Economy and Society Volume 31 Number 1 February 2002: 15–36

Repressed futures: financial derivatives' theological unconscious

Bill Maurer

Abstract

Financial derivatives are credited with bringing to the fore a number of sociological and metaphysical problems for modernity, from the instantiation of particular modalities of risk to the destabilization of referentiality in knowledge-claims about the world. This essay argues that derivatives can take on the particular power they hold in such accounts only through a repression of their mathematical technique. Opening up the black box of the mathematical technique through a history of statistics, it argues that the founding trauma animating derivatives' discursive power is the separation of religion from the technical procedures of mathematics and the stochastic models that give form to trading in derivatives. Derivatives' indexical power is a symptom of this trauma. That symptomatology reveals derivatives to be a moral, not just mathematical, problematic.

Keywords: derivatives; social studies of finance; history of statistics; trauma; religion; referentiality.

Variously positioned scholars make big claims for financial derivatives.[1] This essay does not refute the claims so much as point to their moral and epistemological unconscious.[2] Derivatives are a particular kind of tradable contract. Their trade value is tied to the value of other assets, historically bulk commodities but also corporate shares and currencies. The most familiar derivative contracts are futures contracts, forward contracts and option contracts. A simple options contract, for example, is a contract to sell a commodity at the market price at the moment of the contract's origination within a specified time period in the future. If the market price of the underlying commodity goes up during the term of the

Bill Maurer, c/o Department of Cultural Anthropology, Duke University, Durham, NC 27705, USA; from 10 June 2002: Department of Anthropology, University of California, Irvine, CA 92697-5100, USA. E-mail: w m m a u r e r @ u c i . e d u

ISSN 0308-5147 print/1469-5766 online
DOI: 10.1080/03085140120109231

contract, the value of the contract decreases, since its owner would then have the essentially worthless right to sell the commodity at a price lower than market price. If the market price of the underlying commodity goes down during the term of the contract, the value of the contract increases, since the contract would specify a price higher than the market price and the owner could still make a profit despite lower current market prices. Derivatives thus can function as a hedge against risk or a form of insurance against market fluctuations. They can also be traded in secondary markets, disconnected from plans to actually purchase the commodities from which their value derives and thus can be tools for speculation. A trader might purchase a futures in a particular commodity with no intention of ever using the contract to buy the commodity itself, but rather to speculate on the commodity's price fluctuations, betting, for example, that market prices will increase, thereby increasing the value of the derivative on the secondary market.

Max Weber's 1896 essay on the stock exchange lingered over the concern that derivative contracts encouraged speculation and increased market instability. But he also argued that, while 'speculators who lack both judgement and capital' might, with access to derivatives trading, succumb to an 'increased temptation to gamble', derivatives nevertheless allowed a 'widening of the market', a democratization of it, that he felt was of 'positive importance for the national economy' (Weber 1978[1896]: 375–6).[3] Indeed, the stock exchange was a weapon in 'the relentless and ineluctable economic struggle for national existence and economic power' (ibid.: 377) among nations. Without overarching international agreements to abolish derivative trading, doing so in one country, or 'unilateral disarmament' (ibid.) – in the interests of quelling speculation or promoting what Weber mockingly termed 'ethical culture' (ibid.) – would be economic suicide.

The discursive connection Weber forged between derivatives trading and the sovereignty of the national economy resonates in late-twentieth-century fears about markets and money. Many view the global shift away from Keynesian models of state-based economic development and towards neo-liberal models of 'free' markets as trumping the sovereignty of nation-states to set economic policy and fulfil their obligations to their citizens. Given some very high-profile scandals and losses associated with derivatives trading – one aspect of global financial liberalization – many name derivatives themselves as the culprit in eroding state sovereignty. The most prominent exponent of this idea on the world stage is probably Malaysian Prime Minister Mohamad Mahathir, who blamed the Asian currency crisis of 1998 on derivatives traders and currency speculators.

Neo-liberal promoters, for their part, portray derivatives as mere technique. They may be a complicated technique – such that derivatives traders have been labelled 'rocket scientists' (Jorion 1995) – but still, to neo-liberals, derivatives are simply implements. For example, *The Economