Apprehending the principal strategies of trading provides an operational basis for understanding their construction, outlined in the next section, leading in turn to the determination of the specific logic that has reordered political economy and power ontology in the wake of the growth of finance markets since the early 1970s. But in advance of that, some basic structure and terminology need to be elaborated.

In their simplest standard (Neoclassical) formulation, derivatives are contracts between two parties whereby one side pays out a mutually agreed amount (the ‘delivery price’) if circumstances specified in the contract take place at a designated termination date (‘maturity’ or ‘expiration’).³⁶ The eventualities may be those of prices (of a commodity, company stock, interest rates) at some determined point in the

36. The technical account in this section paraphrases elements of the leading derivatives textbook in English: J. C. Hull, *Options, Futures, and Other Derivatives: Seventh Edition* (Upper Saddle River, NJ: Pearson Prentice Hall, 2009), Ch.1.

future, of cash flows or payment defaults, or other non-monetary eventualities—for example, the weather (snowfall determining skiing conditions and therefore revenue for a resort, a month of rain for agricultural production), livestock populations and disease, technological innovations, and so on. The contracted claim is contingent in a double sense: firstly, it depends upon an eventuality independent from and external to the contracted price, which is known as the underlying asset (sometimes reduced to ‘the underlying’); secondly, in the prevalent sense in which the term is understood in derivatives markets, the eventuality upon which the payout depends may or may not be occasioned, meaning that the contract will lead to a gain or a loss by one party or another, but without certainty as to who will be the gaining/losing party. Gains or losses are made dependent on whether the price agreed in the contract, the delivery price, is higher or lower than the market price of the underlying (the ‘spot price’) at maturity. There are three principal distinct strategies of derivatives trading: arbitrage, hedging, and speculating.

Arbitrage is trading across markets in order to secure riskless gains. For example, buying an asset in one country to sell in another to take advantage of the price differentials and exchange rate across the markets. There are no costs for the arbitrageur other than transaction costs. Such trading, however, quickly eliminates the



differentials from which gains can be made, meaning that arbitrage opportunities are self-limiting.

Hedging reduces risks on a given investment either by locking down prices of assets on a future transaction with a 'forward contract', or by offsetting risks of price movement of owned assets in one direction by making gains from counter-movements of price. Hedging insures against variations in fluctuating financial rates and contingencies in supply-demand levels (crop yields, fuel prices, interest rates, monetary instability, etc.) and stabilizes contract prices.³⁷ Hedging also introduces a risk, because the delivery price set by the forward contract may not be equal to the spot price at maturity, to the cost of one of the signatories.

Speculation, by contrast, is accumulation by trading on market-generated price movements. The speculator buys or sells derivatives contracts in view of the gains to be made on the interplay of the current prices of the underlying, a corresponding derivative, and the difference between the delivery price and the spot price at expiration (the 'strike price'), doing so sometimes to acquire assets at less than market price. The latter strategy gives the speculator much greater leverage than the investor or shareholder who trades in the underlying asset or security at market price. Furthermore, because speculators make gains by market trading,

37. For hedging as a market-based insurance mechanism see R.L. McDonald, *Fundamentals of Derivative Markets* (Boston: Pearson Addison Wesley, 2009), §2.5.



their primary interest is in the *prices* of the assets and financial instruments rather than the underlying assets, the latter being immediately resold in order to realize them as only 'pecuniary assets'.

As speculation demonstrates especially clearly, derivatives markets in general are not markets for vending underlying assets external to them at their 'live' price, nor for investment, which looks to make gains by taking a share of profits or revenues made by the underlying asset as an element of industry, agriculture, and production (in short, in the 'real economy'). This is often the basis for criticism of speculation, along with its maximising market leverage of financial instruments over the non-financial sector, leading to distortions in pricing across all markets as well as a disregard for the fate of the underlying asset and 'the real economy' it represents. Defenses of speculation are based on its 'absorption of risk' since (i) the vending of financial instruments is based on anticipating higher returns, and (ii) speculation is the other side of hedging: the hedge that anticipates and insures against prices movement presumes a speculator who accepts the risk of the differential between spot and delivery prices as worth bearing. Moreover, since speculation exploits the price differentials (spreads) over time as well as between buyers and sellers prices, speculation 'bridges' these differentials, providing liquidity to markets where exchange and trade would otherwise diminish.

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What is important here is that the derivative contract and therefore its market is dependent on the underlying in one regard only: whether or not the conditions stipulated in the contract are met. While the prices of the shares or equities of a company—and therefore investment in it—depend on the history and pathway of its profitability, productivity, growth, energy and resource costs, and so on, the payout of a derivative is determined solely by the terms set up by the contract. Unlike in investment, in speculation gains can be made from decreasing profits, a market crash, or a food shortage, if that is what the contract stipulates and regardless of any other consequences. Moreover, the underlying is but an occasion for drawing up derivatives contracts, their anonymous material. The historical, material, or qualitative particularity of the underlying is irrelevant beyond the *price* conditions set in the contract, as is its fate once the contract expires. By virtue of this endogeneity of accumulation by pricing contracts, and despite the frequent use of the terms ‘investor’ or ‘hedge fund’ to designate activity on derivatives markets, ultimately it is speculation that is the defining category for *all* derivatives contracts and their markets.

4.2. DERIVATIVES: STRUCTURES

Trading in derivatives markets relies on the operationalisation of financial instruments that practically compose them. This section presents a rudimentary elaboration of the primary mechanisms of derivative contracts, from which the general operational logic of finance markets can be extracted. It is this latter logic that will permit the institutional operation of finance markets to be articulated with financiality as the a priori condition for capitalization, in turn allowing the transformation of power wrought by these markets to be grasped. Four basic structures are presented here in order of increasing complexity: forward contracts, futures, options, and swaps. Though swaps were key instruments in the systemic dynamics leading to the 2008 financial crisis, for reasons given below, the speculative logic of finance is most evidently demonstrated by forward contracts and options, which will therefore be the main analytical focus.

A *forward contract* is the most straightforward financial derivative mechanism: the agreement to buy or sell an asset at a certain price in the future.³⁸ The contract itself is traded off-exchange and costs are borne at maturity. Agreeing to buy the asset is called the long position, while agreeing to sell it is the short position. The agreed price is called the delivery price (denoted K);

38. Hull, *Options*, Ch.2.

COLLAPSE VIII

the actual price of the asset at maturity, when it will be traded, is the forward price (denoted S). In its standard account, the contract is made in view of the likely difference between delivery and forward prices yielding a profit or loss for one of the parties. In general, if the spot price is more than the delivery price then the long position makes a gain and the short position a loss. The gains and losses are reversed if the spot price is less than the delivery price. Put schematically, if the spot price of the asset at time t is S_t , then:

- the long position (having agreed to buy the asset)
at time t is worth $S_t - K$
- the short position (having agreed to sell the asset)
at time t is worth $K - S_t$

Illustration

Imagine the cover price of COLLAPSE is set in response to demand.

A forward contract is made at time t_0 for delivery of 25 copies of COLLAPSE with a delivery price of 500 Local Currency Units (lcu), anticipating a market price of 20lcu on its long-awaited publication.

Over time t the spot price S_t of COLLAPSE increases from 20lcu to 24lcu because that issue of COLLAPSE will include a new essay by Quentin Meillassoux.

At maturity, the long position immediately sells all 25 copies at the market price at time t , making a gain of $25 \times (24 - 20) = 100$ lcu, a profit of 20 percent (excluding transaction costs for setting up the contract).

Equally, at maturity the short position sells an asset then priced at 600lcus for the forward price of 500lcus, bearing a loss of 100lcu at the current market rate.

This straightforward illustration demonstrates that derivatives are so-called because they stipulate a price in relation to the spot price which is itself set by the market in the underlying (here, the impending issue of COLLAPSE). What the relative simplicity of the forward contract also exposes is the exogeneity of the underlying to speculative accumulation: while the cover price of COLLAPSE in the illustration is set by content-related demand, the speculator taking the long position has no interest in Meillassoux's essay itself, as demonstrated by her immediately selling the acquired copies of COLLAPSE at the market rate at maturity. This is a necessity of speculative accumulation: there is no pecuniary gain unless the acquired asset is converted into revenue (taking an interest in the content of the publication by holding a copy of COLLAPSE back from the market to read it reduces the overall income). That is, while in this case it is Meillassoux's reputation that drives up the price of the underlying of the forward contract in the imagined competitive market, the speculator is interested only in the increase in price for *whatever* reason. For example, increases in printing costs could lead to the same gains for the speculator even if they mean a reduced net income for Urbanomic. The derivative is

exogenous to the causes for price movements of the underlying other than how they shape the *pricing* of the underlying. Speculation by derivatives is in general content-indifferent, which, again, is why it is not investment. It depends *only* on the spread between the forward price and the spot price at maturity, the latter being set by the market for the underlying.

Futures contracts are forward contracts whose trade is guaranteed not by the counterparties but by the exchange on which the contract is made, as is delivery date (to the month). Traded on an exchange, prices of futures contracts vary according to 'market forces':³⁹ the delivery price of an asset (K) goes up if more traders take a long position (that is, agree to buy an asset at a future date at delivery price) than short positions on it. The contract is then less profitable for the long position in relation to an anticipated increase in the spot price ($S_t - K$ decreases or is negative), but more profitable for the short position ($K - S_t$ increases). Equally, the preponderance of short over long positions (i.e., more selling than buying of contracts at a given delivery price in expectation that K is too high) drives the delivery price down.

In other words, futures markets price forward contracts according to the derivative markets' price movements as well as those of the underlying in its own market. Because of this 'self-correction', the futures

39. Hull, *Options*, §2.3.

market is speculative in the sense that it ‘rewards’ risk-taking on contingent claims: greater gains are to be made betting on a delivery price before there is a preponderant view that it is set too low and before the price of the underlying asset rises to meet it. In the standard account (which will be usurped below), both long and short positions are taken in their respective *expectations* of making a gain by advantage of this spread. As for forward contracts, these anticipations are obviously contradictory (they cannot both be right), but their common condition is that the eventuality upon which a gain or loss is occasioned depends upon the strike price which is necessarily and constitutively unknown at the time the contract is made. Insofar as that unknown comes to be determined by the pricing of the underlying in its primary market, the derivative’s *exogenous* relation to that price is that of a traditionally-conceived wager: the throw of the dice does not depend on the bet made upon it, nor does the speed of the raindrop dripping down a window. By this account, derivatives are then but wagers on a price differential over time, an interpersonal and subjectively-constituted reckoning on circumstances external to the wager itself, predicated upon the non-knowledge of the future.⁴⁰

40. See J.M. Keynes, *A Treatise on Probability* (London: Macmillan, 1921), Ch.2, for probability as a determination of the degree of rationality of a subjective ‘belief’ in an as-yet-uncertain proposition given known propositions (evidence). Following the early analytical philosophy of his immediate milieu, probability for Keynes is however the degree of rational belief between propositions (as ‘objects of knowledge and belief’) and not,

The endogenous price movement of the futures markets is akin to odds on a bet getting shorter or longer depending on what other bets are placed.

As will be seen below, whether derivatives are wagers and, if so, what kind of wagers they are, is a primary determinant of the power ontology concomitant to capitalization's financiality. By way of previewing that extended discussion, it need only be noted that condemnation of derivatives markets as nothing but 'wagers on the movement of prices', prevalent after the 2008 crisis, was common enough at the time of the establishment of the Chicago Mercantile Exchange (CME) and its institutionalisation of futures trading in 1973 (elaborated further below).⁴¹ Gambling—legally defined as a contract settled in cash only—was however proscribed in Illinois at the time, a restriction circumvented with paradigmatic consequences by specifying that any futures contract must be able to be settled by physical delivery of the underlying itself, even if in practice 'delivery was seldom demanded'.⁴² That is, derivatives were legally sanctioned by securing them

as with the wager on future contingencies proposes, between propositions and events.

41. D. MacKenzie, *An Engine Not a Camera: How Financial Models Shape Markets* (Cambridge, MA: MIT Press, 2006), 14–15, 144–5, and 252 for the quoted characterisation.

42. MacKenzie, *Engine*, 145. The vicissitudes of establishing institutional derivatives market in the United States and the struggles of its proponents—notably, founder of the CME Leo Melamed—to differentiate it from gambling is presented in MacKenzie, *Engine*, Ch.6.

as an attenuated mode of trade in the underlying to which they refer, thereby recusing the exogeneity of the derivatives contract to the trade in the underlying. This inhibition to the development of derivatives markets was removed in the US with a 1982 Senate ruling that it was precisely the cash settlement of derivatives trading that demarcated futures contracts from trading on stock indices such as the Dow Jones, a distinction correlative to their regulation by the Commodity Futures Commission rather than the Securities and Exchange Commission (SEC), which itself cleared the way for the regulatory variances between derivatives markets and stock markets.⁴³

Options are contracts for the right to buy (call) or sell (put) underlying assets without necessarily having to trade the underlying asset at the agreed price (now called the 'exercise price' or 'strike price') by the agreed date (the 'exercise date' or expiration).⁴⁴ Unlike forward contracts, there is a contract fee for making an option which is lost if the option is not taken. Options are primarily instruments for hedging. The call option (the right to buy) on the underlying is purchased (long position) in anticipation of the price of the underlying asset increasing from the strike price. If it does not, the trader has to make the calculation as to whether the loss from taking the long position is

43. MacKenzie, *Engine*, 172.

44. Hull, *Options*, Ch.1.

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greater or less than the loss made from the difference between the spot price and the strike price. The put option (the right to sell) is purchased anticipating a fall in price. To take the short position—to sell either call or put option at a later date—is to *write* the option: cash is taken upfront in exchange for the counterparty's right to buy/sell the option, taking the consequence of losing out on the gains (or not taking what would be losses) of the underlying at the option's expiration. For the trader writing the option, it is more profitable to sell the option for a gain then hold on to the security and sell it at a lower price. However, it may be that if the increase in the price of the security is less than that in making the initial option trade, the option is not exercised and the trader writing the option holds both the initial contract fee and the asset at an increased price, which they can then immediately sell.

Illustration

Anticipating COLLAPSE will publish a new essay by Quentin Meillassoux in three months and generate an upward surge in Urbanomic's share prices (listed as URB), a trader takes a long position on 100 call options (that is, purchases the right to buy) for URB shares at a strike price of 50lcu a share. The exercise date is four months from taking the position.

URB's current share price is 45lcu and the option price is 2lcu. The notional value of the option is 5000lcu but the actual credit exposure of the derivative contract—the price of the option itself—is 200lcu.

Four months later: Meillassoux's article proves to be of great importance and URB's equity price rises to 55lcu per share at the option's expiration date.

Exercising the right to buy URB shares at the exercise date (and immediately selling them on the market on which it is listed) results in a gain of 500lcu (the gain per share is $55 - 50 = 5$ lcu $\times$ 100 shares). Subtracting the option price of 200lcu and excluding transaction costs, the net gain for the trader taking the long position on the call option on URB is 300lcu. That is, the trader makes a 150 percent profit on the option after four months.

The counter scenario is that if, say, Meillassoux's article is superannuated before the option's expiration by the publication of a devastating pre-critique of his long-anticipated *L'Inexistence Divine*, URB's equity price drops to 43lcu per share.

Having taken the long position on the call option with a strike price of 50lcu per share, the trader faces the prospect of then making $43 - 50 = -7$ lcu per share.

With the option having been taken for 100 shares, this would lead to a net loss of 700lcu. At that point, it is a smaller loss for the trader to not exercise the call option and just lose the initial outlay of 200lcu.

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If the loss from exercising the call option is less than the loss from not doing so, then it is still worth exercising the call option:

Even though Meillassoux's article is theoretically redundant, continuing interest in it and other material in COLLAPSE leads to URB's share price climbing to 51.25lcu by the expiration date.

The trader then makes 125lcu ($51.25 - 50 = 1.25$ per share $\times 100$ shares) if the call option is exercised.

Though this is less than the 200lcu to take the long position on the call option, the net loss of 75lcu (125lcu from exercising the call option at a market price of 51.25lcu less the 200lcu for taking the long position) is still a smaller loss than *not* exercising the call option (200lcu).

This illustration is formulated with the trader taking the long position on the right to buy the security (the call option), but there are four basic combinations for option positions: long or short positions on call or put options on the underlying.

Though fully established as financial instruments since the inauguration of derivatives exchange trading in mid-seventeenth century Amsterdam and in London half a century later, option pricing was the key instrument for sanctioning the institutionalization of derivatives markets with the establishment of the Chicago Board Options Exchange in 1973 and the standardisation of pricing with the Black-Scholes-Merton

model (elaborated in §5 below). That institutional consolidation overcame the ‘close correspondence between option contracts and gambling’, wherein legislation on the latter, dating as far back as the Romans, set precedent for legislation on the former.⁴⁵ The multiple routes for payout on the option are initial indications of the multiplying paths constructible with this class of derivative, the fabrication of which broadly constitutes the field of financial engineering. Options with straightforward payoff schedules are designated ‘plain vanilla’; ‘exotic options’ have more complex payoff structures structured by more or less elaborate composite of sequenced expiration dates, conditional

45. G. Poitras, ‘The Early History of Options Contracts’, in W. Hafner and H. Zimmermann (eds.), *Vinzenz Bronzin’s Option Pricing Models* (Berlin: Springer, 2009); see also MacKenzie, *Engine*, Ch. 5. The first modern legislation on options was passed in 1697 to address various manipulations of price-setting on exchanges in London, and to distinguish it as a regulated market against its Amsterdam rival. The history of these derivatives can however be tracked back to before these modern mercantile institutions to Thales of Miletus who, in Aristotle’s account (*Politics* 1259a), demonstrated that rational philosophy at its origin could generate wealth if the philosopher so chose. Thales reserved olive presses in the winter ahead of what he predicted by the rational calculation of astronomy would be a large harvest, renting them in the subsequent harvest ‘on what terms he liked’ thanks to the indeed bounteous yield of olives. For Thales, the purpose of this early demonstration of speculative hedging was that philosophers have other interests than wealth generation, a lesson that continues to be observed in the hostility to instrumental rationality; for Aristotle, precursor here to Kalecki, it serves as an example of ‘taking an opportunity to secure a monopoly [that] is a universal principle of business’, a determination that gives priority to the political economic result of Thales’s demonstration and overlooks his primary lesson that reason is posits a contingent relation to the future *qua* financialisation in the service of capital-power, exposing at the origin of philosophy the latter’s identity with instrumental reason from which philosophy is then only contingently and not necessarily distinguished.

expirations, linkages between different assets, options, and criteria, the locking in and out of exit routes from the option, and so on.⁴⁶

Swaps are highly complex off-exchange (OTC) futures contracts whose underlying is not asset prices but cashflows.⁴⁷ Invented in the early 1980s, swaps exchange advantageous rates in different markets to hedge income streams by each party effectively paying for the other's cashflow via an intermediary financial institution. Example: a firm able to obtain preferential terms in fixed interest rate markets wants to borrow funds at a variable rate or for a shorter term than is available in the fixed-rate market. Swapping the preferential loan in the fixed-rate market for a loan obtained by another agency in the variable-rate market advantages not only the first company but also a counterparty seeking what, for it, is a preferable rate on the fixed-rate market. Because both comparative advantages are compounded in a swap, the net cost of the swap is less than that of the total notional amount; in the example above, both parties pay a lower rate of interest than that on the loans each has originated,

46. The vanilla/exotic terminology is attributed to Marc Rubinstein and Eric Reiner's 1992 detailed inventory of complexly structured options. See *Exotic Options, Research Program in Finance Working Papers* RPF-220 (Stanford: University of California at Berkeley), www.haas.berkeley.edu/groups/finance/WP/rpf220.pdf.

47. Hull, *Options*, Ch.5. See also M. Greenberger 'The Role of Derivatives in the Financial Crisis', Testimony to the Financial Crisis Inquiry Commission Hearing, US Senate, 30 June 2010, fcic-static.law.stanford.edu/cdn_media/fcic-testimony/2010-0630-Greenberger.pdf.

resulting in an effective saving or income equal to the difference between the preswap cashflow and the swapped cashflows. This gain is split between the swap's counterparties. Currency swaps similarly take advantage of varying terms in different currencies, and swap contracts extend also to commodity markets, exchanging variable spot prices over a duration with a stable fixed price.

Calculated only in terms of their notional amount, swaps are detached from any relation to nonfinancial assets. Swaps make explicit qua market instruments the abstraction and exogeneity of derivatives from the nonfinancial dimension of the underlying, a structural condition of the 2008 financial crisis. Exchanging repayments across financial markets, swaps interconnect those markets at the point of their primary revenue: a credit-based income stream into the future. Unlike forward contracts or options, the loan generating the cashflow of one party of the swap has to be in place before the swap is made. A position in a swap can be 'warehoused' by the intermediary financial institution until a suitable counterparty is secured as its second 'leg'. A default on that initial loan by one of the counterparties transfers liability of the credit risk to the financial intermediary. The intermediary institution, which takes on a structural role, also composes the swap, thereby providing an ersatz insurance to either party in case of a default in the cashflow of the

counterparty, and taking a systemic role in the emergence and consolidation of the swaps market.

Despite the exchange-like properties of the swaps markets, their insurance-like operation, and the ‘financial calamities’ generated by unregulated swaps markets, including the default of California’s Orange County in 1994 and the collapse of the Long-Term Capital Management hedge fund in 1998,⁴⁸ extensive political pressure in the us leading to the Commodities Futures Modernization Act of 2000 exempted swaps

48. Orange County, California, declared bankruptcy in 1994 after suffering losses to its various funds from large, unhedged positions in interest rate derivatives (Mackenzie, *Engine*, 223; the following account paraphrases Ch.8 of Mackenzie’s book). Long Term Capital management (LTCM) was the poster-child of financial trading in the mid-90s, boasting Scholes and Merton on its Board and generating annualized returns of up to 40 percent (after fees) via arbitrage of small differentials between fixed-income long-term bonds such as government debt. The Russian financial crisis of Summer 1998 caused a market-wide ‘flight to safety’, to ‘safe’ long-term government and corporate bonds that formed the backbone of LTCM’s trading strategy. Its positions were pressured both by extant widespread mimicry of its strategies across the financial sector, reducing its trading advantage, and by self-replicating divestments across the market in response to the crisis. Despite advanced hedging and risk-diversification strategies, the combination of these factors led to highly correlated losses across its portfolio. Providing liquidity to cover those losses from a leveraged position—that is, borrowing money to make trades and returning it (with interest) upon their completion—of about 27:1 (which, while large, was typical of large investment banks at the time) required it to divest from other positions at the wrong moment in the structured portfolio. Counterparty trading and divestment by LTCM’s clients (which included most of the large investment banks) led to yet further losses. By late-September 1998, LTCM’s capitalization was unsustainable, with liabilities of \$100bn on an equity dropping from \$2.3bn to \$400m over that month. Because immediate liquidation of LTCM’s securities would have led to a significant and systemic drop in market prices, the New York Fed orchestrated a \$3.6bn recapitalization and buy-out of LTCM by the major American investment banks in September 1998.

from being traded on exchanges, proscribed their standardisation by statute in favour of regulation by trade bodies, and even excluded the statute itself as a basis for legal challenges to swaps.⁴⁹ Consequently, swaps did not have meet any of the requirements of more formal insurance (a sector regulated by statutory bodies)—in particular, the requirement that the seller have adequate capital to service the default payment. The result of this sectorial activism was threefold: the increasing systemic centrality and interconnectedness of financial intermediary institutions in providing credit in general, the lowering of the price of credit swap arrangements which reduced its net cost, and the expansion of credit beyond any limitations imposed by reserve requirements.

The mid-2000s financial crisis was a direct consequence of the expanded role and systematicity of the intermediary-led systematisation of credit in which the role of Credit Default Swaps (CDS) was crucial. Invented by JP Morgan in 1994, a CDS is a form of insurance against default on a loan and the consequent loss of income for the lender.⁵⁰ The buyer of a CDS pays a premium to a seller to take on an underlying loan

49. Greenberger, 'Derivatives', 5–6.

50. Details of JP Morgan's invention of the CDS are given in G. Tett, *Fool's Gold* (New York: Free Press, 2009), Ch.3. Tett notes how, by 1996, JP Morgan had persuaded the leading US Federal Reserves to reduce the credit reserve requirements of major financial institutions on the basis that the derivatives dispersed risk, making any one institution less susceptible to credit default (49).

in case a 'credit event' (such as default) leaves the lender carrying the credit exposure. That is, the buyer displaces the costs of the default of some designated credit to another party, and removes the loan as a liability from the buyer's balance book. If there is a default, the seller of the CDS takes possession of that credit and the buyer receives compensation equal to its stated cost. In this eventuality, the buyer of the CDS gets reimbursed for the underlying loan—the insurance against default—and the seller pays to take the credit off the buyer's hands, leaving the seller with a double cost: the unpaid debt itself and the payout to the buyer. In case of no credit event, the seller receives the premium payments to maturity. In short, the credit risk is hedged. The CDS is similar to insurance in case of loan defaults, except that (i) the seller of the CDS holds the risk of credit default without holding the credit itself; (ii) the seller can sell the protection without capital reserves to compensate the buyer; and (iii) the buyer need not have any ownership claims over the underlying loan nor any direct insurable interest in it. These latter positions are 'naked' CDSS, the buyer and seller constructing the swap around a 'reference bond' that is owned by *neither* party of the swap, doing so in order to speculate on the reference bond's financial viability. Without any ownership requirements, one underlying can be the reference bond for multiple naked CDSS. Despite the evident credit risks of such

structures, financial establishments and regulators supported the development of the naked CDS market, again in the interest of increasing liquidity for the reference bonds: the increased number of sellers and insurance-like structures against credit defaults enabled a greater number of credit event risks to be bought, and also greater flexibility (and therefore efficiency) in the market for risk, increasing the overall size—now meaning the credit exposure—of the market.

To return to the introductory comments above, then, the 2008 financial crisis was generated by the ‘credit event’ of defaults on CDSS, the underlying of which consisted of interlocked mortgages, the latter being by far the largest credit market in the US and UK. The amplification of this latter credit default by naked CDS derivatives which themselves could not be settled—the financial intermediaries not having to provide capital reserves to do so—explains in part the size of the crisis;⁵¹ its systemic nature is a result of the interlocking of credit by financial intermediaries via swaps, exposing

51. Greenberger notes that though only three percent of the notional amount of a swaps transaction is at risk as credit exposure, ‘a credit default swap’s insurance-like aspects mean that if a default is triggered, the entire amount of the sum guaranteed is at risk’ (‘Derivatives’, 11)—which is why the diminishing of the size of the derivatives markets from its ‘face value’ to its credit exposure, as in the introductory comments above, is not always warranted. Combining the lower estimate of \$35tn of outstanding CDSs in September 2008 with three percent of the rest of the remaining swaps market (\$565tn), Greenberger arrives at a total sum for the credit exposure of the swaps market alone at the time of the financial crisis, wryly adding that ‘even using the most conservative figures for the sake of argument, \$52tn is a very large figure’—equal to world GDP that year.

the credit risk thereby built into the financial system as distributed, uncontained, and without adequate capital backing. The result: systemic default. Furthermore, the deregulation of the OTC sector in 2000 stripped out its supervisory containment and capacity to prosecute, making it, in the words of the chair of the SEC in 2008, a 'regulatory black hole'.⁵²

4.3. DERIVATIVES: CONSTITUTIVE LOGIC

This rudimentary exposition of the derivative mechanisms leading to the 2008 financial crisis provides some operational explanation of its causes and outlines the material conditions for the two Lessons identified in the introduction. Yet this is not sufficient in itself to address the questions posed by the analysis of capital-power: What mutation in modern power-rationality, if any, is instituted by finance-power? And to what extent is capital-power's constitutive financiality instantiated by these facts of financial operation, whose magnitude and global systemicity became explicit only in 2008 as an incontrovertible problem of power determination for the modern state settlement? To address these questions a formulation of the *logic* of finance is required that at once schematises its variety of practices and instruments in relation to the constitutive financiality of capital-power, and also delineates their common

52. Christopher Cox, cited in Greenberger, 'Derivatives', 10.

power ontology with respect to state formation. As will be seen, that determination is directly instantiated as *pricing*.

The distinctive feature of all derivative structures, a feature explicitly demonstrated by forward and futures contracts, is that they are constructed and traded on the basis of a price differential. Trading strategies also exploit price differentials—across markets in arbitrage, but also in time across one market for hedging. At the simplest level of derivative construction, the delivery price of the forward contract (K) anticipates the future price of the underlying asset (S_t); more complex derivative structures take other factors into account (option cost, cashflow dynamics, etc.). The primary question for derivative pricing, then, is how the delivery prices K are set for derivatives, given that they can only be anticipations of future eventualities that must be unknown at the time the price is set but which, per the doctrine of market rationality, are nonetheless supposed to determine the asset price. The answer is straightforward but wholly counterconventional. It is not that markets set the delivery/exercise price but, as with Means's administered prices, that the contract *constitutes the price differential* between delivery and strike prices at a specified future moment in time. Or, in another, equivalent formulation: the contract defers the trade of the underlying in order to institute the price differential *and*, conversely, the price

differential specified by the forward contract is simultaneously a deferral of the exchange of the underlying asset. Put schematically: the forward contract defers exchange to constitute a price differential for an underlying asset in time or across markets, just as its positing of that differential defers immediate vending of the asset. A deferred differential, a differentiating deferral: *différance*, in Jacques Derrida's terminology.

Taken out of its native philosophical element, Derrida's term and its logic serve here only to crystallize the operational constitution of derivative pricing. In formal terms, this logic is as follows: as noted, *différance* combines difference and deferral. Each term is constituted by the other: difference here is not a difference between already established positive terms (A and B) that assumes their presence, which is, for Derrida, the metaphysical mistake of Western thought. Rather, *différance* emphasises 'one of the two themes of the Latin *differre*' in a way that the more conventional 'difference' does not: namely, 'the action of putting off until later, of taking into account, of taking account of time and of the forces of an operation that implies an economic calculation, a detour, a delay, a reserve, a representation—[in short]: temporization [*temporisation*]'.⁵³ Constituted by their *différentiation*,

53. J. Derrida, 'Différance', in *Margins—of Philosophy*, tr. A. Bass (Chicago: University of Chicago Press 1982 [first delivered 1968]), 8, for this and the next two quotes. Translations here and elsewhere are slightly modified. Temporization looks to capture the sense of delaying or time-passing rather

differentiated terms ‘detour’ through one another to establish their quasi-positive but necessarily incomplete determination, a deferral of their self-identification that is a delaying or spacing (*espacement*) of any alleged selfpresence to itself, an ‘itself’ that therefore never arrives as such. The differentiated terms are only ever quasiestablished because of the constitutive deferment of their distinct identities (qua plenitudinous presence). ‘The *a* [of *différance*] comes more immediately from the present participle (*différant*) and brings us closer to the action of “differing” that is *in progress* [emphasis added], even before it has produced an effect that is constituted as different or as difference’. Derivatives *constitute* price differentials precisely according to this *différential* logic of temporization, which is no less their operation: the delivery or exercise price is not the price as and when the contract is drawn up, and without the *noncoincidence* of the delivery price with the strike price there could be no derivative but only spontaneous vending. Addressing the *différential* constitution of the present, Derrida remarks that ‘an interval must separate the present from what it is not for it to be itself, but that interval which constitutes it as present must also in the same blow divide the present

than the general order of time (temporality). The ‘economic calculation’ Derrida mentions in this quotation is in the general sense of the term of a dynamic configuration of interdependent diverse and varied elements, not any specific determination of monetary or fiscal economy such as, here, finance capitalism.

in itself'.⁵⁴ Substituting 'price' for 'the present', the identical scheme holds for the derivative: an interval must separate the price of the underlying from what it is not (that is, the delivery price) for the derivative to be itself, but that interval constituting the derivative (as distinct from exchange of the underlying) divides/defers/detours the present of the derivative between/across its signing and maturity. Consequently,

différance is what makes the movement of the derivative market [Derrida has 'signification'] possible only if each element that is said to be 'priced' [Derrida: present], appearing on the stage of price [presence], is related to something other than itself but retains the mark of a past element and already lets itself be hollowed out by the mark of its relation to a future element. This trace relates no less to what is called the future than to what is called the past, and it constitutes what is called the present by this very relation to what it is not.

For Derrida, that trace of *différance* is the necessarily ineffable temporising constitution of the present; here, in the dimension of finance, it is the derivative contract. The identification of its logic takes a further step with the substitution of price for 'space' in the elaboration of the temporising trace: 'constituting

54. This and the next two quotes: Derrida, 'Différance', 13.

itself, dynamically dividing itself, this interval is what could be called pricing [Derrida: spacing]; the becoming-price of time or the becoming-time of price'. That is, the 'interval itself' is the derivative qua pricing contract: the becoming-price of time or the becoming-time of price. In short, derivative pricing is différential; or, derivatives are a différential pricing.⁵⁵ It is not that

55. Samuel Weber proposes a religiohistorical deconstruction of money as credit-implement in the view of the 2008 crisis in *Geld ist Zeit: Gedanken zu Kredit und Krise* (Zurich-Berlin: Diaphanes, 2009; English version available at www.complit.u-szeged.hu/images/weber_-_money_is_time.pdf). Weber's hybridisation of money, temporization, and modern finance as inheritor of a (Max) Weberian Protestant ethic in order to spiritualise the determination of finance (as a secularized perpetuation of Protestant Christianity, per Walter Benjamin's half-thesis on capitalism) is discarded here for reasons stated in n.24 above. More salient is Brian Rotman's identification of the deconstructive conditions of finance in the proliferation of 'xenomoney' of offshore American currency—Eurodollars—that precipitated the exit from the Bretton Woods monetary regime in August 1971 when the US took the dollar off the goldpeg that had anchored the post-war Euro-American settlement (*Signifying Nothing: The Semiotics of Zero* [New York: St Martin's Press, 1987]). For Rotman, the inconvertibility of money to anything outside of itself leaves it 'signifying' only in relation to future states of itself, including the 'purely financial dynamics' of futures currency markets (93–96). Rotman identifies such endogenously constituted signification with Derrida's excision of a 'transcendental signified' as condition for the sign opening the space of language qua world of floating signification. The identification is however at best only analogical for Rotman, a 'structural morphism' (103). The contention of the present essay, however, is that while the size, growth, and intensity of modern derivatives markets were monetarily facilitated by the removal of the gold barrier (as recognized by Milton Friedman in his 1971 paper sponsored by the founders of the Chicago futures market and dedicated to legitimating its establishment [MacKenzie, *Engine*, 145–48]), the Derridean logic is *directly* that of the derivative contract and its market operationalisation; and then is it the truth of money qua creditory relation (see §11.3 below). The latter truth is espoused by Modern Money Theory, for which the common establishment of creditory basis of money, as its 'unit of account', is uniquely a state operation, its fiscal sovereignty: see É. Tymoigne and L. R. Wray, 'Money: An Alternative Story', in P. Arestis and M.C. Sawyer (eds.), *A Handbook of Alternative Monetary Economics* (Cheltenham: Edward Elgar, 2006).

the derivative records a price movement against a calibrating price—a theorization which, as will be seen, dominates their institutional practice maintaining as it does the supposed secondariness of derivatives to pricing in the ‘real economy’—but that it instantiates/implements the intervallic differentiation characteristic of *différance* in terms of pricing. Here temporization is the condition for speculative accumulation.

The proposed identification is not, however, total. Derrida follows Levinas in extending the past of the trace into an absolute past, an alterity that is constitutive of the present, but irrecoverable to any self-present and hence irremediably anterior to it. Such a past is a necessity because the *différential* constitution of the present is a logically anterior condition to presence and therefore temporally precedes it. The trace *qua* derivative contract is, by contrast, only the finite and instituted *différential* organization of pricing, organized and utilized for capital accumulation without the sacrality guaranteed by the absolute past. Furthermore, while presence-constituting *différance* is a general metaphysical condition corroding any paradigm privileging or presupposing presence as its condition—for example, in the Western tradition, (phenomenological and psychoanalytical) consciousness, semiotics, idealism, empiricism, etc.—derivatives are but regional manifestations of *différential* price-constitution. In particular, if ontology in the Western tradition presumes

presence as its condition and term, derivatives are not preontological (that anteriority being one of Derrida's primary claims for *différance*); rather, their ontology consists of a binding and enforceable contract that is constituted by statute. That is, the institution of derivatives is the constitution of price *différentiation*.

4.4. INSTITUTING DIFFÉRIENTIAL PRICING

The logic of derivatives *qua* *différential* pricing is that of their institutional construction. The schematic form of *différential* pricing just presented consequently facilitates several praxical implementations of capital accumulation. Though some of these configurations may affirm the *différential* organization of pricing as such, others effectively delimit it by coding it in abnegating formats. These various historical-institutional determinations of derivative pricing are advantageous to the present analysis because they give a specific shape to the schematic account of the constitutive logic of derivatives just outlined, thereby enabling both that logic and those particular configurations to be analytically and politically situated rather than taken for granted. In turn, the power-ordering of capitalization as constructed (which is not yet to say constituted) by finance will then be able to be similarly situated.

There are four stages in the demonstration of the politics of *différential* pricing: 1. Its standard account, in

which derivatives are but speculative tracking descriptions of the price-development of a referent external to the derivative—an *anticipatory* constative model of exogenous pricing that commences from the present; 2. Its constitution of complex modes of intrinsically temporal *and* social binding of the present in which the necessary uncertainty and ignorance of the future takes priority, instituting a sociorational ordering of risk in which all price determinations are continually revised; 3. As a wholly endogenous pricing and operationalisation of an unprecedented mode of betting, in which derivative pricing refers only to its own market in a *counterperformative* act that makes explicit the occasional condition of its exogenous reference and of the 'real economy' for price and capital-power; 4. As *absolute*, when the endogeneity of différential pricing is extended to exogenous pricing processes external and putatively 'primary' in relation to derivative markets. It is with this last step that the derivatives pricing operations of financial markets are articulated with the a priori financiality of capitalization. With that final step, the identification of the specificity of capital-power's reordering of power is made explicit—not only in the conceptual-philosophical determination of price temporization, but also in two praxical renditions: firstly, that derivatives are a new kind of wager; and, secondly, that the key technical term 'price volatility' indexes the ontology of derivatives pricing within and beyond its

institutional operations. As will be seen, each of these coextensive determinants of pricing—temporization, the wager, volatility—undergo substantial modification in the course of the analysis, because modern financial institutions inaugurate unprecedented modalities and practices of each, not just reordering power in the state-finance nexus as they do so, but actually reconstituting it.

5. ANTICIPATORY PRICING:

THE BLACK-SCHOLES-MERTON REGIME

Markets for financial rather than commodity derivatives have been massively operationalised since their institutionalization with the Chicago Mercantile Exchange (CME) and Chicago Board Options Exchange (CBOE) in 1972–73, almost contemporary with Derrida's theoretico-philosophical identification of the logic of *différance*. As mentioned, the CME could only be sanctioned by the Illinois regulatory bodies if futures trading was not a form of gambling, a stipulation which required settlement by delivery of the underlying rather than cash.⁵⁶ CME executives obviated the injunction with a three-pronged response: firstly, the underlying *could* be delivered if it was anyway a financial object such as foreign money in currency trading (Deutschmarks to a

56. The institutional history in this section paraphrases MacKenzie, *Engine*, Ch.6.

trader's German bank, for example), as advocated by the CME (a market that was historically inaugurated precisely by the flexible exchange rates consequent upon the decline of the fixed-rate Bretton Woods system), or a market in stock options, the certificates of which could in principle be delivered to the trader, a route preferred by the CBOE. Secondly, legitimating the proposals through personal and political-academic validation, eagerly provided by Milton Friedman at the University of Chicago; and, thirdly, formalising the pricing process in order to remove the guesswork, characteristic of gambling, as to what unknown future prices will be. This formalisation was developed by Fisher Black and Myron Scholes from the late 1960s, and mathematically extended by Robert C. Merton in the early 1970s. Even though it is highly restricted in its assumptions and applicability, the Black-Scholes-Merton (BSM) equation has been the orthodox, integrally acknowledged, and massively operationalised pricing model of derivatives markets since the inauguration of the modern derivatives exchanges.⁵⁷ That institutional consolidation has been warranted specifically by the formalisation's determination of derivatives as constative predictions of price movements exogenous to the derivative, for which the price that the

57. MacKenzie, *Engine*, Ch.5 presents a nuanced appreciation of BSM's theoretical development of precedents formulated by Louis Bachelier in 1900 and Edward O. Thorp in the 1960s, as well as the contingencies leading to its institutional innovation and ramifications.

derivative is written is an initial boundary condition. The putative predictability of options price movement—that is, as ahead of but secondary to the ‘real’ movement of prices happening elsewhere—was thus key to obviating the statutory objections to the political institution of derivative exchanges. The following schematic overview of the BSM equation not only serves to explicate the standard options pricing model, allowing its countertheorization to be better located; it also directly exposes the praxical instantiation of the standard economic doctrine of modern capital-power in its ordering of différential pricing and temporization. Each aspect of the exposition informs the other: the countertheory of price being established here proposes that the standard *ratio* of pricing is in fact vitiated by the very financial operations that are supposed to be constituted by it, doing so, as will be demonstrated, even beyond the confines of institutionalised derivatives markets—that is, at *every* instance of pricing,

The assumption of BSM is that price is a variable measure of what wares are worth to their users.⁵⁸

58. In the technical terms of marginal utility theory, value is derived from ‘the utility that an individual derives from the consumption of a quantity of a particular good [...] determined by his or her subjective assessment of the pleasure, or satisfaction, derived from consumption’, its price being given by the monetization of that exchange (J.E. King and M. McLure, ‘History of the Concept of Value’, preprint from *International Encyclopedia of the Social and Behavioural Sciences* [Amsterdam: Elsevier, forthcoming], 6, www.business.uwa.edu.au/___data/assets/pdf_file/0004/2478883/14-06-History-of-the-Concept-of-Value.pdf). Inaugurated by Jevons, Walras, and Menger in the early 1870s, and institutionalized in Western Europe and

COLLAPSE VIII

Meaning that prices are measures—that is, descriptors—of changing conditions external to prices themselves over time (what Means called ‘market prices’). However, derivatives prices explicitly factor the uncertainty of future prices into the pricing calculation as their precondition—no gains or losses could be made with a derivative if the delivery price could be guaranteed. According to this account, future prices are at best calculated guesses constructed from the known price at the time the derivative contract is made. They are a constative anticipation of the price development of the underlying (exogenous to the derivative’s pricing) in

the US a generation later by Pareto, Marshall, Böhm-Bawerk, and others, marginal utility theory forms the basic premises of Neoclassical doctrine by formulating price setting as a dynamically constituted equilibrium through exchanges made by a subjectively-constituted referent whose ‘desires’ are exogenous to the market (namely, the utility of the good to the consumer who is maximising their utility outside of the market itself). The utility of a particular item qua subjective demand for it tapers out with increasingly ready availability while, on the supply side, artificially high prices on readily available wares can always be undercut by rival suppliers. Equally, scarce goods are highly priced because their scarcity makes them more desirable to a consumer wanting to maximise her or his utility qua consumption, and so each such good requires the consumer to exchange her or his other wares having less marginal utility in order to acquire the good with greater marginal utility (the bartering of many ubiquitous goods for a small number of precious items is a basic example of this exchange). The market is then dynamic and flexible, changing according to the interests of the consumers and quantitative provision of wares until equilibrium is reached as prices meet demand. Adaptable as the theory is to changing situations and needs of consumers and provision to determine price-setting, its presumptions—the utility-maximising consumer for whom exchange is but barter in however attenuated a fashion—contrast starkly with Nitzan and Bichler’s formulation for which the luxury good is a luxury only because it is highly priced, irrespective of its use-value, production costs, or—as will be seen in §10 below—even its exchange ‘value’.

the period up to expiration.⁵⁹ The insurmountable yet structuring difficulty of this formulation is that such anticipatory pricing is in each instance only a reckoning with the 'next step' of a price development that is *in fact* unknown. The problem is resolved by formulating différential pricing as a stochastic process, for which the fluctuations of a *particular* element of the system cannot be predicted (in this case, the 'next' price of the underlying; in physics, paradigmatically, the position or velocity of an individual particle in a gas). The account of aggregate systems-development given the 'random walk' of its elementary units places two stipulations on its formalisation: that succeeding states of elements in the system are discontinuous from preceding conditions, and that the future states of the system cannot be exactly predicted but only described *probabilistically*, meaning a statistical determination of the path development of the system both in its individual elements and in aggregate. Such processes require a calculative model distinct from Laplacian systems, for which the

59. Although the BSM formula is the paradigmatic model for this regime of pricing, the operationally equivalent Cox-Ross-Rubinstein (CRR) binomial tree is the more widely-used formalisation (J.C. Cox, S. Ross, and M. Rubenstein, 'Option pricing: A simplified approach', *Journal of Financial Economics*, 7.3, 1979, 229–63). Option price movements in this model are calculated by a discrete-time branching (a 'lattice') of probabilities of prices increasing or decreasing at a certain time increment. Each resulting probability is a new node for the further calculation of price movements. Consequently, after a few iterations, several branches in the probability tree can lead to a given price. While the paths actually taken by the option can only be specified upon expiration, the increasing or decreasing probability of price movement gives the trader a predictive range of routes.

path development of every element in the system can be directly predicted if the initial conditions are known, as in Newtonian mechanics.

The first stipulation of ‘memoryless’ path development is known as the system’s *Markov property*, which means broadly that the system’s past does not influence the operations and dynamics of its current state;⁶⁰ the second stipulation is characteristic of Wiener processes (after Norbert Wiener, cybernetic pioneer), the best known of which is Brownian motion of particles. Taking market pricing as a Wiener process, the uncertainty of the actual movement of a price in the future is rendered as a probability—a bounded and calculated anticipation—which, by necessity of its mathematical modeling, can only go up or down by a certain bounded percentage at ‘the next step’ given the initial price. Thus the trader exchanges contracts on the basis of probabilities that say nothing about the past or future in fact or in principle. The anticipation of price movement, the measure of changing ‘market forces’, is both memoryless and, given its unpredictability, futureless.

60. For example: the boiling point of water remains the same under constant external conditions irrespective of whether it has previously boiled or been frozen or neither; similarly for the next coin toss, dice throw, or spin of the roulette wheel, if they are not loaded. Or, in the standard caveat of financial funds, ‘past performance is no indication of future results’. Put otherwise, knowledge of any state of a Markov process is adequate for knowledge of its history because that history presents no further information than the present provides. As Hull notes, the Markov property is then a weak form of market efficiency in that for the latter the present price of an equity or stock captures all the information contained in the record of past prices and the market (*Options*, §12.1).

It is only the *present* probability of what the future might be, a calculated ‘perhaps’ which bears all the information of the system’s history. This then is the reduction of différential pricing that was necessary in order to operationally distinguish options pricing from gambling, the latter being explicitly predicated on the present ignorance of the future.

The salient feature of Wiener processes for the construction of the BSM model is that the system equation is composed of two parts, one representing the linear development of the system in time, a drift rate that in finance is the normal rate of return, the second containing a random term indexing the stochastic yet bounded ‘memoryless’ condition of the system’s development. In its standard formation, this second term is provided by a random coefficient drawn from within the standard deviation of a regular probability distribution (a limitation that is not considered overly restrictive because, even if the next step of the random variable is unknown, it is nonetheless bounded). This random term is called the *variance* of the system, and indexes its ‘noise’ against the standard growth rate. Expressing the random walk of the variable more usefully as a function of a continuous time variable (in which the drift rate of the system is expressed) requires the index of its constrained randomness to be given by its *volatility*.⁶¹ Volatility is, for example, the measure of

61. Following the mathematical derivation, the variance of the standard

the uncertainty of returns from investment in a given stock. It is nontrivial in magnitude, since the effect of volatility upon price can sometimes far exceed that of the drift rate over a given time. And it is nontrivial in the formulation of BSM: securing an acceptable level of return requires the reduction, if not the elimination, of the volatility intrinsic to the very formulation of the price development as a Markov process. Given that the derivative price is determined to be strictly exogenous to the *price* of the underlying, the BSM formula structures a portfolio that cancels out volatility by combining a long/short position on the price of the underlying (usually equity stock) with a position on an option on that underlying such that the volatility of one offsets that of the other.⁶² That is, the formula engineers a return on the portfolio at its drift rate, which is the risk-free rate of return of the market, by hedging the price of the underlying against the price of a derivative based on it, a process called 'delta hedging'.⁶³ The linking of the two prices and respective

deviation of the probabilistic determination is the square of volatility. See Hull, *Options*, §13.4 for mathematical account of volatility.

62. For a mathematical derivation of BSM see Hull, *Options*, §13.6

63. The Efficient Market Hypothesis, summarised in Eugene Fama's 1970 formulation that 'prices always "fully reflect" available information' (cited in Mackenzie, *Engine*, 65), follows directly from marginal utility theory: all market-makers use the available information to trade with one another leading to a unique market price. Price thereby reflects an equilibrium that is a 'rational' settlement and disrupted only by further new information. The risk-free rate of return is a result of the Capital Asset Pricing Model (CAPM) developed in the 1960s, in which risks on items of a stock portfolio arriving

volatilities is not entirely arbitrary, in that each price is ‘affected by the same source of uncertainty: stock price movements’.⁶⁴

It is intrinsic to the Wiener process that the solutions to the equation change with time and also with the initial conditions of the primary variable, in this case the spot price of the underlying. Consequently, (i) the solution for the price process of the derivative changes with the price development of the underlying, and (ii) the delta hedge portfolio is only valid for theoretically infinitesimal (but in practice very short) durations; furthermore, (iii) the BSM model can only be constructed if idealized stable background conditions and parameters are assumed, though these are infeasible in practice.⁶⁵ But given these severe constraints, the

at their respective equilibrium prices are counteracted by diversifying the scope of the portfolio (Mackenzie, *Engine*, Ch.2). The ‘risk-free’ portfolio is therefore the stock portfolio with the greatest diversity: the market itself (excepting disruptions to the market as a whole). It follows that higher returns than the market average require portfolios with greater risk—at the limit, the price movement of just one stock. In Mackenzie’s words, CAPM is ‘finance theory’s canonical account of the way stock prices reflect a tradeoff between expected [emphasis added] return and risk (in the sense of sensitivity to overall market fluctuations)’ (*Engine*, 28).

64. Hull, *Options*, §13.5

65. Including: stable borrowing costs (i.e., constant background interest rates), no transaction costs, no dividends during the lifetime of the security (which payout will have repercussive effects on returns on the option), no trading of the securities, no arbitrage opportunities (no external advantage or pressure for monetary reasons), and that trading is continuous (Hull, *Options*, §13.5)—none of which in fact hold. Later developments of the BSM equation allow several of these constraints to be relaxed. For a broad, technically informed dismissal of BSM as institutionally and theoretically underdetermining more practically viable precursors (such as Thorp and Bachelier) thanks to its misguided Neoclassical and therefore idealised

‘equal and opposite’ construction of the portfolio in the BSM model means that the position of the portfolio at the end of a short enough time period can supposedly be known with certainty: it is the expected rate of return of the combined positions in the underlying and the option. And given the expected rate of return, the model and its stipulations can be manipulated to find the right price for options so as to secure a risk-free return over short-enough periods irrespective of the risk class of the underlying. By excising volatility, the BSM portfolio generates returns at the market rate independently of what the underlying is, i.e., independently of the risk preferences of the trader; so it lowers the barrier to riskier underlying assets, thus diversifying and consolidating the market in these asset classes. Such ‘risk neutrality’ is a strategic articulation of the anticipatory model of pricing in the BSM regime. Thanks to the probabilistic standardization of pricing in options markets—quite distinct, then, from betting and its ineliminable risk—the institutional effect of BSM has been to operationally legitimate the establishment of the CBOE and to increase the size of the options markets. Furthermore, in its risk-neutral coupling of options market with those of their underlying, it also enabled an increase in the size of the underlying financial markets too.

determination of pricing, see E.G. Haug and N.N. Taleb, ‘Option traders use (very) sophisticated heuristics, never the Black–Scholes–Merton formula’, in *Journal of Economic Behavior and Organization* 77 (2011), 97–106.

Ineliminable Volatility

The BSM anticipatory pricing equation and its concomitant risk neutrality presume the stability of the background conditions—an idealization which is not only operationally false but which in any case is theoretically constrained to the vanishingly small timespans for which the delta hedge portfolio is valid (i.e., until the ‘next step’ in the random walk of the spot price). Over any ‘extended’ time in which the spot price changes ‘unpredictably’, as it must do according to the initial assumption of the model, different solutions to the BSM equations are required. Consequently, the proportion of derivative securities to the underlying in the portfolio needs to continually change in order to maintain risk-neutrality. That continued recomposition of the portfolio, known as ‘dynamic replication’, follows the price development of the underlying in order to maintain both the risk-neutrality of the portfolio and also the removal of volatility from its return. Yet the development of the portfolio through dynamic replication, which also prices the option component on each iteration, conveys the quasi-random price movement of the underlying—the very volatility that the BSM portfolio is constructed to excise. Two methods make volatility apparent after its theoretical elimination in the BSM model: the historical record of the asset price and the method of implied volatility.⁶⁶

66. Hull, *Options*, §13.12.

Aggregate implied volatility represents asset price volatility as it is manifest through the price development of different options based on a single underlying; a method that permits the price of one option to be used to calculate the price of another option based in the same underlying asset.

The simultaneous occlusion *and* manifestation of volatility from the BSM regime does not necessarily present a problem in practice: priced in time rather than as a punctual theoretical formulation, the price volatilities of the underlying and the attendant option are *indexed* by the dynamic replication of the BSM portfolio. But the theoretical quandary is insurmountable: even though volatility is the very condition for the recomposition of the BSM portfolio, its formulating equation proscribes any explicit determination of price volatility, rendering it unobservable within the terms of that formula and preventing the causes of volatility from being established within the limited determination of those solutions.⁶⁷ In fact, implied volatility is of primary significance in determining derivatives in terms of différential pricing, as can be drawn out by reformulating the preceding result: the requirement for constant iteration of the BSM equation implies that volatility is generated not by factors external to the financial market, but rather by the trading itself.⁶⁸

67. Ibid., §13.13

68. With regard to stock prices, see K. R. French and R. Roll, 'Stock return

But if, in this model, the price volatility of the underlying informs the corresponding option's volatility, and if the BSM portfolio is constructed in order to remove volatility effects, then, contrary to the primary assumption that BSM relies only upon the constative (because exogenous) pricing of the underlying, the volatility of the price of the underlying is in fact *endogenous* to its market, as then is the option pricing. Furthermore, since the delta hedge portfolio is composed of both the underlying and the option, volatility in the option price requires trading in the underlying, generating volatility.

Options pricing in the BSM model does not then in fact refer to an exogenous price. Rather, pricing is constituted endogenously to both the derivatives market and that of the underlying, which are now interlinked.⁶⁹ Options pricing is itself also a market 'force', as is pricing of the underlying in its own market. The BSM regime of option pricing as constative or merely anticipatory

variances: The arrival of information and the reaction of traders', *Journal of Financial Economics*, 17:1 (September 1986), 5–26. With regard to volatility of stock prices, systemically observed to 'be negatively correlated with lagged [unexpected] returns', see D. Avramov, T. Chordia, A. Goyal, 'The Impact of Trades on Daily Volatility', *Review of Financial Studies*, 19:4 (2006), 1241–77. Avramov et al's thesis that such asymmetric volatility is 'governed by the trading dynamics of informed traders and uninformed traders' is extended to the futures market and confirmed in J. Kittiakarasakun, Y. Tse, G.H.K. Wang, 'The impact of trades by traders on asymmetric volatility for Nasdaq 100 index futures', *Managerial Finance*, 38.8 (2012), 752–67.

69. As confirmed and compounded by indices of implied volatility such as the CBOE VIX that then enables the pricing of volatility as itself an underlying for derivative construction.

of exogenous price movements starting from the initial price and hence calculable qua probability cannot then be maintained other than by its static and therefore highly constrained determination. That anticipatory model provides only the instantaneous composition of the delta-hedge portfolio, a falsification of the pricing process of both options and the underlying that is consequent upon that regime's *presentism*. Evidence that the BSM model is wrong is empirically provided by 'volatility smiles' and skews: within the modeling parameters of BSM, the price of a vanilla option only increases linearly with its volatility, and the implied volatility should be independent of expiration and strike price; yet, since the October 1987 stock market crash, prices have taken nonlinear paths in all three regards.⁷⁰ That such curves are manifest after the 1987

70. Specifically, charting implied volatility against strike price yields a valley-like curve whose turning point is the at-the-money option (that is, options whose delivery price is the spot price of the underlying), a curve known as the volatility smile. More systemically, the implied volatility of at-the-money options is also observed to be slightly lower than options in- or out-of-the-money (those with delivery prices respectively above or below that of the spot price, netting a gain or loss). Furthermore, implied volatility of an option changes not just with the strike price but also with expiration, meaning that it is better charted as a volatility surface with a horizontal reference plane having the axes of expiration and strike price. Different markets have different typical curves. Mark Rubinstein was among of the first to model the volatility surface using the CRR formalism he codeveloped ('Implied Binomial Trees', *The Journal of Finance*, 49:3 (July 1994), 771–818) while Bruno Dupire formalized the volatility smile in terms of BSM in the same year ('Pricing with a smile', *Risk* 7 (1994), 18–20), but such 'one factor' models have since been shown to have severe limitations. A multifactor formalism for the development of the volatility surface in conditions where arbitrage across markets is not possible is developed in T. Daglish, J.C. Hull, and W. Suo, 'Volatility surfaces: Theory, rules of thumb, and empirical evidence', *Quantitative Finance*, 7.5 (2007), 507–24.

crash but not before indicates that the pricing process is *not* memoryless: a past event structures all subsequent processes in the system. Bearing a constituting past, options pricing does not observe the Markov property, which is not only the condition for the probabilistic determination of anticipatory pricing, but also for the BSM model tout court. Furthermore, nonlinear implied volatility paths again suggest that volatility is generated by conditions endogenous to markets, including derivative markets—a result leading to the argument, elaborated further below, that if volatility arises from *within* the price process itself, then derivatives pricing has to be distinguished from traditional determinations of betting, in which gains or losses depend on a referent external to the wager itself.

For now, however, the *minimal* result is that options pricing is neither anticipatory nor merely constative. More emphatically—and this is what will move the analysis from the dimension of derivatives as institutional financial operators to the dimension of the power-rationality of capitalization's financiality—implied volatility manifests the différential logic of derivative pricing, which is exorbitant to the presentist determinations of the BSM regime. Instantiating différential pricing and its temporization in fact, the institutional praxes of BSM misidentify and constrain that logic within the stasis of the calculable 'maybe' of anticipation: price development as probabilistic.

Standard financial praxes thereby proscribe the complete account of their own operation as both logically predicated on *and* operationally constituting the volatility (and its pricing) that they institutionalise—that is, an account of price as more than merely constative of conditions and ‘forces’ acting elsewhere. Given the dominance (in theory and pecuniary magnitude) of these standard financial praxes, what is theoreticopolitically exigent is a countertheorization of différential pricing that does not presume either the present price as the basis or inauguration of the pricing process, nor the constitution of price as exogenous to its own institutional process.

6. COUNTERPERFORMATIVE PRICING

Key elements of the required countertheory are provided by the sociological accounts of finance markets given by Donald MacKenzie and Elena Esposito.⁷¹ Both propose that derivatives markets are not constative but performative—in MacKenzie’s words, ‘an engine not a camera’—because derivatives pricing is shaped by the fact and method of pricing itself, rather than exogenous factors such as the vicissitudes of the underlying prior to pricing. MacKenzie’s mainly historical-institutional account identifies two

71. MacKenzie, *Engine*, and E. Esposito, *The Future of Futures: The Time of Money in Financing and Society* (Cheltenham: Edward Elgar, 2011 [Italian: 2009]).

salient regimes of performativity for options markets. The first is ‘Barnesian performativity’ (after Barry Barnes’s sociology of science) in which economic processes and outcomes transform to better fit the theoretical model, in a ‘self-validating feedback loop’:⁷² consequent on the establishment of the CME and widespread use of BSM, ‘the financial markets changed in a way that made the [BSM] model’s assumptions, which at first were grossly at variance with market conditions, more realistic’.⁷³ That ‘realism’ was undone (most intensely in the US) by the October 1987 crash, after which the persistence of regular volatility skews meant that ‘no analysis now finds the [BSM] model to fit the observed pattern of prices of options well’.⁷⁴ Such is the second regime of performativity for which ‘the practical use of finance theory sometimes undermines the market conditions, processes, and patterns of prices that are posited by the theory’.⁷⁵ The ‘undermining’ of

72. MacKenzie, *Engine*, 19.

73. *Ibid.*, 256.

74. *Ibid.*, 202.

75. *Ibid.*, 24. More specifically, while options markets still deploy offshoots of the BSM model for pricing, the risk-management of option pricing now accommodate the ‘wild randomness’ of discontinuous jumps in pricing and volatility that such models gave rise to but can not theorise. Risk-management in this second regime of performative pricing requires an increase the ‘margin requirements’—the initial price of the option deposited with the exchange—so that ‘catastrophic events’ do not force further selling of options and exacerbate price volatility. It also requires a shift from the assumed normal distribution of the BSM model, in which outlier ‘extreme’ events in the tails of the distribution are unlikely, toward the Lévy family of variable distributions with thicker tails, developed in relation to finance

the conditions and results occasioned by and for the very theory that constitutes them more exactly marks out its 'practical' use in this second regime as being *counterperformative*: pricing takes place *against* the constative determination of pricing. For Esposito, distinct from MacKenzie in her adoption of a Luhmannian systems-theoretical approach, such counterperformativity is not an episodic occurrence of financial pricing but rather, and in fact, the primary characteristic of such markets: derivatives markets are necessarily and intrinsically set to run against their theoretical models because volatility is endogenous to pricing itself.⁷⁶ In Esposito's terms, the volatility of derivatives markets indicates how the future stipulated by the derivatives contract 'is unpredictable *because* it is produced by the very present that tries to predict it'.⁷⁷ As implied volatility indicates, the probabilistic anticipation of price development is vitiated in its very instantiation because derivative pricing shifts the price away from the magnitude it putatively predicts as an exogenous referent. In short, derivatives markets *constitute* prices. To understand how and why requires a more detailed exposition of Esposito's argument, which has the

by Benoit Mandelbrot, for which the standard requirements of statistics such as standard deviation and variance can be infinite, meaning that while the techniques developed on the basis of such models are probabilistic nonetheless 'standard statistical techniques evaporat[e]' (Ibid, 108ff.).

76. For the 'wild variation' of the market destroying its regular statistical distribution see Esposito, *Future*, 148–51.

77. Esposito, *Future*, 128, emphasis added.

advantage of leading back to the articulation of the institutional financial operations of derivative markets in terms of pricing qua temporization, which will in turn be the basis upon which the particular determination of finance-power can be made.

Time is the leading category in Esposito's theory of derivatives pricing because for her derivatives are complex time relations fabricated by institutional methods of social organization. Specifically, derivatives mobilise the distinction between the present future, which is 'our current anticipation of the future', and the future present, or the 'present that will become actual in the future'.⁷⁸ What is traded on derivative exchanges is not the future given (the then unknown strike price of the underlying) but the present *risk* of that price against the delivery price.⁷⁹ Derivative pricing consequently refers 'to the present way of seeing the future, not to the unknowable future that will come about later'.⁸⁰ It is constituted in the 'management' of the price movement between present future and the future present. What is managed qua pricing is the

78. Esposito, *Future*, 23–4. There is similarly a past present that is the present as it was in the past but is now passed and inactual.

79. Terminological caution is needed here: what Esposito identifies as 'risk' is called 'uncertainty' in finance markets; see Esposito, *Future*, 36n.26. Standard finance theory follows Frank Knight's 1921 distinction between futures that are measurable/containable (risk) and those that are not (uncertainty). See Knight's *Risk, Uncertainty, and Profit* (Mineola, NY: Dover, 2006 [1921]).

80. Esposito, *Future*, 151; emphasis added.

convolution of the uncertainty of the strike price in the future present anticipated as a present future. And what is priced as volatility in derivatives markets is not then the variability of price at expiration stemming from the present—as proposed in the BSM model—but the *uncertainty* of price given the present inactuality of the future present. That is, derivative pricing makes explicit in the present the relation to an inactual and necessarily uncertain future present—as a present future. As such, it indexes the core characteristic of time in Esposito's systems-theoretical method, namely that because they are never (the) present, the 'past and future are never given, but become actualized as horizons of inactuality for a present that does not last'.⁸¹ In the general pragmatic terms of systems theory, a relation such as the management of price movements between the present and the future constitute 'the unity of actuality and inactuality' which is time. Time, on this account, is always system-specific, in that the maintenance within the present of past and future presents depends entirely on the structure, organization, and capacities of any given system.⁸² Derivative pricing and its volatility are, in short, constructions of time.

81. Ibid., 21.

82. The outline of time presented here condenses and quotes from the salient argument in Esposito, *Future*, Ch.2, especially 21–8.

The specifics of this broad determination can be determined against the general systems theory of time-relation presented by Esposito. Summarily:

- Time is specific to a system, ‘produced in order to organize its operations and make them more complex’ by incorporating the inactual past and future presents into its present actuality. As this paradoxical unity, the present is the primary manifestation of time.
- Because the ‘time binding’ that is the relation between the actual and the inactual depends entirely on the system in question, there is no absolute, ‘objective’ time.
- Rather, the pragmatic incorporation of inactuality into the present enables the system ‘to structure its present operations’ in view of that inactuality. Time therefore permits the complexification of a system to a degree greater than its actuality allows (as with debt in regard to fiscal conditions, for example).
- Thanks to time, the actual and the inactual inform one another, albeit asymmetrically; through anticipation of the inactual and unknown future in the present, and by organising the actual present in view of the future.
- Generally, ‘time allows the system to separate itself from its own operations and its situation, linking it with other (past and future) situations in a complex framework of connections’ that attest to and acknowledge its contingency amongst other possibilities.

The ‘possibilities’ of a system—its unactualised states—are only theoretically and practically available to it because of its time qua relation to the inactual.

- In particular, the revision of plans for the future and reconsideration of the (once future) present is the ‘internal reflexivity of time’. Operators in a system with time know that they can make decisions for an anticipated future which, while itself unknown, permits ‘the freedom to decide differently once that future has become present (a present they will have contributed to and where they know how to intervene)’. Such is the ‘flexibility and freedom’ granted by time. Emancipation is a time relation.
- The freedom of time for an operator in a system is the freedom to choose ‘in a non-random way’, and to re-choose in view of the consequences of the preceding choices. Similarly, the past offers a selectivity of remembrance: ‘everything could be possible, but only some possibilities come about, and these condition the possibilities that are made available for the future’.
- Time’s unity is asymmetric: the past present can only be understood for what it was and wasn’t (qua condition and projection to the future that is now present) in its future, while the future present continues to be strictly unknown but can be anticipated and prepared-for. Furthermore, operations *in the future* condition the future but do not determine it; past operations do determine their future, which is the present.

In these terms, systems have freedom *qua* possibilities constructed via their relations to inactualities of its *present* state.

Esposito's theory of derivatives pricing as counter-performative exemplifies this general theory of systems time and freedom of future revision. As options in particular demonstrate, derivatives build in revisability of trading the underlying at expiration into their contract. Trading of the options contract on derivatives markets 'allows one to make decisions today that affect the way the future will be, while preserving the freedom to decide one way or the other when this future will be present'.⁸³ As opposed to the BSM model, in this case derivative pricing is not constative with regard to an exogenous referent of that process. Rather, it refers to the 'contingency of future events' not only as regards the strike price, which is ostensible (exogenous) content, but primarily as a reflexive (endogenous) consequence pricing itself as a mode of time engineering. That is, the reflexivity or revisability of derivative pricing means 'that future-oriented expectations and decisions [on price] affect what will become present in the future'.⁸⁴ Taking the modality of the 'maybe' up to their expiration, derivatives 'leave the indeterminacy of the future open, and,

83. Esposito, *Future*, 105.

84. *Ibid.*, 127.

at the same time, produce it with their decisions'.⁸⁵ Generating indeterminacies upon which they subsequently act, derivatives are counterperformative. Consequently, these indeterminacies are not random (within the parameter of the standard deviation of a normal distribution, as the BSM model stipulates); rather, they are structured by the 'minimal continuity' of derivatives pricing in the present, a pricing which is predicated on the contingency of revision.

Derivatives are in general thereby devices of arbitrage in time.⁸⁶ As an endogenous process, the reflexive measure of the necessary uncertainty of pricing movement in the present is given within the terms of that pricing system itself: it is volatility, the index of the presence of inactuality in present actualities. And it is priced. What volatility measures in its pricing is the uncertainty of price *given pricing as a time relation*. BSM's presentist and therefore static and anticipatory determination of derivatives pricing proscribes the time relation qua unity of actuality and inactuality that is derivatives pricing from explicitly entering price determinations. It instead reproduces the time relations that derivatives are (vectored *qua* pricing) only as an implicit aftereffect of its probabilistic formulation.

85. Ibid., 105.

86. Ibid., 117.

Risk Order

This partial result marks the way to the political-economic determination of derivatives in terms of differential pricing. However, the logic of *différance* imposes important modifications upon the theorization of such pricing as counterperformative. Crucial to this re-determination is the irreducible sociological dimension of the time relation in Esposito's account, in which it is a corollary of her determination of risk: 'all forms of time binding have social costs, because they [...] also bind the opportunities and perspectives of all other operators'.⁸⁷ That is, since the agents bound in and by the system's time relations can avail themselves of the systemic contingency of revision, the possibilities inherent to a system with time are not only those of its capacity *in toto* but are distributed differentially across elements of that system, in this case the market constituted of participants in the pricing system. Time binding thereby constitutes possibility and limitation with regard to others, which is to say that it constitutes social binding as such, which is in each instance organized and comprehended as the norms of a given social order. Contrary to traditionally-ordered societies, for which norms are determined according to the constraints that have determined and stabilise the present on the basis of the selectivity of the past, social binding

87. This section mainly paraphrases Esposito, *Future*, 30–35 from which all quotations are taken unless otherwise noted.

constituted in view of the inactuality of the future stipulates a reflexive and revisable relation between the actual (present) and inactual (past and future). That is, social binding *qua* time binding requires the revision of social norms. Esposito illustrates by way of an example: ‘the reflexivity of time introduces a future contingency into the present that cannot be bound [...]. How can one accept the production of GMOS (even if it is legal) if one cannot dismiss the possibility that [...] they produce unpredictable genetic damages?’ Such damages are a future uncertainty, necessarily indeterminate in the present yet indexed in it as a risk—now meaning the uncertainty of the future in the present. Consequently, the necessarily social dimension of time binding complexifies the actuality and rationale of social organization—the available justifications of social norms—because the latter are subject to the revisability of the present in view of the future. Time is not a background through which revision of social norms is undertaken; it is that which imposes the necessity of the revision of norms in societies constituted with a view to ordering for future uncertainties. It constrains social orders to effectuate their norms in their contingent and future-facing contemporaneity. As such, societies of reflexive time-binding are definitionally modern. What is characteristic of them is that ‘the current constraint, which should [*qua* norm] neutralize future uncertainties [...] comes to depend

on these same uncertainties', making the ordering itself uncertain in its binding and 'depriving the [social order of the] very meaning of normativity'.

The coeval constitution of social and temporal uncertainties that is modernity is, then, 'a generalized condition of uncontrolled exposure to future contingency'. Given that its norms are contingent and are apprehended as such, any such 'society at risk (*Risikogesellschaft*)' has weak social bonds; it is flexible and adaptable, risk-rich.⁸⁸ To be modern means having no stable and binding criteria to guide actions, either now or in the future. Apparently stable solutions (for example, savings as a secure reserve for money) may lose out on gains elsewhere (the growth of equities markets), but the latter make the gains they do *because* they present a greater risk than the former. A stable judgement on what to do in the present could only be made in the future, not the historically organized actuality of the present. But the future is inactual and itself unknown, which is why all judgements now are themselves only risks. That judgements are made on condition of a necessarily inactual and unknown future and suppose their revision, such that there is no certainty as to what may come to be a gain or a loss, security or damage, is what Esposito calls 'the rationality of risk'—a rationality constituted by the

88. *Risikogesellschaft* is better known in translation through the influential work of Ulrich Beck as 'risk society'.

double necessity of an ignorance of the future and the insufficiency of the past to guide judgements made in the present.⁸⁹

The rationality of risk does not however disable all criteria for judgement. Even though norms as such are deprived of any final authority and legitimating sanction, the rationality of risk nonetheless generates a ‘recursive, circular and revisable’ quasi-order of

89. Esposito, *Future*, 105 for ‘rationality of risk’. This dynamic construction of reason is homologous to Robert Brandom’s ‘strong semantic inferentialism’ (SSI) that provides the basic schema of neorationalism. With Brandom, SSI is a sufficient condition of conceptual contentfulness because inferential relations ‘alte[r] our commitments and entitlements in ways that depend on what is a reason for what’, meaning that the basic operation of reason is the revision of extant propositional content (*Reason in Philosophy* [Cambridge, MA: Harvard University Press, 2009], 13 for the quote; all emphases are added, Brandom’s own emphases being removed throughout.) Moreover, for Brandom reason is primarily deontological because ‘judging and acting—endorsing claims and maxims, committing ourselves as to what is or shall be true— [...] mak[es] ourselves subject to assessment according to rules that articulate the contents of those commitments’ (33). Kant calls these rules ‘concepts’ but Brandom identifies their more general discursive applicability as being primarily the norms to and for which those making inferences are responsible. That responsibility distinguishes the ‘exercise of a distinctive kind of consciousness’ that is ‘sapient, rather than merely sentient, consciousness[,] or awareness’ (9). Moreover, concept formation qua normative rationality is not sui generis to the thinking subject as rational self (Kant) but also social (Hegel), involving extant histories and nonratiocinative languages (Ch.3). Like SSI, then, risk rationality is a necessary and chronic socially constituted revision of norms ‘consisting in practically knowing one’s way about in the inferentially articulated space of reasons and concepts’ (9) according to the ‘bindingness’ (33) of the norms actively and provisionally established by the reasons intrinsic to that recursive process rather than past or future conventions. In the risk-order, the ‘inferentially articulated space of reasons’ is specifically determined as calculative yet open-ended time-binding. Consequently, neither reason nor (anthropological) sentience nor then price are established epistemological terms but come to be known and have traction on social norms thanks only to their respective rational revisions. However, for reasons presented taken up in n.133 below, such an alignment is only hypothetical or formal but is in fact incompatible.

binding uncertainties. That quasi-order is the ‘minimal continuity’ of sociotemporal binding, a binding ‘between the contingency of time and the contingency of observers’ that is enough to form decisions and give the capacity for control, revision, and correction ‘in a non-random way’. Control not over what the future will be as such (per planning), but control as the construction of *possibilities* for the future ‘without knowing or having to know’ whether those possibilities will come to pass. Disestablishing social norms while constructing a binding social reality predicated on uncertainty and constitutive ignorance, the rationality of risk requires and fabricates increasingly ‘complex forms of time management’. Derivatives markets epitomise such complexity by ‘allow[ing] one to make decisions today that affect the way the future will be, while preserving the freedom to decide one way or the other when this future will be present’.⁹⁰ Specifically, by constructing a deferral of the vending of the underlying in view of taking advantage of changes in price once that contract is made and others react to it, the derivatives trader ‘buys contingency (i.e., the freedom to decide otherwise starting from the decision taken today)’. Derivative prices are set not primarily in relation to the underlying or to other market-exogenous conditions, but by expectations and indexes of price movement.

90. Esposito, *Future*, 105.

For Esposito, whatever quasi-order persists in the rationality of risk is 'governed by reference to the uncertainty of the behaviour of others', given that their uncertainty is also attributable to the horizon of a future that is inactual to them. Not only do judgments and actions take place within the constitutive ignorance of reflexive time-binding but, for that reason, 'observers do very well in observing each other because the world is not a primary given [...], but comes into play when one observes what and how other observers observe'.⁹¹ In Esposito's systems-theoretical account, such 'second-order observation' is the primary characteristic of modernity: it is 'the only form of reality still viable' in modernity, in which 'descriptions of the world change the world described'.⁹² The 'minimal continuity' of reflexive time-binding and counternormative social binding resolves for Esposito into the constructivism of reality constituted by and as the integrated sociology of second-order observation that is antithetical to conventionalism. This broad constructivist determination of the quasi-order of societies at risk—of the risk order (the term is not Esposito's)—is the general sense in which *all* judgements and observations in the risk order are necessarily counterperformative. As modern practices of complex time-binding, derivatives markets are counterperformative *per se*, and

91. Ibid., 104.

92. Ibid., 93.

not only when those markets lurch into crises (as MacKenzie holds); and they are systems of second-order observation.⁹³ Consequently, financial markets are not directed to or organized for the 'satisfaction of needs' insofar as these are external to market determinations. Rather, they require

the abandonment of any reference to a given external world, even in the form of the discourses about the difference between investment (which should operate in the real economy) and speculation (which should be a mere financial transaction), where the second should refer sooner or later to the first. Otherwise we have to deal with a pathological development,

93. The account of second-order observation paraphrases and quotes from Esposito, *Future*, 102–4, unless otherwise noted. As Esposito notes (*Future*, Ch.5, n.28) second-order observation is a variant of John Maynard Keynes's beauty contest model in which contestants in a newspaper prize choose the six publicly selected 'prettiest' faces out of a hundred. Rational agents do not select according to their own preferences but according to those that they think popular opinion would select (*The General Theory of Employment, Interest and Money* [New York: Harcourt Bruce, 1964 (1936)], Ch.12, §5). Keynes characterised the professional investor of his time as having reached 'the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be' in a 'battle of wits to anticipate the basis of conventional valuation a few months hence'. In this, financial interests in markets are distinct from the medium-long term investment characteristic of enterprise, the 'social object' of which 'should be to defeat the dark forces of time and ignorance which envelop our future'. Against this injunction, second-order observation as Esposito derives it complexifies Keynes's recursive rational-model further because (i) the observer includes the knowledge that she or he is observed by others as well as observing them, and (ii) the second-order observer is also attentive to the risks and volatility of price movement, thereby including counterconventional combinations in their time-binding calculation (*Future*, 11).

COLLAPSE VIII

with a crazy economy, with gambling and a total lack of control.

Supposing that investment is badly (if at all) served by speculative finance would lead to the criticism of the latter as a 'casino capitalism'; a gambling without constraint or external reference that is destructive of the production that should be its true purpose. This is a commonplace criticism of financial markets, often accompanied by the complaint that risk rationality is distinct from calculative-predictive rationality. The former has no clear results or direct and known consequences; nor does it have any rational or social normative core, only the construction of possibilities that countermand the actuality in which they are conceived. Systems-theory constructivism obviates such criticisms of finance in favour of comprehending the ways in which 'the financial economy binds itself and its operations, not to a correspondence with an alleged given world'. On this basis, the risk-rationality of financial markets is not that of production or of 'the real economy' (exogenous referents for those markets) but rather and only that of risk—that is, the possibilities fabricated by the system for its own counterperformative development via emancipation from extant norms. And such risk has two dimensions to it: generally, what are instantiated in the present are the uncertainties of the unknown future, a making-ignorant of the present

and its constative determinations; and specifically, per instance of pricing, counterperformative pricing generates profits from ‘bucking the trend’ of the market as a system of second-order observation.

Such countermanding possibilities cannot be conceived on the basis of the actuality of the present alone, vitiating the very condition for the probabilistic account of price development in the anticipatory model of BSM. Consequently, to reiterate the argument of endogenous counterperformative pricing from another angle, derivative pricing is constitutive of price movement, and instantiates its own ‘ignorance’:

[P]rice movements always produce surprises that would not arise if there had been no speculation about the future in financial markets. The future projections to which operators are oriented are correct and incorrect at the same time. If done well, they anticipate the way the future would have come about if there had been no attempt to foresee it. In this sense, they sabotage themselves.⁹⁴

Prices *necessarily* go in unexpected directions because their anticipations (in the future present) are necessarily wrong—and only by virtue of the anticipatory price (in the present future). That is, as well as factors exogenous to the pricing system and trade in the underlying,

94. Esposito, *Future*, 128.

pricing as such generates volatility. Implied volatility is for Esposito an effect and measure of the reflexivity of the risk-order itself, with the underlying as a quasi-arbitrary heuristic device to facilitate that measure.⁹⁵ The succinct formulation is that implied volatility ‘indicates the prevailing opinion on the prevailing opinion’. The elaborate version is that, as a measure, volatility is an observation of the systemic dynamics of second-order observation. Such an observation is not external to second-order observation but is itself an endogenously generated manifestation of second-order observation that estimates its own effects on the pricing mechanism that it is—yet another instance of the recursive revisability of such systems. As such, and because it is itself priced and traded on derivatives markets (enabling gains to be made while the markets for the underlying derivative make losses), implied volatility explicitly demonstrates the reality of the financial risk-order. It is an endogenously constituted measure of the rationality and constructedness of the system in and by which it is manifest. What is important in this result is that volatility is ‘not a datum’; rather, ‘it refers to the future’, to the inactuality that constitutes the uncertainty of pricing *qua* risk order. For Esposito, this means that volatility measures only ‘what the changes in the expectations of the operators

95. Ibid., 139.

about these movements are' and affecting the latter as part of its reality.⁹⁶

Esposito's systems-theoretical account of derivatives pricing surpasses the constraints of the BSM model, positively capturing price volatility as a direct and necessary effect of pricing via the notion of counterperformativity, exposing that derivative pricing instantiates the kind of minimal continuity between time binding and social binding typical of risk-order societies. In short, it shows that risk ordering is intrinsic to derivatives pricing. In these terms, the BSM model is a mistaken because unilateral determination of the integrated sociotemporal constitution of price. A more complete account of derivative pricing requires that it be apprehended as *at once* a political economy: the market endogeneity of derivative pricing is at once a complex form of time management and *as such* a complex form of social organization. It is this injunction that returns the overall argument back to Nitzan and Bichler's contention that capitalization constituted via pricing is a political economy of accumulation; but three further steps need to be taken in order to make the two otherwise divergent theories of pricing congruent.

Firstly, the immanent sociality of pricing for Esposito is restricted to traders as the second-order observers who make up the market, and does not extend to the

96. Ibid.

entire and universalisable social complex that is for Nitzan and Bichler the purview of price as organising term for the 'single quantitative architecture' of capital-power. In view of the latter, the endogeneity of the political economy of market pricing must be extended beyond the confines of its immanent social determination. Secondly, Esposito's entire theorization revolves around the primacy of observers and their systematic intradetermination of price. This sociological determination accords with the Neoclassical paradigm in supposing traders' subjectivity as the condition and term of analysis, as indicated by Esposito's reliance on G.L.S. Shackle's theorization of the uncertainty of economics for the economic agent who relies upon her or his imagination in entrepreneurial endeavors.⁹⁷ The argument of counterperformative pricing is anti-realist not just because of this assumed primacy of the sociosubjective dimension, but also owing to the theoretical basis of its constructivism: for Esposito, the volatility of pricing demonstrates that the reality of the derivatives market is indifferent and detached from any referent exogenous to the derivatives markets: (i) volatility does not refer to a reality beyond the system of observation, and (ii) even when it seems to (with, say, the movement of prices putatively in relation to an underlying), that exteriority *qua* real

97. See for example J. L. Ford (ed.), *Time, Expectations and Uncertainty in Economics: Selected Essays of G.L.S. Shackle* (Aldershot: Edward Elgar, 1990).

is in fact predicated on the (system of) observation in its ontology, semantics, and rationality. As such, volatility in this account is an index of what Quentin Meillassoux has influentially called ‘correlationism’, verging here on idealism.⁹⁸ By contrast, for Nitzan and Bichler, all market entrepreneurs follow the logic of differential accumulation that is capitalization’s

98. Correlationism as Meillassoux defines it for noetic cognition is not to be confused with the various correlations of derivatives pricing structures, not least because the latter are derived on the basis of normalised probability calculations whereas noetic-cognitive correlation is the putatively ineliminable subjective structuring condition of knowledge, as instantiated by second-order observers. For Meillassoux the noncorrelational real, the real beyond thought that it yet comprehends, can only be determined by rational thought to be entirely contingent—that is, without cause or reason—meaning that the real of thought is only the contingency of the fact of thinking, which contingency of the real is therefore its absolute condition (*After Finitude*, tr. R. Brassier [London: Continuum, 2008], Ch.3). Consequently, it is Meillassoux’s noncorrelational realism that is schematically analogical to the dyadic contingency of abstraction and revision structuring the underlying of derivative structures even though its content is directly contrary to it. On the basis of the anticipatory pricing model, Meillassoux’s ‘Principle of Insufficient Reason’—that the unique and supreme necessity for thought of the absolute contingency of the real means that nothing of the real is necessary, including physical laws—can be characterised as rational thought’s determination of the real as having the Markov property of memorylessness. But the analogical coherence of the two schema should not belie their substantial divergence: while anticipatory financial models of speculative pricing delimit the contingency of the price of the underlying by probabilistic normalization, for Meillassoux the absolute contingency of reason prevents the establishment of an upper-bound or circumscribed set of possibilities necessary to establish probabilistic calculation (*After Finitude*, Ch.5).

For a relatively nontechnical introduction to financial correlations and their central role in the structuring of the collateralized risk portfolios central to the 2008 financial crisis, despite recognition of their theoretical failure as well as that of delta-hedging in the ‘correlation crisis’ of May 2005, see P. Triana, *Lecturing Birds on Flying: Can Mathematical Theories Destroy the Financial Markets?* (Hoboken, NJ: Wiley, 2009), Ch.4.

dynamic reordering. Determined by that logic, price is 'a calculable measure' that is systemic, ordering, and external to the subjective observation and action which it shapes.⁹⁹ Taking up Esposito's words about implied volatility, then, price 'has its own objectivity to which one can refer', one that overdetermines the trader's subjectivity: the objectivity of its market-endogenous constitution. As Esposito proffers in passing, it is necessary to deduce

a form of rationality that includes the volatility smile and its consequences for markets. According to this rationality, paper markets are not unreal, and their operations are (often) not irrational at all. We should, however, find out what kind of reality and what kind of rationality are at stake.¹⁰⁰

In terms of the systemic objectivity of pricing, such rationality and reality are those of capital accumulation's finance power, but now determined as an *objective* risk order. The systemic objectivity and logic of capital accumulation then require a noncorrelationist theory of derivatives pricing that accommodates both the endogeneity of market making and the sociosubjective dimension mandating Esposito's constructivism. Such a realist theory of pricing is at once also a theory of its

99. Esposito, *Future*, 140.

100. *Ibid.*, 151.

rationality, the latter term incorporating the dimension of both power (from Nitzan and Bichler) and risk (from Esposito). The required theory is therefore a realist ontology of price *qua* rational risk order of capital accumulation. As will be seen, it is this ontology that permits the specific determination of finance power.

Thirdly, Esposito's 'pragmatic' theory or practice of time *qua* freedom upon which the theory of risk is constructed supposes and requires that the present is only actual and the future wholly inactual, the two remaining firmly distinct. In this theory, any derivative's price is the price of 'today's risk', risk in the 'present future', strictly distinct from a 'future present'. Implied volatility is for her 'the projection of the future from the considered present', and risk the anticipation of the inactual future present as a distinct present future.¹⁰¹ Consequently, even if derivative pricing *qua* différential temporization is partially comprehended within the constructivist account of derivatives markets *qua* the reflexivity of time binding and the risk order it inaugurates, the differential organization of that pragmatism (and its counterperformative freedom) remains an attenuated if complex and recursive form of presentism. As such, it is inadequate to the différential organization of derivative pricing that is the mechanism for the relation between the actual and the inactual in Esposito's theory of present pricing of risk as 'management':

101. Esposito, *Future*, 139.

if 'the future is not the present future or the future present, but the difference between the two',¹⁰² then the pricing of risk by derivatives 'manages' the future *qua* inactuality in the present. The present/pricing is then no longer present to itself, but is deferred from itself *qua* futurity. What is deferred from the present in pricing risk is the future: the uncertainty and inactuality that the present maintains. Equally, risk is the present manifestation of future uncertainty and, as such, displaces the actuality of the present into an inactuality within the present. Possibility, the freedom occasioned by the distinction in kind between actuality and inactuality in time binding, is then granted by *différential* temporization. But *différential* temporization also immediately constrains possibility, not because of the limitations of the given actuality of the present but because the constitutive imbrication of future and present means that the future present is not wholly distinct from the present. That is, possibility and the freedoms of the present are constrained because the deferral of the present future from itself opens to the future present *in* the present (which intrinsic condition is also why there can be a present future at all). In the complexity of the partial indistinction of present and future that is the temporization of both, possibility cannot be wholly distinguished from actuality; freedom *qua* possibility is granted by the circumstances of the present. The real of

102. *Ibid.*, 127.

derivative pricing is its actual-inactual temporization, a liberation from the present in priced risk.

Given the minimal continuity of the integrated sociotemporal binding that is risk order, the three redeterminations of derivatives pricing remarked here are coextensive: the real of différential pricing is that of the noncorrelational real of endogenous pricing in its systemic and objective logic of differential capitalization. Elaborating the three redeterminations of risk order in reverse leads to the explicit formulation of this comprehensive identity of the real of derivative pricing, which is in fact finance power in its dual dimensions of financial operations and the a priori of capitalization.

7. PRICE PLASTICITY

The price of an asset in capitalization is *only* a financially formulated magnitude of anticipated earnings. The contention here is that derivatives pricing dilates and makes explicitly manifest the process of that formulation and, insofar as the underlying asset is only a contingency upon which that process is occasioned, its primacy for capitalization. While constraints may be imposed on derivatives construction by jurisdictional authorities regulating contract law, such pricing construction is anyway constructed qua legally-binding arrangement. Consequently, regulatory regimes per se are not an external obstacle to the structuring of

derivative pricing, but an implement determining its construction. Put otherwise, derivatives construction and therefore pricing is variable without *intrinsic* or necessary determination as regards either the mobilisation of the price differences it constitutes or its time-binding. Limitations imposed on derivative construction are wholly contingent and malleable (via changes in regulation, or the invention of alegal or quasilegal derivatives structures—or both, as with the invention of swaps), structuring pricing by constraining their pathways in a dimension that is endogenously constituted, differentiating, and universalisable thanks to the contingency of its abstraction with respect to the underlying occasions. The variability of derivative pricing is only ever realised in locatable and circumscribed contracts specifying particular pricing conditionality and temporization structures.

Exotic options are an operational index of the indefinite variability of derivatives pricing, yet they are constrained by the requirements of the currently prevailing standard model of capitalization. But this standard determination, while dominant, is *not necessary*. Theoretically, the liberation of business from its industrial determination by derivatives pricing (to adopt Veblen's terminology) is a dynamic power-ordering that is simultaneously more extensive and more intensive than the geospatial and industry-based business variants of differential accumulation to which

Veblen remains bound and from which Nitzan and Bichler draw their analysis. It is more extensive because the ‘single quantitative architecture’ of price, coupled to the risk-rationality of derivatives pricing—as a claim on earnings that are *explicitly* unknown, inactual, and constituted by a futurity that is in principle unconstrained—means that financial pricing and claims on earnings can extend transhistorically from the present in which the contract is written to any moment in spacetime, including all futurity, indefinitely (if the legal structures are durable enough). And it is more intensive because, to put the preceding point the other way around, derivatives pricing is endogenously constituted, meaning that the in-principle universal extension of price is operationalised (i) across time (at whatever scale), and (ii) in relation to an underlying that is *therefore* fungible, a contingent conditional for the organization of power qua price. Combined as two aspects of the one instantiation of power-ordering, the universal fungibility of the underlying in derivatives pricing has its systemic correlate in the universal fungibility of pecuniary assets in the dynamic reordering of capital-power—which can, for this reason, be determined as a risk order.

The theoretical consequences extend to the conceptual schema of derivatives pricing, in so far as their in-principle indefinite variation requires a significant divergence from Derrida’s determination of the logic

of *différance*, the elaboration of which requires a last brief return to phenomenology. Unlike Husserl, for whom there is but one single presence even though the lived present as such is an ideal and never any factual lived presence, for Derrida the present is necessarily different from itself, the living present being no less the simultaneity of the lived present *idealiter* (which is infinitely deferred from being manifest as such) *and realiter*.¹⁰³ The infinite *différance* constituting the ideal present takes place *in* the finitude of the real present. The logic of *différance* is thereby exempted from the opposition of finitude and infinitude. Furthermore, because the ideal lived presence is no fact of lived presence, its only manifestation is *in fact* the absence of a lived present: death. Transposing the *logic* of *différential* temporization to the constitutive structuring of derivatives pricing, Derrida's summary of the relation between the factual lived present and its supposed ideality finds its direct analogue in taking the payoff and (where it happens) the exchange of the underlying at maturity not as the terminal point at the outer

103. J. Derrida, *Speech and Phenomena and Other Essays on Husserl's Theory of Signs*, tr. D. B. Allison (Evanston: Northwestern University Press, 1973 [1967]), 99ff. For Derrida, the *différential* constitution of the living present in Husserl's phenomenology is instantiated by the deferral of the ideality of that living present (and that of the pure thought Husserl also relies upon) as it is by the non-ideal present which is no less the living present in fact. The living present is different from/to itself (ideal, factual) and is the fact of its deferral. The Ideal living present—what the living present truly is for Husserl—never appears in fact. It is a Kantian ideal, infinitely because constitutively deferred from the presence that it 'is', a present that is then necessarily different from itself.

limit of the contract (its ‘expiration’ as the terminology for options has it), but rather as one of its intrinsic constitutive and structuring features:

only a relation to the expiration [Derrida: ‘my-death’] could make the infinite *différance* of pricing [presence] appear. In the same blow, compared to the ideality of the positive infinite, this relation to the expiration [my-death] becomes an accident of empirical finitude. The appearance of infinite *différance* is itself finite. Consequently, *différance*, which is nothing outside of this relation, becomes the finitude of the derivative [life] as an essential relation with its expiration [oneself and one’s death]. Infinite *différance* is finite.¹⁰⁴

That is, the in-principle indefinite variability of differential pricing, *including its expiration*, is always manifest in the ‘empirical finitude’ of its pricing, which is the theoretical corollary to the volatility smile: maturity/expiration, which is the constitutive deferral of differential pricing, is but one variable amongst others in pricing. In philosophical convention: the temporization of differential pricing up to and including its termination is *immanent* to pricing.¹⁰⁵

104. Derrida, *Speech*, 102.

105. Once constituted, derivatives markets can be conceptualized as a field of immanent differentiation, for which Deleuzian categories and dynamic schemata provide productive theorization especially of the dual deployment

However, the analogy is not a complete one. The logic of différential pricing diverges significantly from Derrida's deduction of différance from phenomenological consciousness for two reasons:

1. Death and the absolute past are distinct from any living (self-)presence of a consciousness because of the unity and inexchangeability of that consciousness;¹⁰⁶ whereas there is no such constraint on the différential pricing of derivatives. In general, a derivatives contract can be terminated before maturity/expiration (for example, with American-style options). The purported exchange of the underlying required for the structure of the particular derivatives contract and, historically, to distinguish derivatives trading from gambling, is only a conditional term providing

of the actual and inactual, the latter being translated in Deleuzian convention to the virtual, which together compose the real—the latter being contrasted for Deleuze to the possible. See B. Lozano, *Of Synthetic Finance* (Abingdon: Routledge, 2015) and Elie Ayache's characterisation of the market a 'pure becoming' (*The Blank Swan* [Chichester: Wiley, 2010], 39). Such accounts however presume and neglect the constituting deferral of the strike price or expiration at maturity as ordering term of the forward contract, ordering it instead as an inactualized virtuality of the market and thus susceptible to the criticisms put to Esposito's systems-theorization and the BSM regime, upon which such theorizations tend to depend. Jakob Arnoldi hybridises Deleuzian and systems-theoretical notions of the virtual as a space of calculative probabilities distinct to the possible in 'Derivatives: Virtual Values and Real Risks', *Theory Culture Society* 21:23 (2004), 23–42.

106. The condition of the unity of consciousness is not limited eidetic phenomenology. That consciousness has a primary unity is proposed in cognitive neuroscience by Thomas Metzinger, *The Ego Tunnel* (New York: Basic Books, 2009). Ch.2, and for semantic inferentialism by Robert Brandom (*Reason*, Ch.2), for whom it is a condition of philosophy and sapience (see n.133).

the terms for the contract's payoff and determining its market price. The time to expiration is, in other words, but one variable among others in the finite construction and pricing of the derivative and its trading. Consequently, the endogenous différential pricing of any particular derivative, constructed in its finitude thanks to its contractual boundedness, is intrinsically imbricated with its market pricing, which is its exchangeability in advance of its maturity. In distinction to Derrida's phenomenological commitments, the finitude of the différential temporization of the derivative contract is constituted in its exchangeability.

2. Since this means that the market is not outside of the endogenous construction of derivative pricing, a derivative's expiration/maturity is one variable in the more general revisability of derivatives market pricing and their concomitant contingency. This is to reiterate once again that derivatives are *constituted* in the institutions of différential pricing (derivatives markets); but it also makes explicit that the finite temporization of pricing is necessarily imbricated with market trading. The contingency of revision characteristic of derivatives pricing supervenes on the terms of the contract's expiration, which determine its finitude. Consequently, if the expiration and payoff are but variables of différential market pricing, the temporization of pricing is not constrained by its finitude *qua* termination of

the derivative at expiration/maturity, but rather by its termination *qua* marketisation. This is the condition and structure of speculative finance, now distinguished from investment by operationally prioritizing market pricing *qua* the contingency of its revision over its termination in relation to the underlying (meaning the provision of liquidity outside of the market upon expiration/maturity). Moreover, because of the priority of the contingency of revision for différential pricing, the only constraints for market speculation are regulatory, rather than stemming from a putatively 'real economy' external to it. But because such regulations and the institutionalisation of pricing that they permit and impose are themselves as constructed, variable, and subject to the contingency of revision as the pricing mechanisms they regulate, unlike death for the living consciousness the speculatively organized constraints of derivatives pricing are not uniquely determined but somewhat arbitrary.

Combining these two partial results, the speculatively-organised termination of the derivative via its marketisation means that différential pricing is constitutively indefinite in two regards: firstly, the derivative can be traded at any point up to its expiration; and, secondly, its price varies with the derivatives market, not just that of the market of the underlying. Constituted and instituted in the finite but also variable contractual terms of any particular derivative, the price variability

of différential pricing is therefore intrinsically indefinite. In this it diverges from the logic of différence established in Derrida's deconstruction of phenomenological consciousness, for which infinite différence is finite and the différence of the lived present of consciousness is in 'an essential relation' to its finitude *qua* the unique termination that is its death: not only is infinite différence finite for derivatives, finite différence is also *indefinite*.

The two dimensions of variation for différential pricing—the price-setting schedule of the finite because bounded contract, and its market price variability and trading—are constitutive of one another: the indefinite price-variability depends upon the variable finitude of the contract (its expiration, the payoff schedule, amongst other conditionals) and the speculatively-organised variations in what a derivatives contract might be are constructed with regard to their indefinite market variability, not the payoff. This integrated dual variability of the derivative contract with its pricing constitutes the operational terms of the derivative's price-endogeneity in its intrinsic contingency of revision, which is here designated as the *plasticity* of the derivatives contract. In practice, and to reverse-engineer the argument, the plasticity of the derivative is the condition for the indefinition of derivative pricing without which there could be no operative market *qua* contingent repricing of derivatives, the

bounded pricing structures and schedules of which are fabricated in view of that constitutive and endogenous indefiniteness. Or, again, market pricing and trading is the operational manifestation of derivatives' intrinsic operational contingency of revision.

That derivatives are constitutively rather than secondarily speculatively organised in their own markets is demonstrated by the 'closing out' of positions. While futures contracts require the buyer to take delivery of the underlying asset at the expiry date, a trader speculating or hedging on the futures market can exit the contract by executing exactly the opposite trade to the initial one, doing so at any time prior to the latter's maturity. The trader then has a long and short position on the one trade, resulting in no net position at maturity. While the position is then 'flat' and the delivery of the underlying need not be made, the trader can still make a gain or loss—or, more likely in the latter case, circumvent anticipated greater losses—in futures prices over the period. The vast majority of futures contracts are closed out, with delivery of the asset being 'relatively rare'.¹⁰⁷

107. Hull, *Options*, §2.1.

Illustration

The strike price for a futures contract in URB maturing in three months is 50lcu per share. A speculator takes a short position for 100 shares, locking in revenue of 5000lcu at maturity (excluding transaction costs).

After two months, the delivery price of URB shares at expiration is anticipated to be 47lcu at maturity. The trader anticipates a gain of $50 - 47 = 3$ lcu per share, or 300lcu on the contract, provided all the shares are immediately bought at 47lcu at maturity.

The speculator guarantees such a purchase by going long on 100 URB shares priced at 47lcu with the same expiration date as the original trade.

The trader then has a 'flat' position regarding the asset, trade in one position cancelling out the trade in the other, yet gains 3lcu per share by closing out the deal.

If the spot price on maturity looks like it will be greater than the delivery price (say 52lcu), the trader with the short position looks to lose $50 - 52 = -2$ lcu per share on the futures contract.

Closing out the deal by going long with a strike price of 52lcu gives more certainty to the net loss of 200lcu, rather than taking the risk of an even greater effective loss by the anticipated rising price of URB stock.

That more than one position is taken on the same asset (and by the same trader) inflates the nominal size of the market beyond its actual credit exposure. This explains in part the operational causes for the sizes of the financial markets that underpin Lesson Two in the introductory comments above. In terms of the general theory of capitalization, that Lesson is instructive as a practical demonstration of the liberty derivatives markets have with regard to the parochial statutory limitations imposed on them at the historical inauguration of the CME in Illinois. Closing out makes it quite explicit that the delivery of the underlying is but a jurisdictional requirement to be circumvented—one that is historically fundamental but operationally trivial. It is one among other requirements structuring the early derivatives markets and which, rather than containing them by imposing a relation to the underlying, expanded them by liberating the endogenous plasticity of derivatives pricing.

8. THE INFRAWAGER:

THE REAL OF DERIVATIVES PRICING

Closing out operationally demonstrates that the liberation of differential pricing from its exogenous referent is tantamount to the delivery price of the underlying being identified as a conditional within the derivative pricing process rather than as being rooted in the

markets of the underlying. This deracination from exogenous markets is imposed, first, by the endogeneity of différential pricing, which proscribes the exogenous referent from being anything but a variable of the finite temporization constructed by the derivative contract. And it is also imposed because, second, capitalization per Nitzan and Bichler is organised through price *qua* ownership claims and derivative contracts are only juridicofinancial constructions which build in and make explicit the variability of the price over the duration of the contract. That is, the price of the underlying as *object of capitalization* on derivatives markets is determined not on the basis of prices exogenous to those markets, but on the basis of the plasticity of the construction, temporization, and market pricing. That plasticity is the real of derivative pricing. Consequently, the distinction between derivatives markets and gambling is both operationally *and* constitutively rescinded, as the institutional and regulatory development of the derivatives markets demonstrates. What is less directly evident from that history of institutional practices, however, is that while derivatives markets have in more or less attenuated ways formally observed the distinction from received constructions of gambling for regulatory reasons, they have also inaugurated and massively operationalised an unprecedented mode of the wager.

Derivatives pricing cannot be identified with conventional notions of gambling, in that the standard wager depends on an exogenous referent that is uncertain at the time the wager is made (archetypically, the throw of the dice) from which occasion the wager itself (as an if-then payout conditionality) is distinct, and which it cannot affect without vitiating the very meaning of the term (archetypically, loading the dice), a schema designated here with the term *extrowager*. In the *extrowager* the gambler is constituted by her or his necessarily limited knowledge of an inactual future occurrence, a subjective manifestation of the inadequacy of finite epistemology to ontology. In these terms, the anticipatory BSM regime attempts to bypass the constraints of the *extrowager* (the prohibition of gambling), while observing them (the constitutive exogeneity of what is priced to the pricing process itself). The contention here is that, in formulating options pricing as an *extrowager*, as derivatives typically are, the BSM regime apprehends and domesticates the realist constitution and ontology of the wager inaugurated by derivatives markets. This domestication is reiterated in another format by Esposito's systems-theoretical account of derivatives pricing process as a sociosubjective construction. Furthermore, however prevalent and institutionally dominant such accounts of derivatives pricing may be, the latter is distinct in kind to the *extrowager* because of the constitutively

endogenous operation of différential pricing and its concomitant indefinite plasticity. To be exact:

- It shares with the extrowager the exogeneity of the underlying as condition of the derivative's pricing process.
- Yet différential pricing is distinct from the extrowager in that the former is an endogenous operation with an indefinite plasticity until expiration for which the conditional exogenous referent is operationalised as only a contingent abstraction of the pricing process. Derivatives pricing is conditional upon whether the set conditions at expiration will transpire or not, and, if so, what the payoff will be.
- The price of the derivative itself as well as (indirectly) the spot price of the underlying at delivery are themselves then priced in their markets (and its pricing is itself priced in the volatility markets); that is, any instance of derivative pricing is a wager placed not just *in* an indefinite betting process but also *on* it.
- Derivatives markets pricing is thereby akin to odds lengthening or shortening on a bet according to what other bets are placed. However, while the price of odds changes for the extrowager according to what other bets are placed, its changing odds and prices are always in reference to the exogenous circumstances conditioning the payout.
- In contrast, what is unprecedented about derivatives

pricing is that its plasticity explicitly subordinates that external determinant for pricing to its *own* process, such that the market refers to the changing prices operationalised via that market.

—What is priced by derivatives markets, then, is the pricing process *itself*. Unlike the extrowager, derivatives pricing is an *infrawager*, for which the terms at expiration are not externally determined conditionalities but only parametric constraints.

Displaced to the activities of traders, the processual and referential endogeneity of pricing is what Esposito calls second-order observation. Its determination *qua* infrawager, in contrast, explicates différential pricing as an impersonal institutional fact, rearticulating its counterperformativity in terms of the objective dimension of price. It is the real of derivative pricing not as a sociology of derivative pricing but as the ontology of *all* betting as a pricing process. Because the referent of the extrowager is the assumed condition and terminus of the wager, it proscribes identification of the endogenously constituted conditionality of the derivative pricing process as well as the contingency of abstraction with the underlying. This mistake is the consequence of a more or less implicit correlationism, the error of which is in fact exposed and operationally negated by the explicit manifestation of the infrawager in derivative pricing. Put the other way around, the

operational and practical exposure of the infrawager by derivatives markets is the historically unprecedented liberation of both the wager as such and of price from their assumed historical and theoretical subordination to exogenous terms that are not, in fact, conditions of pricing.

Commencing instead from the ontology of the infrawager, as the logic of pricing requires, it is, in Elie Ayache's formulation, 'easiest to withdraw' the underlying 'from underneath the contingent payoff and subsequently to claim that contingency is absolute and no longer derivative on that state'.¹⁰⁸ That is, the derivatives contract is not predicated on the underlying but *entirely* on the indefinite plasticity of the infrawager—including the price at expiration, which is only a structuring parameter. Thus the real of the infrawager, manifest and institutionalised as derivatives pricing, consists solely in its twofold contingency: the contingency of abstraction (the universal fungibility of the underlying) and the contingency of revision (the indefinite plasticity of différential pricing). Establishing that the infrawager is the endogenously-constituted and -referencing real of derivatives pricing provides the basis for the final steps to complete the present argument; namely, to generalise the determination of pricing beyond the specific institutional practices

108. E. Ayache, 'The Turning', in *Wilmott Magazine*, June 2010, 45, www.ito33.com/sites/default/files/articles/1007_ayache.pdf.

of derivatives markets to price as such (its intensive aspect) which, per Nitzan and Bichler, is the single universal architecture of capitalization (its extensive aspect). The two imperatives for this comprehensive theory of price are, firstly, that it specify the articulation of finance in its practical dimension (institutional operations of capitalization via ownership claims) with financiality (the *a priori* of capitalization); and consequently, that the theory of price advanced must also provide a specific determination of finance power and thereby the primary characteristics of the state-finance nexus and its cogency (however riven and incoherent it may be in theory). It is Ayache's theorization of pricing that advances the generalisation of pricing required here, thanks to its positive determination of pricing as such as instantiating contingency *qua* absolute futurity, thereby (to go beyond the terms of Ayache's own argument) specifying the mode of time binding of capitalization not in the dimension of its sociology but of the real of price that is its ontology.

9. ABSOLUTE VOLATILITY

Though Ayache's argument is not directly that of the infrawager, his principal contentions are congruent with it, namely (i) that forward contracts have no price process shadowing a succession of prices outside of the derivative itself. Predicated instead on the

contingency of the underlying as its real, (ii) the price process given by the stochastic model and its elaborations are ‘eliminated’. Consequently, (iii) the only reality derivatives prices have is that of the long/short position as the contract is re-entered (or not) every day the market is open, and no less (iv) at expiration. Ayache’s claims follow from the observation that the real of the derivatives pricing process *in the present* is not the ‘path’ of différential pricing, which is the dynamic actualisation of its temporization. Rather (and this is what Ayache adds to the determination of the real of derivative pricing) ‘what exists today’ for the forward contract (here a metonym for the derivative structure in general) ‘are contingent claims, paying 1 or 0. [...] *[B]oth belong to the world now* and also to the world “taking place”’.¹⁰⁹ In addition to the contingency of abstraction that is the universal fungibility of the underlying of the forward contract, the derivative is also contingent in that it posits a speculative ‘as-yet-unknown’ eventuality. That eventuality does not preexist the contract but is fabricated by it; the contract constitutes it in its inactuality and unknowness. The two outcomes are the ‘branches’ of two different realities only one of which will be actualized at expiration *because of the contract*. It follows that the derivative contract is, in Ayache’s terms, always a ‘contingent claim’. The contingency identified by Ayache is one

109. Ayache, ‘Turning’, 41; *emph. added*.

that the derivative constitutes and inaugurates and, as such, can be designated as its *thetic contingency*.

What this third contingency of the derivative constitutes is its deracination, not with regard to the underlying (from which the derivative is deracinated by the contingency of abstraction) but rather the deracination of price itself in the pricing process: it posits that ‘the world is actually what it is in reality’—the derivative has a particular price in fact—‘except that it could have been different’—only one of the contingent inactualities is actualised, the other remains inactual.¹¹⁰ Thetic contingency is the necessary prerequisite of derivatives pricing, in that ‘the contingent claim is only conceived as the written formula that it is (pay \$1 if S is greater than K , 0 otherwise)’, and also that the endogenous variability of pricing in the infrawager supposes price not to be a fixed given but, precisely, *revisable*.¹¹¹ Inaugurated and instituted by the derivatives contract, the thetic contingency of pricing is endogenous, real, and absolute for it.

This requires a revised determination of différential pricing. The thetic contingency of différential pricing means that:

110. Ayache, ‘Turning’, 36.

111. The quote is from E. Ayache, ‘The End of Probability’, *Wilmott Magazine*, October 2010, 41, www.ito33.com/sites/default/files/articles/1011_ayache_0.pdf.

- Derivatives are not just a counterperformative time-binding of the present and the future in which the deferring and displacing of the present into the future prevents the actuality of the present from being constituted as clearly distinct from the inactuality of the future.
- What is to be added to that determination of derivative pricing qua temporization, is that the constitutive futurity of the différentially organised present of risk pricing is that of the splitting of the future payoff—that is, the thetic contingency inaugurated by the derivative contract.
- That eventuality is endogenous to the pricing process, absolute yet presently unknown. The only relation to it in any present is speculative.
- The time-binding of derivatives pricing is consequently a constructed relation of the (thereby deracinated) present to the contingency of the *split* future, which will be both actualised and (with the eventuality that does not transpire) inactualisable.
- The logical a priori of the derivatives contract in the present is the absolute futurity of its thetic contingency.
- That is, to vector Esposito's formulation of the risk order across the dimension of the real of pricing: the inactual dimension of the present of pricing (risk) is ineliminable, even in any future present. The present can never be determined as a full actuality, not even in

COLLAPSE VIII

the future present; what is real to derivatives pricing is an absolute future that it endogenously constitutes.

The future present is therefore itself susceptible to revision in the way Esposito describes, as integral to a social binding permitting the future revision of decisions made today, but now with regard to the real of the infrawager. The logical a priori of the contract in the present is the absolute futurity of its thetic contingency. Consequently, the deferral of derivatives pricing is not that of a durational extension of the present (that would be the anticipatory formulation) but an irreconcilable and endogenous splitting of the present. That thetic, futural contingency occasioned in the present is the precise sense in which pricing is necessarily counterperformative: *it* is the positing of a future supervening on any continuity of the present, a futurity that is absolute for différential pricing. In Ayache's words, the thetic contingency of the forward contract is the 'real thread of the future' in the present qua pricing, up to and including its payoff.¹¹²

As the absolute of derivatives pricing, thetic contingency is the truth of its counterperformativity. Consequently, three preceding determinations of derivative pricing need to be revisited, the third of which is taken up in the next section.

112. Ayache, 'Turning', 41.

Anticipatory pricing. Future prices cannot ever be predicted or anticipated, because the delivery price *qua* conditionality structuring the derivative ‘collects as one writing the two branches of the alternative incompatible in actual reality’. That is, the pricing process is inaugurated by *positing* a split futurity that then not only refutes but also vitiates the possibility of anticipation *qua* extension of the present.¹¹³ Which means that anticipatory models of actual price movement, including but not restricted to BSM, are only retrofitted elaborations, provided at maturity, of how the strike price was supposed to have been reached. The counterpossibilities to the actual price development of the derivative are, *qua* probabilities, only idealized, retrofitted reconstructions of a futurity; while once real in their inactuality, they were *never* actualised. Such counterpossibilities are a consequence of the absolute futurity of différential pricing: just as the future present of différential temporization is itself revisable because it too is constituted by the absolute thetic contingency of the real of the infrawager, so the past that determines the present as its actual yet revisable future is itself saturated with the unactualised eventualities of the past, of yet-other-futures for the past that are not the present from which they are apprehended. These past inactualised eventualities are only fictive idealizations in that they have not in fact

113. Quoting from Ayache, ‘Turning’, 41.

been actualized and, unlike future inactualities, they remain perennially inactual given that actuality turned out to be the present from which they are surmised. That is, they are only possible, never real. Furthermore, with derivatives pricing, such past inactualities cannot be predicated on an absolute past in counterpoint to its endogenous absolute futurity because, being logically predicated on that futural contingency and historically inaugurated by the contract, the *a priori* of the pricing process cannot precede it in time. Or, as Ayache puts it, the anticipatory articulation of the price process always and necessarily comes ‘after reality, not before’.¹¹⁴ Inversely, mistakenly presuming that derivative pricing takes place against a stable time background rather than instituting a temporization of contingent futurity, the probabilistic calculation of price development assumes that ‘possibility precedes reality and that the different possibilities facing the world become realized as time passes’.¹¹⁵ As such, retrospective-anticipatory pricing regimes—which take derivatives pricing to be strictly secondary to price movements and actualities elsewhere—repudiate the futural contingency that is the real of derivative pricing.

114. Both quotes in this paragraph are from Ayache, ‘Turning’, 37.

115. This is not to refute any and all manifestations of probabilistic formulations of pricing of contingent claims. Ayache supports the ‘episodic’ deployment of probability and stochastic control in the trader’s daily market interventions (‘Probability’, 42).

Volatility. Previously designated as volatility, the endogenous thetic contingency of derivative pricing can now no longer only be rendered by its 'implied' derivation by which, recall, it can only be reconstructed consequent to its preclusion by the constraints of anticipatory pricing models (BSM), or as an effect of the reflexivity of derivative markets as a risk-order (Esposito). Rather, volatility is the absolute of derivative pricing: there is no derivative pricing without the splitting of the real of price into unknown actual and inactualisable futures; without, that is, a futural contingency that, in the endogeneity of the derivative market pricing, is instantiated in the indefinite plasticity of the infrawager. That contingency of revision is however actualised only by virtue of the operations of derivatives markets: the actuality of derivative pricing is, precisely, its price, instantiated nowhere else but in the dedicated market of the particular derivative. Consequently, 'the reality of the whole market worms its way into every attempt that possibility undertakes to precede the real'.¹¹⁶ The real of derivative pricing is then endogenously constituted and actualized in its plasticity as a marketised futural contingency. While this is a familiar result, reiterating in other terms that derivative pricing is volatile because it is counterperformative, the formulation advanced here makes explicit that the ontology of price qua différential temporization

116. Ayache, 'Turning', 49.

is necessarily predicated on an absolute futurity. That is, what is realized in every instantiation of derivative pricing is a volatility that is absolute for it.

The thetic contingency of an ineliminable futurity that splits the present—the absolute futurity inaugurated in différential pricing—is the real of derivative markets. The innocuous account of the derivatives market as ‘the place where contingent claims get prices attached to them’¹¹⁷—a put must be met by a call, a short position by a long position—is a prelude to the comprehensive determination of market operability as the endogenously constituted material occasion—the institution—by which the futural contingency of derivative pricing is actualised and manifest with each reiteration of pricing. As condition of the plasticity of derivatives pricing, the market is the material topology—more exactly, given that in the technical vocabulary of the market, the put option is said to be ‘written’, it is the *toposcription*—of the absolute volatility that is the actualisation of the futural contingency of derivative pricing. A number of equivalent formulations follow: necessarily instantiated in the derivatives market, the futural contingency of derivatives pricing *requires* its dynamic yet metastable toposcription, meaning that ‘only the market preserves contingency in the present’;¹¹⁸ or, as Ayache puts it

117. Ayache, ‘Probability’, 42.

118. Ayache, ‘Turning’, 43.

elsewhere, the market is ‘the medium of contingency’.¹¹⁹ Emphasising the endogeneity of pricing, ‘the market is its own source of contingency’;¹²⁰ emphasising instead the absolute volatility instantiated by that institutional toposcription, market pricing can be characterised as a ‘technology of the future’.¹²¹

To be clear, and to draw the argument back to the broader political economy of derivatives markets: the ‘preservation’ of contingency by derivatives markets, its technology, is necessarily contrary to stability. The ontology of these market institutions is predicated on

119. Ayache, ‘In The Middle of The Event’, in R. Mackay (ed.), *The Medium of Contingency* (Falmouth: Urbanomic, 2011), and ‘The Medium of Contingency’, *Pli* 22, 2011, 62–87. While market pricing is a medium of contingency, following Nitzan and Bichler it is also at once the medium of power. The implied codetermination of contingency and power via price is explicated in §11.1 below. The subordinate point is that, determined as these mediations, finance theory is a variant of media studies. Vogl similarly proposes that finance demonstrates the general characteristic of all media, that they ‘communicate themselves in their operation’ as well as the communicated ‘content’, in this case because the control over the contingent future sought by finance is betrayed by the ‘time-critical processes’ that finance markets are (‘Taming Time: Media of Financialization’, tr. C. Reid, *Grey Room* 46 [Winter 2012], 82). However, Vogl’s argument obviates the primacy of volatility in the pricing of risk and, following Keynes, also predicates the contingencies generated by market pricing on time distinct to the ‘control’ of price. Ayache’s and Esposito’s otherwise divergent theses are, rather, that the temporization of market pricing is constituted by the latter’s contingencies. That is, the market is a medium of contingency and consequently a medium of time qua futurity. Still opaque, however, is what that futurity is with respect to both the contingency and power it posits, and this is what §11.2 below elaborates.

120. Ayache, ‘Turning’, 49.

121. E. Ayache, ‘The Next Question Concerning Technology. Part 1: The Significance of Dynamic Replication’, *Wilmott Magazine*, June 2007, 33 [www.ito33.com/sites/default/files/articles/0703_nail.pdf].

the absolute volatility (thetic contingency) and indefinite plasticity (contingency of revision) of derivatives pricing that together constitute such markets as risk-orders. Locating the instantiation of pricing identifies the market as the sociotechnical condition—the institution—for the contract-exchange that determines price on each occasion. Ayache literalises that condition as the trading pit for options, whereas Esposito notes that derivatives markets are, amongst other markets, now geospatially ‘distributed [...] as a ubiquitous form of calculation and reasoning’, in accordance with the weakening norms of jurisdictional authority in the geospatially attenuated institutional forms of the risk-order.¹²² Furthermore, and to begin the redetermination of the contingency of abstraction that will be taken up more fully in the next section, since derivative pricing is liberated from any intrinsic or necessary relation to the underlying, and given that there is no ‘cause’ for the contingency of pricing outside of the endogenous pricing process, for Ayache that contingency is instantiated primarily by the existential participation of the derivatives trader in the pit who, in Badiou’s fashion, is subjectivised by its eventhood¹²³—a singularisation effected, without standing in complete contradiction to Badiou’s philosophy despite the theoretical-political incongruity with it, as a personalized embodiment

122. Esposito, *Future*, 69.

123. Ayache, *Blank Swan*, §4.3.1–2.

of the second-order observer who is Esposito's systemic agent. But such determinations are again epiphenomenal and inadequate precisely because they are subjectively organised rather than determined by the logic of differential capitalization. Against such correlational determinations, the real of différential pricing that is the absolute volatility of the infrawager must rather be apprehended in terms of its impersonal, socio-institutional ontology. Taking up that injunction, as the next section does, provides the argument for determining the ontology of price in general to be the real of derivative pricing, a result that in turn permits the operational and a priori dimensions of finance to be coarticulated without subreption.

10. PRICE IN GENERAL, VALUE, ARKHÉDERIVATIVE

That volatility is the absolute of derivatives pricing does not revoke the delivery price as a constitutive conditionality for that process. There can be no derivatives pricing without the delivery price as a structuring parameter. Moreover, in Ayache's formulation, only at the expiration of the derivative pricing process is 'the contingent claim really derivative on its underlying because its price is then settled and rigorously equal to that function of the underlying called the payoff'.¹²⁴ That is, maturity/expiration is the one point at which

124. Ayache, 'Turning', 45.

derivative pricing is convertible to the price of the underlying asset, a moment conventionally called the *valuation* of the contract and thereby of the pricing process. In Ayache's terms, valuation is when the 'underlying' of the derivative transfers from the paper on which the contract is written to the asset, a figurative articulation of the conversion of the endogenous plasticity of the pricing process to its determination by the price of the exogenous referent in its own market, a determination cashed out as the payoff. Valuation is the completion, exhaustion, and conclusion of the pricing process.

Because valuation is determined by the difference between the delivery price and the strike price at expiration, the former being a static structuring conditional of the pricing process while the latter is also set in the market of the underlying asset, it seems that valuation is an external, structuring boundary condition for derivatives pricing. The institutional distinctions between derivatives markets and those of the underlying assets (when the latter are nonfinancial) confirm the exteriority of valuation to the plasticity of derivatives pricing. Yet price volatility is operationally generated by activity in any market, including those trading assets to which the derivatives refer (§5 above) and, theoretically, determined as it is by the difference between delivery and strike prices, the valuation of a derivative is precisely what is itself priced and varied

by derivative markets. As such, valuation is an *internal* boundary condition to the derivative pricing process even as it conditional on the price of the underlying asset in *its* own market. The valuation of the underlying is, as Ayache puts it, ‘dictated by the programmatic character of the payoff schedule’.¹²⁵

At best, then, valuation is determined on the one side in relation to the price of the underlying in its own market or, on the other, by an internal boundary condition for derivatives pricing. The two sides are constitutively and institutionally distinct and, as such, the determinations of valuation are in opposition. But they are not incoherent or contradictory; nor can the ambivalence of valuation be settled by a more exacting analysis. In Derridean terms, valuation is a *supplement* to derivatives pricing, a term held to be outside of the derivatives pricing process but structuring it as a conditioning origin, principle, or terminus, yet which in fact is only stipulated as an extrinsic determination by that process (for example, for Husserlian phenomenology, the lived present is a supplement of what is in fact a differentially constituted present). That supplementary condition is what permits différential pricing to be subordinated to the anticipatory regime of pricing, which is premised on valuation; and what permits the infrawager that is the real of price to be correspondingly determined as an extrowager, in which the real

125. Ibid., 47

of pricing is its exogenous referent (in the case of derivatives, the price of the underlying asset). Equally, however, if derivative pricing is instead predicated on the infrawager and its différential logic as its real, as has been established here, then the supplementary condition loses its prerogative over the pricing process and must instead be determined in terms of its real.

To anticipate the next steps of the argument, and without confusing the specific meaning of derivatives valuation with the generality of value as such, what this 'supplementless' determination of valuation means is that (i) value is in every case an exogenous cipher for pricing, and that (ii) price is in every instance predicated on its absolute volatility, including the price of the underlying in its own market. The argument on value follows from that on price, which is itself a general theory deduced from the comprehensive theory of derivative pricing:

- Valuation is the conversion of the derivative at expiration/maturity in its own market to another market in which the underlying is priced. In valuation, the pecuniary magnitude of the derivative contract payoff is exchanged in its *equivalence qua price* for the asset in its own 'primary' market.
- 'Equivalence qua price' across markets supposes the commonality of price for both the derivative and the asset as pecuniary magnitudes. And because value

is the conventional term for the conversion point of one market to another via price (as discussed further below), price itself then being determined as a value because of its exogenous referentiality across markets, ‘valuation’ is the appropriate conventional term to designate this moment in the derivatives pricing process.

—The valuation of the derivative and therefore of the underlying asset is, however, at once priced by the derivatives pricing process itself and, *qua* volatility, modified by it. Furthermore, valuation cannot be recused from derivative pricing without mistakenly limiting derivative pricing to the standard format of the extrowager—an extrojective circumscription that is in any case proscribed by the logic of the différential constitution of the infrawager, according to which the identity of terms cannot be preestablished.

—That is, if valuation is an exchange predicated on prices, this now means that the putatively exogenous referent of the derivative’s valuation—the price of the underlying in its own market—is not in principle distinct from price as it is constituted by différential pricing. If it were so distinct, derivative pricing would be inequivalent to price in the markets for the underlying, vitiating valuation in particular and derivative markets in general, as well as fracturing the ‘single quantitative architecture’ of pricing in capitalization.

—For *this* reason, valuation as the conversion point from one pricing process to another is constituted by

and manifests the two contingencies—thetic (absolute volatility) and revisability (plasticity)—of derivative pricing. As such, and as already noted, valuation is an internal structural conditionality of the derivative pricing process. But ‘internal’ now indexes only its institutional formats: the exchangeability of derivative pricing with prices outside of derivative markets via valuation means that the infrawager is the structural and ontological condition of price per se; and the absolute volatility of derivative pricing is the absolute of price within *and* outside of derivatives markets.

—The price of the underlying is thus *institutionally* external to derivatives markets, but *constituted* in their logic. Or, inversely, derivative pricing exposes and makes institutionally and operationally manifest the general condition of pricing as such. Extending outside of the specific institutions of derivatives markets to the fact of price as such, the différential ontology of derivative pricing is the real of price per se.

On the basis of that general theory, Ayache’s characterisation of the absolute volatility of derivative pricing, that the ‘written and material character of the contingent claim repeats that value is in fact unsettled and that it could have been different (i.e., it is a price)’ holds even for prices outside of the derivative

markets.¹²⁶ More broadly, it is intrinsic and necessary to the valuation of derivatives that *all* prices ‘could have been different’ *because* any price means that another price could have been given thanks to the plasticity and absolute volatility of pricing.

Value

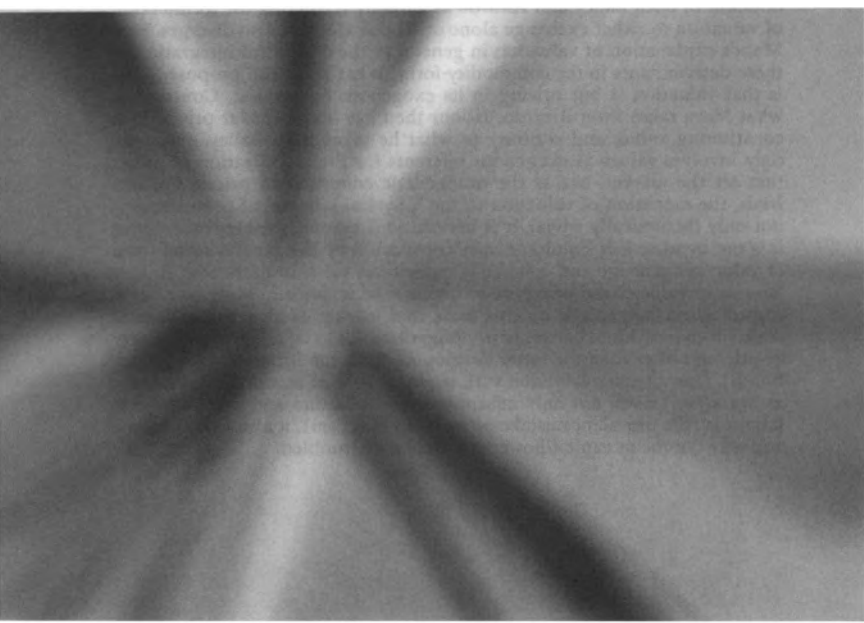
Though this means that price is in general predicated on the real of derivative pricing that is the infrawager and its dyadic contingency, the supplementary determination of valuation persists in the primary sense informing the term ‘valuation’: that price reflects value (or, at least, it should). As noted above, the value of derivative pricing is its payout, occasioned in its putative exchange for the (price of the) underlying, at which point the derivative pricing process vacates the operating logic of the infrawager and converts into a mercantile exchange; as the terminology for options has it, derivatives and their markets *expire* when they are exchanged for the underlying asset. More generally, value is the exogenous determination of pricing which, in the standard determinations of Neoclassical and Marxian doctrine, also anchors it—the very same conversion of pricing that was operationally imposed by the regulators of the early CME. Formally, the argument against the priority of value over price follows quickly from its différential logic: what is

126. Ayache, ‘Turning’, 45.

conventionally supposed as the condition and referent of price is in fact constituted *and* deconstructed by the latter. Price deconstructs value, and that deconstruction is explicitly manifest in derivative pricing. Substantially, the endogenous constitution of price qua infrawager means that the value-referent of price is not established on the basis of circumstances external to the relevant market such as trade, scarcity, demand, use, labour, or any other determinant external to pricing, all of which beg the standard economic question of how these heterogeneous nonpecuniary conditions and specificities can be commonly calibrated via pecuniary magnitudes.¹²⁷ As closing out and the universal

127. In obviating even the means of means of production as a prerequisite of pricing, this result goes farther than Ian Steedman's conclusion that 'in general, profits and prices cannot be derived from [Marx's] ordinary value schema' but rather only from the 'physical schema' of physical production and labour costs' ('Value, Price and Profit', *New Left Review* 1.90, March-April 1975, 78). Marxist criticism of Steedman's argument focus on the formal idealizations of the static model of production Steedman inherits from Piero Sraffa's *Production of Commodities by Means of Commodities* (1960). While Steedman and Saffra both present NeoRicardian critiques of Marxian value-theory, recuperating the division in kind between price (exchange, distribution) and value (production, labour), with Steedman dispensing with valuation as a necessary mediation between labour and price, the claims of the main argument here correspond more to Samuel Bailey's 1825 criticism of David Ricardo's derivation of value on the basis of labour rather than in terms of exchange alone.

For Marxism, all such results can only be errors: Marx's primary theoretical contribution is the synthesis of production/labour and distribution/exchange with his labour theory of value in Capital 1: that theory is not an account of the generation of value by labour alone (Ricardo's thesis) but of labour as an abstract social form constituted by exchange determined in its universal instance by money. Bailey's thesis is that such exchange is the common term of value. As I.I. Rubin remarked in the 1920s, given the dialectical unity of labour as a social form (exchange) and concrete action



fungibility of the underlying make explicit, the operation and dynamic of price in derivatives markets are

(labour), any separation of its aspects is only a mistaken hypostatization of its comprehensive constitution ('Abstract Labour and Value in Marx's System' tr. K. Gilbert, *Capital and Class* 5 [Summer 1978]). Rubin's resolution however also throws up its own difficulties on how exactly values then change between the input and output of a production process, and how they are converted to prices. The latter is known as 'the transformation problem' and was addressed by Marxist theorists countering Steedman's result by insisting mainly on the intratemporality of value-development and, with regard to price, the dialectical integration of value via the commodity form, constituted on the one hand by labour in its concrete instance (as the yet-to-be-realised form of value, its substance in Hegelian terms) and, on the other, by exchange (as the realized form of value or, per Hegel, its appearance), with money as the (universal) abstract equivalence of value in general (see in particular E. Mandel [ed.], *Ricardo, Marx, Sraffa* [London: Verso, 1984]; G. Carchedi, 'The Logic of Prices as Values', *Economy and Society*, 13.4 [November 1984]; A. Freeman and G. Carchedi [eds.] *Marx and Non-Equilibrium Economics* [Cheltenham: Edward Elgar, 1996]; and A. Freeman, A. Klimam, J. Wells [eds.] *The Value Controversy and the Foundations of Economics* [Cheltenham: Edward Elgar, 2004]).

While the argument of the main text here is congruent with the Marxian criticism of both Bailey and Ricardo as wrongly restricting the formulation of valuation to either exchange alone or labour alone, it also diverges from Marx's explanation of valuation in general as the dialectical integration of these determinants in the commodity-form. What is instead proposed here is that valuation is but pricing in its exogenous conversion. Contrary to what Marx takes from Ricardo, labour then has no particular privilege in constituting value; and contrary to what he takes from Bailey, exchange only involves values as exogenous referents for the mobilization of prices that set the market, not as the ontogenetic condition of prices. On this basis, the extension of valuation to the 'physical schema' of production is not only theoretically trivial, it is necessary: if labour is value-constituting it is not because it is simultaneously constituted by the general social form of value in exchange and concretely constitutes value in particular. Rather, labour is value-constituting only because it is priced. Moreover, with regard to exchange, it is on this basis that market exchange at whatever scale (from individual bartering or obligation) has to be taken as a modality of pricing rather than the latter developing from the former (as per Adam Smith). Constituting valuation with regard to labour as a primary category, as Marx(ism) does, not only misapprehends valuation and therefore what labour is (the prevalent mistake of political Marxism), it also explains how and why dominant capital-power is not thereby troubled.

overtly liberated from these exogenous determinations irrespective of whether they are cast subjectively (in the Neoclassical paradigm) or objectively (in the Marxian paradigm).

In other words, given the contingency of abstraction as a condition of price in relation to value, price in general is not an epiphenomenon or overcoding of values that preexist it, nor an order of marketisation imposed upon them. Rather, in the condition of capitalization, price is the *precondition* of valuation. That is, the condition for the variability, transformation, and equivalence of value—the intrinsic mobility and multiplicity of values synchronically or diachronically—with regard to price is not value, but pricing. As such, price has no intrinsic value. And because value has no basis outside of the pricing process determined as the infrawager constituted in its triadic contingency (thetic contingency together with the contingencies of revision and abstraction), value has no intrinsic value.¹²⁸ Value is not then a condition or necessary limitation on pricing and therefore on capitalization, as a real other to them, but only one of the assigned variables of

128. The three main ideas of Nietzsche's later philosophy from the period of composing the *Zarathustra* book (1880s) onwards—the will to power, the revaluation of all values, and the eternal return of equivalences (as an idiomatic translation of *ewige Wiederkehr des Gleichen*)—can then be identified as variants of the deconstruction of value by price. In rendering the transmutation of valuation in terms of the philosophico-religious traditions of moral value-formation and their modern weakening, Nietzsche correctly identifies the determination of modernity in non-financial terms yet, for that reason, largely misapprehends its constitutive elements.

the real of price, a real exposed as such by derivatives market operations. On the contrary, value is but the exogenous determination of price, the conversion of one pricing process to others or to what lies outside of price altogether. As such, and as both Marxism and Neoclassical orthodoxy stipulate, value subtracts the contingency of abstraction from the triadic contingency of price in general, now meaning that value is not only a reduction of pricing to the dyadic (thetic and plastic) contingency characteristic of the infrawager but also that, since price, valuation extends the structure and contingencies of the infrawager outside of price and in other terms.

The formal result above is thereby substantially confirmed: assuming the supplementarity of value as the basis of pricing, price deconstructs value. In the condition of capitalization, value (commonly identified with the qualitative) is a financial term in principle and in fact (it is quantitative). Derivatives pricing exposes, institutes, and operationalises price as the differential variability of value in general, but without delimitation by an exogenous referent, and thus as a valueless process. Equally, the variability of reference characteristic of value, which is indefinite because value has no intrinsic value, is the condition made explicit and exact as 'abstract pecuniary magnitudes' in a universalisable 'single quantitative architecture' organized by and for capitalization: as price, that is,

for which valuation and what is valued (whether or not it is opposed to price, for example as use-value) are only functional occasions for the instantiation of a capital-power.¹²⁹

The Arkhéderivative

That a price ‘could have been different’ even once it is set and a value given, and that values (are liable to) change are demotic articulations of the general theory of price advanced here: that price is constituted in the triadic contingency of the abstract infrawager. Implicit in the commonplace of price contingency, and now fully exposed, is that, rather than prices arising from exogenously-derived valuation, values

129. Confirming from a completely obverse aspect one of the primary theses of communization theory, that because labour is constituted by the value-form, contrary to orthodox Marxian praxes which vectors class struggle via labour organization the only viable exit from capitalism is rather the (theoretically organised) abolition of labour, establishing in its stead ‘immediate social relations between individuals’ (Endnotes, ‘Communisation and Value-Form Theory’, *Endnotes* 2, April 2010, endnotes.org.uk/en/endnotes-communisation-and-value-form-theory). In terms of the logic of the main text here, and to preview later developments, such a claim is a perfectly symmetrical abreaction to the strictly endogenous constitution of pricing, and thereby abets finance-power from a putative ‘outside’. Communization is consequently a politics entirely compatible with now-prevalent finance-power, reconstructing in other terms the exclusion of anthropological interests from the endogeneity of the infrawager—if, that is, communization is in any way a politics: the evacuation of power-price determinations in the ‘immediate social relations between individuals’ abolishes the futurity and calculative risk of abstract sociality by which, as argued below, politics is constituted, proposing instead a countermodern ethical relationality. Or, as Endnotes themselves affirm, the ‘radical politics’ of their conclusions are in fact strictly and wholly ‘anti-political’.

are variable by virtue of their price-ontology. Nitzan and Bichler, Esposito, and Ayache each formulate variants of this primary thesis. Nitzan and Bichler note that price as the elementary unit of capital-power cannot be established because both the anticipated earnings and the future normal rate of return for the asset, meaning that the basic discount price formula can not in fact be known. Accordingly, the price of capitalization in the present, which orders industry, is always and necessarily speculative, variable (plastic), and contingent (abstract) and thereby permit differential accumulation—that is, they are administered prices. For Esposito, derivatives pricing is a particularly complex and advanced form of sociotemporal binding that determines the present as revisable (plastic), maintained primarily with regard to the inactual and unknown future (absolute volatility), a condition typical of the risk-order constituting modernity in general. And for Ayache, referring to the contingency of the definite uncertainty of the absolute volatility of price explicitly posited by derivative pricing (thetic contingency), each price ‘successively repeats the whole genesis of price’.¹³⁰

Each is however only a partial and circumscribed determination of the general theory of price according to which price as such, and value after it, are constituted by and instantiated as différential pricing

130. Ayache, ‘Turning’, 42.

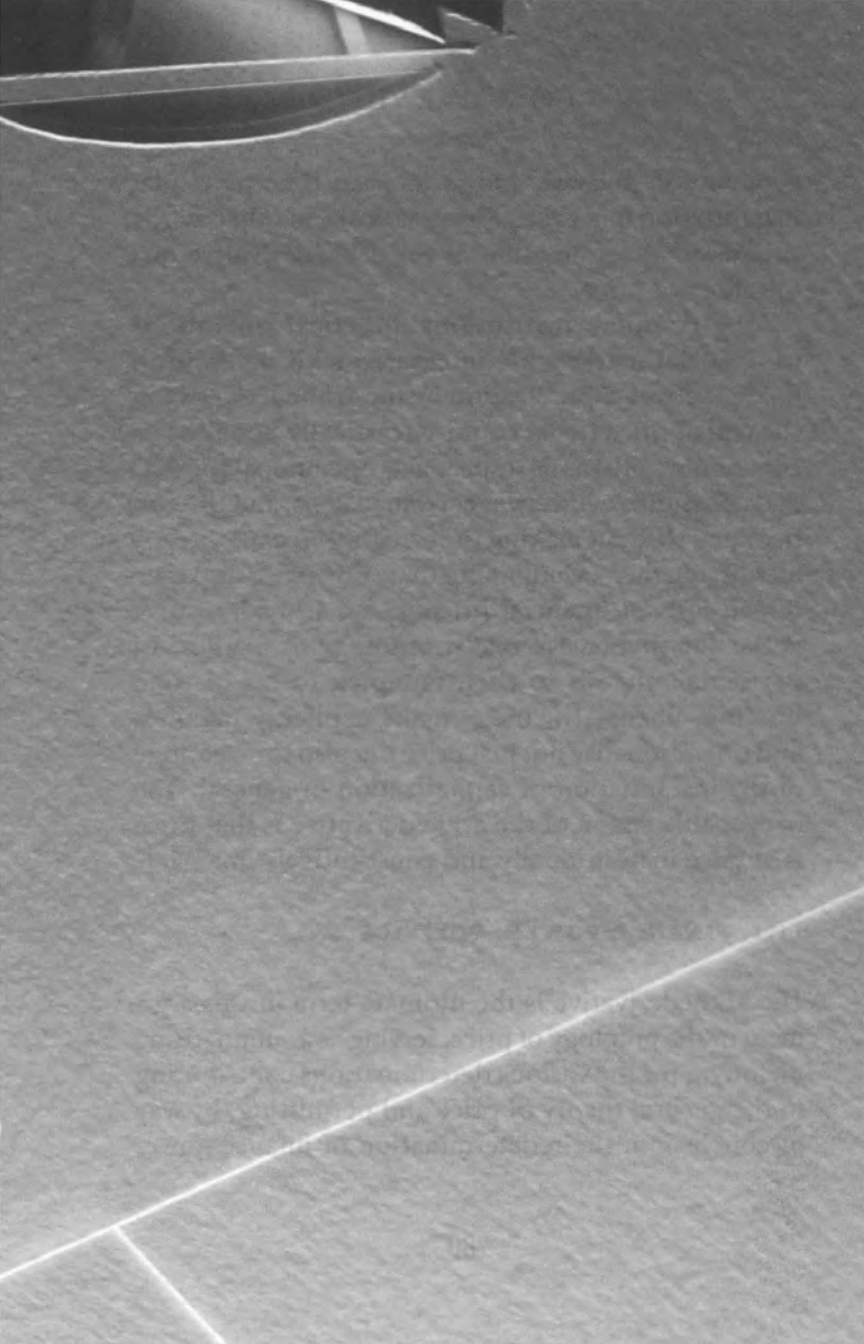
wherever and however spontaneously they happen. Furthermore, the ontology of price, which is the general and realist theory of the ‘genesis’ of price repeated by each price, is explicitly materialized, institutionalized, and operationalised *qua* derivatives in their markets. But, to return to the organizing caveat in the introductory comments above, if the financial operations of derivatives markets are empirical-institutional *manifestations* of the ontology of price per se, the two dimensions referred to—institutional practices and ontology—cannot be directly identified: for all of their transnational systemic integration, derivatives markets are a parochial set of institutional constructions for capital accumulation via complex ownership claims formulated via specific juridical-financial contracts; on the other hand, the ontology of price as such is the a priori of pricing in *every* instance. Following Derridean convention, wherein the writing that is the logically a priori condition for speech, though it may be historically posterior to speech, is demarcated from the historical manifestation of writing by designating the a priori an ‘arkhéwriting’, the conditional primacy and priority of the derivative for price as such is here designated the *arkhéderivative*.¹³¹ The term is a

131. Though it is not named as such, arkhéwriting is at the core of Derrida’s *Edmund Husserl’s Origin of Geometry: An Introduction* (tr. J. P. Leavy (Lincoln, NE: University of Nebraska Press, 1989 [1962])), §VII, esp.89), in which a modality of writing is identified as the historical and logical condition of science. That derivation is rehearsed in Chapter Six of *Speech and Phenomena*, where arkhéwriting is explicitly named (85, translated as

theoretically-organized construction articulating and exposing the two dimensions of pricing via one other, integrating them without direct identification.

That the operations of financial markets are constitutively predicated on the ontology of price is a trivial consequence of identifying the arkhéderivative. The non-trivial corollary is that financiality, the a priori of price in capital power, is also predicated on the arkhéderivative. The arkhéderivative is then the a priori of the *political economy* constituted by the ontology of price. That is, the arkhéderivative is not only manifestly and explicitly operationalised by finance markets for capital accumulation, it is also the ontology of every instantiation of capital-power. As regards the former, it is not just the *fact* of price but also the ontology of price that is made explicit and operationalised by the complexities of the time-binding of derivatives pricing. As regards the latter, the arkhéderivative is the ontological a priori of capitalization, as political

'protowriting'), becoming a primary thematic in *Of Grammatology* as an explanans of the constitutive role of the expressive/extensive dimension of signification in the otherwise idealised accounts of structural linguistics (tr. G.C. Spivak [Baltimore: Johns Hopkins University Press, 1997 (1967)]), 59–61, from which the following quotes are taken). That arkhéwriting is the a priori 'of all linguistic systems' means for Derrida that it cannot be an object in any language nor 'enrich the scientific [or] positive description of the system itself' as the object of a science. Derrida's retreat to transcendental-empirical or essence-appearances disjunctions at the very point that he surpasses them leads to his influential but therefore restricted characterisation of writing per se as primarily literary (59), distinct from the protoscientific synthesis of the real of writing for which Husserl also provides reasons.



economy in general, *and* in its each time particular instantiation qua price. Financiality is, in other words, the power determination of the arkhéderivative qua ontology of price.

The complex institutional-practical operations of financial markets are integrated with the a priori financiality of capitalization by the arkhéderivative in the real of price (what could sarcastically be called its common-wealth) as its respectively operational (power) and constitutive (infrawager) dimensions, and this can be stated without making the category error of directly identifying them. Conjoining these otherwise disparate dimensions of financial pricing, the arkhéderivative is the comprehensive realist ontology of finance. In particular, thanks to their complex forms of time-binding, financial markets make explicitly manifest and operationalise not just price but also the ontology of the instantiation of capitalization in general. The irrevocable lesson of the arkhéderivative is that price is at once institutionally and constitutively financial.

11.1. FINANCE-POWER: POLITICS

The arkhéderivative is the ultimate term in this argument or the ontology of price, serving as a summarising metonym for the various determinations contributing to the general theory of price and permitting, by way of conclusion, the redetermination of finance-power

as a risk-order constituted by price contingency. That redetermination is not an arbitrary or parochial issue for theorizing the political economy of capitalization: if the arkhéderivative is the real of finance in its constitutive and operational dimensions, then derivative markets are the truth of market financiality *qua* the dynamic power-ordering of capitalization. Moreover, that dynamism is constituted by the triadic contingency of the arkhéderivative, generally actualized by the universal fungibility of what is priced (contingency of abstraction), the variability of price (contingency of revision), and the futural absolute volatility of pricing (thetic contingency). These are the primary conditions of the risk-order instituted by price; a risk-order determined now not in terms of the sociology of the markets but in terms of the real of price. That risk-order is also and immediately a political economy, because in constituting the financiality of price, the arkhéderivative is no less the ontology of capital-order. As a consequence capital order is necessarily a risk-order.

Distinct from the broad characterisation of modernity as a 'society at risk' (as per Esposito's systems-theoretical determination) social-institutional order in capital power is contingent not because the future is uncertain in the present in general (Esposito) but, more exactly, because the present of capital power—socio-temporal binding—is split by the absolute volatility of pricing into the realisation of incompatible futures.

Turning now to Nitzan and Bichler's account, capital power is dynamic and transformative not only because of the strategically common conflict between capitalists (which again would be a sociological determination of the political economy of capitalization), but because that conflict is itself only possible via pricing because the latter is constituted in the arkhéderivative *qua* the dyadic contingency of the infrawager, manifest in the standard discount price formula of capitalization as the uncertainty of its inactual variables. And because the arkhéderivative is the condition of capital-power, the absolute volatility of pricing theorised by Ayache per force instantiates capital-power. In general, the actualisation of the arkhéderivative's triadic contingency *qua* price is in every instance capitalization's dynamic and transformative social (re)ordering (including the stability and preservation of extant power configurations, for which the only absolute is their futural contingency and whose stability thereby needs to be actively maintained by repricing). The arkhéderivative is the dynamic metastability of the capital-order.

The triadic contingency instantiated *qua* price is not just one of pricing with regard to other prices and value but—precisely because price is the ordering schema of capitalization—also the intrinsic contingency of the constitution and organization of capital-power. It is in other words *price* that necessitates politics. The capital-order, which is a risk-order, is constituted

as a political economy. Even if it is a commonplace that finance, exemplified by derivatives pricing, is necessarily a mode of capitalization qua social ordering, the ontological corollary established here is that, predicated on the arkhéderivative, social power qua capitalization is transformable, mutable, and contingent as a futural unknown.¹³² Such is the contingency of revision conditioning the risk-order of finance-power, for which (i) the financiality of the arkhéderivative ‘depriv[es] the very meaning of normativity’ from the social order, and (ii) capitalization instead implements the continual and nonterminal revision of social order via price. Consequently, the only basis for the dynamic institution of power in capital-order is capital-power, instantiated by price, the logic of which is organized by differential accumulation.

It follows that differential accumulation is not a norm but a politics, the term now futurally determined as the normless revision of power qua risk (that is, instantiating and capitalising on the futural

132. Roberto Mangabeira Unger proposes that the modern social order is an endlessly plastic and transformable ‘artifact’ by virtue of acknowledging society to be constructed by human imagination and creativity rather than posited as a given (Z. Cui [ed.], *Politics: The Central Texts* [London: Verso, 1997 (1987)], 3–18 and 172–204). That ‘negative capability’ of social institutions (contrasted against their extant positive terms) is dedicated to emancipating subjective experience from established scripts but is however often practically constrained and circumscribed by extant elite configurations and ‘entrenched’ social structures. While the latter point is uncontentious, in the terms of the thesis of the main text here Unger’s proposition psychonaturalizes and thereby cloaks the sociopolitical plasticity wrought by capitalization as the prevailing condition of modernity.

contingency of price).¹³³ Such politics is a recusal of

133. This result countermands the political and theoretical adequacy of neorationalist doctrine to the modernity it claims to advocate for and advance via Left Accelerationism. A short detour into Brandom's philosophy demonstrates why: the consistent and thorough synthesis of judgements in Brandom's 'strong semantic inferentialism' (SSI) consists of three simultaneous activities (*Reason*, 36–38): (i) the consistency of critical responsibilities 'requir[ing] judges to renounce commitment to contents that are incompatible to other commitments' or their consequences, because each can 'serve as a reason to give up the other'; (ii) completion via ampliative responsibilities, requiring the judge to accept other commitments on the basis of what she or he is already committed to; and (iii) the warrant of justificatory responsibilities, requiring the giving of reasons for one's commitments by recourse to prior commitments. The synthesis of judgements in SSI results in the transcendental original synthetic unity of apperception at the base of Kant's account of the epistemological subject: normative revision integrates (= unity) the endorsements intrinsic to inference-making (= synthesis) by the judgement that these norms inaugurate (= original) by a sapient being (= apperception). Furthermore, these conditions are not just those of judgement but necessarily also of what is judged, which is the content of the concept (= transcendental not formal logic). This latter objective dimension of the unity of apperception constitutes a representational relation to the content of the concept that is therefore intrinsically determined by the constraint of consistency, meaning that in its rational validity of no one object or subject in its unity can maintain incompatible properties (principle of non-contradiction), though two different subjects/objects can exhibit the inconsistency between them (45). The subjective dimension of such necessary exclusions and consequences are its deontic or normative relations (responsibilities and liabilities), and the objective corollary is their 'alethic modal' relations, meaning that a 'single object just is what cannot have incompatible properties (at the same time). That is, it is an essential individuating feature of [...] objects [that they] have the meta property of modally repelling incompatibilities' (48) as a necessary consequence of their having 'objective validity' by inference. Hence, rational inferentialism necessitates a unified and coherently integrated subject and object of judgement that each repudiates incompatibilities.

Against the homology between reason qua SSI and risk-rationality proposed in n.89 above, neither of these two principal conditions of SSI holds for pricing in its thetic contingency and the concomitant future-constituted risk-order, for two reasons: firstly, contrary to the normative performativity of rational inference, pricing is counterperformative and necessarily goes in the 'wrong' direction to any that might be inferred by stipulation of an 'ought'. Secondly, pricing's absolute volatility is precisely and only the positing of a futural contingency qua incompatibilities of what

the future will be even once the contingency they construct is settled (the price 'could have been different'). As such, pricing in its absolute volatility instantiates and maintains incompatibilities rather than repelling them. Consequently, pricing and the risk-order do not comply with the deontic constitution of the subject in its ordinary synthetic unity of apperception, or to the alethic modality of the object's noninconsistent validity, or to the thus coordinated inferential consequences and deontic adumbration. In formulating the basic unit of judgement not in the predicative form of <If p then q> but in the contingent formulation <If p then q or r or s or ..., where p is insufficient to determine q, r, s....>, the risk-order vitiates reason qua the positive freedom and authority of normative constraints (60).

In Brandom's terms, which have an immediate political overdetermination, it follows that pricing and the risk-order of capitalization are not rational but are conditions of unfreedom (cf. Negarestani, 'Labor'). But such a Brandomian critique of capitalization via pricing is only a doctrinal result, one among several consequences to the incompatibility of the risk-order with the normative synthetic unity posited by philosophical reason. What can also be inferred is:

- that as a discursive social practice with some rules (the logics of differential accumulation and differential pricing as well as the delimited regulatory requirements for markets), the risk-order is quasirational precisely because it posits an order that maintains incompatibilities;
- that risk-rationality is a nonnormative modality of reason, meaning that the social order of risk is shaped not by rational norms but by inferential processes whose logic surpasses that of the deontic-alethic modalities of unified synthetic judgement;
- given the expansion of inferential pragmatics in the risk-order beyond Brandomian doctrine, the latter is an unnecessary and limiting commitment to philosophical-rational determinations of inference and reason. More assertively, the deontic-alethic modalities of incompatibility-repelling synthetic unity postulated by SSI are undone by the risk-order of capitalization, which socially instituted practice constitutes the very political modernity of which SSI claims to be the philosophy and moral-conceptual authority.

Philosophical adequacy aside, the incompatibility of risk rationality and SSI formulates a schema for the politics of normative reason with regard to the risk-order, both of these being taken as practices of revision. Affirming SSI, the subjective and objective unity it instantiates as well as its subtending normative constraints mean that SSI necessarily counters the construction of incompatible inferences characteristic of the risk-order of capitalization. But that is to repudiate the primary futurity constituting the risk-order thanks to pricing. This repudiation is evident in Brandom's affirmation of Hegel's configuration of the rational integration of conceptual content by

norms which, thanks to the arkhéderivative's contingency of abstraction, is exacerbated in its scope by the universal fungibility of what may be priced (in contrast, then, to the typical but restricted referent of capitalization—production for Marxism or, in its more recent biopolitical overdetermination, 'life', or for Veblen, 'industry').¹³⁴ What is indexed here by the

the process if 'recollection (*Erinnerung*)', which provides a 'genealogical [...] vindication' of inferential commitments 'currently being integrated' (16, and Ch.3)—another variant of synthetic unity of reason now with regard to the sociohistorical fabrication of discourse which, tellingly, is the way that reason 'is the way [reason] moves forward, by looking backward' (23). Inferential reason is then a synthetic traditionalism at a variety of scales and venues—sociohistorical, subjective individual, and objective validity—all of which will come to be integrated with one another. By contrast, asserting the risk-order of capitalization *qua* generation and maintenance of incompatibilities, rationality is not an attribute primarily of sentience but of pricing, reason being here determined with regard to the futural contingency of temporization. That practice prevents retrospective semantic vindication and, concomitantly, the formulation of an original synthetic unity as the organizing term of reason or the quasinorms it posits. In terms of SSI, risk-rationality inaugurates what Meillassoux elsewhere calls the Principle of Insufficient Reason not with regard to the insufficiency of the ontological causal relation as basis for what happens next that concerns Meillassoux (see n.98) but as the constitutive insufficiency of the very establishment and construction of semantic-discursive inference-making itself, vitiating the 'bindingness' of any normative construction.

If, following Brandom, the Enlightenment is the 'development of secular conceptions of legal, political, and moral normativity' predicated on the 'conception of normative positive freedom' as formulated via SSI in its necessary sociohistorical dimension (60)—which is the to-be-vindicated philosophy of political modernity according to neorationalism—that determination of modernity misidentifies it as the coherent generation of retrospectively constituted and integrated semantics rather than the futural positing of incompatibilities. As such, the Enlightenment has little if any salience for apprehending the risk-order of capitalization.

134. These determinations are compounded via the recent emphasis on the 'precarity' of life-work and experience in neoliberalism: see M. Lazzarato, *The Making of the Indebted Man*, tr. J. D. Jordan (Los Angeles: semiotext(e), 2012) and C. Marazzi, *The Violence of Financial Capitalism*, tr. K. Lebedeva

otherwise paradoxical formulation of an order without norms that is universal in principle, is that the real of capitalization is not constituted materially, normatively, or conventionally, but by stable-enough institutions positing a contingent yet power-hierarchical relation to an indefinite future via price.

If differential accumulation means that price variability is the reorganization of power, the redetermination of capitalization in terms of the arkhéderivative means that power is now not only a power over *what* the future may be—the standard criticism that capitalism segments the future in favour of those with the greatest capital, though since finance-power such a segmentation is in fact all that politics is *qua* the power-organization of the future. Predicated on the arkhéderivative, power is moreover power over the organized uncertainty that price posits in the present (thetic contingency). To elaborate: because the real of price is the endogenously constituted infrawager, the futurity of the arkhéderivative is itself priced as its volatility. As such, the futural thetic contingency of pricing is itself subject to the power instantiated on each occasion of price. Consequently, price *qua* the magnitude of power of social institutions is the paradox of the magnitude of social power over uncertainty, a measure of the size of a futural contingency *instantiated* by price.

and J. F. McGimsey (Los Angeles: semiotext(e), 2011). With respect to finance-power, precarity is but an anthropological-industrial incidental determination of generalised price sabotage.

Capitalization is thereby determined as a risk-order of power not only extensively, across the entire 'spectrum of social institutions' or 'societies at risk', but also intensively in each instance of price. Price indexes the magnitude of the absolute volatility of power in the present. It is not then that risk is to be priced by derivatives markets but, constituted in the arkhé derivative, price itself is the magnitude of risk, which is to say the magnitude of absolute volatility that is posited in the present. It is a measure of the futurity of the present, *a quantification of différential temporization*. Consequently, the political economy of price since finance-power is immediately the politics of futurity itself.

Finance-power instantiated via price is therefore analytically dual: it is the magnitude of power in the holistically organized present of intracapitalist conflict *and* it is the magnitude of the thetic contingency of power. For all of the analytical distinction, the two determinations are however not operationally or ontologically distinct, and for two closely aligned but operationally distinct reasons:

- (1) In general, risk is *in fact* indistinct from all price *qua* power. It is not just that power involves risk, such that the greater the power the greater the risk. Rather, price is at once the magnitude of power *and* the quantification of the futural contingency concomitant with any instance of power, no matter

what the magnitude. Price is both the magnitude of power and the magnitude of futurity *qua* systemic uncertainty—so price itself is ‘systemic risk’. Since price is necessarily determined in regard to capital-power, every price is intrinsically an occasion of *political* economy, of what, where, and how much power over futurity is to be had—a systemic conclusion that is effectively dramatised by the size and consequences of the credit default that comprise Lesson Two of the financial crisis.

(2) Sectorially, as the toposcription of the absolute volatility of price, priced risk is the power magnitude of the futural contingency of power’s instantiation. Extensively operationalised *qua* accumulation by derivatives markets, priced risk is how one sector of the entire spectrum of social institutions assigns a power-magnitude to the futural contingency of price. In doing so it gives the futural contingency of power a power-determination in the present and, at once and for that reason, subjects the *systemic* power-organization of risk-pricing to the triadic contingency of price, which is what is dramatized in Lesson One of the financial crisis.

11.2. FINANCE-POWER: AUTOSABOTAGE

While the pricing of risk by derivatives markets operationally demonstrates that they empirically institute finance-power as an infrawager, the single 'abstract pecuniary magnitude' that is price is at once quantified power (capitalization) and quantified futurity (absolute volatility). That duality of price can only be analytically (rather than ontologically or operationally) demarcated: more emphatically, the constitutive ontology of the risk-order is given in the *unicity* of power and futurity via price. Predicated on the arkhéderivative as political economy is—as all politics is—and taking the power-futurity duality of risk-pricing by derivatives markets to be the explicit historical-institutional manifestation of that constitutive condition, this section elaborates in theoretical terms what the political economy of a risk-order constituted by price entails, providing the basis for the more explicitly institutional-sectoral consequences of the power organization of the state-finance nexus that is taken up in the concluding section.

Operationally, derivatives pricing *qua* infrawager means that prices in derivatives markets are conditions for further pricing and also conditional upon them. Because of the universal fungibility of the exogenous reference of derivatives (its contingency of abstraction), and because price is the instantiation of capital-power,

the endogenous plasticity of derivatives pricing (its contingency of revision) is then primarily the direct dynamic reorganization of capital-power *on itself* according to the logic of differential accumulation, and only incidentally the reorganization of capital-power outside of the pricing process (qua value). Returning to Means's distinction as it is taken up by Nitzan and Bichler, pricing primarily with regard to other prices is to set administered prices rather than market prices. With derivatives markets, it is not that revenues are fixed against the variable cost of production, as in Means's industry-based account, but that derivatives trading *qua* infrawager sets prices only on the basis of 'back-calculat[ing] the mark-up [the price of the derivative] necessary to realize a rate of return'. That is, derivatives are not priced competitively but rather to maintain a mark-up, doing so in real-time rather than the medium-to-long-haul typical of industrial processes. In terms of the arkhéderivative, the infrawager is the plastic reorganization of administered prices, and the market as a whole is comprised of this price setting of the market. But administered prices are set not only via their immediate markets but also by the organization of the spectrum of social institutions, the general name of which, with respect to what Veblen calls industry, is sabotage. Consequently, sabotage is a primary characteristic and necessary effect of financial markets. There are two distinct aspects to this conclusion:

—From the optic of industry exogenous to derivatives pricing, the plasticity of the latter is pure sabotage because derivative pricing is directly a magnitude of endogenously-constituted capital-power. This is just to reiterate from another angle the criticism of the finance sector's siphoning of capital, productivity, and social reproduction in general.¹³⁵

—However, the industrial determination of derivative pricing is strictly speaking only incidental to the latter *qua* infrawager. The endogenous operationalisation of derivatives pricing is primarily the plastic redetermination of prices and therefore of power *within* the price-terms of those markets. Operationalising the arkhéderivative, derivatives markets *directly* redistribute power *qua* capital accumulation in its own terms, rather than those of what, for it, is only the incidental condition of historical precedents or needs (for example, production or consumption).

If sabotage is the vitiation of industry because business implemented via administered prices diminishes social capacity in favour of the price organization of power via capitalization, the infrawager of derivatives pricing is, in contrast, the *intensive* determination of

135. See Lapavitsas, *Profiting*, 146; Marazzi, *Violence*, 44-46; and Hudson, 'Goldman Sachs'. Nitzan and Bichler complicate the basic assumptions of this claim and received assumptions on the global political economy of the finance sector in 'Imperialism and Financialism: A Story of a Nexus', *Journal of Critical Globalisation Studies* 5 (2012), 42-78, www.criticalglobalisation.com/issue5/42_78_IMPERIALISM_AND_FINANCIALISM_JCGS5.pdf.

the operational dynamic of sabotage. It is the sabotage of capital-power by capital-power across time and markets via price plasticity, an autosabotage. To be clear: the intensive autosabotage of capital-power is not operationally distinct from its extensive determination as industrial sabotage; but it is also not reducible to the latter, given the explicitly universalising and abstracting contingencies of the infrawager *qua* real of price. In its most general determination capital-power is not just counterproductive (a ‘negative industrial magnitude’); it is also and primarily (as a positive *financial* magnitude) its own intrinsic counterpower: the autosabotage of dynamic price-setting in its own terms which, constituted in the infrawager of the arkhéderivative, is intrinsic to *all* price. Price *qua* capital-power is then necessarily its own partial countermanding; the very instantiation of capital-power is at once the instantiation of its own counterpower, the sociological corollary of which is the intracapitalist struggle in differential accumulation.¹³⁶

136. The standard reference for the endogenous fragility of economies relying on financial intermediaries (primarily banks) is Hyman Minsky’s *Financial Instability Hypothesis (Stabilizing an Unstable Economy)* (New York: McGraw-Hill, 2008 [1986]), Chs. 7–10). Minsky notes that the increasing innovation and elasticity of financial instruments by financial intermediaries encourages short-term lending and leverage, fuelling economic booms and expanding balance sheets for financial intermediaries. Short-term borrowing by commercial banks in these conditions are however overextended against their nonfinancial assets and also susceptible to market volatility. Consequently, and counter to the investment-supporting claims legitimising finance, long-term investment undertaken and facilitated by financial intermediaries is driven by short-term price movements on unregulated

COLLAPSE VIII

Misfortune and Historicity

The real of price qua power is, in sum, extensive and intensive differential sabotage. In its intensive determination of financiality, price endogenously instantiates a power gradient, incapacitating in some respect that which it overpowers by outpricing it. That which is outpriced is also a term of capitalization, just a lesser one. However, if prices set the market then the market is the toposcription not only of capital-power *qua* autosabotage but also, at once, of the thetic contingency instantiated on every occasion of price. That is, pricing is not autosabotage only in respect of the incapacitation of what is thereby outpriced, in relation to other prices in the presently and historically comprised capital-order, but also, as elaborated above, in respect of its intrinsic thetic contingency whereby the extant society-wide organization of power is futurally risked to the degree indexed by the magnitude of a particular price. While the two counterpowers of the arkhéderivative—autosabotage and futural contingency—can be

markets whose instability thereby extends to the entire financial system. For Minsky, the endogenous instability of finance is institutionally formulate rather than located in the fact of price. Minsky's hypothesis has been extensively taken up in theorizations of the 2008 financial crisis. A striking example of this literature discussing the global expansion of the dollarised shadow banking system as condition for both the systemic reach and magnitude of the 2008 financial crisis, paraphrased in the above account of Minsky's hypothesis with regard to the development of financial innovations, is presented in J. Tokunaga and G. Epstein, 'The Endogenous Finance of Global Dollar-Based Financial Fragility in the 2000s: A Minskian Approach', PERI Working Paper Series 340, January 2014, www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_301-350/WP340.pdf.

analytically demarcated, they are again inextricable and mutually constitutive in the ontological unicity of finance articulated by the *arkhé* derivative. In that unicity, it follows that price-sabotage risks the market. That is, price is simultaneously the power over present *and* futural disestablishments of power, an autosabotaging futural contingency of capital-power. The several aspects of this unwieldy characterization of finance-power—autosabotage, futural contingency, and capital—are effectively synthesized by the term ‘misfortune’, but only if it is taken in this precise sense. Instantiated via the misfortune of price, then, capital-power’s dynamism necessitates the persistent contingent reorganization and revectoring of capitalization, a reorientation and contingency in time-binding whose direction and gains necessarily cannot be secured.

The determination of the *arkhé* derivative as a misfortune of power—meaning, to reiterate, an autosabotaging futural contingency of capital-power—is the comprehensive ontology of the market *qua* risk-order. As such, it is a systemic determination of capital-power, providing a diagnostic matrix for its historical development. Taking ‘capitalism’ as the name for the holistic systemicity of capital-power, the misfortune intrinsic to pricing means that there is no necessary or required direction, orientation, or identity to capitalism; its ordering via price is also the occasion of its contingent reordering. The only sociohistorical constraint for

capitalization, given its organization by differential accumulation, is that one capitalist accumulated more capital-power than another, and some sectors against all others. But that is only a constraint of its reason, not a prescription as to who or what will have the greater capacity for capitalization (meaning setting larger prices), nor for where and to what capitalization will be directed. That is, the duality of price-power's misfortune as regards sabotage and futural contingency is the constitutive condition for the sociohistorical contingency inaugurated by and as capitalism, thanks to which price's contingencies of abstraction and revisability are preserved across capital-power's necessary social-systemic operation.¹³⁷

137. In terms of Aristotelean categories (*Nichomachean Ethics*, Book VI), finance-power is then a *tekhné*, a process whose ends (teloi) are exogenous to that process and which may therefore never be attained by it (example: a building may never be completed). Aristotle distinguishes *tekhné* from *poiésis*, an artificial process with intrinsic ends (example: live music, which is heard as it is played), and *phúsis*, processes which always and necessarily have intrinsic ends (nature). The exogeneity of purpose to process in *tekhné* is why in general any technical process can be repurposed, and why in particular whatever is repurposed is a technics (including then nature). For Massimo Amato and Luca Fantacci, the problems of modern finance stem precisely from its operational divergence from its intrinsic purpose, which is investment via completed debt promises within given time frames (*The End of Finance* [Cambridge: Polity Press, 2011]). Securitization, intermediation, and large-scale complexity have also anonymised finance, vitiating what for Amato and Fantacci ought to be the intimate purpose of finance but which condition is here recognized as the consequence of its constitutive technicity. The emancipation of technics from the modern category of energy (which is predicated on work and thereby determines ontogenesis via the intrinsic ends or 'entelechy' common to *phúsis* or *poiésis*, a logic organising both Marxian and Neoclassical economic doctrine) is proposed in S. Malik, 'Tekhné is Fond of Tùkhé, and Tùkhé of Tekhné: Energy and Aristotle's Ontology', *Tekhnema* 5 (1999), 124–53; an emancipation that

Constituted *qua* finance-power, capitalism is realised only in more or less local, more or less large power conflicts. It has no necessary operational, social, cultural, or institutional identity, nor (*qua* différential pricing) any constitutive identity in its logic. Contrary to Marxian doctrine, then, internal contradictions do not necessitate its expansion or its demise.¹³⁸ Equally, capitalism cannot extinguish or supersede itself at a putative conversion point (the reassuring myth of singularity).¹³⁹ The constitutive misfortune of financiality proscribes any terminal or tendential logic or practice of capitalization, instead advancing only increased magnitudes of capitalization (which itself requires more complex, integrated, *and* differentiated forms of social-order *qua* risk-order). The history and future of capitalization is comprised only of the interminably tactical, dynamic reorganization of price, power, and the 'entire spectrum of social institutions' along both external and internal vectors of finance, the latter having ontological, operational, and political precedence. Constituting the identityless increase

implicitly countermands the DeleuzoGuattarian transcendental energetics underpinning Nick Land's convergence thesis (see n.139).

138. That contradictions within the capitalist totality drive the territorial expansion of capitalist countries via colonial and imperial domination is first proposed by Rosa Luxemburg, *The Accumulation of Capital*, tr. A. Schwarzschild (London: Routledge, 2003 [1913]).

139. This is the characteristic claim of Right Accelerationism. See N. Land, 'Meltdown', in R. Mackay and R. Brassier (eds.), *Fanged Noumena* (Falmouth: Urbanomic, 2011 [1994]) and 'Teleoplexy: Notes on Acceleration', *#Accelerate*, 509–20.

in aggregate capital-power, enfuturing the present in the autosabotage of pricing, the misfortune of the arkhéderivative is the historicity of capital-power.

11.3. FINANCE-POWER:

THE STATE-FINANCE NEXUS REDUX

Price is the measure of the political economy and the power over misfortune. The operational toposcription of finance-power via the abstraction of the number scheme of price markets means that markets are the basis for the comparison of finance-power in all times and places. Returning then to the contentions of the introductory comments above, the power magnitude and constitution of derivative markets can be directly compared to other organizations of power *in terms of the ontology of finance*—which is to say, by comparison of their respective prices. In particular, taking up Haldane and Alessandri's comments in terms of finance-power, the threat that the finance sector now presents to states is twofold: firstly, if GDP is a proxy for state power in global political economy (for reasons to be presented shortly), then for the most part the transnational derivatives markets outprice state-level GDP, which is to say that, in terms of the power theory of price, these markets overpower states even if the latter have jurisdictional power over them. The political and theoretical question of relative powers then has

to be recast as a question of whether statutory authority, stemming from state sovereignty, is endemically more powerful than finance-power, and sufficiently so as to not be overpowered by the latter's quantitative determination. The second identified threat to state sovereignty from finance markets is that all juridical aspects of state power in Westphalian modernity are territorially constrained, including the typical determinations of what that power is tantamount to: the monopoly over violence, guarantor of security, popular autonomy, legislative centrality, bureaucratic control, the ipseity of authority, the paramount status of popular sanction, and so on. Whatever determination of ultimate power is given to state sovereignty, its reach and legitimacy is necessarily territorially limited and constrained, particular (up to and including its global or extraterrestrial extension, as in some science fiction or political theory). As such, it is unable to attain the universal extension permitted by the 'abstract universality of magnitudes' constituting and actualising finance-power in its price-organization.¹⁴⁰

140. In Gilles Deleuze and Félix Guattari's terms, such quantitative abstraction is the primary condition and vector of capitalism's 'deterritorialisation' as a countervector to the system of capture that is the State and its particularising-segmenting codifications (*Anti-Oedipus*, tr. R. Hurley, M. Seem, H. R. Lane [Minneapolis: University of Minnesota Press, 1983 (1972)], Ch.10, esp. 251–54). Capitalism's 'lines of flight' from State territorialization are nonetheless fundamentally constrained and 'reterritorialising' for Deleuze and Guattari insofar as capitalism is axiomatically organized by the commodity form and production for the market. That axiomatic is for them the progenitor of capitalism rather than invented by it, and requires the historical institutionalization of various

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That is, the (necessarily universal) geospatial extension of finance-power is in principle if not historically in fact greater than the (intrinsically particular) power of state sovereignty.

In terms of finance-power, the territorial exorbitance of finance-power to state sovereignty does not threaten the latter so long as the capacities of their economies and revenues are greater in magnitude than the resources of financial organizations. However, if 'causality has reversed' between states and financial institutions, as Haldane and Alessandri put it, because regular defaults of monarchical loans in early institutional capitalism are replaced today by

organized State forms according to its level of development. Revoking the basic Marxian determinations of capitalism's axiom that Deleuze and Guattari adopt, capitalization in the logic of differential accumulation can instead be construed as a wholly formal axiom that is operationally aterritorial and abstractly constituted (via pecuniary magnitudes) and which, in its intrinsically dynamic constitution of intracapitalist conflict via the infrawager, is therefore unbound in its overall axiomatic production—hence, its extensive and intensive universalism. Equally, as discussed in the closing sections below, insofar as pricing relies on enforceable regulations of money and contract (including the 'convertible abstract rights' that secure private property [Deleuze and Guattari, *A Thousand Plateaus*, tr. B. Massumi (Minneapolis: University of Minnesota Press, 1987 [1980]), 454]), the state form is indispensable to capitalism, which means that capitalization is not so much the reterritorialising deterritorialization Deleuze and Guattari propose as it is an each-time territorially inaugurated deterritorialising. 'Territory' in these formulations is only the limitation imposed by sovereign jurisdiction rather than a geospatial factum: any such factum can be subordinated to the reorganization of jurisdictional authority and is thus not at all intrinsically bound to the figure of the nation-state even if that has been its dominant historical configuration. For the specific transformations of Westphalian jurisdictional and financial institutional infrastructures to facilitate transnational capitalization since the 1970s see S. Sassen, *Territory, Authority, Rights* (Princeton: Princeton University Press, 2006).

crises in financial markets requiring state interventions in order to sustain not just that sector but also the entire social order, then in terms of finance-power this reversal is only a historical transformation: the greater power is determined only by which sector has the greater price. That aggregate magnitude is determined for states primarily by their operational capacity and revenues, which is precisely what GDP indexes. Furthermore, given that nonfinancially generated operational capacity and revenues of states from production and consumption are again constrained in the Westphalian settlement by material and territorial factors determined by the inviolable borders sanctioned in that regime, the pecuniary magnitude of nonfinancially generated annual GDP for even the largest states is necessarily constrained in a way that the plasticity of pricing and market-interconnectedness of finance are not. The 'price magnitude' of finance as an operational sector can then in principle be greater than that of any state—or, because finance-power is endogenously constituted, the sectorial price of finance can always be exorbitant to any of its previous levels including that constrained by state-level organization. The current size and transnationalism of financial markets is an institutional-historical figure of the hybrid configuration of finance-power and state sovereignty, the relative sizes of global derivative markets (by credit exposure) and state GDPs indicating the approximate

equality of their respective finance-powers at the level of most of the wealthiest states, and the greater power of finance market to the majority of nation-states. Which is to say that it is not that power has 'reversed' between states and the finance-sector over the course of modernity, but that while state sovereignty has been the toposcription of the largest financial powers in that period, that historical condition is now in mutation and no longer a historical given. That is, thanks to the increasing aggregate price of derivatives markets, finance is now relatively more emancipated from the primary political configuration of historical modernity and, with that, the state-finance nexus is reorganised and revectorised.

To elaborate this reorganization by way of conclusion: as Nitzan and Bichler remark, the sovereign state is but one of the social institutions in the arrangement of capital-order, albeit the one that has been most dominant in securing the normal rate of return against which all differential accumulation is pegged. But that congruence between sovereignty and finance-power is also countermanded by their typological disparity. If sovereignty is constituted by the indivisible unicity and centrality of its decision as much as by the assumed supremacy of its performative diktats, in contrast finance-power is constituted by the primacy of its thetic futural contingency, the plasticity of the infrawager, and its misfortune. For all of the

complexity of the power-misfortune duality of price, its quantitative determination in every instance rescinds qualitative particularity as the term of power, whether that particularity is organized in terms of history, tradition, authority, or the other semantically rich or impoverished meanings typically invoked to warrant sovereignty (up to and including the transcendentalism of its theological determination).¹⁴¹ Minimally, then, finance-power is typologically a counterpower to sovereignty: the primacy and irreducibility of sovereignty *qua* determinant of power is violated by finance-power both in principle (quantity and triadic contingency against the particularity and the insuperability of authority) and socio-institutionally (finance markets outprice states). Finance-power threatens sovereignty not just because its greater financial magnitude and its absolute volatility prevails, but because the splitting of the present by price in the contingency of its irreconcilable futurity overpowers the otherwise assumed and inviolable authority of sovereignty.

That threat is manifest, and state sovereignty is degraded with regard to the arkhé derivative, when states are outpriced by finance markets—as is largely the case today, thanks to neoliberal institutional activism since the early 1970s. Exemplified by the invention of the CME and other derivatives markets, the

141. C. Schmitt, 'All significant concepts of the modern theory of the state are secularized theological concepts', *Political Theology: Four Chapters on the Concept of Sovereignty*, tr. G. Schwab (Cambridge, MA: MIT Press, 1985), 36.

consolidation and expansion of derivatives markets since the 1970s not only operationally liberates the real of price from nonfinancial determinations such as production and material resources (the putative ‘real economy’), it moreover concretizes and manifests the countermanding of any necessity or finality of value, price, or other financial measure, per the ontology of price. Consequently, the aggregate price magnitude of the financial institutions operationalising the arkhéderivative in its own terms are limited only by regulatory requirements and the tactical assessments of a risk-rationality—a liberation unavailable to modern state sovereignty. Thanks to finance-power, sovereignty is no longer the supreme power, but is itself now subject to contingency. More exactly, the very conditions of legislation sanctioning and regulating finance is itself now constituted in terms of the contingency of finance-power.¹⁴²

142. The disambiguation of misfortune is politically and analytically crucial here. By an argument similar to Esposito’s, Vogl too proposes that thanks to finance capitalism ‘danger and chance have returned in an archaic form, as *túkhe* or fortune’ in contrast to the historically preceding welfare societies that sought to ‘tame contingency’ (*Specter*, 130). Consequently, ‘the hazardous whims and caprices (*Launen*) of age-old figures of sovereignty have returned under modern conditions’. The present thesis is precisely the contrary: the arbitrariness of sovereignty is anything but contingent while the contingency of finance-power is highly risk-rationalised and anything but arbitrary. And now the latter dominates the former, further obviating sovereign caprice. Which is also why, for all the vast discrepancies in wealth implemented by neoliberal policy, it ought not to be designated as a neofeudalism (as Hudson or Lazzarato do, for example) nor, for that matter, is it the biopolitics that Vogl mistakenly proposes finance to be in its ‘determining [of] the life processes of a society by a single force’.

Ineliminable Statism

What is established here is that, cogent as it may otherwise be, the state-finance nexus is riven in its power ontology. The argument is not primarily that the operational-historical growth of the finance sector deprioritises sovereignty in favour of other modes of power (a Foucauldian variant of the thesis), or that the indebtedness and other financial commitments of the state (whether it be monarchical, or a parliamentary democracy, bureaucratic control, autocracy, etc.) require it to resort to finance markets to maintain itself. Rather, whatever power can be summoned by the state thanks to its sovereignty can be (i) determined as a specific magnitude in any particular instance, and (ii) that magnitude is comprised of the aggregate prices it can command from jurisdictionally-bounded institutions and social organization. The 'command' of prices is not that of a state-controlled economy, but rather the price that the state can raise on the basis of its sovereignty (taxation being the obvious example). While this injunction practically presumes the hierarchy of social institutions and order, the channeling of command via price, qua instance of finance-power, necessarily imposes a dynamic reorganization of social order. In its conservative formulation, this partial conclusion proposes that states are committed to their reorganization in order to sustain their integral role in the general ordering of social institutions by capital-power.

This is, to reiterate, not a reordering *directed* by sovereign command, but a political-economic transformation in which sovereign power has a key, *judicious* role.¹⁴³

And it is this last-mentioned condition that provides the more comprehensive formulation of the reorganising command structure of states in the condition of finance-power: that sovereignty is not the theoretical or operational basis of political *economy* nor exempted from it, but is institutionally and theoretically determined by it. This consequence is partially recognized, in other terms, in Modern Money Theory (MMT), for which state sovereignty is tantamount to the authority to impose and maintain money as legitimate unit of account for creditory relations, generating a demand for those units and also destroying them (by removing them from circulation) via taxation.¹⁴⁴ The immediately relevant argument of MMT is that monetary policy is fiscal policy is social policy, and there is no monetary economy without state debt (which is therefore a public virtue). In terms of the broader argument of power typology advanced here, this would mean that state sovereignty is nothing but a term of political economy,

143. See P. Mirowski, *Never Let a Serious Crisis Go to Waste* (London: Verso, 2013), 56.

144. See n.54 above, L. R. Wray, *Modern Money Theory* (Basingstoke: Macmillan, 2012), Ch. 2, and, for a discussion of the genealogy of MMT, 'From the State Theory of Money to Modern Money Theory', Levy Economics Institute Working Paper 792, March 2014, www.levyinstitute.org/pubs/wp_792.pdf; also P. Tcherneva, 'Chartalism and the tax-driven approach to money', in P. Arestis & M. Sawyer (eds.), *A Handbook of Alternative Monetary Economics*, (Cheltenham: Edward Elgar, 2006), 69–86.

and that, as such, it is not typologically distinct from finance in either its institutional operation or ontology. Yet if the state is a financial institution, it is the only one that fabricates and imposes money on a population that must then use it to pay taxes, and it is for this reason also a distinct and unique financial institution in its sovereign power. Taxation is the state's premonetary but nonetheless financial claim over the power organization of social institutions. In terms of finance-power, taxation is the price of the state—the price of monetisation—for the nonstate sector. Furthermore, as condition of the monetary arrangement of price, the sovereign state is only a subordinated necessity for the chronic reordering of complex modern societies qua risk-orders. Which is only to reiterate through the monetary dimension of finance-power that sovereignty and finance comprise a nexus—modern capitalism—that is at once congruent and also internally disparate, but is in any case constituted as finance-power. As such, the state-finance nexus is a particularly prominent, because systemically ineliminable, example of a general requirement of capital-power: that finance-power maintain institutions in order to advance capitalization, including, for example, sovereign jurisdictions with the authority to sanction and enforce the contracts fabricating derivatives (jurisdictions which in theory need not be nation-states).

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The Political Risk of Futurity

In general, then, finance-power is bound to capital-order, an organization of power by which greater and lesser magnitudes of capitalization can be socially implemented—and transformed at every instance thanks to the price indexing of that power-ordering: price *qua* misfortune transforms the order of power it measures. Constituted by the arkhéderivative, the dynamism of capital-power (‘the most dynamic of all historical orders’) is not reducible to nor predicated on the history or sociology of the capital-order but is a *result* of the thetic futural contingency and auto-sabotage of price. Capital-power is in other words a prevailing risk-order dedicated to the future contingency of the present and, at the same time, to its partial incapacitation. Two mutations to primary categories of modernity can then be identified, serving here as terminal remarks:

Statist futurity. In the political economy of sovereignty, statism and even sovereignty itself cannot be opposed to futural contingency. On the contrary, in the near-equality of aggregate price levels of (necessarily local) states with (necessarily crossbordered) derivative markets the state is a particularly privileged organization in capital-ordering, but one that now has a surmountable price: as noted, because derivative markets operate across borders, their monetary levels are not limited by the monetary constraints

that particular states have to observe, an operational-historical exorbitance that is theoretically warranted. And because states are now explicitly priced (if not outpriced) sovereignties, they too occasion not just the autosabotage of capitalization (which is the standard criticism of the state by advocates of the so-called 'free market'), but also the thetic futural contingency of pricing. To use Ayache's formulas, the state too is a medium of contingency or a technology of the future.

Dynamic and plastic rather than static (despite the etymology, which provides only a lexical rather than semantic constraint here), the state as a political-economic term deposes the inviolability of sovereignty in its actuality and also its theoretical-ideological justifications. The state may be a term of social sabotage, but in this it is not typologically distinct from any other instance of capital-power (which is why the 'free market' is an untenable doctrine); it is distinct only with regard to its still relatively large size in terms of prices it can set, in being an identifiable actor, and the authority to explicitly transmit its finance-power across all social institutions by law and taxation. As the price of monetisation, taxation itself is at once dually sabotage (the standard libertarian complaint) and, typically, a large power over collective thetic futurity.

Political Reason. Requiring an order yet dynamically transforming it without certainty in its thetic futural contingency, finance-power observes and instantiates

a risk rationality to which even sovereign states as prominent modes of power are subordinated. If power in modernity is predominantly organized between states and capitalists, it has been primarily determined across that history according to a risk-rationality. This is a history of sabotage in order to accrue power via price setting. And it is inextricably also politics, the chronic transformation and contestability of power ('it could have been different') predicated on the definitely uncertain future posited each time by price. It is not just that politics is inaugurated with each price qua instantiation of capital-power, apprehended now as a sabotage-contingency duality. Politics itself now means not just *what* the future will be but also the power over the magnitude of futural contingency and who or what owns it across the entire social order, including but not limited to the sovereign state. As such, politics is not predicated on the relation to statedom, although that, also, is not proscribed. Rather, politics is more generally both constituted and determined by risk-rationality, which is to say with a view to the uncertainties generated by the autosabotage of power and the contingencies of abstraction, revision, and thetic futurity of the arkhéderivative that splits the present from itself. Politics in risk-rationality is then occasioned in terms that are not commutative with qualitative determinations of authority and command, and it moreover rescinds any priority conventionally

granted to them—and, with that, it also rescinds reason in its sovereignty (if ever there was such) or social normativity, maintaining both only so as to reorganize the necessary misfortune of price.

The Coup de Dés, or the Materialist Divinization of the Hypothesis¹

Quentin Meillassoux

MATERIALISM BEYOND ATHEISM

Readers of *After Finitude*² will no doubt ask why I became interested in Mallarmé's *Coup de dés*, what link my study *The Number and the Siren*³ could possibly have to the speculative positions that I developed there concerning the necessary contingency of every being. I would simply say the following: The *Coup de dés* is, as far as I know, the greatest poem ever to be dedicated entirely to eternal Chance; and to the role of the human (and specifically of the poet, in Mallarmé) confronted with this dark absolute, the only

1. This text is an edited version of a talk given at Miguel Abreu Gallery, New York, 6 May 2012.

2. Q. Meillassoux, *After Finitude: An Essay on the Necessity of Contingency* (London and New York: Continuum, 2008).

3. Q. Meillassoux, *The Number and the Siren: A Decipherment of Mallarmé's Coup de dés*, tr. R. Mackay (Falmouth and New York: Urbanomic and Sequence Press, 2012).

one recognised by the moderns. What I find striking in this poet is that, in the face of a Chance held to be insuperable, he does not renounce his hope for the *divine*—a divine that takes on an extraordinarily original form which I shall try to unveil in what follows.

Now, Mallarmé's gesture is entirely *materialist*. Thus, as a materialist, it interests me: because (and this is a fundamental point to grasp in order to understand my own trajectory) materialism is not an atheism. For *materialism does not consist in denying gods, but in materializing them*. It is Epicurus, of course, who founds this gesture: for him, the gods exist, but they are not the gods of the mob—the gods of religion and superstition who are feared or praised. The Epicurean gods are atomic beings, immortal in fact, since they are born by chance in the intercosmic spaces where the gains in atoms are always equivalent to the losses, and thus conserve bodies indefinitely. This is why the gods care nothing for our existence, and do not concern us either: they are not bothered by terrestrial affairs, since they remain immortal only on condition that they stay where they are. This is also why they are not essentially different from us: we are identical to the gods, except that we are mortal—a relatively unimportant difference. The materialist philosopher is thus one who knows how to be like a god among men. For to be divine is nothing more than to be filled with life as a god might be, to be for a moment equally happy as man and as god:

which comes down to the joy of satisfying the limited requirements of our nature. The joy of satisfying one's thirst with a little water makes us equal to the divine at the moment it is quenched.

Going beyond the particularities of Epicureanism, we might say that, most profoundly, materialism consists in that thought, now largely forgotten, that unveils to us a divine *norm* for a life entirely avowed to a hazardous absolute. 'Norm' is to be understood here in the sense of the latin *norma*: the carpenter's square. The divine norm of materialism allows the subject 'to be straight', to find his verticality without religion or metaphysics. It does not separate him from gods, but on the contrary gives him access to the true god, one that is material and born of chance. Whence the potent irreligious significance of materialism. Atheism is always impotent against religions: contenting itself with denying religious gods, it remains haunted by their absence, and ceaselessly reimparts that which it refuses—as the term itself indicates: a-theism, that which can only be defined as the negative of the religious god and in relation to him.

Atheism thus always leads back to what it refuses, in the mode of absence and haunting, and unfolds infinitely in its own impotence. Whereas materialism saturates the space of thought with the absolute—the pure meaninglessness of Chance—and with what I call the Ultimate—pure hazardous gods, the most

successful creations of a perfectly absurd becoming. Constructing its life and its thought between these two extremes, between the meaninglessness of the absolute and the divine success of contingency, the materialist wages his struggle and prosecutes his critique against religions and metaphysics alike. Against scepticism, he affirms that the absolute is thinkable—for to refuse thought's ability to grasp the absolute is to reserve the absolute for a belief purified of all reason (in this respect, scepticism has always been the loyal ally of faith). Against atheism, it affirms that the gods are real, material, and that they orient our existence without alienating it. Against metaphysics, subject to various forms of the Principle of Sufficient Reason, it denounces the pseudo-necessities of ideology, which justify the powers that be, or powers yet to come, and unveils the real contingency beneath false essences and supposed idealities.

Materialism—if we relate it to the Epicurean gesture, without reducing it to the particular form he gave it in his philosophy—materialism alone, I believe, can hope to deliver us from religious gods. But the paradox is that materialism also delivers us from its own gods, from the material gods that it theorises as ultimate yet perishable points of chance. For what is singular about materialism—a position far more irreligious than the negation of gods—is that it tells us that, certainly, gods exist, but that they are *secondary*.

They are models, perhaps, but not masters. They are ‘patterns’ that allow us to outline more easily the apparel of our existence—but the ‘pattern’ matters less than the suit whose cutting-out it allows. Certainly, the gods remain important for Epicurus, but far less important than your way of running your life here and now, by modelling yourself on their reality. Certainly, for Epicurus, the gods exist—but so what? This is a secondary matter for the sage, who occupies himself with men rather than with gods. The gods don’t care about us, and we care more about men than about gods. And this is indeed the contrary of idolatry: not to make of god, on the grounds that he exists, the most important thing. To allow gods to exist, but to ‘secondarise’ them: not to obey them, but to avail ourselves of the knowledge we have of them, so as to cease to preoccupy ourselves with them *any more than that*, and above all to live fully as a human amongst humans. Such is the slogan of every true materialist: god exists, or could really exist, that’s a fact—but not the most important one.

It is this materialist gesture that I try, in my own way, to revive today, in my philosophical investigations. I believe that the materialist, on one hand, must radicalise the meaninglessness and the contingency of the absolute; and on the other hand, must think the configuration of the divine that the most radical contingency allows to exist—stripped of any necessity,

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but subsisting at least as a forever real virtuality of this absurd becoming. I certainly do not believe that gods exist as a remarkable product of chance atomic encounters—but I believe that materialism well and truly consists in thinking the most remarkable emergence of which contingency is capable; that materialism consists in drawing up the most extreme map of the possible, and in living according to the intense effect that this possible exerts upon existence, once it is understood as real possibility and not as mere reverie.

THE METER AND THE CODE

Now, I insist that this revival of the divine gesture of authentic materialism is precisely what Mallarmé already achieved, in his own unique way, in the *Coup de dés*: he produced a poem that I call authentically, and not banally, atheistic, because, through the sole power of Chance, it brings about a configuration that is divine, but nonetheless wholly human. It is a materialist god who rules over these pages, and by the same token a secondary god—one who seeks only to produce an effect on our lives (your life being, all the same, more important than that of Mallarmé's god). In the conclusion of *The Number and the Siren*, I say that the *Coup de dés* is an 'exact atheism'. But I define this exact atheism of Mallarmé's ironically—precisely as the contrary of an atheism; as that which

makes of the divine the articulation of the Self and of Chance—and thus as something that departs from atheism, to become a true and vigorous materialism. What I describe therefore is a Mallarméan renewal of the Epicurean gesture.

As I state quite plainly, I am convinced that Mallarmé's poem is coded. But what is totally original in Mallarmé is that he tried to use this question of encryption to resolve the problems of his epoch, which concerned, in particular, the question of *metrics*—that is to say, the question of the writing of poems according to regular forms, rather than in free verse.

Until the *Coup de dés* (written in 1897, in its two different versions), Mallarmé only writes poems in regular forms; that is to say, he adopts a metric linked to fixed forms such as the sonnet, to fixed numbers of syllables, and to rhyme. He continues to do so even though he is confronted, from 1887 onward, with the new form (or refusal of form) that is free verse, and which abandons all traditional meter. But then suddenly, in 1897, everything explodes, and we have a poem even more audacious in form than free verse, namely the *Coup de dés*. The enigma is that there is no mediation between the strict metric of all previous Mallarméan poems, and this stupefying poem of quite unabashed transgression, which no-one really understands (not even the free verse poets) when it is published for the first time in 1897. In order to better

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grasp the meaning of this abrupt break, I want to show that the *Coup de dés* is in fact not a form (even an exacerbated form) of free verse—that it is not an intensified refusal of metricity—but that it proceeds from another logic entirely; and that the only way to understand this logic is by way of the discovery of a procedure of encryption.

I do not agree with critics such as Ronat and Roubaud that it is a matter of a defence of the old metric (in particular, the alexandrine); rather it concerns a new meter, and a new count. The *Coup de dés* is a eulogy to counting in poetry, and an apologia for the thesis that what essentially distinguishes poetry from prose is that the poet is the one who counts, who ‘calculates’, albeit in a rhythmic and not solely an arithmetical sense; he for whom every number counts. This granted, the *Coup de dés* fundamentally speaks to the role of number in poetry, and defends meter in a completely unprecedented manner.

THE MASTER AND THE POET-PRINCE

The *Coup de dés*’s shipwrecked Master who throws the dice in the stormy waves is surely poetic Meter, in the process of being drowned by the tumultuous waves that are none other than the segments of text exploding onto the Page of the *Coup de dés*. These fragments have all the characteristics of free

verse, exacerbating its refusal of classical form. It is free verse that submerges Meter. In this way, the terrible tension between the two forms is dramatically brought to life, and Mallarmé will try to resolve it from a poetical, not just a critical, point of view: through the writing of a poem rather than through a theoretical intervention.

The Master of the *Coup de dés* holds the two dice in his hand. This theme, as we know, was already present in *Igitur*, the unfinished tale of 1869. The crisis that provoked this poem goes back to the discovery of the Nothingness which Mallarmé writes of in his 1866 correspondence: the discovery that there exists no God capable of guaranteeing the absolute value of the poetic symbol, as was still hoped by the first romantics, perhaps even by Baudelaire himself. He therefore writes this fable, which was never to be published, in which he imagines a young poet-prince, *Igitur*, inspired by Hamlet, who descends into the tomb of his ancestors, asking himself whether he must perpetuate their destiny. His whole hesitation is condensed in the question of whether or not to throw the two dice he holds in his hand, to try to obtain a double six. These ancestors represent the line of poets whose heir Mallarmé wishes to be; and it is a question of knowing whether it is still worth the effort of producing the twelve of the perfect alexandrine, even when one knows that this alexandrine will no longer be the

result of a divine inspiration, but that of meaningless chance. Language no longer being a bond between man and God, but one chance among others, what point is there in throwing the dice? What point is there in continuing to seek the sublime verse, if the divine vocation of the poem, its claim to replace the old religion, is no longer subtended by any transcendence? The romantics refused to perpetuate the old Catholicism: but they claimed that they did so in the name of a more profound understanding of the beyond, not because it is illusory. The drama of Mallarmé himself, transposed into the hesitation of Igitur, is that he no longer believes in the existence of a super-terrestrial reality, but still cannot manage to renounce the idea of a religious and higher vocation of poetry.

The poet thus hesitates between two possible endings that he could give the tale, without managing to decide on one of them—whence the unfinished character of his fable: either Igitur throws the dice and provokes the derisive anger of his ancestors (they make a furious wind whistle in the ears of the hero), because the poet resumes the gesture of his forebears, but does so for opposite motives (chance having become the moderns' sole god); or—the other ending proposed in the manuscript—Igitur keeps the dice in his hand without throwing them, and proceeds to lie down upon the tomb of his ancestors. We already find, in these two endings, the opposition between a kind of

‘Sartrian’ solution—one boldly assumes the absurdity of the world by throwing the dice—and a solution that puts us in mind of the process of writing according to Blanchot: one writes the exhaustion of writing, a writing that unfolds indefinitely, in a trial of its own impossibility.

Igitur must of course be read in relation to *Hamlet*—it involves a decision at once fatal and impossible, which must separate an absolute before and after, and which, because of its own radicality, seems inaccessible to any resolution. Now, these themes are manifestly taken up once more in the *Coup de dés*, nearly thirty years later. The Mallarmé of 1897 comes back to this thematic from 1869 because he understands that in the *Coup de dés* he will be able to transfer the theme of the death of a verse guaranteed by the divine, to the crisis of free verse. The Master must throw the dice to know whether he will produce once more a universal metrical verse, or whether everything will be lost to the chance of non-metrical verse, the representative of subjective temperaments of different poets, lacking all necessity. The same crisis of nothingness is at play across the distance of decades; in 1897 it directly compromises the future existence of the poetry practiced by Mallarmé.

‘NOTHING / of the memorable crisis / WILL HAVE TAKEN PLACE / BUT THE PLACE / EXCEPT / PERHAPS / A CONSTELLATION’, writes Mallarmé. The ‘memorable crisis’ is the crisis of free verse, from which nothing will

escape unless meter, classical among all, can escape it victorious. The danger would be that one of the two forms of verse should drown the other. On the contrary, the two forms have to coexist in some original fashion. And yet when we read the *Coup de dés* we cannot see, *a priori*, anything but an exacerbated explosion of free verse. Could there be some way for a metric to be inserted into a poem that apparently breaks so completely with all the old rules?

THE BOOK AND THE MASS

In fact, we find another example of this will to maintain a metric 'on the terrain of free verse' in Mallarmé's *Notes for the Book*. Mallarmé was obsessed his whole life with the writing of an absolute Book, the Great Work which, in a public letter to Verlaine, he called 'Orphic Explanation of the Earth'. This obsession also must be understood in the framework of the religion of art. Mallarmé very seriously tried to write a text that could replace the Bible. We might think he was being ironic here, given the hubristic nature of such a project: but this is, I believe, to misunderstand him—so far was this project from being out of reach, that in fact he wholly succeeded in it, in any case according to his own criteria for success. But only in the *Coup de dés*, as we shall see; I maintain that the *Coup de dés*

alone realised the whole project of the Book, but via a wholly new route.

In the *Notes*, Mallarmé describes a ceremony of reading that is quite obviously designed to replace the Mass. This is a most strange ceremony: we see a room, with ‘assistants’ seated before a scene, and on the scene two pieces of furniture, two racks containing loose-leaf pages which an ‘operator’, as anonymous as a priest, takes up and joins one to another, according to a combinatory so complex that the reading of the whole Book would take place over a period of five years.

Now, the reader of these *Notes* cannot but be struck by the numerological obsession that runs through them. For the manuscript is essentially composed of numbers, of calculations on numbers, of measurements as to the material and financial aspects of the Book, of various quantities involved in the ceremonial context of its reading. These Numbers, on one hand, have an obvious link to the alexandrine: there must, for example, be twenty-four assistants in the reading room, and the size and the price of the book are also linked to multiples or divisors of twelve. It thus seems clear what Mallarmé is seeking to do with these strange calculations: The poet perceives that the alexandrine is being driven from the poetical text by free verse; free verse seems to demonstrate that the 12 is contingent for poetry. So the 12 takes refuge in the material surroundings of the text and in the context of its reading

(size, price, number of volumes, assistants, and so on), and no longer concerns its content. We understand that the poet seeks a way to reinsert the metric—the count—into poetry, by finding new functions for meter

Nevertheless, it is hard to see how this procedure of enumeration is meant to have saved the alexandrine, and restored its necessity. But what is interesting, for our purposes, is to ask whether the *Coup de dés* did not continue this ‘counting mania’, but make it more effective: through the writing of a poem that, however apparently non-metrical, would contain within itself, in its very composition, numbers that are not immediately visible, but that would constitute the result of the Master’s throw. Thus the Master would have admitted that the waves of free verse were destined to visibly engulf poetry—including the *Coup de Dés*; however, in this poem there would have existed a metrical principle—not immediately accessible, but underlying its composition. If this is what Mallarmé did, then the *Coup de dés* could no longer be considered as a radicalisation of free verse, but must be understood as a metamorphosis of metrical verse. The *Coup de dés* would not have pushed one step further the rupture with classical constraints, but would have tried to reinvent them. Mallarmé would then have written what I would willingly call a poem in *essential verse*: a verse neither free nor metrical in the old manner, but capable of uniting radicalised free verse and a reinvigorated

metrical verse. This would be a poem we could call ‘hyper-metric’: in the guise of being ‘hyper-free’, it would be yet more rule-governed than classical verse, but according to a rule encrypted within the poem itself.

Now, the only cipher that appears, written out, in the *Coup de dés*, is Seven. The final throw of dice that compensates for the failed throw of the Master gives rise to a ‘Septentrion’, a stellar seven that seems to mark a possible success of the voyage despite the surrounding disaster. What could the Seven symbolize for Mallarmé? Already, in the last Page—the page where the Septentrion emerges—we find a clue to this stellar 7 under whose aegis the meaning of the metrical count governing the whole of the *Coup de dés* is placed. We read—running from the penultimate to the final Page—the second great announcement of the Poem: ‘NOTHING / WILL HAVE TAKEN PLACE / BUT THE PLACE / EXCEPT / PERHAPS / A CONSTELLATION’. This Constellation is said to be ‘cold with forgetfulness and desuetude’ —‘not so much’, however, it is added—‘that it fails to number / on some vacant and higher surface [that is: in the stellar sky, but also on the vacant surface of the page] the successive impact / starrily / of a total count in the making [that is to say, of a total count that is in the process of being produced *at this very moment as we read the poem*] keeping watch / doubting / rolling / shining and meditating / before finally halting /

at some last point by which it is consecrated / Every Thought Emits a Throw of Dice’.

I believe that what is described here is that there is a metrical count that is in the process of being summed, of being totalised, as the reader arrives at the end of the poem, and that will be completed by a ‘consecration’. In metrical poetry, the count is obviously always completed at the end of the verse: it is when I read the end of an alexandrine that the summation of the twelve syllables is produced effectively in the verse. Let us suppose, then, that the whole of the *Coup de dés* was written as one single verse, that is to say (since a verse for Mallarmé is always two verses rhymed together) as two adjoined verses, each symbolically of 12 pages. What Mallarmé is describing here is what happens at the end of a poem, in which something is in the process of being summed—and the total count is completed precisely with the word ‘consecrated [*sacre*]’ which, at the same time, would designate the final crowning of the Septentrion. ‘Consecrated’ would then be the last word that completes the count (still enigmatic) of that unique Number that cannot be another. The stellar throw of dice is thus a mental throw of dice, and the sky is not the night sky, but the white of the page. The reader believes that the poem is describing to him a stellar night outside of the book, but in fact Mallarmé describes what he himself is doing: he ‘enumerates’ his ‘total count in the making’, which is like a glorification of a Meter to come.

THE SIMPLEST OF METERS

If we start out from the hypothesis that 7 is the secret and constellatory Meter of the poem, we still need to find out *what* it counts. To conclusively track down this enigma, we will take a look at the final ‘moral’ of the Poem: ‘Every Thought emits a Throw of Dice’. We can propose the following interpretation: when you think, you must pass by way of language, and thus you must use a certain number of linguistic units. For example, the declaration ‘I love you’ (in English) has three words, eight letters, five vowels, etc.—it produces a series of implicit numerical counts. But these counts are a matter of pure chance, of a simple dice throw, in regard to the meaning of the phrase. There is no link between ‘I love you’ and the numbers 3, 8 and 5—no link, that is, apart from a purely chance one. However, what is proper to the poem is precisely to contest this purely chance link between thought and count, by associating the meaning of the verse to the enumeration of the syllables necessary to formulate it. To conquer chance ‘word by word’, as Mallarmé writes in one of his critical texts—to try to associate meaningfully sense and count, such is the supreme task of poetry—even if the struggle seems lost in advance. But in that case, doesn’t this conclusion ‘Every thought emits a throw of dice’ contain the metrical key that will permit us to know what the final 7 counts?

In other words, won't the secret of this 'moral' of the poem be to indicate to us the linguistic unit we must enumerate in order to obtain the unique meter? Let's now ask whether there exists a linguistic element that, counted *in this phrase*, would give 7 as a result. There is indeed one such, and it is the simplest that could be: *the conclusion of the Coup de dés*—'Toute Pensée émet un Coup de Dés'—*contains 7 words*.

Our hypothesis follows naturally from this: What if Mallarmé had counted the words of his poem? What if his meter was 'lexical' rather than syllabic? In this case we should have to present the matter as follows: the conclusion, 7 words long, would represent in some way the 'musical' key of the poem; it would indicate that the *Coup de dés* is written 'in 7', as a sonata might be written 'in C', the 7 being isolated for itself in the final phrase, clearly separated from the rest of the text. On the other hand, the unique Number, properly speaking, would be the result of the 'total count in the making': it would have the word 'consecrated [sacré]' as its last element, and, being greater than 7 (since from the first word to the word 'consecrated' there are, at a glance, many hundreds of words), it must contain 7 in a sufficiently remarkable fashion that we would hesitate to put it down to chance alone when we discover it.

If 'consecrated' was, for example, the 777th word of the poem, we would indeed have a Number linked in a

remarkable way to 7. Another cipher, however, has an immediate significance for the *Coup de dés*: namely 0, since it is the obvious symbol both for nothingness and the void, and for the vortex, the whirlpool that is described as circular and in which the ship and the Master are lost. So we can imagine three other Numbers capable of representing our Meter, formed exclusively from 7 and 0: namely, 700, 707 and 770. If we end up with one of these four counts, we will be able to say that we have not necessarily taken a wrong turn. Any other result, on the other hand, will discredit our hypothesis entirely. But even if we arrive at one of the four numbers, this will not be enough. A simple chance could have given rise to this sum. To be sure that a Meter is genuinely encrypted in the poem, Mallarmé would have had to have given us the means, *within* the poem, to validate this possibility. In other words, the poem would have to speak implicitly of one of these four numbers, as in a ‘charade’ or a riddle.

As I show in *The Number and the Siren*, we can read the central page of the poem— the page of the ‘COMME SI’, or ‘AS IF’—as the site of this charade. The ‘SI’, assimilating the Master, decapitated by the waves, to the Saint John (*Sancte Iohannes*) of Mallarmé’s *Noces d’Hérodias* (‘COMME SI’ = ‘LIKE S.I.’), also refers to the seventh note of the simple *sofège* scale in French: ‘doremifasolaSI do’ (in ‘a simple insinuation’, as the *Coup de dés* tells us, in a line studded with ‘si’—‘insinuation

simple silence precipite'). 707 thus describes the central passage of the poem—two 'Comme si' (7) swirling around a central vortex (=0)—and, by making the count of words in full, we can also verify that *the final word 'sacre' is the 707th word of the poem.*

But what can we conclude from this? We are satisfied with having proved that there does indeed exist in the *Coup de dés* an encrypted meter, counting words rather than syllables; but at the same time we remain frustrated, because we don't understand how this is supposed to resolve the problem of modern poetry, nor how the strange Meter is a unique Number that cannot be another.

TREASURE OF THE BLACK DRAGON

To resolve this question, we must start again from the fact that, in the decade between 1885 and 1895, Mallarmé sought to respond to two challenges: that of free verse, which demotes meter to being nothing more than the chance of gratuitous or political invention; and that of Wagner, who usurped from the French poets the project of founding a religion of art. According to Mallarmé, Wagner sought to transpose to the German people what the Greeks did with tragedy: to make them see themselves through mythology, through a reflection of themselves on the stage. Now, for our poet, the Greek stage cannot

constitute a new religion after Christianity—because the stage is precisely a *representation*, a fiction. And the moderns cannot go back to a religion of representation. For, in the meantime, we have tasted something else: the Latin Middle Ages. And what did they deploy, of which the Greeks knew nothing? The Mass.

Mallarmé is no longer a believer, certainly; but he always remains interested in the device of the Mass (indeed, Deleuze criticises him for this). The mass is not reducible to a scenic device, because the priest is not an actor: he does not *replay* the Passion upon a stage, but assures the *real* presence of God through his coded gestures—ceremonial (the Eucharist) and sometimes very simple (his withdrawal, facing the audience). The mass brings us something on the order of *presence*, not representation: God is there, and not only his fiction. This Passion descends into the very host, and it even allows for a physical assimilation. There is a real fact here. Mallarmé was persuaded that, if modern poetry was incapable of grasping for itself this capacity of the Mass to really diffuse the divine, to pass from representation to presence—what he calls the ‘treasure of the black dragon’—Christianity would never be dethroned. It is this treasure that we must steal in order to put an end to the old religion. He theorises this in the 1895 text ‘Catholicism’, where he broaches the question of the real assured presence of the Eucharist. Now, 1895 is also the year when he stops

work on the *Notes for the Book*. This is surely no chance occurrence: for the ‘Mass’ of the Book proposes only readings and scenic representations—no real ‘diffusion’ of the divine. When Mallarmé understands that he has thus taken a wrong turn—that he has fallen into the same impasse as Wagner—he abruptly changes direction, and directs his energies toward the writing of the *Coup de dés*, whose premises appear the same year in one of his critical texts (‘The Book as Spiritual Instrument’). But how will the *Coup de dés* resolve this vertiginous aporia: how will it realise a poem capable of bringing about a real presence of the divine, and not a mere representation of the absolute? How, moreover, to envisage such a diffusion of the divine, when poetry is deployed under the reign of Nothingness, and no longer under that of the old religious transcendence?

MASTER OF CHANCE

If we admit that there is an encrypted meter in the *Coup de dés*, it must be understood that nothing in this poem, *nor indeed in any of Mallarmé’s oeuvre*, allows us to deduce the existence of this meter: you can spend your whole life reading Mallarmé’s writings, and you will find no clue to put you on the right path. If I discovered it, I did so simply because I had a stroke of luck, one day, when I had the preposterous idea of counting the words of a sonnet in which this principle had

already been put to work in 1894 ('À la nue accablante tue'). But *it is not by chance that this discovery was made by chance*. For Mallarmé had manifestly confided to chance alone—to an accidental enterprise—the care of discovering his meter. There is nothing in his whole oeuvre that allows us to rationally deduce that he had undertaken such a wager—precisely because he wanted it to be Chance, and not the erudition or the intelligence of a reader, that discovered his procedure. Mallarmé thus threw the dice into the aleatory sea of historical reception, a code whose discovery nothing could guarantee.

In Mallarmé's poem, the dice throw is not merely represented: *it is really effectuated*. The poem is performative, because Mallarmé does exactly what he describes the Master as doing. He asks himself, hesitating, whether to throw his stellar Number into the ocean of posterity. Will he play out his destiny as a poet by confiding to his own divinity—Chance, rather than Providence—the care of revealing one day the metrical and stellar calculation by which he hopes to open a new passage for poetry?

Once we understand that Mallarmé *is* the Master, that he is the real thrower of a Number really hidden in the cloud of our misunderstandings as we read the poem, we understand that we are faced with a true Passion. Christ sacrifices his flesh, but Mallarmé sacrifices meaning (the meaning of his oeuvre). It is a

sacrifice yet more spiritual than the christic sacrifice; in a certain way it removes the corporeal immediacy of the latter, in order to express it in a higher form. We can then understand Mallarmé's attachment to a Meter whose essence lies not so much in giving its rhythm to verse as—let us recall—in assuring its cultural dimension. The encrypted Meter allows the silent reader of the *Coup de dés* to evoke once again the presence of a real Poet having assumed the really possible sacrifice of his oeuvre. It is a mental Eucharist that makes of the silent reading of the poem a solitary but universal ceremony—perhaps the only type of ceremony that a modern can perform without making himself ridiculous.

But we still don't understand what is necessary about the Number—what is 'divine' about it, in short. The only divinity accessible to the poet of Nothingness, as we know, is Chance. Now, only Chance is eternal—this is what, literally, the title of the *Coup de dés* tells us: 'A Throw of Dice will never abolish Chance'. In other words, everything is subject to chance, every throw falls into the contingency of the aleatory—except for Chance itself, which no throw of the dice can ever engender or destroy. Thus, The Eternal is Chance—Chance is our only Infinite. Now, in order for the Number to be not only the fact of a contingent throw, that of a simply human and particular poet—in order for it to acquire a necessary dimension—it must

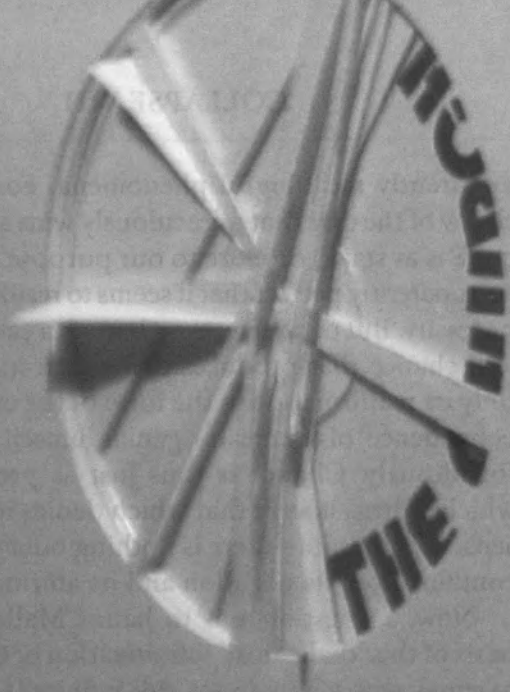
fuse with Chance rather than simply being the result of Chance: 'If it was the Number / it would be / Chance': that is, if the Number comes, then it will be, not the derisory *result* of Chance, but *nothing less than identical* with Chance—since only Chance 'cannot be another'. But how can a Meter fuse with Chance, and participate in its divinity?

HESITATION AND INFINITIZATION

To understand this final enigma, we must return to *Igitur*, the unfinished tale of 1869. During this period, and under the influence of his friend Villiers de l'Isle Adam, Mallarmé became interested in Hegel. He probably knew Hegel through Edmond Scherer, who in the 1860s wrote a controversial review of the philosopher's work. Now, in this article, Mallarmé could have discovered Hegel's speculative—rather than arithmetical—conception of the infinite. Hegel considered that the divine infinite is infinite in the precise sense that it has nothing outside of it; which explains why the true God is for Hegel a Christian God, that is to say a God who is incarnated in a singular man. For if God was only God, enjoying a transcendence like that of the Jewish or Koranic God, he would precisely not be every thing, since he would not be human. The purely divine God does not have the finite in him, and consequently he is limited by the finite—limited by the

contingency, finitude, or imperfection that is external to his nature. In order for God to be authentically infinite, he has to pass into man, become man, become Jesus, thereby incorporating the finite into his own process. But God also must not remain in the state of humanity; in this case he would be but finite, and would lose his divine part. He must therefore return into his infinity enriched by finitude: Jesus must be crucified, must die, and reascend to the Father. As one commentator on Hegel says: in order for the infinite to pass, the finite must pass away. God must die as a man and rejoin himself in his proper infinity, permitting the passage of the human Christ to the eternal Christ of the trinity. The infinite therefore contains eternally the moment of its finitude, as abolished in the crucifixion.

Now, it seems clear that, in *Igitur*, Mallarmé attributes *to chance itself the properties of the divine Hegelian infinite*. In this tale, it is *chance* that nothing escapes, that nothing is external to—no longer God, who is now cast down into nothingness: which is why “Chance” (‘Hazard’—now written with a ‘z’ to recall the Arab etymology: ‘a game of dice’) is explicitly qualified as infinite. Now, chance is always manifested in two basic ways: it can manifest itself firstly in an obvious way, in all the failings of existence, all the inconsequential throws, mediocre verses. And in this sense it is ‘affirmed’ by reality in its everyday mediocrity. But it can also be ‘denied’ by reality, when suddenly there emerge



apparently meaningful phenomena. For example, a throw of the dice that miraculously wins a game where a life is at stake; or more to our purpose here, a verse so apparently perfect that it seems to result from divine necessity. But of course, even in such a case, it is in fact still chance that produces this effect: its negation is only its reaffirmation in the form of the extraordinary 'coincidence' of the creator-genius himself, engendered fortuitously. Chance is thus just as present in that which affirms it as in that which denies it; and in this sense it is infinite—there is nothing outside it, since it contains both its negation and its affirmation.

Now, a question was to haunt Mallarmé on the basis of this 'dialectical' infinitization of Chance: how to equal, with a human act, this infinity? Chance is the figure of the divine within us: to become equal to it would thus be to bring ourselves closer to the divine, eternally meaningless part of ourselves. But through what act, since every act is finite, contingent—that is to say, *produced* by Chance, but not *identical* with it? The act that most closely approximates to the infinite so understood, according to Mallarmé, is *hesitation*. In hesitation you are virtually what you are and what you are not. You are at once he who is on the point of committing an action, and he who nevertheless ceaselessly holds back from it. You are 'between' the two, and you conserve these opposites potentially within you. In one of the endings of *Igitur*, the hero



seems to hesitate, retaining the dice in his hand rather than throwing them. But he ends up renouncing the throw, and lays down forever upon the ashes of his ancestors. The master of hesitation is obviously Hamlet, the model for *Igitur*, and fundamentally, for Mallarmé, the only play, to write and rewrite—he is very radical on this point—because its intrigue is precisely that of the infinite. But here again, in Shakespeare's play, the hero ends up choosing—he kills his father's murderer, and himself dies of being thus finitized.

Let's come back to the *Coup de dés*. If Mallarmé had known the equivalent of a Passion, he would have produced not only a human sacrifice, but a divine one: not only a finite, but an infinite one. Christ is not only a crucified man, he is a crucified man-god. To overcome Christianity, one must produce not only a Passion (the sacrifice of the meaning of the poem to Chance), but a Passion that infinitizes the sacrificer, that is to say one that infinitizes Mallarmé himself. Now, 'THE MASTER / hesitates'—the Master's sole action is his hesitation in throwing the dice. And this hesitation, unlike that of Hamlet or *Igitur*, is *never* overcome by a determinate resolution. Very simply, we know nothing of the Master, apart from his hesitation, become eternal. Has the throw taken place or not? Is there a Number or not? This is what seems to have been consigned forever to a hypothetical status. And this is why Mallarmé does not write, in conclusion, 'NOTHING WILL HAVE TAKEN

PLACE BUT THE PLACE / EXCEPT A CONSTELLATION', but instead: 'NOTHING WILL HAVE TAKEN PLACE BUT THE PLACE / EXCEPT *PERHAPS* A CONSTELLATION'. The constellation has perhaps taken place, but perhaps not.

On this basis, we can understand whence comes the necessity of the 'unique Number': it cannot be another, *because it is infinite*—that is to say, because *it already contains within itself its other*, its proper non-being, *qua undecidable hypothesis*. It is; but just as much, it is not: it is the eternally hypothetical result of a throw that is infinite because forever hesitant, and thereby capable of equalling the necessity of Chance itself. Mallarmé would himself be infinitized, by making himself the thrower of the Dice who produces *and* does not produce the unique Meter: making himself, for all eternity, the thrower and non-thrower of the two Dice of the unique Meter.

However, this seems to contradict our own conjecture: for, according to what we have said, Mallarmé *did* throw the dice, and produced his Number, 707—a Number too precise not to be contingent, and thus hopelessly finite. But everything would change, were this number charged with an internal hesitation that infinitized it: a hesitation that, at once, made it equal and not equal to 707. How could this happen? Very simply, if we were *almost* certain that the poem was coded, but at the same time not entirely sure of it—if *the count of words was not entirely certain to be equal to 707*.

If there was a 'slippage' in the code, if in the count of words there was a possible hesitation, this would mean that, for all eternity, Mallarmé would have sacrificed the certainty of his gesture, even once his poem was decoded. In doing this, he would have produced a real fact—his gesture of encryption—that would be at the same time a hypothetical fact. Mallarmé, the signatory of the poem, would become, forever—that is to say for the posterity of his readers—infinite: he would have thrown *and* not thrown the dice, he would have drowned himself in chance, infinitized himself in it, like a Hamlet at once real and fictional. A mixture of a real individual and a hypothetical fiction. This would give us a religion of art whose one and only character would be Mallarmé—but not the real, biographical Mallarmé; instead, Mallarmé the signatory of the Poem, and who, as signatory, makes himself equal to Chance.

It is by identifying just such a 'slippage', a 'quavering' in the count, a 'hesitation' that is condensed into one, central, word of the poem—the 'PEUT-ÊTRE [perhaps]' whose count (one or two words?) is uncertain—that I argue, in *The Number and the Siren*, that the *Coup de dés* succeeds in making the number 'divine', and fulfils the conditions of Mallarmé's Book: as the site of the ceremony, of the 'real' or diffusive presence of the divine, and of the advent of a mental song (the poem must be read silently, seen and not read out in public, in order for all its graphical and spatial effects

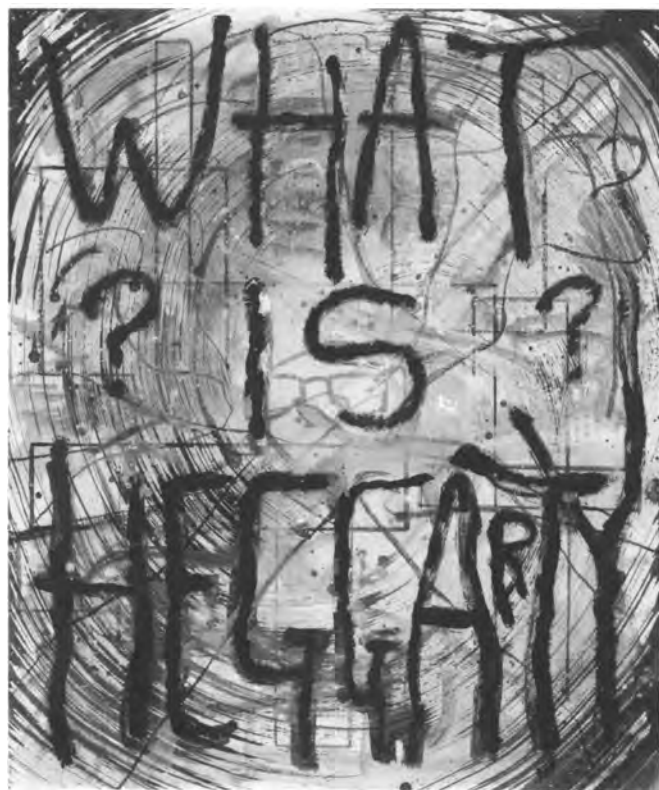
to be deployed). But it also possesses this last remarkable property with which Mallarmé wished to endow the Book: fundamentally it would not have been written ‘by’ anyone; its author is ultimately anonymous. For the *Coup de dés* escapes its readers, who will never know what the biographical Mallarmé did or did not premeditate—to code, not to code, to hide from himself his own intentions—and Mallarmé will never have known (if he did code the poem) whether or not it was ever decrypted by some lucky chance. No one can grasp both sides of the truth—neither author nor reader—and the Poem thus functions according to a logic that belongs to it alone.

A NEW MATERIALIST GESTURE

In conclusion, you may be worried by this reading—if not Christian then at least christological—of Mallarmé. But to my eyes, this reading, I repeat, is above all materialist. From Epicurus to Mallarmé, the gesture is in truth, I believe, fundamentally the same: the divine exists, but it is not what is essential. For Mallarmé succeeded, in a certain way, in assuring the triumph of modernity: that ‘religion of art’, that immanent replacement for the old religion that our teachers assured us had failed, or had even engendered political crimes, Mallarmé did bring it to fruition successfully. There is, thanks to the *Coup de dés*, a divinization of the

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poem, and the birth of a new cult. But this triumph, this cult, this religion, are not at all what we expected—or that which we mocked or condemned. This new cult is simply the silent reading of a book, the remembering of a hypothesis, a play upon the count of words. It is more and better than Christianity, without being any more than that. It is the reinvention of the divine as being nothing grandiose, nothing transcendent; as not being that which matters most in our lives; and at the same time as that which participates in them with an elegant and very beautiful discretion. It is the most effective way in which to repeat such a materialist gesture. To reinvent otherwise than Epicurus and Mallarmé these secondary gods—here, in my opinion, is a task for a philosophy rendered over to its immanentist power.



Mr Heggarty Goes Down

Sean Ashton

Illustrations by Nigel Cooke

I

You sometimes hear of men who walked out on it all, who upped and left without warning, went forth in their slippers for cigarettes and never came back. Their families say things like *His coffee was still warm* or *He never took his keys* or *Look, there's his jacket*, as if the poignant iteration of these details will be enough to secure the return of their loved one. And sometimes they do—sometimes they do come back, these inconspicuous men who thought to exempt themselves from human affairs. But mostly we learn that they have stepped out of time, as well as place.

Our man had it the other way round. Our man thought to step outside of time, but not place—at least, that is how it seemed to us. Like our notional

fugitive, his exile was self-imposed. And yet he never moved. He never went anywhere. On the contrary, he took root. And was all the more distant, all the more unreachable, all the more aloof, for his rootedness. On three separate occasions he seemed to take leave of his body. You might say that a kind of seizure passed through it. On emerging from these interludes, he professed no memory of their effects—even going so far as to suggest it had not been he but some other man who had succumbed.

It was this denial of the incidents, rather than the incidents themselves, that finally led Geoff Alloway to demand his resignation. But there was nothing in his contract that said he *couldn't*—there was nothing that said he *couldn't* lie down in a corridor for nine hours, or walk very slowly through a library over the course of an entire day, or, having tendered his banknote to the cashier in the university canteen, remain there, with his arm outstretched, like a man feeding swans, till security came to remove him. Those were the symptoms, and I give them to you like that, straight up, with no qualification, because that is how they happened: as abrupt and freestanding deviations from the normal course of things.

But let me give you the sufferer. The man in question was Doctor Richard Heggarty, a colleague of mine in the Visual Arts Faculty at East—— University. A new recruit, Doctor Heggarty had given a good account

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of himself in his behavior. The fact observed in his

unfortunate was that he was taking a risk with

himself. He was taking a risk with his

life. He was taking a risk with his

future. He was taking a risk with his

family. He was taking a risk with his

reputation. He was taking a risk with his

honor. He was taking a risk with his

integrity. He was taking a risk with his

character. He was taking a risk with his

virtue. He was taking a risk with his

conscience. He was taking a risk with his

peace of mind. He was taking a risk with his

happiness. He was taking a risk with his

well-being. He was taking a risk with his

future. He was taking a risk with his

life. He was taking a risk with his

of himself in his interview. The one obstacle to his appointment was his age: Were we taking a risk with someone so young? We eventually decided that his intellectual credentials outweighed his inexperience. His research profile, moreover, attested to an expertise sorely lacking in our department, his doctoral thesis having focused mainly on performance art, an area of our field in which—I will be frank with you—we had no collegiate interest. Our only mistake, perhaps, was to imagine Dr Heggarty a mere scholar of that discipline, when it would be more accurate, with the benefit of hindsight, to call him a practitioner.

He was only a month into his tenure when we realised all was not well. It was the last Friday of October. I had completed my tutorials early, and was thinking of making a dash for the station when I went up to the main office to check my pigeonhole.

As I walked in, the secretary handed me the phone. It was John Rusbridger, our Course Leader, and he sounded like he'd been running. I asked what was wrong, and he told me that Richard Heggarty had gone down.

'What do you mean, he's gone down?'

'I don't know,' said Rusbridger with levelling breath. 'He's just—gone down.'

'Fallen?'

'Not exactly, no.'

'Is he hurt?'



‘I don’t know. He won’t talk, he’s...’—there was a pause, the swing of a door, footsteps as Rusbridger found somewhere quieter—‘he seems fine, but he’s... he’s just not moving.’

Heggarty had gone down in the skywalk, an aerial corridor that joined the Visual Arts Faculty to the main campus. When I arrived, Den Ganley, Geoff Alloway, Rusbridger and a number of other senior lecturers were in attendance. There was also a porter and three girls I recognised as Heggarty’s students.

‘The porter found him,’ said Rusbridger. ‘Apparently he’s been here since ten.’

‘He didn’t think to tell us earlier?’

‘The porter? He assumed it was a student.’

Heggarty was often mistaken for a student in that first month. He was a decade older than his charges, but he looked younger than some of them. I could see why the porter hadn’t told anyone; the skywalk was used as an exhibition space for student work, and much of it was of a performative nature. The ancillary staff had been told to leave anything they found here alone, and most of them avoided it altogether, preferring to take the lift down to the ground floor to get to the main campus. A cleaner came once a week to mop the floor and wipe the push plates, but otherwise the students had the run of the place.

Heggarty was lying on his side in the middle of the skywalk. As the crowd parted to let me through,

Ashton—Heggarty Goes Down

I saw immediately that nothing was wrong with him. He had placed himself in the recovery position, but there were no visible injuries and he gave no sign of physical or mental distress. It was clear that Heggarty had not fallen; why, then, was he lying on the floor?



Everyone agreed that he had prostrated himself voluntarily.

‘He has chosen to go down,’ said Rusbridger. ‘But why? And why here?’

‘In point of fact, John,’ said Den Ganley, ‘if a man has to go down, it may as well be here.’

He was right. It may even have been that the skywalk was the best place of all.

‘You’ve tried talking to him?’ I bent down to examine Heggarty more closely. ‘Richard?’ His mouth was open, and a pool of saliva had formed on the linoleum. ‘Richard?’

I asked him to blink if he could hear me, but there was no response. He was scarcely animate. He had reduced himself to human rubble, a pile of organic matter. The only difference between Heggarty and the surrounding architecture was that Heggarty breathed. His breathing was quick and shallow, like a child’s, but at least he breathed.

The first thing was to get him out of there. We decided to move him to the couch in Rusbridger’s office. As we took the strain, however, Heggarty stiffened and began shaking—imperceptibly at first, then more violently as his displeasure at being touched became apparent. I’d grabbed him by the armpits and Den Ganley had hold of his legs. Two others moved in to support his torso, but as they slid their hands under his back, Heggarty’s face began to change colour.



‘Whoa!’ said Rusbridger. ‘He’s not breathing.’

We set him down; as we did so, Heggarty exhaled and resumed the recovery position. We tried again, but as soon as we moved in, he stopped breathing. This happened several times: whenever we advanced, Heggarty held his breath till we withdrew.

‘This is absurd,’ said Rusbridger. ‘We’re getting nowhere. Less than nowhere—we’re getting further away.’

It was true. Moreover, Heggarty’s respiratory defence had divided us: those who’d gone for his upper body were scattered to the south entrance, while those who’d gone for his legs were dispersed to the north. We were like two parties of climbers, one hailing the other from either side of an impassable gorge.

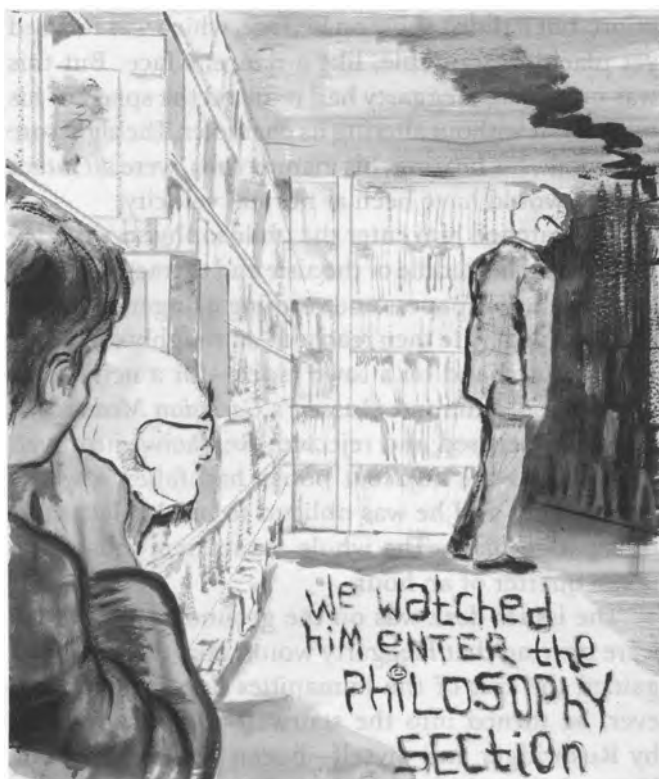
‘Now what?’ said Den Ganley from the opposite end of the skywalk. ‘What do we do now?’

The second incident happened in the library. This time, it was me that called Rusbridger. Rusbridger came rather less urgently than I had three weeks earlier, a coffee in one hand and a danish in the other.

‘Well,’ he said casually, as he arrived on the scene, ‘at least we won’t have the same problem as last time. At least he’s moving.’

And he was. Dr Richard Heggarty was moving. Just. Rusbridger shook his head. ‘What’s he doing?’

Ashton—Heggarty Goes Down



‘What does it look like, John? He is moving as slowly as possible: as slowly as it is possible to move without coming to a standstill.’

He was moving so slowly that everything else looked speeded up. It should have required immense

effort, but it didn't show on his face, which was focused yet placid, inscrutable, like a dancer's face. But this was no dance; Heggarty had reduced the speed of his movement without altering its character. The signature of his gait, his bearing, his mannerisms, were all intact, as they would have been at normal velocity.

We watched him enter the philosophy section. He stopped in the middle of the aisle and extracted a book, turning the endpapers and running a finger down the contents page. He then reached—at roughly the speed of a minute hand on a town clock—for a neighbouring volume, Edmund Husserl's *Cartesian Meditations*, which he perused and rejected. Replacing it proved difficult, for the adjacent books had fallen towards one another and he was obliged to use his left hand to separate them. The whole manoeuvre must have taken quarter of an hour.

The issues desk was on the ground floor, and we were praying that Heggarty would take the lift. As he gained the exit of the humanities department, however, he turned into the stairwell and—chaperoned by Rusbridger and myself—began the long descent. He made two detours, one to the toilet and another to the photocopier. By the time Heggarty got his book stamped, it was five o'clock. A single task had consumed an entire working day.

Heggarty refused to discuss the events in the skywalk and the library; whenever we raised the matter,

he claimed to have no recollection of his actions, professing disbelief that we could attribute them to him. If this amazed us, it infuriated Geoff Alloway. If Heggarty would not acknowledge his condition, how could he seek help with it? There were several meetings with the Head of School, all of them unproductive, and it was only Alloway's threat to recommend professional counselling that appeared to dissuade Heggarty from further transgression. For there were no more incidents—not till the last week of the summer term.

I'd gone down to the canteen early one day to beat the lunchtime rush, and was surprised to find a long queue moving very slowly. In fact, it was not moving at all. Everyone had been served; dinners were going cold on their plates, and people were getting angry.

The man at the front of the queue—it was Richard Heggarty—was oblivious to the mounting irritation. Heggarty had frozen mid-transaction, his arm extended toward the cashier. As I approached, I saw that his five pound note had torn as she'd plucked it from his grasp. The cashier had the 'promise to pay the bearer on demand the sum of ...' and Heggarty was left holding the Queen. Between the pledge and its guarantor was two feet of space. And this was all that existed for Heggarty, who stared into it, as though into a volcano, until security arrived to take him away. He offered no resistance, borne off like a mannequin, still clutching the torn bank note. That was the last time we saw him.

II

Apart from his indiscretions in the skywalk and the library, and his all-too public swansong in the canteen, Heggarty was a model worker—diligent, conscientious, and popular with the students. It was our reluctance to ascribe a pathological cause to his behaviour that made us turn to his research for answers. The Dean had demanded an official report, and Geoff Alloway wanted me and Rusbridger to write it. Many were the discussions we had, the conjectures and hypotheses we assayed, in completing this task, and I shall limit myself to our most plausible thesis. I say ‘plausible’, but we can’t discount the possibility that this was the conclusion we were meant to reach—the conclusion that Dr Richard Heggarty *wanted* us to reach.

Heggarty had left behind a number of notebooks, boxfiles, folios and sketchbooks, which we studied at length. At his interview we had noted his interest in the radical empiricist philosopher David Hume, and sure enough his papers abounded with references to the work of that great man. Hume, it will be recalled, held that there is no reason to suppose that just because certain effects have always been seen to follow certain causes, they shall go on doing so, of logical necessity. Hume’s scepticism of causal necessity fascinated Heggarty. It was John Rusbridger’s contention that our colleague had mortified himself by placing his body in the service of this philosophical notion.

The theory was expounded one evening in the pub after work. Rusbridger had examined Heggarty's papers more closely than I, and as he laid the material on the table I saw that he'd singled out several passages for discussion. He selected one, and read from it:

"If, as Hume says, there is no logical reason to suppose that things must continue as they have always done simply *because* they have always been that way, then I do not know what right we have to assume that the moon will be in its anticipated place tomorrow..."

Rusbridger paused to evaluate the impact of this proposition. Heggarty seemed to have lumped Hume in with all the other iconoclasts. Like many sceptics, Hume could be something of a logical contortionist—capable of proving the opposite of what we know to be the case—but he was not meretricious, like Zeno with his pert paradoxes, his refutation of motion and so forth; or outlandish, like Berkeley with his glib denial of matter. I suggested to Rusbridger that our inability to say whether a certain cause shall go on producing a certain effect was a shortcoming of *logic*, not of causality. Logic and contingency are mutually exclusive. That's what Hume was getting at.

'The point is,' continued Rusbridger, paraphrasing Heggarty's notes, 'the point is that prior empirical experience does not entitle us to be certain of any future event. You will allow that anything is possible for those who take Hume at his word. You will allow

that, for the card-carrying Humean, it is not impossible that I, John Rusbridger, shall rise unaccountably to the ceiling before finishing this pint.' And he held his brew aloft, as though rehearsing the ascent.

'I stake everything I own on the opposite eventuality,' I said, placing my wallet on the table.

Rusbridger declined to meet the wager. 'We must curb our prejudices,' he said, raising a cautionary finger. 'Our purpose is not to challenge the validity of these notions but to examine how our colleague came under their sway. Contemporary proponents of Hume's scepticism of causal necessity hold that hitherto universal laws—gravitation, for instance—may one day cease to operate. Now it follows, does it not, that if universal laws were to change, then that change would have to occur at some point in time and space?'

I pointed out that if the laws were indeed 'universal', then they might be expected to change everywhere simultaneously—at every point in time and space.

'I was coming to that.' Rusbridger reached into his briefcase and took out one of the sketchbooks we'd found among Heggarty's things. 'You have anticipated Heggarty's own feelings on the matter.' He found the relevant passage: "Everywhere or somewhere?" See—he too wrestled with this conundrum.'

He opened the book and weighted it down with his pint. The pages were covered with thumbnail sketches, each contained in its own box, each depicting

a solitary figure in a different position and a different architectural context. The size of the drawings made it hard to identify the setting, but some could be deduced from the stance of the figure, which seemed to imply escalators, train carriages, bus stops, shopping centres. More interesting were the lines surrounding the figure, which appeared to denote movement.

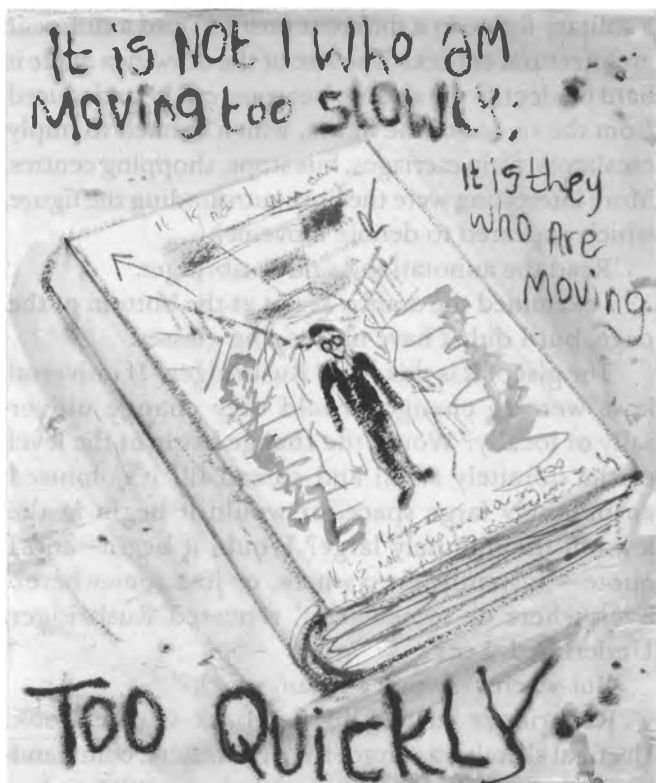
‘Read the annotation,’ said Rusbridger.

I examined the crabby script at the bottom of the page, but I didn’t have my reading glasses.

‘The gist of it is this,’ said Rusbridger. ‘If universal laws were to change, would they change universally or locally? Would the change begin at the level of the infinitely small and spread till it colonised an infinitely large space, or would it begin at the level of the infinitely large? Would it begin—and I quote—“instantly, everywhere, or just somewhere?” Everywhere or somewhere,’ repeated Rusbridger. ‘Underlined. See?’

‘But where?’ I said. ‘I mean, which?’

Rusbridger turned to the back of the book. The final sketch was larger than the others, commanding a whole page. Again, it depicted a lone figure, but this time the architecture was more discernible—I could make out bookshelves, striplighting, a checkerboard of ceiling tiles receding into the distance. Again, there were lines surrounding the figure, denoting movement: the movement of people, onlookers, their limbs and



faces warped and stretched, as though documented by a camera's long exposure. There was a caption beneath the drawing. I read aloud:

'It is not I who am moving too slowly; it is they who are moving too quickly.'

‘Heggarty in the library,’ said Rusbridger. ‘On the previous page he asks where it would happen—the alteration of universal laws. On the next, he gives his answer: not everywhere but somewhere. Not universally, but locally.’

‘In the body of a senior lecturer?’

Rusbridger drained his pint. ‘Why not? We must think of that body not as the body of a senior lecturer, but as a mere locus in time and space. We must think of it as nothing more than a localised cluster of atoms destined to participate in the disinterested continuation of the cosmos. Another?’

While Rusbridger was at the bar, I pictured our former colleague in his interview, primed, expectant, eager to prove himself. I thought of his CV, his research profile, the sincerity with which he’d outlined the qualities he would bring to the post—all reduced, now, to a ‘cluster of atoms’, a mere organism: the organism known locally as Dr Richard Heggarty.

It was these words—‘the organism known locally as Dr Richard Heggarty’—that Geoff Alloway quoted back to us after reading our report. When we arrived in his office to hear his verdict, he’d already begun destroying the evidence, tearing the pages from the comb-binding and feeding them individually into the shredder.

He sat down at his desk and read from a page singled out for more exacting criticism. “‘If universal

laws should change locally rather than universally”, he began, “it stands to reason that they need a locus, a point in space and time in which to inaugurate themselves. Our colleague—our erstwhile Dr Heggarty—was that locus, or so it seemed to him...The incremental nature of his progress through the library, the reduction of his ambulation to minimal velocity, was, to all intent and purpose, from his perspective, the new order of things...”

As we watched our purple prose disappear into the shredder, we were forced to concede that we’d overdone it, that we’d entered too enthusiastically into the spirit of Heggarty’s project, the better to comprehend it. We’d begun our report by stitching together salient passages from Heggarty’s notebooks, meaning to paraphrase them later into plainer English. But we’d been seduced by his style and left many intact—too many, we now realised. Only on hearing our words aloud did we see that most of them were Heggarty’s.

‘And what about the incident in the skywalk?’ asked Geoff Alloway. ‘There’s no mention of it.’

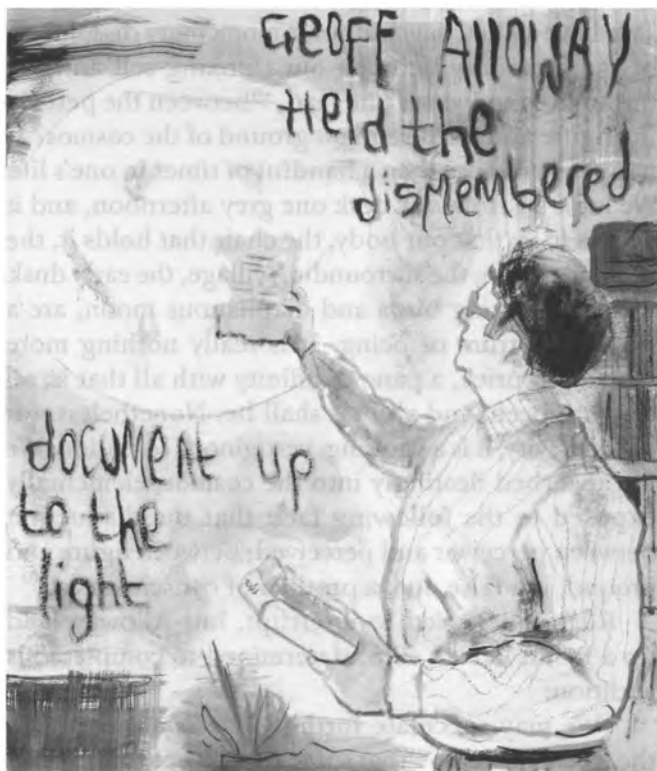
We’d consigned it to a long footnote on page sixteen. We directed our line manager to the relevant passage. Geoff Alloway held the dismembered document up to the light, his pupils dilating as they tried to focus on the eight-point text:

“We have all felt, have we not, a momentary dissolution of the boundary between our thinking self and the unthinking universe,” he read, “between the perceiving figure and the insentient ground of the cosmos? It happens no more than a handful of times in one’s life. We look up from our desk one grey afternoon, and it occurs to us that our body, the chair that holds it, the room we are in, the surrounding village, the early dusk, with its roosting birds and diaphanous moon, are a single spectrum of being. It is really nothing more than a pin-prick, a pang of affinity with all that is, all that has been, and all that shall be. Nonetheless, for all its brevity, it is a vaulting, vertiginous sensation. We are absorbed fleetingly into the cosmos, elementally exposed to the following fact: that the distinction between perceiver and perceived, between figure and ground, is a false one, a product of consciousness.”

Rusbridger tried to interrupt, but Alloway held up a hand, like an actor determined to complete his audition:

“We may speculate further,” he continued with theatrical disdain, “that some experience this dissolution of figure and ground more acutely than others; that in certain men and women these interludes are more pronounced, more intense. Perhaps Heggarty was one such man. Perhaps, as he reached the middle of the skywalk, this interlude, this cosmic caesura, extended far beyond its normal duration, and he sought

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to extend it further, to prolong it, to maintain the porosity of the boundary between figure and ground for an indefinite period. It was at this point that he went down. One moment, he was separate from the universe, observing it, making his way through it,

going from A to B with the characteristic aloofness of the human species; the next, he was barnacled to it. At that moment, the passage from A to B became, not just unlikely, but an impossibility in the mind of Richard Heggarty, since how can one pass through what one is part of...”

Geoff Alloway removed his spectacles and looked at us gravely: “Barnacled”, gentlemen? *Barnacled*?”

We realised, when we discussed the matter down the pub that evening, that we’d neglected the one issue we’d been expected to address: whether or not Heggarty had faked his condition. Geoff Alloway needed to tick one of two boxes—‘mental illness’ or ‘professional misconduct’—and our report had not allowed him to do that.

We preferred to put the question another way: Did Heggarty really believe his body to be the site of a local alteration of universal laws? Rusbridger said that it didn’t matter. What mattered—what mattered to Heggarty—was whether we would recognise such an alteration if it chose an individual as its incipient point, or whether we would dismiss that individual’s behaviour—his response to the perceived alteration—as madness.

I reminded Rusbridger of the conviction of Heggarty’s words: *It is not I who am moving too slowly; it is they who are moving too quickly.*

‘Those words smell of psychosis,’ he conceded, ‘of the belief that one’s own perspective, no matter how different to the prevailing consensus, represents the true order of things. But they smell far too strongly of psychosis to ring true.’

‘A simulated psychosis?’

‘I’d call it a “rhetorical” psychosis.’

‘You’re going to have to unpack that for me, John,’ I said. ‘And fast. It’s nearly eleven.’

‘I shall do better than that,’ said Rusbridger. ‘I shall ply it with Glenfiddich and make it walk on its hind legs.’

We both had full pints as the bell went for last orders, but Rusbridger insisted on a pair of single malts.

‘I put it to you,’ he began when he returned with two doubles, ‘that Heggarty has identified Hume’s scepticism of causal necessity as a confluence of personal and cosmic psychosis.’

According to Rusbridger, Heggarty had been exploring the idea that personal psychosis was a local manifestation of cosmic psychosis. In other words, personal psychosis was the alteration of universal laws experienced from the perspective of an individual organism. By ‘experienced’, he did not mean that the organism ‘beholds’ the alteration as an extrinsic phenomenon, but that it participates in it: that it goes down in the skywalk, moves slowly through the library, stands motionless in the canteen, not through personal

volition but through cosmological decree. Hume's scepticism of causal necessity forces us to contemplate the possibility of unaccountable alterations, radical contingencies. The ones mooted by contemporary philosophers were often playfully cataclysmic—the abeyance of gravity, stars that emitted darkness rather than light—but Rusbridger saw no reason why these contingencies shouldn't be more quotidian, more humdrum, why they shouldn't be more behavioural, why they shouldn't implicate *Homo sapiens* directly. Heggarty's 'mortification' was one such example. A stage-managed example, true: a ruse designed to anchor his research in a somatic sense. And why not? If you can't simulate gravitational abeyance or stellar inversion, why not lower your ambitions and posit your body as the site of a putative cosmic caesura?

Radical empiricism had outgrown its theoretical methods and must now embrace corporeal means—this was John Rusbridger's reading of Heggarty's work.

'It's a call-to-arms,' said my colleague, rapping the table with an open palm. 'A covert one, I'll grant you, but a manifesto of sorts. Look at the programmatic tone, the demagogic exhortations to the reader to "place his body in the service of a new discipline". Evidently, he sees himself as a figurehead. It's there in his prose style. His prose has the manic assertiveness of one who believes he is addressing posterity.'

‘A pity we had to let him go then,’ I said, ‘if Heggarty felt himself to be at the vanguard of something. That might’ve been useful for us. We could have tucked into his slipstream.’

‘You and I?’ said Rusbridger. ‘Acolytes?’

‘Why not? Look at us, John.’

He knew what I meant. What had we done lately? What had we achieved, during the last five years of our tenure? When did we last give a conference paper or submit something to an academic journal? Where was Rusbridger’s book, his much vaunted rereading of late modernism, his ‘rebuttal of Greenberg and Fried’, as he liked to style it? And where was my study of the Hungarian photographer Rudolph Balogh, slated for publication in ’04, but now annually deferred? How was that coming along?

‘Admit it,’ I said. ‘Heggarty’s activities have galvanised us. Why, your exegetical work has been nothing short of astonishing, John.’

Rusbridger blushed. He had done his best to decrypt Heggarty’s papers. But a simple question remained unanswered:

‘What is Heggarty?’ I asked.

‘What do you mean?’

‘Like you say, he eschews analytical methods for direct action. Corporeal intervention. What does that make him? A performer? An activist? An artist?’

We both felt the disappointment. To attribute all this to art seemed to condone rather than explain it: by consigning it to an arena of bourgeois transgression, we were shielding it from serious intellectual scrutiny.

‘I mean, are we to regard Heggarty’s actions as a body of work?’

‘Perhaps,’ said Rusbridger. ‘Though I for one believe the incident in the skywalk was improvised.’

I don’t know why, but this amused me. ‘A study? A “preliminary sketch”, as it were?’

Rusbridger smiled, then looked sternly into his whisky. ‘When Heggarty awoke that morning, I do not think he said to himself, “Today I shall go down in the skywalk”. I do not believe he foresaw that course of action. More likely, he parlayed an existing sensation—that momentary sense of being subsumed into the cosmos—into something more permanent. The sensation is more common than he imagined; it is even possible that he thought it was unique to him.’ Rusbridger swivelled towards me in a gesture of hastily manufactured epiphany: ‘It is even possible he misconstrued it as a form of Gnostic “inspiration”.’

The lights had come on, chairs were being stacked, the barmaid was standing over our table with a dishcloth. ‘Let’s not bring the Gnostics into this, John,’ I said, handing her my glass. ‘Not at this late stage.’

But Rusbridger wasn’t done. ‘What about the incident in the canteen?’ he said, as we got up to leave.

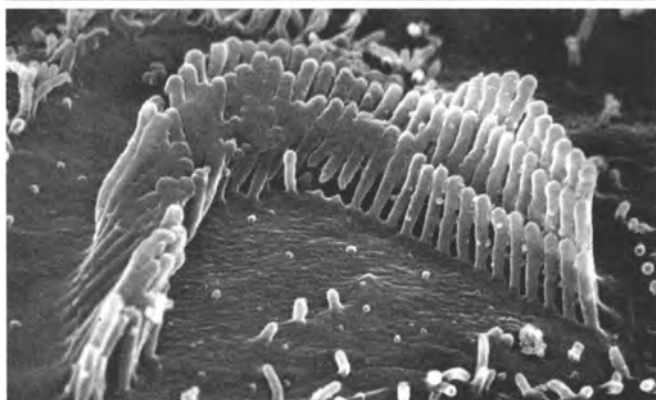
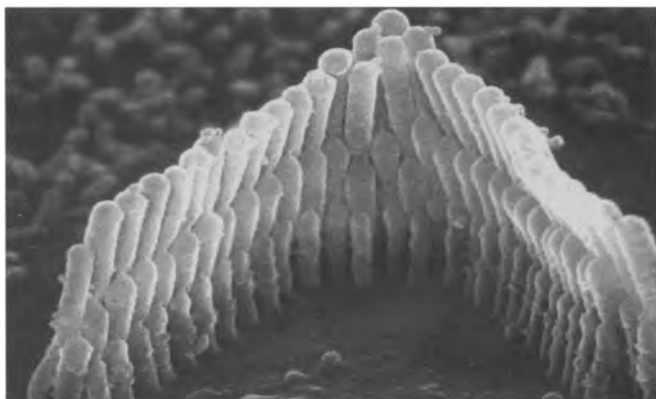
‘There’s no mention of it anywhere.’

‘Maybe he didn’t have time to write it up.’

‘Perhaps he’ll send for us when he does?’

‘I think it more likely that he’ll publish his findings elsewhere.’

I wish I hadn’t said this now. If I hadn’t said it, we wouldn’t feel compelled to keep an eye on the literature associated with Heggarty’s field. And that was the problem, wasn’t it: what was his field? To our knowledge, there was no quarterly devoted to bio-philosophical interventionism or onto-cosmological situationism. We think it unlikely that he’ll go through the standard publications, the art periodicals and cultural theory journals, but we keep tabs on them anyway: *Critical Inquiry*, *The Grey Room*, *Interregnum*, *The British Journal of Aesthetics*, *Hapax Legomenon*, *Op. Cit.*, *Brontosaurus*, *Texte Zur Kunst*, *The New Kilmarnock Review*....And nothing. Nothing yet.



Healthy, moderately damaged, and severely damaged stereocilia.
Images by Dr. J. O. Pickles, University of Queensland, 2002.

CAUTION

GegenSichKollektiv

**DISCLAIMER: WE TAKE ABSOLUTELY NO
RESPONSIBILITY FOR POSSIBLE DAMAGE
CAUSED TO YOUR HEARING IN THE CASE
THAT YOU DECIDE TO REALIZE THE
CAUTION EXPERIMENT**

COLLAPSE VIII

HISTORICAL CONTEXT

Ancient life was all silence. In the nineteenth century, with the invention of the machine, Noise was born. Today, Noise triumphs and reigns supreme over the sensibility of men.

RUSSOLO, 1913

And when Joshua heard the noise of the people as they shouted, he said unto Moses, There is a noise of war in the camp.

EXODUS 32:17

Noise and danger have walked hand in hand throughout history: from apocalyptic biblical trumpets to the current Long Range Acoustic Device used as a sonic weapon, for example, at the London Olympics in 2012. Outside the ‘official’ battlefield, in the context of art and music, people have tried many times to take noise to its ultimate conclusion, to its physical limits. Many stories are told, ranging between legend and fact. It is said that at the end of the 70s, Throbbing Gristle (and presumably Monte Cazazza) carried out infrasound and ultrasound experiments in their Hackney studio in order to force an unwanted group of Gypsy neighbours to leave the area.

And the speculations of David Bowie and William S. Burroughs about the Black-noise bomb, the French patent for Dr. Gavreau's infrasonic generator, which anyone can purchase for 40p and presumably use to build a Sound Ray Machine in their basement—an idea that also came to haunt Jimmy Page. A whole generation of noise and 80s industrial musicians dreamt about a warehouse with military spec sound equipment able to reproduce these low frequencies at very high volume thanks to speakers built entirely of metal or stone—A sort of cyberpunk reworking of Artaud's Theatre of Cruelty. Even in the case of the Cybernetic Culture Research Unit (under the command of Sadie Plant and Nick Land), exercising an inhumanism that appealed to the galvanic potencies of rave music, it seems that the dream was to explore the limits of sound in the same collapsed playground in which they were redeveloping nonconceptual negativity. Ray Brassier said of Land:

If you're accelerating, there are material constraints upon your capacity to accelerate, but there must also be a transcendental speed limit at some point. The ultimate limit is not a limit at all for him, it's death, or cosmic schizophrenia. That's the ultimate horizon. Land unabashedly endorses this remarkable thesis of *Anti-Oedipus*, but strips it of all its palliatives, about how this might generate new forms of creative

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existence, etc. For him it's just: 'at the end of the process is death'.¹

We wish to try to find a way of obliterating the constraints upon noise's capacity to accelerate negativity to the point of self-abolition.

SETUP

We want to take noise to its ultimate consequences by contemplating the possibility of the existence of an audio support which contains the most damaging audio material to the human hearing apparatus. Henceforth we will call it: CAUTION Object.

The justification for this: to reintroduce risk, chance and extremity back into experimental music.

The questions raised by this game are the following: Is it necessary to have a physical experience of the content of the CAUTION Object (which would result in damage to your body or nervous system)? And if not, then could the conceptual development of this proposal alone—if taken to its ultimate consequences—develop the potential of noise?

1. R. Brassier, 'Accelerationism', talk given at *Accelerationism* symposium, Goldsmiths University of London, 14 September 2010. <http://backdoorbroadcasting.net/2010/09/accelerationism/>. Transcript at <http://moskvax.wordpress.com/2010/09/30/accelerationism-ray-brassier/>.

RULES OF THE GAME

We will provide the necessary elements to generate the material conditions to experience what is believed to be the most damaging sonic material for the human ear.

You will have three choices:

(A) To generate the listening experience and take the physical risk.

(B) To explore the conceptual potential of this proposition by considering that the subversive qualities of noise rest at the level of abstract form rather than that of its sonic qualities.

(C) An alternative path, which we will call 'Dialectical Conception of Noise'.

A. SENSATION OBLITERATES CONCEPTION

In case of deciding to listen to the content

A certain amount of scientific/medical research is necessary to certify the functioning of the device (CD, computer, etc.) designed to produce the experience of the content of the CAUTION Object. Some appropriate

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information is presented below. As far as the physics of the CAUTION Object is concerned, we have two questions:

(A1) Which audio signal (which may be electronically represented in either digital or analog format) is scientifically verified (by which we also mean that it is materially possible to produce) to be most dangerous to humans—not only for the human hearing system, but also for the subject's health ('condition of an organism or one of its parts in which it performs its vital functions normally or properly')? In other words: Which is the most audio-band frequency most hazardous to the human?

(A2) Depending on the answer to the first question, what protocol and material conditions are necessary in order for this experiment to be carried out? The risk and opportunity at the time of listening to the CAUTION Object involve a direct activation of the listener's performative activity; therefore their decision is subject not only to the level of their commitment to their prior decision (whether or not to listen to the CAUTION Object), but also depends on how the sensory experience determines their subsequent behaviour: to expose themselves to a greater or lesser extent, or to adopt immediate protective

measures, depending on the level of risk they ultimately find they are prepared to face.

‘PHYSICS’ OF THE CAUTION OBJECT

A1. Frequency

For a sinusoidal time course, the number of repetitions per time unit is called the frequency, measured in Hertz = 1/second. The healthy human ear can hear frequencies ranging from 20Hz to 20,000Hz. According to the *Working Paper on Infrasound Weapons* produced by Hungary for the United Nations in 1978, the frequency thought to be most dangerous to humans is between 7 and 8Hz. The infrasound frequency of 7Hz is the median frequency of the brain’s theta rhythms. The current consensus seems to be that 4kHz is the most sensitive frequency for the cochlea. Noise damage at this frequency causes often irreparable outer hair cell damage, which causes hearing loss. The damage is due to excessive mechanical energy delivered to these very delicate structures. Energy transmission through the middle to inner ear is at its most effective at roughly 4kHz, depending on the size of the subject. Thus frequencies near 4kHz are potentially the most damaging.

The delicate structures of our hearing system are well protected inside the skull. For sound transmission, the outer ear canal acts like an open pipe with a length

of about 20 to 30 mm. Its quarter-wave resonance is responsible for the high sensitivity of our hearing organ in this frequency range, indicated by the dip of the threshold around 4KHZ. This high sensitivity, however, is also the reason for high susceptibility to noise-induced damage in the region around 4KHZ.²

Hair cells that are tuned to frequencies near 4KHZ are particularly vulnerable to noise damage. Therefore, audiograms of patients with noise damage often have characteristic 4KHZ notches.

There are not many experimental studies with humans. In order to estimate expected effects, studies usually evaluate related temporary hearing loss (or temporary threshold shift, TTS) experiments using damage criteria obtained from the parallelism between TTS and permanent hearing loss (or permanent threshold shift, PTS), and assess the results of experiments on animals in an attempt to extrapolate these findings to human hearing.

It is assumed that the lack of available research material studying the effect in humans is accounted for by the fact that the Department Of Defense and related private research organizations carry out most of these experiments, with the results obtained remaining private and restricted from public knowledge.

2. G. Mazzola, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhäuser. 2003), 1036–7.

Doctor in physics Jürgen Altmann, whom we consulted during this research, has carried out several theoretical studies, but without carrying out any experimental trials on humans. His answers to our questions were most unenlightening, and served only to confirm evident disinformation about the frequency content potentially harmful to humans. Most studies in this area limit themselves to observing the irrefutable damage caused by exposure to audio at very high sound pressures over short periods of time—for example, shock waves from explosive blasts.

A.1.1. Sound Pressure Level and Time of Exposure

Sound intensity is measured as sound pressure level (SPL) on a logarithmic decibel (dB) scale. Normally it is not the ‘signal’ but rather the sound pressure level in certain frequency bands that produces damage. Noise-induced hearing loss (NIHL) is an increasingly prevalent disorder that results from exposure to high-intensity sound, especially over a long period of time. ‘NIHL usually occurs initially at high frequencies (3, 4, or 6 KHz), and then spreads to the low frequencies (0.5, 1, or 2 KHz)’.³ Aural pain usually occurs on crossing the region of 140dB (200 Pa), but signs of pain need not in themselves indicate permanent damage.

3. J.-D. Chen & J.-Y. Tsai, ‘Hearing Loss among Workers at an Oil Refinery in Taiwan’, *Archives of Environmental Health* 58:1 (2003): 55.

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Eardrum rupture occurs in the audio region above 160dB (2 kPa). At levels of about 200dB, lungs begin to rupture, and levels above about 210dB can lead to death.

The research carried out by the group SARA (Scientific Applications and Research Associates) concludes that:

Infrasound at 110–130dB would cause intestinal pain and severe nausea. Extreme levels of annoyance or distraction would result from minutes of exposure to levels of 90 to 120dB at low frequencies (5 to 200Hz), strong physical trauma and damage to tissues at 140–150dB, and instantaneous blastwave type trauma at above 170dB. At low frequencies resonances in the body would cause hemorrhage and spasms; in the mid-audio range (0.5–2.5 KHz) resonances in the air cavities of the body would cause nerve irritation, tissue trauma and heating; high audio and ultrasound frequencies (5–30 KHz) would cause heating up to lethal body temperatures, tissue burns, and dehydration; and at high frequencies or with short pulses, bubbles would form from cavitation and micro-lesions in tissue would evolve.⁴

4. SARA report, 10 February 1995.

A.2. Recipe for CAUTION (Material Conditions of the CAUTION Object's Output Device)

Download the audio computer software Supercollider from <http://supercollider.sourceforge.net/downloads/>. Execute the following Supercollider code in order to generate a 4KHZ tone:

```
{SinOsc.ar (4000)}.play
```

Equipment to amplify signal to 170dB: Obtaining a sound system that reaches 170dB is no easy task. We would like to present just a couple of examples, one low- and one high-tech.

Alan Dante from Lorton, Virginia set a new world record on 31 August 2013, in a dB drag competition⁵ with a 180.5dB peak using a single Digital Designs subwoofer. Dante's concrete-filled Volvo contained a Digital Designs 9918Z 18-inch subwoofer receiving 26,000 watts of power from four Stetsom 7KD amplifiers. To power that system, Dante used 15 Powermaster 16-volt batteries and a Flux Capacitor. This is just one indicative example for guidance. It would be difficult with this exact equipment to ensure our goal. We think that 44,000 watts of power (the strength of a big-city radio station) may serve to reach the target.

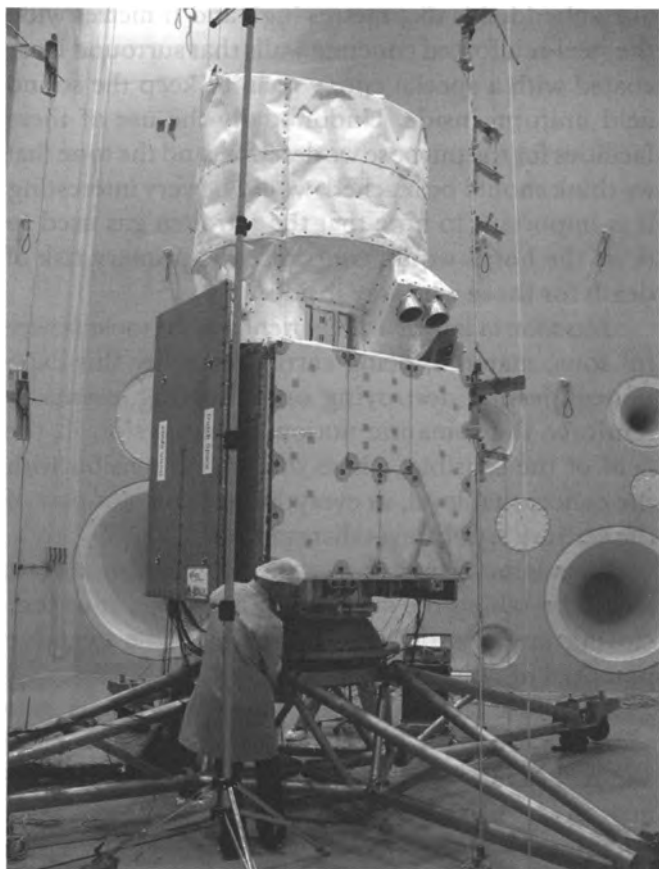
5. dB drag racing is a competition rewarding the person who can produce the loudest sound inside a vehicle.

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Regarding speakers, the 9918Z by Digital Designs can achieve as much as 180.5dB through its 18-inch subwoofer. Four Stetsom KD amplifiers capable of producing a total of 26,000 watts have powered the speaker in a known previous event.

It is worth highlighting that during dB drag racing, the test tone consists of a very short resonating tone between 30Hz and 70Hz, called 'the burp'. This is a much lower signal, and reaching 170dB with a 4KHz tone may be more difficult, given the lack of previous experiments and tests, but a 4KHz tone is thorny enough to cause irreversible damage at these incredible amounts of sound pressure.

We also have the example of the Large European Acoustic Facility (LEAF) in the Netherlands, a facility which consists of four different horns with cutoff frequencies of 25Hz, 35Hz, 80Hz and 160Hz plus three high-frequency generators used to realistically simulate the spectral noise pressure levels present in spacecraft launches. These acoustic noise tests are designed to ensure that no damage will occur during the rocket launch, and use nitrogen gas to produce sounds as loud as 154dB. Despite having been announced by the press as 'A Speaker So Loud It Can Kill You', and despite the European Space Agency having claimed that 'no human could survive', the fact is that the frequencies that being used at LEAF are again far from being a 4KHz tone. The wall in which the horns



Aeolus Structural Model in the Large European Acoustic Facility (LEAF)
[Image: ESA-Anneke Le'Floch].

are embedded is 16.4 metres high and 11 metres wide, the steel-reinforced concrete walls that surround it are coated with a special epoxy resin to keep the sound field uniform inside. Undoubtedly the use of these facilities for the purpose we describe, and the tone that we think should be reached, would be very interesting. It is important to note that the nitrogen gas used to drive the horns would constitute the primary risk of death for those who stay inside.

Sensation in isolation: Experiencing the most powerful sonic material, being carried away by this experience, despite destroying one's hearing, seems to reinforce the romantic notion of immersion in the field of the sensible, where there is no tension with the conceptual level, as everything that is not part of the sensory spectrum is disregarded.

What is more, in each case, the experiencing subject would be taking the last turn of the game, thus foreclosing any possibility of socializing the negative potential of noise.

Therefore this would be noise in its most conservative form: an escapism not only from society and reality but from life itself (if you take this experiment to its ultimate consequences), without giving anything in return, without yielding anything apart from one's own subjective experience. This would be an individualised form of self-abolition.

B. CONCEPTION OBLITERATES SENSATION

In the Case of Deciding Not to Listen to the Content

How could the subjective physical experience of the CAUTION Object impede our access to the supposedly subversive attributes of noise as an abstract form?

The usual presentation of a subjective process of interpretation (in this case the interpretation of the CAUTION Object) implies access through experience. This experience would inevitably be mediated by our senses, which would also determine our perception of the aesthetic context. This subjective perception of the aesthetic context subordinates the production and reception of noise to criteria of taste and to individual (physical and cultural) determinations. Gadamer described the ontological character of the work of art as an experience of reality, being, and truth, in contrast to the abstraction of aesthetics' consciousness and its subjectivist character. Thus, we have to figure out how to extract the 'real' from the physical experience of the CAUTION Object, and how to deal with all of the aesthetic constructions triggered by our cultural baggage, intellectual abilities, aesthetic education, social class, gender, race, etc.... Aesthetic consciousness tends to undermine the game's cognitive

claims so that it is only understandable from the point of view of the players' own subjectivity.

The Kantian tradition in the study of aesthetic experience focuses attention on the plane of the subject by emphasising individuals' subjective experiences. It is according to this proposition that Kant establishes the autonomy of art, his well known form of disinterested contemplation of beauty, and the more vexed assumption that beauty has nothing to do with truth. Far from aspiring to return to this question, what we want to recover here is the idea that emerges from Gadamer's work: the idea that the freedom of subjectivity activates itself in the game. The players are not playing a game; it is the game itself that plays them. But the 'freedom' of the game does not mean an absence of rules; to play is to found an order. Therefore the players subsume their voluntary freedom to the rules of the game. If the game is successful, it will generate an act from which a different type of freedom might emerge: a compulsive freedom that is indifferent to ourselves as individuals. Understanding this act as a superimposition of rule-conforming behaviour onto pattern-governed behaviour,⁶ our actions as players within the game are laced with the conditioning pattern that results from the game itself and its rules. A pattern-governed behaviour operates in line with our

6. R. Brassier, 'Unfree Improvisation/Compulsive Freedom' (2013). http://www.mattin.org/essays/unfree_improvisation-compulsive_freedom.html.

cultural and biological determinations. To assume and conform to the rules of the game is a precondition for our acting according to the rules. The optimum execution of the game pursuant to the rules depends on this agreement—an agreement which seems to evoke an action that goes against the impulsiveness of subjectivity: one must relinquish the autonomy of subjectivity in favour of being able to perform the game according to its rules.

How does the certain objective nature of a rule-based game activate the freedom of a subjectivity within the context of this game? Passing through the pattern and the rules of the game entails an acknowledgement of our lack of freedom in the facultative activity—what is understood by Brassier as *the gateway to compulsive freedom*;⁷ recognizing the unfreedom of voluntary activity, being aware of how objectivity generates subjectivity. *The subject as agent of the act is the point of involution at which objectivity determines its own determination*.⁸

Gadamer appeals to a kind of rationality free from ends which is characteristic of human games: children giving themselves rules to play by. We are interested in this perspective because it connects with Brassier's idea of compulsive freedom. For Gadamer the game is ultimately the self-representation of the

7. Ibid.

8. Ibid.

movement of the game. We believe that the game metaphor in his work *Truth and Method*⁹ does not imply the annulment of human freedom, but rather represents a vindication of man's place in all understanding and puts us on the horizon of the genuine idea of responsibility.

George Berkeley stated that our knowledge of physical objects begins in experience, and that physical objects cannot exist apart from our experiences of them. This submission is closely connected with correlationist thought, the assumption of the impossibility of a mind-independent reality. The confusing association between ideas and experiences is derived from the act of identifying the 'act' of thinking with the 'object' of thinking.

In this game such confusion is averted, since we will have two distinct paths to choose from: conception or sensation.

Noise's subversive potential lies at the level of abstract form; and not in any alleged radicality attributed to its sonic content (volume, frequency, pitch, etc.).¹⁰ But why do we want to try to develop noise conceptually? Because we think that the promise of noise in its sensorial expression has lost its subversive

9. H.-G. Gadamer, *Truth and Method* (London: Sheen and Ward, 1989).

10. R. Brassier and Mattin, *Metal Machine Theory 3: An E-Mail Conversation*, http://www.mattin.org/essays/METAL_MACHINE_THEORY_3.html.

qualities—as we have seen, even the extreme exercise proposed above would represent a cul-de-sac.

We aim to propose the use of reason as an engine for developing noise beyond subjective experience. Because we think noise has the potential to exacerbate the rift between knowing and feeling by splitting experience, forcing conception against sensation.

Brassier again shows us a series of dead ends in subjective experience:

The task can be achieved by exposing the entirely contingent, conventional character of the phenomenological self-image promulgated through the myth of subjective interiority; by denouncing the hallucinatory character of privileged access [the lynchpin of all foundationalist demands]; and by inveighing against the illusory authority of the first-person perspective; myths which, whether taken separately or in combination, serve to shore up the subjectivist ideology through which liberal democratic capitalism convinces a stupefied population of consumers that they are sovereign individuals, naturally endowed with freedom of choice, and that the interests of subjective freedom coincide with the interests of a free market economy.¹¹

11. R. Brassier, *Alien Theory: The Decline of Materialism in the Name of Matter* (PhD Thesis, University Of Warwick, 2001). <http://wrap.warwick.ac.uk/4034/>.

Taking this into account, what might the conceptual path in the production of noise be? The question, we believe, is not a straightforward one.

The work of some of contemporary noise artists may serve as an example. Jliat (James Whitehead), Jarrod Fowler, Mattin, and Taku Unami, for example, have shown works where conception obliterates sensation. This can be very interesting, but also (like bad conceptual art) runs the risk of evacuating sensation and reifying conception, since it does not preserve the *tension* between conception and the sensory. If we look at some of these works, we can see how a cryptic use of language, or the context of the piece's presentation, can operate as a shortcut to highlight the cognition of the work—a very dangerous manoeuvre that reifies conception. In fact, conception is the only material presented in the suggested framework, which means that it operates in a context where abstract ideas must be adapted to the rigorous parameters that govern disciplines within the formal sciences. In the field of arts the problem is different: in art, the abstract entities are rarely based on axioms and rarely follow logical thinking; even in the naive assumption that some artwork is produced under such epistemic vehemence, as Deleuze and Guattari stated, art's plane of composition is not equal to science's plane of reference.

There is a transition here from noise conceived as 'unwanted sound' to noise conceived as

something endowed with aesthetic attributes (which the subject receiving the experience may or may not enjoy), because of its transgression of initial conception or initial definition. The power of noise lies in its capacity to generate conceptual shifts in the listener's perspective. As noise is always redefined, we need a material with which the concept associated with noise will be able to operate—a sensory component that forces you to consciously think about the real in the experience of what you are feeling.

Walter Marchetti said that if you think about music, this is already music; but in that case, reifying the process of conceptualization means that there is no tension with the material. Here, the disturbance in the conceptual process is completely alien to the physical danger proposed on the 'A' path. Obviously, if you only think about this game, this poses no risk for you. You are safe with your knowledge wherever you are reading about this. There is no risk, no problem. You can think of this text as a substitute activity for experiencing the CAUTION Object, but it does not share the dangerous attributes of listening to the most damaging sonic material for the human ear.

C. DIALECTIC CONCEPTION OF NOISE

Subjectivity disappears once the play of chance is accelerated, once the formation and the obsolescence

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of combinations is so fast that all fixed conglomerates vanish in favour of an incessant chaotic and anonymous process.¹²

Noise, by means of combining conceptualization and sensory sonic material, defies your epistemic categories if it places you in an unprecedented situation where you are defenceless. In order to do this we dialectically need both parts: Sensation (perception/experience) and conception. In this process, a tension is generated which it is essential to conserve.

Looking at historical examples, we find that in the early 60s Robert Ashley started to use unwanted audio feedback for musical purposes. Soon after that, The Beatles recorded the song 'I Feel Fine', starting with a feedback note produced by McCartney's bass which was picked up on Lennon's semi-acoustic guitar. This voluntary process related to an aesthetic purpose is a commodified sound which is entirely contrary to the idea of noise as unwanted sound. In this case there is no danger because there is no material or sensory threat to the listener.

Throughout the career of the seminal band Whitehouse (also English) we can think in depth about the conceptual possibility of experimenting with noise as an unwanted and threatening event. In the path

12. G. Lipovetsky, 'Power of Repetition', in R. Mackay and A. Avanessian (eds), *#Accelerate: The Accelerationist Reader* (Falmouth/Berlin: Urbanomic/Merve, 2014), 228.

of composers such as Ashley, Whitehouse tried to challenge listeners' perceptions as to what music was really capable of, or how one could be completely uncompromising through the making of noise, and thus to explore power relations, violence and abjection. However, today the methods used by Whitehouse are already part of the canon of noise.

Both the example of Whitehouse and the previously mentioned experiments in totalitarianism of Throbbing Gristle, or even, looking further back, the 'noise of modern life' called upon by Russolo and Marinetti at the time of Futurism, should be addressed rigorously. We must take note of how these ideas of future, speed, risk, technology, youth, and violence were accompanied with an aesthetic, performative and ideological affiliation which flirted (or flirts) with fascism, in part because of a fascination with a fetishized, naive and erratic idea of nihilism and the extremes of human existence.

In order to unfold the future, the commitment of noise must be to head toward a discontinuity with the past and the present, a discontinuity characteristic of the constructive statutes of the future. We can only update the definition of the risk involved in noise by way of a historical analysis that clarifies which contingencies generate the possibility of risk, and under what conditions this will help us to clear the way for a epistemic construction of risk and its role in noise.

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There is no room for melancholia over futures past, which inevitably cancels the future and involves the repetition of stupid mistakes.

How to assume the possibility of risk? If you know that experiencing a given work unequivocally implies pain and destruction, then there is no chance or possibility of experiencing the risk in an uncompromising way. So in order for this dialectical conception of noise to function, the contingency and the proximity of damage must be encountered as a set of unwelcome circumstances.

As Wikipedia states:

Risk is the potential of losing something of value, weighed against the potential to gain something of value. Values (such as physical health, social status, emotional wellbeing or financial wealth) can be gained or lost when taking risk resulting from a given action, activity and/or inaction, foreseen or unforeseen. Risk can also be defined as the intentional interaction with uncertainty. Risk perception is the subjective judgment people make about the severity of a risk, and may vary from person to person. Any human endeavor carries some risk, but some are much riskier than others.

How we can connect the concept of risk with the concept of noise? We can think of situations where

you are not sure whether you are being damaged by sound or not. How can we generate situations where unwelcome circumstances can appear?

In the first two cases discussed above there are no unwelcome circumstances: an end is sought, but we would hardly choose to accept the uncompromising physical damage. It would be a case of masochism—in which case it would involve the expectation of a desired event. Only if it is to some extent unwanted or unpredictable is it noise.

We thus face the necessity of generating epistemic uncertainty. A computational device designed to generate a unknown random possibility of non/activation. The CAUTION Object could carry out this assignment. You would have to place your trust and commitment in the randomness intrinsically generated by the system which will decide in lieu of the whole audience whether or not the CAUTION Object is played.

With this last option, CAUTION entails the contingency of games of chance. The tension to which we appeal in the 'Dialectic Conception of Noise' is the same tension between knowledge and contingency.

We are aware of the complexity entailed by invoking a device that generates a random chance. In UNIX-like operating systems, /dev/random is a special file that serves as a blocking pseudorandom number generator. This is performed by an algorithm for generating a

sequence of numbers whose properties approximate the properties of sequences of random numbers. The solution would be based on associating even or odd with the performance or non-performance of the CAUTION Object.

But why would an audience subject themselves to this experiment?

What we propose here is to restore the risk in noise through the objectification of experience in the cognitive sense. It is completely absurd and anachronistic to continue to assume that noise as a musical genre is the bearer of qualities such as chaos, when, each time we hear an album or attend a concert, we receive exactly what we expect from it. Noise must involve a self-generative event.

Because of the magnitude of the exercise, it very likely needs to be implemented collectively. As a matter of fact we think it must be done collectively.

The question that is being posed with this experiment is the following: Given that today aesthetic production is no more than the valorization (in capitalist terms) of any form of activity that was previously dismissed, with a concomitant acceleration of forms of individualization, what kind of noise could challenge this valorization? Inevitably, it must be something that questions the notion of aesthetics altogether.

If aesthetic experience has to do with the sensible, this type of experiment has to do with the possibility

of the destruction of sensibility: Something barbaric, something unprecedented, something that might not happen, but where, even if the sound is not produced, the collective experience is linked with risk, and not only cognition.

In this sense one shares a sense of fragility, of not knowing, of having no control. Something might happen from which there is no return.

We think that what is required is a noise where individual subjectivity is subsumed under the rules of a game wherein certain danger may be possible.

This could be a collective form of self-abolition in the sense that we leave behind our own desires, tastes, and forms of consumption in order to share a possible destructive experience; negativity in the most material sense.

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Peirce's Tychism: Absolute Contingency for our Transmodern World

Fernando Zalamea

Charles S. Peirce (1839–1914) proposed a complex pragmatic architectonics, with multiple information channels and nested control layers, constructed in order to understand the world *simultaneously* in its most abstract generality and its most concrete specificity. Subtended by five basic structural girders—the pragmatic(ist) maxim, the cenopythagorean categories, universal semeiotics, a dialectics of determination and indetermination, a triadic classification of sciences—Peirce's system is particularly well attuned to an evolving comprehension of the World. The architecture of the system, with its pervasive reflections and overlapping frames, recalls the gothic cathedral evoked by *À la Recherche du Temps Perdu*, but transcends even the work of man, striving to capture

a general design in Nature, a reality independent of communities of inquirers. Peirce's architectonics provides an extensive arsenal of *intersecting* instruments for the partial understanding of a complex reality in which are merged—on a *frontier* crossed over by constantly iterated and deiterated information—the richness of the external cosmos and the multiplicity of semiotic systems internal to cultural communities. It should therefore come as no surprise that Peirce's architectonics supposes a *continuum* which weaves together cosmos and humanity, which makes possible the systematic study of the bordering processes characteristic of any semeiosis, and which makes it possible to contrast the *back-and-forth* miscegenation of the whole edifice. On the other hand, many forms of invention, according to Peirce's celebrated theory of abduction, occur via *breaks* in continuity, via some type of uncontrolled modal lapse where *chance* enters into the picture. Peirce's *creative tension* between sedimentation and wavering—where *contingency* often dictates the divergent paths to be followed—propels all human endeavours, and, in particular, seems to command our present, Transmodern condition.

**1. TYCHISM OR ABSOLUTE CHANCE:
THE FOUNDING CONTRADICTION**

At the beginning of the 1890s, Peirce introduced the concept of tychism:

In an article published in *The Monist* for January, 1891, I endeavored to show what ideas ought to form the warp of a system of philosophy, and particularly emphasized that of absolute chance. In the number of April, 1892, I argued further in favor of that way of thinking, which it will be convenient to christen *tychism* (from *tyché*, chance). A serious student of philosophy will be in no haste to accept or reject this doctrine; but he will see in it one of the chief attitudes which speculative thought may take, feeling that it is not for an individual, nor for an age, to pronounce upon a fundamental question of philosophy. That is a task for a whole era to work out.¹

Opening up a formidable task that it would fall to a whole era to work out (witness the present volume of *COLLAPSE*) Peirce introduced a pillar of his late (1890–1910) philosophical system with a *fundamental*

1. "The Law of Mind" [1892; CP 6.102]. References of the form [*xyzt*; CP *a.bcd*] signal a year of Peirce's writing (*xyzt*), a volume (*a*) and a paragraph (*bcd*), referring to C.S. Peirce, *Collected Papers* (CP), 8 vols., eds. Hartshorne, Weiss & Burks (Bristol: Thoemmes Press, 1998; new reprint of Harvard University Press's original edition, 1931–1958; electronic edition: Intelix Corporation, 1992).

contradiction in terms: *absolute chance*. Isn't chance everything *but* absolute? How can chance—contingent, fleeting, discontinuous—be thought as an 'absolute'? Doesn't this stand in contradiction to Peirce's very own system—a relative architectonics always open to evolution, and which never accepts an absolute *status quo*? We do indeed have *in fact* a contradiction, but one that sparkles with creativity. As with Florensky's antinomy between the visible and the invisible,² or Thom's aporia of the continuous and the discrete,³ we are in the presence of a *founding antinomy* of thought. In *attempting* to posit a form of chance as initial, archetypical, 'absolute', Peirce enters into the first of his three cenopythagorean categories⁴—*firstness*—oriented towards the immediate and the spontaneous, the free and the fresh. *Free chance* may be thought as a first, but never instantiated (thus becoming already a second) nor normatively established (becoming a third). Nevertheless, the usual contexts of *contingency* (forms of secondness) *may* be embodied as *projections* of a free concept (first). This could seem just a vague ideal, were it not for contemporary mathematical Category Theory, wherein free objects, algebras as projections of free

2. P. Florensky, *Beyond Vision: Essays on the Perception of Art* (London: Reaktion, 2006).

3. R. Thom, 'L'aporia fondatrice delle matematiche', in *Enciclopedia Einaudi* (Torino: Einaudi, 1982), vol. XV, 1133–46.

4. For good presentations of the categories, see 'A Guess at the Riddle' [1887–88; CP 1.356–7] or 'Lectures on Pragmatism' [1903; CP 1.322].

objects, and initial, archetypical topoi, have been completely formalized.⁵

In relation to the three categories, Peirce classifies three ubiquitous, universal forms of evolution:

Three modes of evolution have thus been brought before us: evolution by fortuitous variation, evolution by mechanical necessity, and evolution by creative love. We may term them *tychastic* evolution, or *tychasm*, *anancastic* evolution, or *anancasm*, and *agapastic* evolution, or *agapasm*. The doctrines which represent these as severally of principal importance we may term *tychasticism*, *anancasticism*, and *agapasticism*. On the other hand the mere propositions that absolute chance, mechanical necessity, and the law of love are severally operative in the cosmos may receive the names of *tychism*, *anancism*, and *agapism*.⁶

Tychism—that is, the operative condition of absolute chance (1.1) in the cosmos, commands an embodied *tychastic* evolution (1.2), which, in turn, can be elevated into a doctrine of *tychasticism* (1.3). The *molten*, founding antinomy (1.1) thus gives rise to separated, *well defined* fortuitous variations (1.2), and to a pervading doctrine

5. For an understanding of Peirce along these lines, see F. Zalamea, 'A Category-Theoretic Reading of Peirce's System: Pragmatism, Continuity and The Existential Graphs', in: M. Moore (ed.), *New Essays on Peirce's Mathematical Philosophy* (Chicago: Open Court, 2010), 203–33.

6. 'Evolutionary Love' [1893; 6.302].

(1.3) in which contingency *has to be* taken into consideration. The result completely *opens up* Peirce's philosophical system, allowing (and *supporting*) creative contradictions, introducing dynamical dialectic tensions, and begetting a web of systemic, hierarchical interactions.

2. TYCHISM AND SYNECHISM: THE DIALECTICS

Peirce's indetermination/determination adjunction shows how some considerations as to continuity must be set within a hierarchy of levels and meta-levels. Over the meta-level of a meta-generic *continuum* (a 'continuum of higher generality')⁷ can schematically be drawn the *lower* (*i.e.* locally multi-layered) back-and-forth between *tychism* and *synechism* which pervades Peirce's architectonics:

Permit me further to say that I object to having my metaphysical system as a whole called Tychism. For although tychism does enter into it, it only enters as subsidiary to that which is really, as I regard it, the characteristic of my doctrine, namely, that I chiefly insist upon continuity, or Thirdness, and, in order to secure to thirdness its really commanding function, I find it indispensable fully [to] recognize that it is a third, and that Firstness, or chance, and Secondness,

7. 'The Logic of Events' [1898; v 6.191].

or Brute reaction, are other elements, without the independence of which Thirdness would not have anything upon which to operate. Accordingly, I like to call my theory Synechism, because it rests on the study of continuity. I would not object to Tritism.⁸

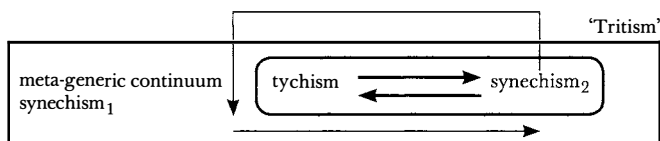


Figure 1. *Tychism-synechism adjunction drawn over a generic continuum*

The introduction of elements of ‘pure chance’—the characteristic indetermination of tychism—can thus be seen as a contextual *ingredient* within a much more general process, wherein the primacy of the *continuum* is never contested. Indeed, the *continuum* happens to be the truly generic concept on which the ‘design’ of Peirce’s architectonics can be sketched, since it is the only one that allows multiple intra-level internal reflections in the edifice. This explains Peirce’s (otherwise cryptic) motto:

Tychism is only a part and corollary of the general principle of Synechism.⁹

8. Ibid. [1898; CP 6.202].

9. ‘Letter to William James’ [1897; CP 8.252].

In fact, Peirce's *continuum* combines the three categories: through a modal and plastic character, it includes a spectrum of *pure potentiality* (firstness); through breaks and cuts, the scale of numbers acts and reacts (secondness); through generic gluings and connections, the rule of continuity holds (thirdness).¹⁰ Tychism—with all its related concepts, 'absolute' chance, free chance, pure potentiality—stands, in firstness, as a counterpart to thirdness. Contingency *liberates* the hard and fast ruling of the *continuum*. Creativity and its abductive variants construct a *back-and-forth dialectics* with sedimentation and its normative variants. We are in the presence of some sort of *chemical* reaction between polarities, as Novalis had well fathomed;¹¹ a mathematical chemistry of opposites that Reza Negarestani has brilliantly situated at the basis of an architecture of decay.¹²

Saturation and decay are pendulous movements that pervade not only Peirce's architectonics, but also our Transmodern world. Diverse forces of saturation bring us nearer to continuity, bridging new frontiers and enriching Peirce's *summum bonum* (the continuous growth of potentiality). On the other hand, many shifts in the direction of decay are related to *contingent*

10. See F. Zalamea, 'Peirce's Logic of Continuity: Existential Graphs and Non-Cantorian Continuum', *The Review of Modern Logic* 9 (2003): 115–62.

11. Novalis, *Notes for a Romantic Encyclopaedia* (Das Allgemeine Brouillon) (Albany: State University of New York Press, 2007).

12. R. Negarestani, 'Undercover Softness: an Introduction to the Architecture and Politics of Decay', *COLLAPSE VI* (2010): 379–430.

situations in which chance produces new, unexpected combinatorial perspectives. Both growth (third) and decay (first) are fundamental, when seeking an active-reactive balance (second). Decay, Negarestani says, 'is an irresolute process of building that potentiates architectures', a 'subtractive' force, 'concurrently intensively negative and extensively positive'.¹³ Writing independently of Peirce, the Iranian philosopher turns out to be very close to the American: it is indeed the subtractive, intensively negative Tychism that potentiates Peirce's extensively positive Synechism.

3. TYCHISTIC SYNECHISM: A TRANSMODERN CONJUNCTION

After Modernism and Postmodernism, *Transmodernism* has been advocated as a more faithful neologism for our plastic and transient age. Introduced by the Spanish philosopher Rosa María Rodríguez Magda,¹⁴ the term 'Transmodernism'—both diachronic and methodological—seeks to reintegrate many awkward postmodern differentials, to balance some supposed breaks with more *in-depth sutures*, to counter relativism with a *topological logic* wherein certain *universal relatives* provide invariants beyond the flux of transformations.

13. Ibid., 386.

14. See R. M. Rodríguez Magda, *La sonrisa de Saturno* (Barcelona: Anthropos, 1989), and R. M. Rodríguez Magda, *Transmodernidad* (Barcelona: Anthropos, 2004).

COLLAPSE VIII

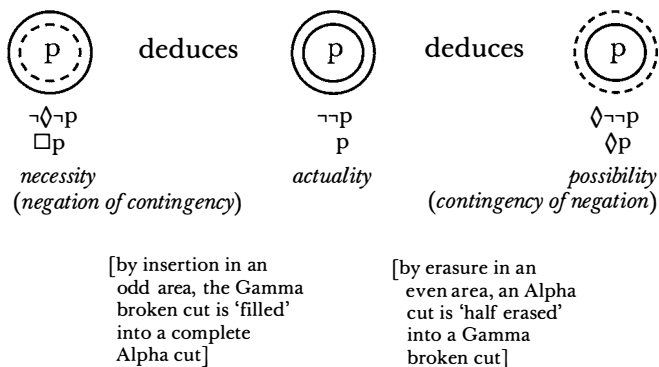
A rich counterpoint emerges between Postmodernism and Transmodernism: break, locality, differentiation, contradiction, ambiguity, the impossibility of universals, 'all is equally worthwhile', Death—'Postmodern dissonances' if you will—are now contrasted with revision, local/global dialectics, oscillation between differentiation/integration, partial gluing of relative coherences, a fabric of vagueness/exactness, relative universals, 'some are more worthwhile than others', Renaissances—a sort of Transmodern harmonics. *Both* the dissonances and the harmonics are fundamental for our epoch, but one should not forget the necessary swings of the pendulum.

In many ways, Peirce's architectonics already included most of the salient features of Transmodernism, a situation that perhaps explains the unusual relevance of Peirce's thought at the beginning of a new millennium. In fact, Peirce's system is essentially topological, open to all sorts of continuous transformations (pragmatic maxim, triadic semiotic, classifications of sciences, synechism, etc.), and in particular, the system is able to represent a 'bimodal'¹⁵ net of *both* differentials and invariants, thus providing a full understanding of the *TRANS*- prefix. At its very core, Transmodernism is open (i) to a *conjunction* of opposites, in this case Tychism and Synechism, and further (ii) to a

15. The term, due to Jean Petitot, refers to the simultaneous static and dynamic status of many concepts and objects, particularly in the Modern and Transmodern world.

distributive—differential and integral—analysis of the development of the contradictory conjunction at play. *Contingency* enters into the panorama as a dynamical factor which multiplies the ‘growing of potentiality’, thus complying with a full instantiation of Peirce’s esthetical *summum bonum*.

Amazingly enough, Peirce was able to embody his (i) *tychistic synechism* in a fully-fledged logical calculus, thanks to his Gamma existential graphs. The ‘broken cut’ is defined as the *topos* of *contingency* (possibility of negation), generalizing standard negation (Alpha). Then, applying to the broken cut to the general writing/erasure rules proper to the existential graphs, Peirce proves the fundamental laws of *normal* modality:¹⁶

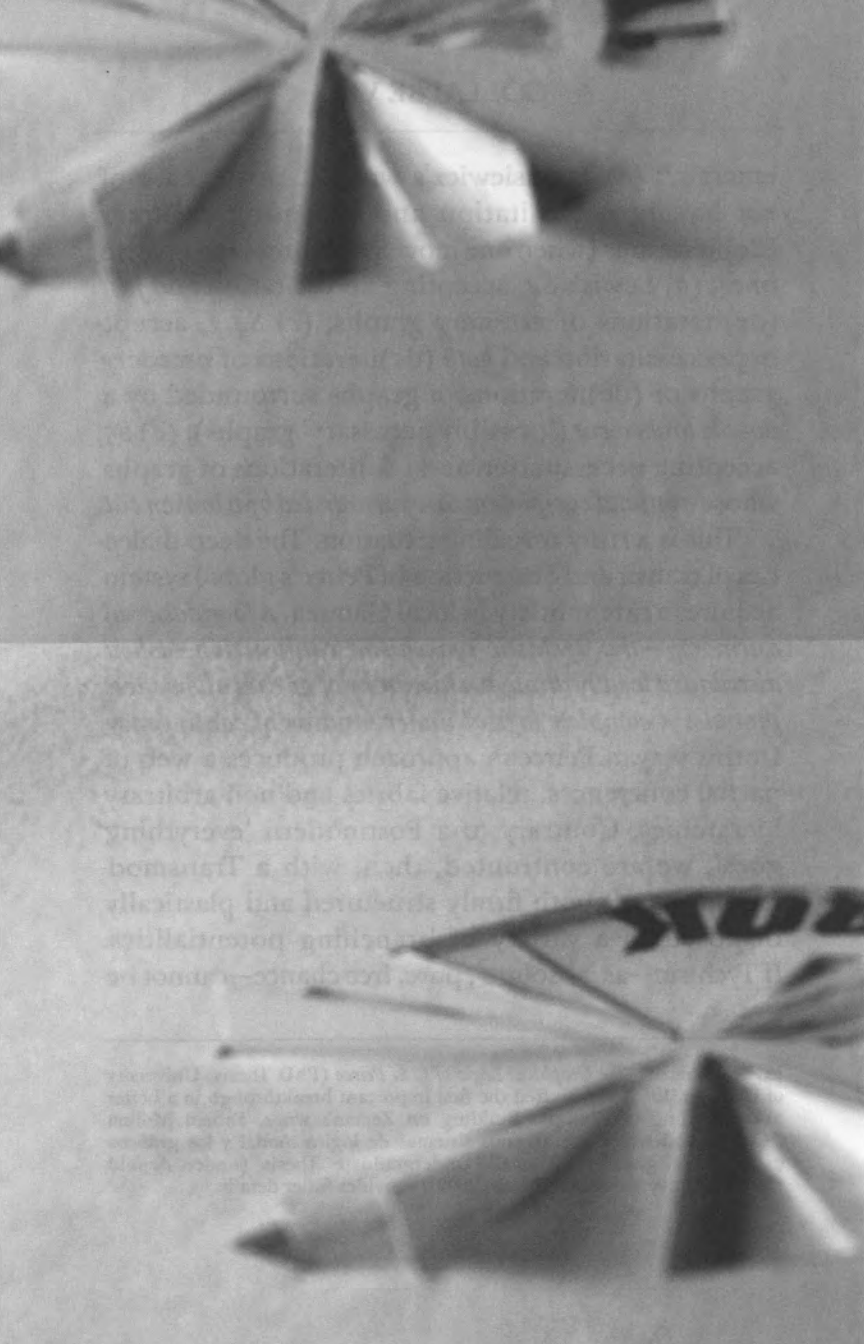


16. ‘Some Topics of Logic Bearing on Questions Now Vexed’ (Lowell Lectures) [1903; CP 4.516].

The extremely simple and plastic transformations of the cuts prefigure *exactly* Thom's dialectics between the continuous (Alpha's complete cut) and the discrete (Gamma's broken cut). Moreover, Peirce's topological logic shows—in a precise, theorematic way—how contingency, an instantiation of Tychism, may be encompassed within a wider *TRANS*formational calculus of *topoi*, an instantiation of Synechism.

The topological logic of modulation goes even deeper if we look at the multiple (ii) *distributive gradations* of the iteration/deiteration existential graphs rule (moving information *back-and-forth* through cuts). We must observe, first and foremost, that if one allows arbitrary insertions of the necessity cut (a double cut formed by a broken cut inside an Alpha cut) for graphs marked on the page—a fact which corresponds to modal *necessitation*: α provable forces $\Box\alpha$ provable—then a Gamma system cannot also accept arbitrary iteration/deiteration through broken cuts, since then one can prove that Alpha and Gamma cuts are equivalent.¹⁷ Thus emerges in Gamma an important *obstruction* to arbitrary iteration/deiteration, and a series of *partial resolutions* of that obstruction is precisely what gives rise to intermediate modal systems. Specifically, the following representations of intermediate systems

17. We thank here many personal communications (2010) of Arnold Oostra.



emerge:¹⁸ (a) Lukasiewicz's weak *L*, in the case of *not* having necessitation and accepting *arbitrary* (de)iterations (when one movement forces the inverse one); (b) Lewis's *S4*, accepting necessitation and *just* (de)iterations of *necessary* graphs; (c) *S4.2*, accepting necessitation and *both* (de)iterations of *necessary* graphs or (de)iterations of graphs surrounded by a *double broken cut* ('possibly necessary' graphs); (d) *S5*, accepting necessitation and (de)iterations of graphs whose *minimal components are surrounded by a broken cut*.

This is a truly revealing situation. The deep dialectics of transit and obstruction in Peirce's global system acquires a rare subtlety in local Gamma. *A foundational antinomy—the 'tychistic synechism' conjunction—when distributed locally through a hierarchy of partial allowances, provides a complete logical understanding of contingency.* In this way, a Peircean approach produces a web of partial coherences, relative fabrics and non-arbitrary hierarchies. Contrary to a Postmodern 'everything goes', we are confronted, then, with a Transmodern appraisal, both firmly structured and plastically disposed to a variety of branching potentialities. If Tychism—as 'absolute', pure, free chance—cannot be

18. Jay Zeman, *The Graphical Logic of C.S. Peirce* (PhD Thesis, University of Chicago, 1963) constituted the first important breakthrough in a better understanding of Gamma. Building on Zeman's work, Fabián Molina ('Correspondencia entre algunos sistemas de lógica modal y los gráficos existenciales gama de Peirce' [Undergraduate Thesis (under Arnold Oostra), Universidad del Tolima, 2003]) provides fuller details.

COLLAPSE VIII

constrained, on its own, by any governing structure,¹⁹ all of its subsequent instantiations (ordinary chance, contingency, breaks, variations) nevertheless enter into a *grand* architectonics. Our contemporary disorientation might be better understood if we took into *serious* consideration Peirce's system, with all its natural, dialectical, adjusting instruments, which help us to circumnavigate the Relative and to handle the furious winds of Contradiction.

19. Nevertheless, Peirce himself tried to 'axiomatize' Firstness, that intrinsically elusive category. He introduced a *swa* as 'something which is without reference to anything else', and provided some 'axioms' for swas: the excluded middle does not hold for swas, no swa exists, any swa is independent of its possible representations, a swa is not a whole constituted by parts, etc. See C. S. Peirce, *Categorie* (ed. Fabbrichesi) (Bari: Laterza, 1992), 130–35.

Quantum Mechanics as Generalised Theory of Probabilities

Michel Bitbol

PROLOGUE

The thesis I will defend here comprises two propositions: Firstly, quantum mechanics is not a physical theory that happens to make use of probability calculus; it is *itself* a generalised form of probability calculus, doubled by a procedure of evaluation that is probabilistic by way of its controlled usage of symmetries. Secondly, quantum mechanics does not have merely a predictive function like other physical theories; it *consists* in a formalisation of the conditions of possibility of any prediction bearing upon phenomena whose circumstances of detection are also conditions of *production*.

PROBABILITIES, SIGNS, AND SECONDARY QUALITIES

Before developing and justifying the above propositions, I should like to return briefly to the prehistory of probability calculus, between the sixteenth and seventeenth century. This return will help us in overcoming certain prejudices about probability that are the product of an intermediate era (roughly, the eighteenth and nineteenth centuries), and in approaching quantum mechanics with an open mind. I mean in particular the prejudice that consists in conceiving probability merely as the expression of a certain subjective ignorance of underlying processes, processes which play out in and of themselves, according to determinist laws.

So what conditions permitted the collective elaboration, from the seventeenth century onward,¹ of probability calculus? Ian Hacking has furnished an extensive list of such conditions,² but he insists upon one in particular. This crucial condition is the development, in the sixteenth century, of sciences of *signs* or of *secondary qualities*.

1. One precursor is Jerome Cardan, in the mid sixteenth century. But his work remained isolated, with no real influence, and his main treatise on games of chance was only printed for the first time in 1663, in the era of Pascal and Huyghens.

2. I. Hacking, *The Emergence of Probability* (Cambridge: Cambridge University Press, 1975).

The distinction between primary qualities and secondary qualities—in other words, between properties that show themselves such as they are intrinsically, and properties imputed to material bodies on the basis of impressions or signs that result from their interactions with the sense organs—is usually attributed to Locke. It can ultimately be traced to Galileo, Descartes and Robert Boyle. But in fact we already find the trace of it earlier, in Jerome Fracastor, a doctor in the first half of the sixteenth century.

From the moment when the distinction was recognised, an opposition could develop between the sciences of first causes and exact proofs (such as astronomy, geometry, and mechanics), and the other sciences (such as medicine and chemistry) which were reduced to *prognostics* acting on the basis of signs, phenomena, or sensible secondary qualities. It is in the field of so-called ‘inferior’ sciences, these sciences of secondary qualities, that the notion would crystallise of an opinion supported by signs, which in part gave rise to the concept of probability. The clues as to the outbreak of an epidemic, or the symptoms of an illness, which are secondary in relation to the supposed primary causes of the epidemic or the illness, were, for example, called ‘signs of probability’ by Fracastor in his book *On Contagion*.³

3. Ibid., 28.

This close association between the birth of the concept of probability and the elaboration of the concept of secondary qualities bears an implicit lesson for the understanding of the privileged link between quantum mechanics and probability. For, as Heisenberg wrote, quantum physics confronts a situation where *even* spatio-kinematic variables of the position and quantity of movement, which were considered at the time of Descartes and Locke as direct and 'primary', must be taken as indirect manifestations, relative to an instrumental context—in short, as secondary.⁴ To the universalization of the notion of secondary quality, or of the relativity of phenomena in regard to a context, responds, in quantum mechanics, the universalization of the pertinent domain of probability.

One can guess, however, from this short summary, the reason why the concept of probability remained embryonic and marginal in the natural science of the first half of the seventeenth century; a reason which also explains, albeit belatedly, the contemporary reticence to take entirely seriously a physical theory built on a probabilistic armature, such as quantum mechanics. This reason is that, from the beginning, probabilities were considered as a predictive lesser evil in a situation where one finds oneself momentarily incapable of offering a descriptive account based

4. W. Heisenberg, *Philosophical Problems of Quantum Physics* (Woodbridge, Connecticut: Oxbow Press, 1979), 38.

upon well-founded principles and truths (truths concerning efficient causes if one is Aristotelian, figures and movements if one is Cartesian). It is no surprise, under these conditions, that all the efforts of the players in the first scientific revolution were focused on elucidating causal links or describing a real universe of primary qualities by way of geometry, rather than seeking to systematise the estimation of the uncertain in the shifting circumscription of secondary qualities.

THE UNCERTAIN AND THE MIDDLE OF THINGS

As Catherine Chevalley quite rightly emphasises,⁵ the estimation of the uncertain only began to constitute an entirely separate theme of investigation in the work of an anticartesian thinker, Pascal, for whom ‘the end of things and their beginning are hopelessly hidden from [man] in an impenetrable secret’.⁶ If man must content himself, according to Pascal, with ‘perceiving some appearances from the middle of things, in an eternal despair of knowing either their beginning or their end’,⁷ he cannot denigrate the appearances in favour of an ungraspable backworld governed by principles. Man must learn to inhabit his milieu; he must know how to focus his attention upon the play

5. C. Chevalley, *Pascal, contingence et probabilités* (Paris: PUF, 1995).

6. B. Pascal, *Pensées*, fragment 199, in *Oeuvres complètes* (Paris: Seuil, 1963), 526.

7. Ibid.

of his experimental manipulations and the phenomena that result from them; he must admit the inconsistency of cutting up the world into separate and intrinsically-existing objects, since phenomena are so tied one to another that it is impossible to know how to grasp one without grasping all; he must understand, also, that no cognition can free itself from the nexus of interrelations, but can only situate itself within it, remaining cognizant of the perspective from which it derives. Finally, man must consent to make the effort to domesticate the uncertainty that is his lot, by mathematizing directly the relations between antecedents and expectations, and between expectations and observations.

Of course, probability calculus was able to develop after Pascal by freeing itself of what some would call an epistemological pessimism motivated by the vertigo of the impenetrability of the Divine plan. The tone, in Laplace's 1814 *Philosophical Essay on Probabilities*, is almost antipodal to the latter, since Laplace here affirms the omnipotence of a Principle of Sufficient Reason incarnated by a God whose work is transparent. According to Laplace, 'the curve described by a simple molecule of air or of vapour is governed in a manner just as certain as that of planetary orbits: the only difference between them is that which our ignorance places there.'⁸ And it is only in this interval between

8. P. S. de Laplace, *Essai philosophique sur les probabilités* (Paris: Courcier, 1814), 4.

the in-principle determination of all things and our perhaps provisional ignorance with regard to them, that probability has any place: ‘probability’, Laplace continues, ‘is relative in part to our ignorance, and in part to our cognitions’.⁹

Such a conception perfectly fulfilled its office in the framework of classical physics, and particularly in classical statistical mechanics (leaving to one side the more recent problematic of sensitivity to initial conditions). But, faced with the recurrent question of the essential or nonessential character of probabilities in quantum physics, and the difficulties it presents to the thesis of probability-ignorance, it was worthwhile our returning before Laplace, and recalling that the calculus of probabilities made one of its first appearances upon an entirely other philosophical terrain. It emerged in Pascal, as we saw, on the basis of a recognition of anthropological limits, of an epistemology close to operationalism, of a generalised holism, and of a gnoseological perspectivism. One cannot but be struck in observing that *all* these traits are present in the most current interpretations of quantum mechanics, and that there is no acceptable interpretation that does not include at least one of them. The most frequently encountered trait, including in the most reliable ‘hidden variable’ interpretation, is *holism*.

9. Ibid.

INDETERMINISM AND CONTEXTUALITY

These two historical remarks—one on the association of the concept of probability with the concept of secondary qualities, the other on the conception of probability calculus as an instrument for the predictive mastery of our situation of entanglement in the network of natural relations—will now help us to undo two interpretative knots of quantum physics, both of which relate to *indeterminism*.

The first concerns the notion, very widespread since Heisenberg's foundational works of 1927–30, of an uncontrollable *perturbation* that the agent of measurement is supposed to exert upon the microscopic measured object. It is interesting to note that this 'perturbation' was assigned a twofold role by those who conceived of it.

On one hand, as Bohr emphasises at the end of the 1920s, the uncontrollable perturbation constitutes the reason for the *indivisibility* of quantum phenomena—that is to say, the impossibility of separating in the phenomena that which belongs to the object and that which belongs to the measuring agent. Perturbation would explain, in other words (borrowed this time from Heisenberg), that quantum physics leads to a generalisation of the model of secondary qualities—with their obligatory reference to the context within

which they manifest themselves—to the detriment of that of primary intrinsic qualities.

But on the other hand, according to the 1927 article where Heisenberg presents his so-called ‘uncertainty’ relations for the first time, the perturbation is also that which takes account of the *indeterminism* of quantum physics. The incompressible and uncontrollable perturbation by the agent of measurement is what prevents complete knowledge of the two groups of variables that compose the initial state of a particle. Consequently, concludes Heisenberg, the principle of causality, which links in a constraining fashion an initial state and a final state, is inapplicable in quantum physics.

The model of ‘perturbation’ thus allows us to bring to light a close relation between contextuality and indeterminism, since perturbation has as a consequence the contextuality of phenomena as well as an indeterminism in regard to them. A relation which is, perhaps, historically translated in the confluence of the concepts of secondary quality and probability at the time of their birth. Unfortunately, the image of the perturbation of the object by the measuring agent also has a major inconvenience which did not escape Bohr or Heisenberg, and which Karl Popper later emphasised: Basically, this image begins by bringing into play a universe of objects endowed with primary spatial and kinematic qualities, and then invoking their mutual alteration so as to subsequently justify

the putting aside of the concept of primary quality and the generalisation of that of secondary quality.¹⁰ In this image, then, one puts forward the representation of a universe of figures and movements, with the unique aim of demonstrating its inanity, or (what comes down to the same thing, for a verificationist epistemology) its in-principle inaccessibility.

The image of ‘perturbation’ thus represents a meta-stable moment in the reflection on quantum mechanics. It invites us to surpass it, in two opposite directions: Either we take wholly seriously the *premises*, and we try to construct an empirically-adequate theory of the inaccessible spatio-kinematic processes that are postulated—this is the strategy of the authors of certain hidden variable theories. Or, on the contrary, we take wholly seriously the holistic *consequences* of the image of perturbation, namely the indivisibility of the quantum phenomena, its unsurpassable *relativity* to an experimental context, and we develop a conception of physical theory that no longer appeals to an imagined representation of the supposedly constitutive moments of the phenomena—this is the strategy that Bohr adopted from 1935 onward, not without certain shortcomings.

It is reassuring for those who, like myself, have chosen to push the second strategy to its ultimate

10. On this point, see M. Bitbol, *Mécanique quantique, une introduction philosophique* (Paris: Flammarion, 1996), Chapter 3.

consequences, to observe that it is possible to establish a *direct* formal link between indeterminism and contextuality, without need of an intermediary furnished by the image of perturbation. In 1935, Grete Hermann published a small book in which she hinted at such a link.¹¹ This young German philosopher remarked that the possible causes of a quantum phenomena *cannot be used to foresee it*, because they are only ever defined afterwards, *relatively* to the very circumstances of the production of this phenomena when measured. Later, at the beginning of the 1950s, Paulette Destouches-Février proved in a much more rigorous way a theorem according to which every predictive theory bearing upon phenomena defined relative to experimental contexts certain of which are mutually incompatible, is ‘essentially indeterminist’.¹²

DETERMINIST IDEALS, INDETERMINIST PROJECTIONS

Let us remark now that, through what has been said above, a second interpretative knot concerning the relation between quantum physics and indeterminism

11. G. Hermann, *Les fondements philosophiques de la mécanique quantique*, tr. A. Schnell and L. Soler (Paris: Vrin, 1996), 90.

12. P. Destouches-Février, *La structure des théories physiques* (Paris: PUF, 1951), 260–80. This theorem is perfectly compatible with the existence of hidden variable (or rather, hidden process) theories, since it bears only upon the link between effective or possible phenomena, and not the link between processes in principle inaccessible to experimentation (see paragraph 5).

has been implicitly undone. It was often asked in the 1930s whether quantum mechanics, with its probabilistic, or even 'statistical' (as Einstein had it) character might one day be rendered obsolete by a determinist theory of the individual underlying processes. The response of the last forty years research to this question is somewhat sibylline, but all the more instructive philosophically.

The first lesson to be drawn from this research is that *it is not impossible* to formulate theories which dictate the intrinsic properties of individual objects via determinist laws, but which also reproduce exactly the predictions of quantum mechanics.¹³ These so-called hidden variable theories simply find themselves subject to certain constraints, principal among which are non-locality¹⁴ (that is to say, the instantaneous mutual influence of the properties of arbitrarily distant objects) and contextualism¹⁵ (that is to say, the influence of the measuring device on the postulated properties). These two conditions, however, do raise problems. The nonlocal concept of instantaneous interactions at a distance¹⁶ introduces a formal conflict

13. D. Bohm & B. Hiley, *The Undivided Universe* (London: Routledge, 1993).

14. J. Bell, *Speakable and Unsayable in Quantum Mechanics* (Cambridge: Cambridge University Press, 1987).

15. S. Kochen and E. Specker, 'The problem of hidden variables in quantum mechanics', *Journal of Mathematical Mechanics* 17 (1967), 59–87.

16. At this stage we must avoid confusions of vocabulary and ideas between standard quantum mechanics and hidden-variable theories,

(albeit one without practical consequences) with the axioms of relativity theory.¹⁷ As for contextualism, it

which may lead one to believe wrongly that standard quantum mechanics encounters the same problems as hidden-variable theories with regard to nonlocality. Standard quantum mechanics leads us to *foresee correlations* between distant experimental events; but, in itself, it furnishes *nothing that could be taken for an explanation* of these correlations. In particular, it does not imply in itself any idea of *nonlocal* interactions. All one can remark is the *nonfactorisability* of the components of a global state vector which furnishes (correlated) probabilities of the results of two distant events. But the current interpretation of the state vector poses the temptation to a semantic overdetermination of nonfactorisability. For in this interpretation, a state vector represents the 'state' of a 'system', and not merely a generalised instrument of the probability calculus of experimental phenomena. Whence the nonfactorisability of the state vector was understood as the *nonseparability* of the states of the subsystems that composed the system; and this nonseparability was sometimes confused with the nonlocality that implies instantaneous influence. The difficulties and confusions here come from the mixing up of an operationalist and predictive orientation with implicitly ontological and descriptive elements (the concepts of 'system' and 'state').

Hidden-variable theories have at least the advantage that they seek to furnish an *explicitly* ontological interpretation of quantum mechanics, bringing in the intrinsic properties of objects. On this basis, they can claim to *explain* correlations. The correlations are explained either in applying the concept of causes common to the postulated intrinsic properties (local hidden variable theories), or by invoking instantaneous interactions at a distance between these properties (nonlocal hidden variable theories). The explanation via common causes having been excluded by Bell's theorem, it remains to partisans of hidden variable theories to confront the consequences of the explanation via instantaneous interactions at a distance.

Let us just indicate that an attempt to generalise explanation via causes common to *contextual phenomena* rather than to properties, without soliciting any structure other than that of standard quantum mechanics, and consequently without falling victim to Bell's theorem, can be found in M. Bitbol, *Mécanique quantique, une introduction philosophique* (Paris: Flammarion, 1996), 189–91.

17. But, it will be asked, are there not *also* difficulties in adapting standard quantum theories to relativistic theories, in spite of the advances realised by Dirac and the creators of quantum field theory? Doubtless. However, in the light of the remarks made in the preceding note, one might think that these difficulties are *not of the same nature* as those met with by hidden

has as a consequence that measurements do not at all allow us to accede, point by point, to continuous and determinist processes which, according to the theory, would take place in and of themselves in nature *if one had not modified them by seeking to bring them to light*. In other words, the theory itself implies that the ‘independent’ determinist processes that it describes are inaccessible to experience.

The conclusion to draw from this is certainly not that we must cast anathema on hidden variable theories, but simply that it is indispensable to revise their ambitions downward. We have seen that one of the principal objectives of their advocates was to reopen the question of determinism, against those who affirmed overhastily that this question had already been settled (in a negative sense) by quantum mechanics. Standard quantum mechanics may well have been ‘essentially indeterminist’ in structure, but if one could reproduce its results in an *other* theory comprising determinist processes, the determinist option would regain all of its credibility. It is true that the *ontological* question of

variable theories. Hidden variable theories confront relativistic theories *on their own terrain*—that of the *description* of spatiotemporal events that can be treated *as if they occurred of themselves*. On the contrary, standard quantum theories operate on a completely different plane: that of the prediction of phenomena whose production is conditional to the presence of appropriate contexts that are sometimes mutually incompatible. The problem of the putting into concordance of standard quantum theories and relativistic physics thus very probably pertains to the difficulty in defining an appropriate terrain upon which the two theoretical universes can encounter each other, rather than to a direct conflict.

knowing whether the ultimate laws of nature are or are not determinist is *undecidable*, because determinist appearances can result from a statistical regularity, and, inversely, indeterminist appearances can be a translation of deterministic chaotic phenomena.¹⁸ But at least one could still hope for determinism to rediscover its traditional status as a guiding thread for research. Yet we have been disabused of even this hope. For in hidden variable theories, the determinist stance does indeed seem to have been lost, even at the level of its epistemological fecundity. The determinist stance was only fruitful because it compelled researchers to conceive of networks of univocal bonds underlying phenomena, to design the type of experiment that would allow these bonds to be brought to light, and to thus define often unprecedented classes of phenomena. Unfortunately, this process is blocked from the outset by the in-principle inaccessibility of the bonds that underlie phenomena in contextualist hidden variable theories capable of reproducing quantum predictions. Once the reciprocal current of information between the determinist project and the definition of new domains of experimentation dries up, the attempt to pursue this project formally becomes nothing more than a *jeu d'esprit* whose principal (if not sole) interest is its

18. On this subject, see Jacques Harthong's 'fifth conflict of transcendental ideas', cited by A. Dahan-Dalmedico in A. Dahan-Dalmedico, J.L. Chabert and K. Chemla (eds.), *Chaos et déterminisme* (Paris:Seuil, 1992), 405; and J. Harthong, *Probabilités et statistiques* (Paris: Diderot, 1996).

serving as an intellectual stimulant for specialists in the foundations of modern physics.

This situation does not justify, for all that, the inverse excess—namely, indeterminist dogmatism. All one is within one's rights to observe is that henceforth, in the physical sciences, the advantage of epistemological fruitfulness will belong to the stance that consists in maximally developing predictive capacity to the detriment of descriptive ambition, the calculus of probabilities rather than determinist models of evolution.

It is true that many thinkers do not stop there; they tend to extrapolate the epistemological observation of the fecundity of the indeterminist option into an ontological affirmation of the intrinsically stochastic character of the laws governing the world. But their position is easily acceptable on the methodological plane, without it being necessary to follow them in the metaphysical aspects of their conclusions. As James Logue has shown in his *Projective Probability*,¹⁹ every coherent system of probabilistic evaluation can be interpreted in realist fashion—that is to say, it can be understood as expressing propositions whose truth status is independent of the means of testing them. And this interpretation in turn might lead the authors of a probabilistic evaluation to project it onto the world. We should not be surprised, in these circumstances, that quantum physics' coherent system of probabilistic

19. J. Logue, *Projective probability* (Oxford: Oxford University Press, 1995).

evaluations, without the counterbalance of a fruitful determinist programme, could have been conceived by researchers as eminent as Popper (and even Heisenberg, in his own way) as translating, in part or as a whole, a ‘real’ or ‘existent’ characteristic of the world.²⁰ Popper, for example, holds that the world is made of capacities, of potentialities or of natural propensities, which manifest themselves experimentally through particular statistical distributions of phenomena, and which are reflected in quantum theory in the form of a probabilistic algorithm.

Incontestably, the partisans of an ontological indeterminism thereby deliver themselves, just as much as the defenders of hidden variable theories, to what Kant would have denounced as an attempt to extend the application of our concepts beyond the limits of experience²¹—the sole advantage accruing to the partisans of ontological indeterminism being that they limit themselves to directly hypostasizing the quantum formalism’s mode of operation, rather than seeking to

20. K. Popper, *A Universe of Propensities* (Bristol: Thoemmes, 1992).

21. This accusation is addressed to someone who takes Popper’s declarations on propensity more literally than Popper himself. For Popper recognised that the *metaphysical* question of determinism remains undecidable before, just as after, quantum mechanics. He considered simply that only the abandonment of dogmatic determinism could open the way to nonconventional theories of change that may prove more fruitful than the causal and spatiokinematic theories inherited from the first scientific revolution of the seventeenth century. One of these alternative theories is no other than the theory of propensities. See K. Popper, *The Open Universe* (London: Routledge, 1988), chapter 4.

develop a new one. But ought we to reproach them for this? Since every coherent system of probabilistic evaluation can be read in a realist mode, since nothing prevents the interpretation of the quantum algorithm of probability calculus as translating an order of natural propensities, why would we prohibit them from *adhering* unhesitatingly to such interpretations? Why would we refuse their *belief*, without ulterior motive, that quantum theory describes a reality made of pure potentialities?

The type of response we shall try to give to this question is of an epistemological rather than metaphysical order. We shall not ask if reality *is* or *is not* made of potentialities that have the structure of the probabilistic algorithm of quantum theory, but only whether or not we lose anything on the plane of understanding if we interpret this algorithm in realist fashion.

Let us say right away—and this is the meaning of James Logue's statement of equivalence—that neither the practitioner of probabilistic evaluation nor the quantum physicist lose anything whatsoever to such a way of seeing things. They may even gain something that is at the heart of every profession of realist faith—namely, the seriousness with which they consider their theoretical entities, and the motivation for research.²² On the other hand, the philosopher really does have

22. See M. Bitbol, *Schrödinger's Philosophy of Quantum Mechanics* (Dordrecht: Kluwer, 1996), paragraphs 5–9.

something to lose in allowing himself to be fascinated by the sole relation between theory and world. For this stance does not at all incite him to reflect upon what the theory owes to the *situation* of man in the world, and in particular what it owes to the very practice of experimental investigation. Unlike the scientist in his everyday work, the philosopher cannot content himself with *occupying* the Pascalian situation of the man in the milieu that he explores; he must *think* this situation, and charge himself with enunciating its consequences. The scientific researcher, moreover, also has an interest in adopting the reflexive stance from time to time, when she arrives at periods of reorientation in her work. And everyone knows that she finds herself almost inevitably led to do so when science is going through revolutionary times.

A GENERALISED THEORY OF PROBABILITY

It is this type of reorientation that we shall now proceed to undertake. We are going to suspend judgment on the subject of a hypothetical partial isomorphism between quantum mechanics and the real in which we experiment, and interest ourselves selectively in what the structure of this theory owes to the form of experimental activity itself.

Let us begin by rapidly recounting, to this end, the architecture of standard quantum mechanics:

1. The formal kernel of this theory consists in a vector space defined on the set of complex numbers, and endowed with a scalar product; in other words, *Hilbert space*.
2. Upon this space are defined specific operators, called ‘observables’, which furnish, through their ‘eigenvalues’ the list of possible results of an operation of measurement.
3. A vector in Hilbert space, called a *state vector*, is associated with each *preparation* (that is to say, with that which, in an experiment, fixes the initial conditions for measurement).
4. By applying *Born’s Rule* to this state vector, we obtain a function assigning *probabilities* to the results of any measurement whatsoever that is made subsequent to this preparation.
5. As variable spatiotemporal intervals and diverse physical circumstances can separate the end of the functioning of the preparation and the operation of measurement, we take account of them by way of an *evolution equation* of the state vectors: Schrödinger’s equation in the non-relativistic case, Dirac’s in the relativist case.

Here I would like to insist upon the major difference between the probability functions in the classical theory of probabilities and those that are obtained on the basis of the state vectors of quantum mechanics by applying Born’s Rule. Classical probability functions

associate a number between 0 and 1 with each ‘event’ in the broad sense, defined by Kolmogorov²³ as a subset of elementary events. The set of these subset-events comprises the empty set and the exhaustive set, and it is endowed with a Boolean algebra structure by the operations of union and intersection. In other words, classical probability functions are defined upon a Boolean algebra. On the contrary, taking account of the properties of Hilbert space, quantum probability functions are not defined upon a Boolean algebra; they are defined upon different and richer structures called ‘orthoalgebras’.²⁴ I will avoid detailing the axioms of orthoalgebra, and content myself with indicating that the concept of orthoalgebra is not unrelated to Boolean algebra. One might even consider that orthoalgebras constitute a generalisation of Boolean algebras, and that, correlatively, quantum probability functions generalise classical probability functions. For an orthoalgebra contains Boolean algebras as its substructures; and, on the other hand, the restriction of a quantum probability function to these Boolean substructures is equivalent to a classical probability function.

23. A. Kolmogorov, *Foundations of the Theory of Probability* (New York: Chelsea, 1950).

24. R.I.G. Hughes, *The Structure and Interpretation of Quantum Mechanics* (Cambridge, MA: Harvard University Press, 1989), 220.

This structural disparity between classical and quantum probability functions justifies our refusing to content ourselves with the observation that quantum mechanics 'uses' probability theory. *Quantum mechanics itself consists, in part, in a new and broadened form of probability theory.*

A METACONTEXTUAL PREDICTIVE FORMALISM

It would, however, be a shame to limit ourselves to this superficial and formalist exposition of the situation. We can easily enough understand the reasons for the emergence of a new sort of theory of probability by showing that it is a practically inevitable response to the characteristics of the class of experimental phenomena that quantum mechanics deals with. Principal among these characteristics, as already pointed out in our reflections on the concept of secondary qualities, is *contextuality*; in other words, the inseparability of the phenomena and the experimental context of its manifestation. It is this that imposes a great many of the structural characteristics of quantum theory.

But to really bring to light the very strong link between contextuality and quantum mechanics, we must firstly analyse what makes the contextuality of quantum phenomena uncircumventable, and differentiate it from other, more benign and easily surmountable forms of the relation of determinations to a context.

In all sciences, as in many ordinary situations, we can say that to each experimental or sensory situation there corresponds a whole gamut of possible phenomena or determinations. For example, to a context represented by the cones of the retina there corresponds a scale of colours, to a context represented by a ruler corresponds a scale of lengths, to a context represented by a thermometer corresponds a scale of temperatures, and so on. But as long as the contexts can be conjoined, or as long as the determinations are indifferent to the order of intervention of contexts, nothing prevents our fusing the scales of possibilities into one sole scale relative to one sole global context, and then passing over this context in silence and treating the elements of the scale as if they translated so many intrinsic determinations. The presupposition that nothing prevents us from retracting the context is automatic when one makes use of the propositions of ordinary language: for the latter allow us to attribute many determinations to the same object as if they belonged to it. It is important to note that this presupposition and this mode of functioning of language are associated with a classical, boolean logic and a classical, kolmogorovian, theory of probabilities.

But the appearance of obstacles to the conjunction of contexts, or the observing of a lack of independence of phenomena vis-à-vis the order of utilisation of contexts, as is the case in microscopic physics when

one tries to measure canonically conjugated variables, renders traditional methods useless. The strategy of not taking account of the experimental context fails, and it becomes imperative to make explicit the contextuality of determinations.

In this situation that confronts quantum physics, boolean logic and kolmogorovian probability, at first glance, only survive fragmented into many sublogics and many probabilistic structures, each of them associated with a particular context. To *each* experimental context is associated a scale of possible determinations and a scale of attributive propositions which belong to a classical, boolean, sublogic; and to each determination chosen from the set of possible determinations corresponding to *a* given context, can be attached a real number that obeys Kolmogorov's axioms of probability. But these sublogics and these probabilistic substructures cannot be *fused together*, for they depend on distinct contexts that cannot, in general, be conjoined. Under such conditions, we seek to *articulate* them with each other, respectively in the framework of a metalogic and a metacontextual probabilistic formalism. What is remarkable is that when one constructs such a metalogic, in taking account *only* of the impossibility of conjoining the diverse scales of possibles, one arrives at structures isomorphic with the celebrated nondistributive 'quantum logic' of Birkhoff

and von Neumann.²⁵ And what is more, when one tries to construct a metacontextual probabilistic formalism, in constraining oneself *only* to respect Kolmogorov's axioms separately for *each* scale of possibilities, and utilising *one unique* generative symbol of subfunctions of probabilities for each preparation, one arrives at a class of structures whose vector formalism in Hilbert spaces of quantum mechanics is hardly a peculiar case. The form of the evolution equation of quantum mechanics is itself derivable from the general conditions bearing upon the temporal stability of the status of the tool of probabilistic evaluation of the state vector.²⁶

In its function as a theory-framework, quantum mechanics is consequently nothing less than a *meta-contextual form of probability theory*. It brings together the conditions of possibility of a *unified* system of probabilistic prediction bearing upon phenomena inseparable from sometimes incompatible contexts.

25. P. Heelan, 'Complementarity, Context-Dependence, and Quantum Logic', *Found. Phys.* 1 (1970), 95–110.

26. Bitbol, *Mécanique quantique, une introduction philosophique*; M. Bitbol, 'Some steps towards a transcendental deduction of quantum mechanics', *Philosophia naturalis* 35 (1998), 253–80. The essential theorems that allow us to arrive at these conclusions are due to J.L. Destouches, P. Destouches-Février, G. Fano, A.M. Gleason, et J. Bub. See P. Destouches-Février, *La structure des théories physiques* (Paris: PUF, 1951), and R.I.G. Hughes, *The Structure and Interpretation of Quantum Mechanics* (on the subject of the theorems of Fano, Gleason and Bub).

COLLAPSE VIII

It only remains to complete this theory-framework with various symmetries²⁷ in order to draw from it various particular varieties of quantum theory.

DECOHERENCE AND PROBABILITIES

We have seen that, short of confronting the grave epistemological difficulties of nonlocal hidden variable theories, quantum probabilities cannot be taken as the expression of an *ignorance* on the subject of processes or events that happen *of themselves* within nature. The quantum calculus of probabilities bears upon phenomena whose occurrence is suspended by the intervention of an appropriate context. The problem is that, qua physical theory, quantum mechanics has a vocation to universality. The metacontextual probability calculus which is its principal constitutive element must therefore be able to be applied without restriction and on every scale. But, in our familiar environment, isn't the classical (Kolmogorovian) theory of probabilities perfectly utilisable? And doesn't this classical theory, unlike its quantum equivalent, function such that nothing prohibits us from considering it as

27. 'Quantum mechanics is not itself a dynamical theory. It is an empty stage. You have to add the actors [...] the missing element that has to be added to quantum mechanics is a principle, or several principles, of symmetry.' S. Weinberg, in R.P. Feynman & S. Weinberg, *Elementary Particles and the Laws of Physics* (Cambridge: Cambridge University Press, 1987), 87.

expressing a partial ignorance as to intrinsic properties and autonomous events? Thus is posed a problem of *compatibility*, between quantum probability calculus (valid in principle on every scale) and the classical calculus of probabilities (valid in practice on our scale).

The principal objective of theories of decoherence is to test this compatibility. For they allow us to prove that, when applied to complex processes involving an object, a measuring apparatus, and a vast environment, quantum probability calculus is reduced, *up to a very weak approximation*, to the classical calculus of probabilities. This is manifest in the quasi-disappearance of the terms of *interference* typical of quantum probability calculus, and isomorphic to those of a wave process, in favour of a quasi-validity of the classical rule of the additivity of probabilities of a disjunction.

However, rare are those physicists who are content with this purely *probabilistic and predictive* formulation of theories of decoherence. Some among them have even cherished the hope of utilising decoherence as a means of explaining the *emergence* of a classical world, on the basis of a quantum world supposedly ‘described’ by a universal state vector.²⁸ The major obstacle they find themselves up against is that, in order to be able to derive, on the basis of a purely quantum calculation, the classical laws and behaviours that prevail

28. M. Gell-Mann, *The Quark and the Jaguar. Adventures in the Simple and the Complex* (New York: Abacus, 1995).

at the human scale, they have not been able to avoid introducing hypotheses that already contain anthropomorphic elements.²⁹

These discomfitures encourage us to demand no more from decoherence theories than a retrospective assurance of a mutual consistency that is *in practice* sufficient between quantum probability calculus and the presupposition, at once fundamental and elementary, that subtends its experimental test. This presupposition consists in admitting that macroscopic events (like the deviation of the pointer of an apparatus) themselves arise in the laboratory, that their trace is for all time available for any researcher who desires to repeat the observation, and that the utilisation of probability calculus *with regard to them*, consequently, only expresses a partial ignorance as to what they are.

QUANTUM FIELD THEORY, PATH INTEGRALS, AND METACONTEXTUAL PREDICTIVE FORMALISM

The reflections above, it is true, hold something surprising for certain contemporary physicists. For, in manipulating a concept of field sometimes insufficiently

29. Bitbol, *Mécanique quantique, une introduction philosophique*, 410-18. For a close critique of the ontological claims of theories of decoherence, see B. d'Espagnat, 'Towards a Separable Empirical Reality', *Foundations of Physics* 20 (1990), 1147-72. R. Omnès's response can be found in R. Omnès, *The Interpretation of Quantum Mechanics* (Princeton, NJ: Princeton University Press, 1994).

distinguished from its classical equivalent, and in taking literally the processes that are figured imaginatively in Feynman diagrams, a non-negligible number among them ended up behaving as though the conceptual problems that quantum mechanics raised at its birth were but a bad memory. If physics ‘describes’ the evolution of fundamental fields, and/or if it manages to ‘describe’, equally, the dynamics of particles (considered as a state of excitation of a field) by way of the procedure of Feynman path integrals, why still preoccupy oneself with that old Bohrian notion of the inseparability of the phenomena and its experimental conditions of manifestation? Why bring to the fore a notion as opaque for the theoretical physicist as that of ‘measurement’?³⁰ Why insist obstinately upon the *predictive* rather than *descriptive* status of quantum theories? Isn’t it possible that many of the philosophical perplexities of the creators of quantum mechanics were linked to the use of a formalism (that of vectors in Hilbert space) which, in the most advanced theories, has been rendered obsolete by the formalism of path integrals?

The response to these questions is that, in truth, *none* of the epistemological constraints exerted by

30. Let us remark in passing that, if it is true that the concept of ‘measurement’ cannot claim any particular status within the field of validity of physical theories (since it is not distinct in principle from other physical processes), it belongs to the conceptual resources of a background that is *logically prior* to any *experimental, testable* theoretical elaboration. It thus has an uncircumventable *metatheoretical* function.

the standard quantum mechanics of 1926 have been relaxed by contemporary varieties of quantum theory, and that new constraints of a similar order have even been added to them. Whatever representations they may give rise to, current quantum theories *always* operate as generalised, metacontextual instruments of probabilistic prediction. And this stems from the fact that they are *always* confronted with phenomena inseparable from their context of manifestation. So as to shore up this response, it will be sufficient to evoke rapidly the renovation of philosophical reflections invited by quantum field theory, and then to redefine the relations between the formalism of state vectors in Hilbert space and that of Feynman path integrals.

The central trait of quantum theories, which is that they consist in a metacontextual structure of probabilistic prediction, is rediscovered, not only intact but amplified, in quantum field theory. At the end of a reflection on the formalisms of Fock spaces, Paul Teller concludes: 'states [in Fock space] simply characterise propensities for what will be manifested with what probability under various activating conditions. Among the items for which there can be propensities for manifestation is the occurrence of various numbers of quanta...' ³¹ In other words, far from having rendered superfluous contextual notions such as those of propensive state,

31. P. Teller, *An Interpretive Introduction to Quantum Field Theory* (Princeton, NJ: Princeton University Press, 1995), 105.

‘observable’, and conditions of ‘activation’, quantum field theories have generalised their application. The concept of quantum field is derived from the classical concept of the field by putting local observables into correspondence with local functions, and through the introduction of relations of commutation (or anti-commutation) for certain couples of observables. As to state vectors in Fock space, they allow not only the calculation of the probability that this or that ‘property’ of a particle will manifest itself in a given experimental context, but the probability that a certain *number* of particles will be detected under the appropriate instrumental conditions. This number itself is treated as an *observable*, the set of whose possible values *under appropriate conditions of detection* is identified with the set of whole natural numbers. To the contextualisation of the *predicate* of objects typical of standard quantum mechanics, then, quantum field theory adds the contextualisation of the notion of the denumerable *bearers* of predicates.

That one must from now on hold the very concept of ‘particles’, and not only that of ‘properties of a particle’, to be relative to a context of manifestation, is rendered particularly evident by the relativistic phenomenon of so-called ‘Rindler particles’. This phenomenon is observed when accelerating a detector in the ‘void’.³²

32. The formal translation of the concept of the ‘quantum void’ is a state vector in Fock space identical to those of vectors belonging to the observable ‘Number’ that is associated with the eigenvalue *Zero*.

The *accelerated* detector responds, in this environment where no detector *at rest* would detect the least particle, as if it were plunged into a thermic bath of particles.³³ It is thus quite clear that one cannot treat particles as objects that ‘are’ there or ‘are not’ there, independently of the conditions of their detection. One has only the right to speak of *phenomena of detection* that imply, indissociably, a milieu (say ‘the quantum void’), a detector, and the dynamic state of this detector. Quantum field theories now appear as particular elaborations of the metacontextual probabilistic framework of quantum mechanics—elaborations adapted to a broadened class of contextual phenomena, belonging to a relativistic domain, and pertaining to the formal concept of ‘bearer’, beyond that of ‘property’.³⁴

Now we come to Feynman path integral formalisms, which have often supplanted standard formalisms in the modern practice of quantum field theories.³⁵

This state vector associates a null probability with the detection of a number of particles larger than zero by a detector at rest.

33. Teller, *An Interpretive Introduction*, 110.

34. The link between the intervention of *relativistic* processes and the mobilisation of the concept of ‘bearer’ alongside that of ‘property’ is made immediately comprehensible by a clarifying remark of B. d’Espagnat: From the fact that the energy-mass equivalence established by the Theory of Special Relativity, d’Espagnat remarks (in *Le réel voilé* [Paris: Fayard, 1994]), it can always happen that a ‘property of objects’ (kinetic energy) is transformed into ‘objects’ (one or several particles).

35. In *superstring* theory, the linear pathways are replaced by *tubes*, and the summation effectuated by an integral bears upon these tubes of spacetime whose section is an annular ‘string’.

Although the functioning of path integrals is illustrated by linear diagrams evoking spatiotemporal trajectories of particles, their role is only to permit the calculation of the *probability* of a final experimental event (at a certain point) under condition of the occurrence of an initial experimental event (at another point). Here, the dependence of the phenomena whose probability is calculated on an instrumental context is only implicit, but it plays a no less capital role in the very principle of the calculation to be carried out. For what does one concretely do when one evaluates a path integral? One sums ‘probability amplitudes’, then one takes the square of the modulus of the sum thus obtained, to obtain the *probability* one seeks.³⁶ Now, the distinction between probability amplitudes and probabilities corresponds pretty much to that between virtual experiments and actual experiments. Read in the framework of standard formalism, probability amplitude is nothing other than the scalar product of the state vector and of a vector belonging to an observable corresponding to an experiment that *would have* taken place (but which did not) in the interval that separates the two actual experiments.³⁷ On the contrary, probability is calculated for the result of an experiment that will *actually* take place,

36. R.P. Feynman & A.R. Hibbs, *Quantum Mechanics and Path Integrals* (New York: McGraw Hill, 1965); R.P. Feynman, *QED: The Strange Theory of Light and Matter* (Princeton, NJ: Princeton University Press, 1988).

37. Generally, these experiments consist in making (virtual or actual) measurements of the *spatial position*.

or which already has done. The path integral formalism, just like that of Hilbert space vectors, manifests the metacontextual predictive structure of quantum theories. It consists in evaluating the probability of a contextual phenomenon by summing the terms corresponding to *virtual intermediary contexts* distinct from those in which the phenomenon is effectively manifest.

Let us add to this two other circumstances that suggest close relations between the functioning of quantum theories utilising a vector formalism in Hilbert space, and those making use of path integrals: Firstly, Feynman has demonstrated the equivalence between the formalism of standard quantum mechanics, which puts a Hamiltonian operator in place in Schrodinger's equation, and the path integral formalism, which uses the corresponding Lagrangian function.³⁸ What is more, just as certain principles of symmetry determine the Hamiltonian form of Schrodinger's equation, it is the principles of symmetry that allow us to fix the density of the Lagrangian of each interaction, and thus to determine the path integral.³⁹ The use of such principles of symmetry has as its most concrete consequence the modulation of path integrals (and consequently also that of the probabilistic evaluations that result

38. Feynman & Hibbs, *Quantum Mechanics and Path Integrals*, chapter 4.

39. G. Cohen-Tannoudji and M. Spiro, *La matière-espace-temps* (Paris: Gallimard, 1990), 185.

from them), annulling the amplitude of certain of the diagrams that intervene in the summation.⁴⁰

EPILOGUE

All of this leads us to conclude with two propositions that are valid independently of the variety of quantum theory or formalism utilised: Every quantum theory combines an invariable element—a metacontextual form of probability theory—and a variable element—a set of symmetries. The association of these two elements makes it a system of probabilistic evaluation suitable for a class of experimental situations whose extension depends upon the symmetries brought into play. As soon as one accepts that there is nothing more to be understood in quantum mechanics, a whole world of non-physical applications of the theory opens up, in game theory,⁴¹ perception theory, or linguistics.⁴² Conversely, the very success of these exotic applications testifies that quantum mechanics is indeed in its essence a metacontextual form of probability theory.

40. S. Weinberg, *The Quantum Theory of Fields I* (Cambridge: Cambridge University Press, 1995), 428

41. A. Lambert-Mogiliansky & V. Danilov, 'Expected Utility Theory under Non-classical Uncertainty', *Theory and Decision* 68 (2009), 25–47.

42. P. Bruza, K. Kitto, D. Nelson, & C. McEvoy, 'Is there something quantum-like about the human mental lexicon?', *Journal of Mathematical Psychology* 53 (2009), 362–77.

A Formal Deduction of the Market

Elie Ayache

PROBABILITY

Kolmogorov's probability formalism¹ is pure mathematics and knows nothing of experiment, trial, event, or realization. It is an abstract measure theory in which a function, called measure or *probability*, maps a field of sets into the set of positive numbers and verifies certain axioms of additivity. The passage to the limit in countable sums of measurable sets and the notion of sets of measure zero are its main characteristics. Random variables are mappings between the sample space (the set of elementary events) and the real set, and are said to be measurable as soon as the pre-images of the mapping are measurable.

1. A. N. Kolmogorov, *Foundations of the Theory of Probability* (New York: Chelsea Publishing Company, 1950).

The words 'event', 'random' and 'probability' are part of a semantic apparatus that has been superimposed on the formalism. When used as labels at the formal level, these words do little more than hint at one possible interpretation of the formalism. Realization, trials, and thus statistics, are just one possible interpretation of the probability formalism—and there may be others. In Kolmogorov's own words, 'Every axiomatic (abstract) theory admits, as is well known, of an unlimited number of concrete interpretations beside those from which it was derived.'²

In asking what the meaning of probability may possibly be, I will consequently embrace, in the following, a different angle than the one from which probability is intuitively understood as the 'degree' (whatever that means) to which a certain event is known to, or expected to, happen. I will inquire what other interpretations can be given of the probability formalism, even if such interpretations prove to be so radically new as to rob probability of its usual intuitive meaning and to make it almost inaccurate to continue to speak of the 'probability' formalism.

You may ask what the point could be in giving alternative meanings to the probability formalism that may disconnect it altogether from the original intuition of probability and from the physical reality that probability was meant to represent. My quick answer

2. Ibid.

is that derivative pricing and trading, or for short, the derivatives market, or for even shorter, the *market*, are in my view a consequence of an interpretation of the formalism that is utterly foreign to statistics and to the corresponding intuition of probability. The formalism in its finest form (i.e. Brownian motion) has produced a new reality—the market—that has nothing to do with statistics or with the idea that outcomes are *realized* at each trial and generate *statistical* populations.

The probability formalism is peculiar in that reality itself is a part of its concrete interpretation. If the dialectical opponent of form is to be called *matter*, then we may say that reality is a part of the matter of probability theory. Is this a hint that materialism is different, and perhaps more general, than realism; and that metaphysical insights as to what we mean by reality and by matter are to be gained from the question of probability and its formalism—more deeply so than from other formalisms in which the pair form/matter is at play? And would it then surprise us that a philosopher such as Davidson should lean on the example (and even the precedent) of the probability formalism to suggest what an axiomatic theory of truth might look like?³

Interpretation is usually supposed to connect a formalism with the real world, with reality or with

3. D. Davidson, *Truth and Predication* (Cambridge, MA: Harvard University Press, 2005).

concrete models. For instance, certain primitive terms are involved in a list of axioms in Hilbert's formalization of geometry or in Mach's formalization of mechanics, and we later interpret them as straight lines and circles, or as solids and mass. Similarly, formal probability can subsequently be interpreted as objectively inherent in the chance set-up that produces random outcomes (dice, roulette)—what Popper calls the generating condition⁴—or as mentally contained in the mind of the subject. In that sense, the interpretation of the formalism bestows reality on probability. However, we also say of a probable event that it will either be *realized* or not; and we commonly believe that an event of probability equal to 1 is *realized*. We can observe, therefore, that reality enters into the semantics of probability theory at a more basic level than the question of the reality of the probability: before we ask, along with the realist or the antirealist, whether the probability of a certain event is real or not (in the sense of belonging to the ontology of the world and residing either in the object or in the subject), there is first the sense of reality according to which we say that the event in question will either happen or not. The very notion of *event*, which is more elementary than probability in the formalism, calls for the notion of *fact*, and therefore that of *reality*.

4. K. Popper, *Realism and the Aim of Science* (New York: Routledge, 1983).

We shall see that even this first level is open to interpretation, and therefore to variation, and that an event of probability 1 may not need to be linked with the idea of realization. The intuitive meaning of the word ‘event’ as a ‘happening’ may have to be revised. Even reality, in the sense of actual occurrence or realization, may not have to be part of the ‘realization’ of the formalism (now understood at the higher level of its interpretation). Perhaps reality will gain a wider meaning from its peculiar double entry in the semantics of the probability formalism.

As a matter of fact, in addition to the two levels or meanings of reality (reality as in realization and reality as in realism), we will finally consider a third one: a new brand of reality that is, this time, literally triggered by the formalism. The reality of the market is something we shall *deduce* from the formalism—not the market as a preexistent reality that was waiting for an interpretation to later make its terms correspond with those of the formalism but, astonishing as it may sound, the market as something that will literally *come into being* following a certain interpretation of the formalism. It is as if the market were an accident, something we could construct from the formalism but that was not meant to be.⁵ This final brand of reality is reality in the sense of genesis and inception.

5. G. Simondon, *Du Mode d'existence des objets techniques* (Paris: Éditions Aubier, 1958).

FORM, MATTER, REALITY

Everybody knows that Kolmogorov developed his formalism based on statistical heuristics. He had in mind repeatable experiments, and he thought of the probability of a certain outcome as the frequency of its appearance in finite sequences of successive trials. The notion of independent random variables was precisely introduced to suggest repetition. As for countable additivity—and one can argue, measure theory as a whole—it was ultimately adopted to demonstrate the strong law of large numbers,⁶ which ultimately gave probability the *precise* objective meaning of a limiting frequency. (As for subjective probability, it required only coherence from the theory, not the full extent of the law of large numbers.)

Measure theory is of the essence as soon as infinitary events are considered, and we need to exclude sets of measure zero. However, what probability theory specifically brings, over and above measure theory, is the notion of independence and repetition, or the notion of independent trials. Ultimately the purpose is to demonstrate the strong law of large numbers, which is believed to be the distinguishing feature of probability theory. (In the case of von Mises, probability is even

6. The strong law of large numbers is a theorem that was proven by Émile Borel in 1909. It states that the frequency of appearance of a certain event A in a series of independent trials converges to the probability p of that event almost surely, or in other words, with probability equal to 1.

defined after the law of large numbers.)⁷ No matter that infinite sequences of trials may not empirically exist; the meaning of probability—and meanings are real, albeit not empirically verified—is that the frequency will precisely converge to that number in the infinite long run, in an appropriately repeated experiment.

To be more exact, the strong law of large numbers is a mathematical proof in Kolmogorov's formalism, and is therefore unquestionable; however, in order for it to connect with reality, and for probability to acquire its objective and precise meaning, it is necessary (1) to interpret the formal sequence of independent identically distributed (iid) random variables that appear in the strong law as repeated trials of the *same* experiment (indeed, there is no such thing, in the formalism, as a material die that one would grasp, lift and throw over and over again, so one has to force this image through an external interpretation); and (2) to interpret the probability equal to 1 as triggering the realization of a certain event (Cournot's principle).⁸ Now, *sameness* (the sameness of a repeated experiment) and *realization* (the realization of an event) are two terms that are

7. R. von Mises, *Probability, Statistics and Truth* (New York: Dover, 1981).

8. Cournot's principle is the principle according to which an event whose probability is very close to 1 will happen. Surprising as it may sound, this principle is not part of probability theory. Kolmogorov adds it separately to the axioms of the theory in a paragraph entitled 'Relation to Experimental Data'. Indeed, it is an *interpretation* of the formalism of probability theory, or a bridge between the formalism and reality, to specify as a *meaning* of a probability close to 1 that the event to which this probability is assigned by the theory will empirically happen.

foreign to the formalism; so it is only through an *interpretation* that the formal proof of the strong law of large numbers could endow real probability with this meaning.

Now, note that the random variable which converges almost surely⁹ to the mean of the iid variables is, in the case of the law of large numbers that interests us, the average of the infinite sequence of random variables that take value 1 or 0, depending on whether the outcome whose frequency we are measuring appears or not in the corresponding trial. The event that will be realized with probability 1 is not, therefore, a *specific* infinite sequence in which the frequency of the outcome of interest can be checked, but the whole set of all sequences in which the frequency of the given outcome is equal to the mean. In other words, the event that is realized almost surely in Kolmogorov does not distinguish between permutations of occurrences. Additionally, measure theory is here to exclude exceptional events in which the given frequency is not verified—for instance, sequences in which the desired outcome never appears.

The very idea of randomness seems to prevent us from identifying (term by term) the actual sequence of outcomes that is supposed to realize the frequency. Even if one were to argue from the realization of the

9. 'Almost surely' means with probability equal to 1 (see footnote 6 above).

whole set of sequences to the realization of a specific one, its membership in the set is here to remind us that the sequence could have been otherwise, provided the overall frequency of the outcomes is preserved. We should be reminded that von Mises, who adopted the alternative approach to Kolmogorov, in that he defined probability *in terms of* the realized frequency in the actual infinite sequence, took special care to reintroduce randomness in what could otherwise have looked like an actualized sequence in which all is finished and done and the frequency is checked ex-post. The *axiom of randomness* which he introduced for this purpose provides that the infinite sequence in which the limiting frequency exists (and is defined as the probability) preserves the limiting frequency through sub-selections.

To be more exact, given the infinite sequence in which the frequency is assumed to converge, the axiom of randomness requires that you may have no way of selecting an infinite sub-sequence (looking only at outcomes previous to the place you are currently sub-selecting) in which the limiting frequency would be different. Von Mises called *collectives* the sequences of outcomes which exhibited this remarkable property. One might wonder if such collectives could ever exist—formally, of course, for they certainly do not empirically exist.

The existence of collectives was proven mathematically, albeit non-constructively. Not only do they exist, they are dense in the set of all infinite sequences. The drawback, however, is that a collective is not identifiable term by term. One cannot construct a collective by definition, for otherwise one would know how to construct a sub-sequence that violates the frequency. In the words of von Mises: ‘In the case of the collective, we must be satisfied with its abstract “logical” existence. The proof of this “existence” is that it is possible to operate with the concept of a collective without contradictions arising’.¹⁰

As a result, even though it looks as if von Mises is considering sequences of outcomes in an ex-post fashion, the axiom of randomness really prevents one from imagining that the ‘next’ outcome is ever given. As a matter of fact, the axiom of randomness reinstates the ex-ante stance in which a random generator is at play at each step, really guaranteeing that we cannot see and foresee the next outcome. Being an empiricist, von Mises did not want to believe in the existence of such a random generator or in the reality of ex-ante probability, and wanted only to consider the observable outcomes. However, we saw that the axiom of randomness, which he definitely needed, precisely reintroduced the undesirable tension between ex-ante and ex-post.

10. von Mises, *Probability, Statistics and Truth*, 88.

The only way to reproduce the ex-ante stance unambiguously is to adopt an approach like Kolmogorov's. His approach may even be better than ex-ante, as it is not clear that anything (an event) ever happens at all that would justify our even speaking of ex-ante, let alone of ex-post. Indeed, not only is the outcome never actually drawn in Kolmogorov's formalism, but one could argue that the infinite sequence of iid random variables involved in the strong law of large numbers are not even chronologically indexed. Each random variable in the sequence remains a variable (i.e. a complete mapping) and is never 'thrown' in a single outcome. And the statement of the law is, as we have seen, only a probabilistic statement concerning the overall random variable which is the average of the individual ones. One can always imagine that the whole sequence is 'realized' in one throw, as a single sample, if at all. Chronological sampling is only an image, which is forced on us by the image of the material die and the corresponding interpretation. Only if we interpret the individual random variables in the sequence as throws of the same die (and thus as repeated throws) does this impose the image that the die is thrown, collected and thrown again in an identifiable sequence.

This is not to mention that realization ultimately is an interpretation too. In a paragraph titled 'Relation to experimental data' and separate from the axioms,

Kolmogorov specifically indicates that one can be practically certain that the event with very high probability would occur.¹¹ If the meaning of the probability being close to 1 is that the corresponding event shall occur, this gives us no idea what the meaning of a probability p that is less than 1 might be. The only statement linking a probability that is less than 1 and a probability that is equal to 1 is the strong law of large numbers, which, as we have seen, does not tell us which specific sequence is realized and, correlatively, tells us nothing about the individual throw that is chronologically inserted in such a specific sequence and whose individual probability we are after.

EXTENSION VS. INTENSION

The meaning of probability that we want to decipher seems, therefore, to be in tension. The probability that the face 'six' will come up is said to be equal to $1/6$ only insofar as a frequency of $1/6$ shall be realized in an overall event in which *it is not clear which specific, chronological sequence of outcomes is actually realized*. The very idea of probability and of a random generator seems to compel us to say something about the die we are *chronologically* holding and about the *chronologically* next sample; however, the meaning that

11. A. N. Kolmogorov, *Foundations of the Theory of Probability* (New York: Chelsea Publishing Company, 1950), 4.

probability ultimately receives from the strong law of large numbers ‘reshuffles’ chronology and destroys it. The image of the material die emphasises the idea of a chronological sampling in which probability is defined for every throw; yet the very notion of ‘realization’, which suggests the idea of a transition from the possible to the real and gives probability its apparent meaning, really concerns an ultimate and global event with no relation or correspondence to the local throw.

The point is difficult to appreciate, because we are holding the die and expect to be able to say something about the next throw (in time). There seems to be something inherent, pressing and measurable about the propensity of the die to generate the next outcome with some probability. However, what’s really *next* is not what’s next in *time* (for chronology is only an image); it is what is next in the sense that the whole sequence of variables unfolds, in nonchronological fashion and in nonidentifiable extension. The next extensional throw is an image which we think finds its coherence in infinity because what is realized is the limiting frequency; this realization is then rolled backwards to the next local throw we are considering, and lends it the idea that the next outcome will be realized in time and its probability will play out in time; but this usage of infinity ultimately contradicts the extensionality and identification of the ‘next’ throw. There is something pressing to say when holding the

die—however, this won't take place in time. The whole trouble that mars interpretations of probability originates from this confusion. There is something local, but not ex-ante: A new metaphysics of chronological intension rather than extension, linked to place and no longer to extensive time.

Time, and the intuition of *waiting and seeing* that a probability-1 event gets realized, have to be retired from the interpretation of probability altogether. Adding Cournot's principle to the formal (timeless) strong law of large numbers, we obtain the statement of realized frequency in the infinite run, only to realize that this realization cannot really unfold in extensive time because, to repeat, it is infinite, and it does not identify, as per chronology, one member of the realized series after the other. The conclusion is that nothing really happens, nothing is realized, in time. The static and timeless *realization* of probability is that it is a distribution of mass, that mass means matter, and that the only matter here—the only reality here—is the fact that a static die lies on a certain unique face, because it was forced to do so by the surrounding matter and the surrounding world—and *that this face could have been different*. This contingency, when it is understood intensively and not extensively—as a difference that is infinitely, repeatedly reintroduced in the face as the completed statement of reality—is then equivalent to the infinite strong law of large numbers.

The random variable is *one* thing that relates to *many* outcomes. It is an instance of the dialectics of the one and the many. Now, the sequence of independent identically distributed random variables that is involved in the strong law of large numbers is the dual or conjugate view of the same dialectics. The variables share one probability distribution (the one) yet they are independent (the many).

Rather than mass distribution, the conjugate view taken by the law of large numbers is frequency. Mass distributed among outcomes in one view; outcomes distributed along frequencies in the other. Mass summing up to 1 in one view; averages converging with probability equal to 1 in the other. One view is extensional; it takes the *different possible*, yet unrealized, outcomes under one heading. The other view is intensional and therefore dynamic; it takes one realized outcome at a time, and then argues, infinitely, that *it could have been different*.

Taking the dual representation and using integral calculus to average the sequence of iid variables in the infinite long run instead of averaging the static probability distribution of the random variable, this reorientation of thought, once we understand that chronology is a false illustration of the sequence of random variables (because of the fact that the chronological sequence of outcomes is not extensionally identified), is how the *strike of contingency* should be understood.

The strike of contingency is internal difference and intensive infinite repetition. It says of a thing that it could have been different *before* saying that a thing is. The fact that it could be different does not add other individuals to the contingent thing. It speaks of its singularity: it is unique, it is what it is *insofar as it could be different*. This strange way of recognizing the multiple as the intrinsic difference of the one—as its *singularity* instead of its *individuality*—implies a new way of counting. This will no longer involve frequencies but, as we shall see, the *money account*.

MONEY

It is no accident that the impossibility of gambling systems should be (following von Mises) a more fundamental characterization of randomness than the invariance of the frequency in all sub-selections of a given infinite sequence (keeping in mind that this axiom of randomness precisely prevents any sequence from being given). It is commonly believed that the axiom of randomness prevents any sequence from exhibiting any recognizable betting pattern, or any frequency of appearance of the outcome of interest that would differ from the odds at which the bet is offered. This, of course, is the reason why you are statistically prevented from making a fortune when betting against a truly random generator. It is believed that a certain property

of frequency (randomness) entails a property of the gambling strategy (break-even). However, Jean Ville, on which Glenn Shafer and Vladimir Vovk¹² base their work, has shown the opposite, by allowing the gambler to take fractional bets, in a dynamic strategy that is the ancestor of the dynamic rebalancing known to derivatives players today. He has shown that some sequences that are random in the sense of frequency can be vulnerable to a gambling strategy using fractional reinvested bets, whereas sequences that are invulnerable to gambling systems are, of course, random in terms of frequency.

This suggests that money, which is the medium through which gains are accumulated, is ultimately a more fundamental ‘counting device’ of randomness than the frequency count. (It is more ‘liquid’.) This is no accident and, in my view, corresponds to the fact that randomness is ultimately incompatible with the extensional chronological view where one outcome is chronologically followed by the next.

Contrary to the current saying, time is not money, because money is more fundamental than time. As a matter of fact, Shafer and Vovk propose an alternative interpretation of the probability-1 event that no longer takes place in time, but in money. Instead of Cournot’s principle, which prescribes that a probability-1 (or

12. J. Ville, *Étude critique de la notion de collectif* (Paris: Gauthiers-Villars, 1939); G. Shafer & V. Vovk, *Probability and Finance, It's Only a Game!* (New York: Wiley, 2001).

approaching 1) event is ultimately realized, and therefore induces the notion of the probability of the throw being tensed in time through the strong law of large numbers, Shafer and Vovk propose a constructive trading strategy such that we would make a fortune if the probability-1 event were *not* realized. Making a fortune being morally impossible, this in theory entails that the probability-1 event will be realized. However, the real import of Shafer and Vovk's work is that the outcome no longer matters. When all we had was probability, we could only wait for the probability-1 event to happen (or not happen), and had nothing real in our hands in the meantime. With Shafer and Vovk, we have the real constructive trading strategy in our hands, in the meantime. This dispenses with time.

It is well known that martingales provide an alternative formal presentation of probability theory.¹³ However, when martingales are regarded no longer

13. Originally, a martingale is any strategy for placing bets (not necessarily a strategy with guaranteed positive outcome). Ville formalized the concept by calling 'martingale' the strategy's capital process, or the real valued function that assigns to each sequence of outcomes the capital that you will have accumulated by betting on each outcome and having settled your bets. In a fair game, the value of the bet is supposed to reflect the probability of the outcome and your capital gains are not supposed to grow indefinitely. As a matter of fact, the expected value of your future accumulated gains must be equal to the gains you have already accumulated. If the concept of probability was not available and you only knew of money and of betting, the condition that your capital process should not grow to infinity could be used as an alternative to probability. This is done by Shafer and Vovk: 'We say that an event happens almost surely (that is, with probability one) if there is a nonnegative capital process that diverges to infinity if the event does not happen' (Shafer & Vovk, *Probability and Finance*, 53).

as a formal alternative, but as an alternative to the traditional *interpretation* of the probability formalism—the interpretation that revolved around Cournot's principle and the corresponding notion of *realization*, and produced the notion of frequency as a consequence—the connection with reality that we end up with is no longer the notion of the potential realization of the possible, but that of the *present reality of the trading strategy*.

In fact, all that Shafer and Vovk have done is to recognize the fundamental role that *price* could play, as opposed to probability. We usually think of price after probability, and more or less identify the price of a contingent payoff with its expected value. Now consider, with Shafer and Vovk, that a probability of 1 no longer means that something possible is realized; and think, therefore, that probability no longer means that a certain frequency is realized in the long run. Nothing is realized, in this sense, and 'probability' is no longer probability. Time series still exist, of course, but they have been robbed of the notion of a random generator. Time is unavoidable, but it is no longer essential to contingency. Frequencies are still empirically observable, but they no longer mean anything as far as probability or 'what to do next' is concerned.

Following this logic, price no longer depends on the prior concept of probability, but becomes what Shafer and Vovk mean it to be—namely, the price at

which you buy the bets (possibly fractional), or in other words the entry ticket into the trading strategy. Price means what it means insofar as money is what it is. And what money is, is that medium such that the gains you accumulate in it would eventually diverge to infinity if something didn't come to pass. However this, as we said, is no longer the issue, because time and possibility are no longer fundamental; what is fundamental is what money permits us to have *now*—and this is the present strategy.

Now, Shafer and Vovk's position sounds unrealistic, because who is to sell you the bets in reality and to settle them step after step? De Finetti has already conceived of subjective probability as betting odds;¹⁴ however, what he had in mind was a single event (not an infinite series as in Shafer and Vovk), and a single agent (a banker). In the infinite game proposed by Shafer and Vovk, they call the opponent 'reality'. Reality is supposed to offer the bets and to settle them. When this reality happens to be the actual financial market, it all comes together nicely, because you buy a security at its market price in the morning (the bet) and you settle your bet at its closing price in the evening.

Shafer and Vovk do not imply that in the majority of cases (which are other than financial) we should actually create the corresponding market—for chances are that we would then relapse into the temptation of modelling

14. Bruno de Finetti, *Theory of Probability* (New York: Wiley, 2 vols, 1974).

the corresponding prices probabilistically, either objectively (some data generating process) or subjectively (the market as a bunch of agents), thus relapsing into saying that probability is more fundamental than price. In cases which are not readily financial, Shafer and Vovk mean by money something purely 'imaginary', whose only role is precisely to show that there is another way of addressing the contingent event than waiting and seeing, being tensed in time. What they wish to eradicate is the notion of the random generator. To repeat, all of this is taking place at a higher metaphysical level, and ultimately money should be seen as an alternative to time. What is interesting, now, I think, and would press the point even further, is if we were to even think of the 'real' money involved in the financial markets as this 'imaginary' thing Shafer and Vovk have in mind. In other words, to think that the financial markets are the real proof that random generators do not exist.

EX-ANTE VS. EX-POST

Now a really provocative (perhaps even revolutionary) thought: This is about Brownian motion. Brownian motion is a mathematical formal construct; it is a fiction that is true and unquestionable in theory, but not in reality. In empirical reality, we find only phenomena that approximate Brownian motion. The movement of the pollen particle is truly irregular at

any scale that we can *observe*, and there is no notion of speed that we can physically attach to it; however, it is not infinitely divisible like true (formal) Brownian motion. Stock prices are empirically unpredictable at any scale that we can trade them; however, we cannot divide their trajectory beyond the minimum tick, etc. True Brownian motion is not real, but only formal. But my provocative thought is that the derivatives market—which is real, of course—may *really* be the consequence of true, mathematical Brownian motion.

We saw that the infinite series of outcomes of a random experiment do not empirically exist, since no one can really wait indefinitely. And yet this didn't stop von Mises—an empiricist—from requiring them in order to define probability. Similarly, the infinite sequence of random variables does not empirically exist, yet this doesn't stop us from leaning on Kolmogorov's strong law of large numbers in order to give probability its real objective meaning. As a matter of fact, the passage to the infinite limit is not the real obstacle standing in the way of making sense of the objective probability of the *next* throw of the die. The real difficulty lies in the incompatibility between the axiom of randomness and the *extensional* identification of the series of outcomes. Randomness in von Mises prevents us from identifying the collective term by term. Similarly, randomness in Kolmogorov prevents us from identifying a particular extensional sequence

of outcomes in which the frequency convergence would be observed, because the convergence in the strong law of large numbers concerns random variables that remain unrealized, and an average random variable whose probabilistic convergence to the mean does not distinguish a particular realization of the sequence.

As a result, there is tension between the strong law of large numbers (either in von Mises or in Kolmogorov) and the notion of *propensity*, or the idea that there is something tensed and pressing to say about the probability of landing, say, a 'six' with the next throw of the die. Ultimately, it is the notion of random generator that is untenable (a philosophical view defended by Popper), along with the ex-ante attitude that it precipitates. Of course, random variables and random processes do exist mathematically, and can be defined as a function of a variable t that we call 'time'. And this, in turn, can suggest the image that the next outcome is literally generated before our eyes, and therefore that an ex-ante attitude is legitimate. However, when the formalism is interpreted in physical time, we do not know what it means for a physical variable to *follow* that process or to be generated randomly, other than the fact that it would produce a statistics whose limiting frequency would be equal to the instantaneous probability. And this would again put into conflict the meaning of probability, which we wish to be real and inherent in the *next* throw, and the idea of randomness,

which ultimately destroys the identifiable extensionality of the next throw.

This led Shafer and Vovk no longer to speak of frequencies as the basis of probabilities, no longer to count occurrences extensionally and identifiably one after the other, but to integrate all of that into the money account. It is not individual occurrences that should count (nor frequencies), but occurrences integrated against a financial payoff. It is for this reason that the impossibility of a gambling strategy is a more fundamental characterization of randomness than invariant frequencies. Shafer and Vovk write:

Our *hypothesis* of the impossibility of a gambling strategy is not a statement about probabilities. It is a hypothesis that relates a certain game to the world, which we can state before we compute probabilities for events from the prices in the game. [...] Our understanding of the impossibility of a gambling system, as something prior to the computation of probabilities, is relatively novel. It departs from the thinking of Cournot, Lévy, and Kolmogorov, for they formulated principles for interpreting zero or small probabilities, not hypotheses expressed without reference to probabilities. Von Mises anticipated our way of thinking, for he did say that the impossibility of a gambling system is something more primitive than probability. But his allegiance to this idea was half-hearted; in the end he refused to acknowledge

that the impossibility of a gambling system is more fundamental than invariant frequency.¹⁵

Because they no longer count individual occurrences, Shafer and Vovk no longer wait for the event to happen. Their attitude is no longer *ex-ante*; it is no longer tensed in time. As noted above, the fact that the impossibility of a gambling system should come before frequency and probability as a definition of randomness (rather than being a consequence of randomness defined in terms of frequencies or patterns of occurrences) drives Shafer and Vovk to relinquish the principle according to which a probability that is equal to 1 means realization (Cournot's principle). They drop the whole idea that something is realized with some probability, and correlatively the whole idea of a random generator. They drop the transition from the possible to the real, which we call 'realization'. Their attitude is no longer one of waiting and seeing. Instead of realization of the possible and the *ex-ante* attitude, they adopt the *reality of the winning strategy*. Even though the winning strategy is here and now, this is in the sense of place, not of time (we do not really care about the outcome). The strategy is local, yet it is not *ex-ante*. For this reason, I call it, strangely enough, *ex-post*.

This is the same idea, really, as saying that what is fundamental in the case of the insurance company is

15. Shafer & Vovk, *Probability and Finance*, 56.

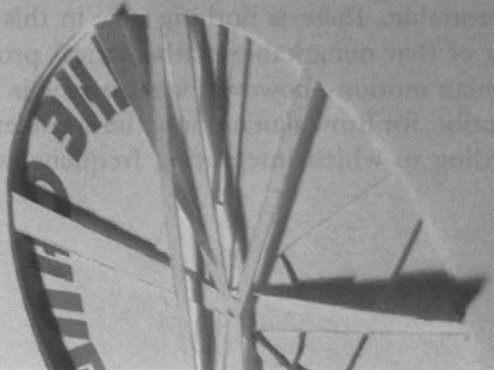
the ex-post accounting equation, rather than a certain ex-ante attitude towards future contingencies. It is because it breaks even on average over the whole population it is insuring, it is because its money account allows it to perform this integration, that the insurance company is able to face a single case and deal it with it *as if it were assessing its individual probability and insuring an individual*. It is the integrality and integrity of its financial account that allows it to reverse time and transform into an ex-ante question what is only an ex-post equation.

The ex-ante attitude is an artifact. It is a representation or a figure of speech. To consider the probability of the single case ex-ante is only shorthand for a long sentence in which it is stated that the individual is part of a population of insured people and that the insurance company has broken even on average. For this reason, when the ex-post accounting is recognized to be more fundamental than probability, when probability is no longer considered in a void but in a circle, in an institution (in this present case, the insurance company) which allows the account to be closed and the ex-post accounting to take place before we seemingly regress to the ex-ante attitude—or equivalently, when the winning strategy of Shafer and Vovk is considered in the place that allows it to be set up regardless of the outcome—then I say that the outlook is ex-post. Ex-post here means that we understand that the ex-ante attitude is

COLLAGE VII

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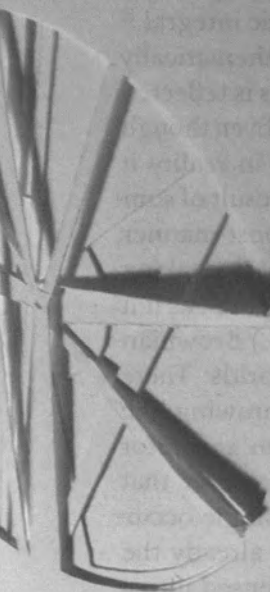
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only a derivative abuse of language; it is parasitic on the ex-post attitude, which is prior and fundamental.

BROWNIAN MOTION

Now, to go back to Brownian motion, it seems that, thanks to a formal-mathematical wonder, we are able locally to have the infinity we were missing with von Mises's sequences of outcomes. Given any interval that follows a certain point in time, no matter how narrow this interval, we can subdivide it infinitely and get the infinite random sequence we wanted thanks to the infinitely fractal character of Brownian motion. Notice here that the imperative of randomness down to every shrinking interval (which in turn potentially contains an infinite number of sub-intervals, all containing randomness) is what prevents us from ever drawing the graph of a Brownian path. In other words, it prevents that path from being extensionally given, just as von Mises's collectives were not given; except that this non-extensionality of the Brownian path is locally condensed in every shrinking interval, and it translates into the path being nowhere differentiable. There is nothing new in this—we are aware of that remarkable mathematical property of Brownian motion—however, what is new is to try to transcribe, for Brownian motion, the argument above, according to which integrating frequencies against



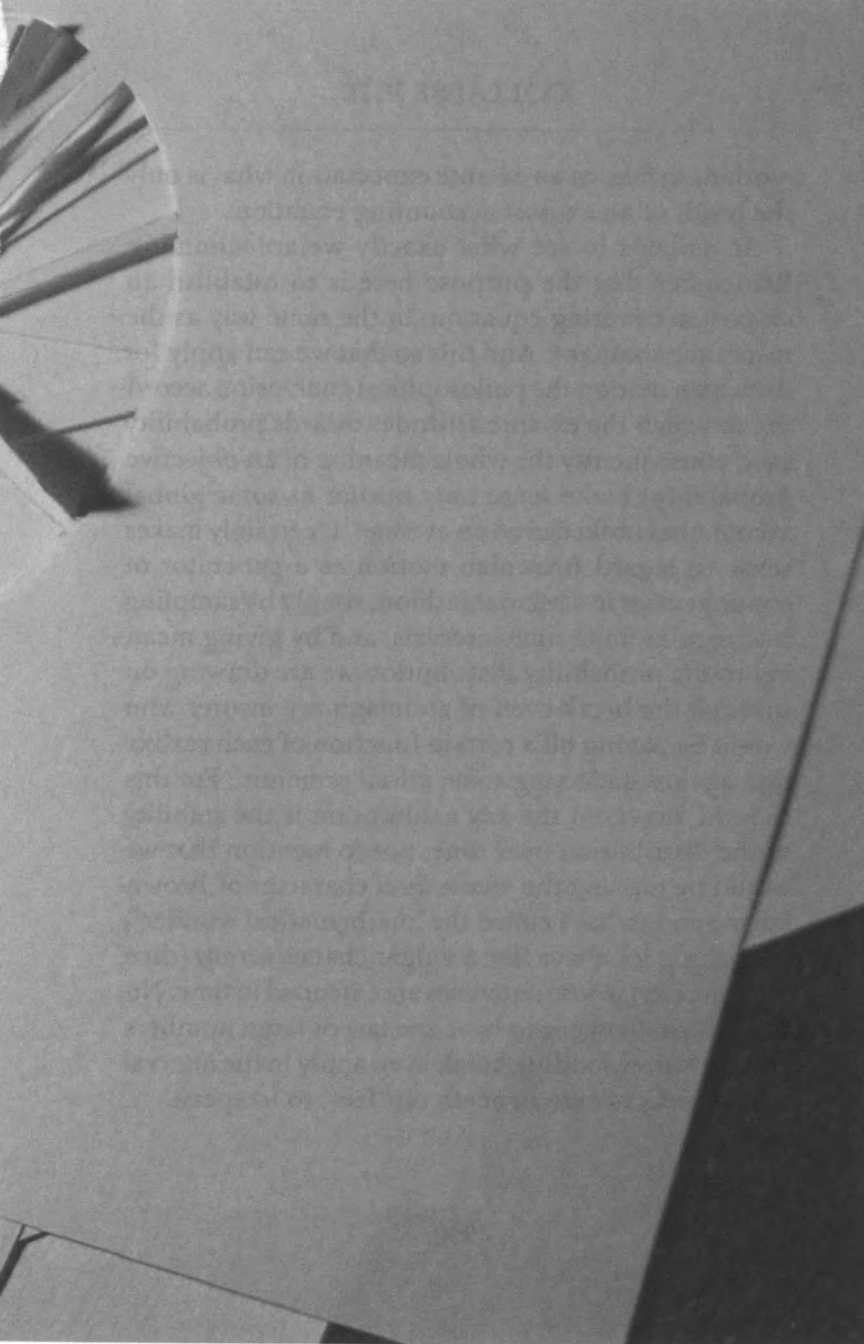
...the bottle is a simple, functional object, designed to hold liquid. The bottle is made of glass, a material that is both durable and transparent. The bottle's shape is simple and functional, with a long neck and a wider body. The bottle is shown in a black and white photograph, which emphasizes its form and the texture of the glass. The lighting creates strong shadows and highlights, giving the bottle a three-dimensional appearance. The bottle is lying on its side, and the neck is pointing towards the top right of the frame. The background is dark and out of focus, making the bottle the central subject of the image.

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financial payoffs is more fundamental than counting or integrating occurrences. The stochastic integral is more fundamental than the stochastic differential in Brownian calculus; the integral is constructed, and its convergence is somewhat in the spirit of the law of large numbers before the differential is introduced. As a matter of fact, the differential is only a symbolic notation; what really exists is the stochastic integral.¹⁶

There is still nothing new in this, mathematically speaking; however, what is new is how this is reflected in the debate between ex-ante and ex-post. Even though the stochastic differential looks ex-ante, in reality it refers to a stochastic integral which is the result of summing up a lot of contingencies in an ex-post manner, exactly like the insurance company—except that taking the limit in the shrinking interval makes it look as if it is ex-ante. (Limits are always nonintuitive.) Brownian motion seems to offer the best of two worlds: There is something we seem to be drawing or throwing like a die. There is the impression of a random generator and the corresponding ex-ante outlook. However, that next differential we are drawing is not a single occurrence, it is already a whole integral, it is already the whole strong law of large numbers, condensed into a shrinking interval. We no longer need, with Brownian

16. S. N. Neftci, *An Introduction to the Mathematics of Financial Derivatives* (New York: Academic Press, 2002).



motion, to fake as an ex-ante expectation what is only the result of an ex-post accounting equation.

It remains to see what exactly we are summing. Remember that the purpose here is to establish an ex-post accounting equation, in the same way as the insurance company. And this so that we can apply for Brownian motion the philosophical conclusion according to which the ex-ante attitude towards probability (and consequently the whole meaning of an objective probability) make sense only insofar as some global account has broken even on average. It certainly makes sense to regard Brownian motion as a generator of contingencies in actuarial fashion, simply by sampling it at regular finite time intervals, and by giving meaning to the probability distribution we are drawing on through the break-even of an imaginary insurer who would be paying off a certain function of each realization against collecting some initial premium. For this to hold, however, the key assumption is the stability of the distribution over time, not to mention that we would be missing the whole *local* character of Brownian motion (what I called the ‘mathematical wonder’) by making it behave like a vulgar chance set-up (dice, roulette, etc.) whose outcomes are extended in time. No, the real challenge is to have the law of large numbers and the corresponding break-even apply in the interval that shrinks to zero beneath our feet, so to speak.

On the other hand, when all is local as we want it to be, there is no guarantee that the probability distribution will not change over time (think of derivatives practice and theory, where we commonly make volatility depend on stock price and time). This local character does not offer us the possibility of consolidating our accounting equation over time, like the insurance company, by averaging in our books the repetition of the contingency. The whole thing was designed to be continuous in time, so there are no ‘comebacks’ or rehearsals that allow us to conceive a contingency as a part of a statistical population. The account cannot wait ‘behind’ for the next contingency to inscribe in it a new mark while making it look as if it is the first time again. The next contingency has moved ahead of the account in time—so what I am suggesting is that the account should be ‘portable’, that it should follow us as we go. The strange and difficult thing I am trying to say here is that the combination of time continuity and randomness at any scale, even though it seems to be freezing everything on the spot, on the contrary presses us to move along. There is a kind of irreversibility here.

The conclusion I would like to draw—and I admit that my reasoning is highly speculative—is that the only way to combine (1) a break-even caused by the law of large numbers, (2) the locality of Brownian motion, and (3) the running account, is by considering an account that moves in a self-financing way.

What we need to average out in the shrinking interval (in which the law of large numbers applies, no matter how narrow we make it) are typically the differences between a derivative payoff moving along with us, and the proceeds of the dynamic self-financing strategy that is meant to hedge it. Of course the derivative is not expiring at every second (so that we could speak of a ‘continuously moving payoff’); what I mean by payoff is just its market price—as this is what the dynamic replicating strategy tracks at all times before the actual maturity and the actual final payoff.

(One tends to forget that the real crucial assumption of Black-Scholes-Merton is that the derivative price is *given* as we track it.¹⁷ Now, BSM bootstrap this price from their own intent to value the derivative; they assume the value is given, and then they show how to establish it. The point remains that locally, before their argument is completed and closed, the given value can only mean the market price. How could they be *tracking* something whose dynamics ultimately will have to be a result of their own construction? It is only in physics that you assume that something is pre-given by nature and therefore can allow yourself to make that ‘given’ a part of the equation whose resolution will ultimately say what the ‘given’ is worth. BSM assumed that the market was nature.)

17. F. Black and M. Scholes, ‘The pricing of options and corporate liabilities’, *The Journal of Political Economy*, 81:3 (May–June 1973), 637–54.

What makes our conclusion revolutionary is that the interpretation of probability, or saying what probability really means, *when it is transposed to Brownian motion*, seems no longer to involve an insurance company who could alone look at probability in a seemingly ex-ante fashion and could alone give it meaning because what it is doing in reality is breaking even on average in an ex-post accounting equation. Rather, the interpretation of probability under Brownian motion seems to involve local derivative replication and local derivative pricing. I insist on the word 'local' so as to block any temptation to infer things statistically through some extended time series. The only 'statistics' is the single option price, and therefore it has to be considered as given. One should not infer Brownian volatility from the history of underlying prices, but from the instantaneously given derivative price. This is what is done in practice, and *implied volatility* is indeed the only working concept.

To repeat, if the real meaning of probability involves looking for the ex-post accounting equation that expresses a break-even, rather than looking for frequencies that converge, then in the Brownian case, the only ex-post accounting that takes full advantage of the local character of Brownian motion (i.e. of the combination of continuity and irreducible randomness at any scale) is the local replication of derivatives. What sounds amazing in this conclusion is that

the derivatives market (I mean the real one) seems to emerge as a consequence of the ideal and formal properties of Brownian motion, *combined with* the will to interpret them in reality and to give them meaning. (This is comparable to giving meaning to ‘ordinary’ probability through ordinary statistics.) It is as if a Big Bang had happened, and all of sudden derivatives and their underlying had come into being and into trading—i.e. the market had come into being—right after Brownian motion was interpreted.

An objection: How could this be true when we all know that the underlying price doesn’t follow Brownian motion in reality, not to mention that the continuous time limit does not exist in reality? Startling as it may sound, I wish to answer that, in order to understand the coming into existence or the genesis of the derivatives market (or to understand its concept, if you will) you need to push Brownian motion to its ultimate mathematical, ideal consequences. Yes, something real can begin to exist after a purely mathematical finding (see David Deutsch’s *The Beginning of Infinity*).¹⁸ Market-makers in derivatives *really* came to the market because of continuous local dynamic replication and because instantaneous volatility was all they needed to compute the instantaneous hedge (hence implied volatility, which exists on the spot). It is a wholly different thing if, after the whole thing had come into

18. D. Deutsch, *The Beginning of Infinity* (New York: Penguin Group, 2011).

existence, we then recognized that this ideal theory will be questioned and criticized and revised because *option prices*, as given by the market, will in fact not respect the theory—what is known as the ‘smile problem’.¹⁹

As a matter of fact, this observation further supports my point, rather than challenging it. Indeed, ideal Brownian motion and the ideal consequence of break-even in the hedging account are now questioned by the *market derivatives prices*, not by empirical analyses of the time series of the underlying (to the effect that the underlying does not follow Brownian motion historically but admits of jumps and stochastic volatility and what have you). Let the jumps and stochastic volatility be introduced in the derivative pricing models by the market-given derivative prices that we need to match instantly and locally, not by the history of the underlying! (This is what all derivatives traders in fact do,

19. The ‘smile’ phenomenon is the observation that options prices, as empirically given by the options market, do not agree with the Black-Scholes-Merton option pricing model and the assumption it makes that the price process of the underlying is governed by Brownian motion with constant volatility. Instead of reading as outputs of the Black-Scholes-Merton formula with the same volatility number plugged into it, empirical options prices require a different volatility number to be plugged into the formula each time we wish to apply it to explain them theoretically. Although written on the same underlying, options with different strike prices will thus imply different volatility numbers. Out-of-the-money options (call options whose strike price is above the underlying spot price and put options whose strike price is below the underlying spot price) will typically imply a volatility number that grows larger and larger as the strike moves away on either side of the spot price, thus exhibiting a curve whose shape resembles a smile. The smile problem consists in finding an alternative model to Black-Scholes-Merton to try to explain this phenomenon.



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and what urgently needs a philosophical explanation.) Once again, option pricing-and-hedging is, crucially, local; and, crucially, has nothing to do with statistics. This is the inception.



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GEGENSICHKOLLEKTIV was founded by no-one, nowhere and hosts dissidents of reality as it appears to us. GegenSichKollektiv work towards subjective depersonalisation by using nihilism as a form of cognitive discipline reconsidering our relationship to the structures of reality beyond the multiplicity of readings of post-structuralism.

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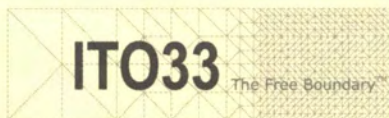
COLLAPSE

Philosophical Research and Development

VOLUME VIII

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COLLAPSE VIII examines a pervasive image of thought drawn from games of chance. Surveying those practices in which intellectual resources are most acutely concentrated on the production of capitalizable risk, the volume uncovers the conceptual underpinnings of methods developed to extract value from contingency—in the casino, in the markets, in life.



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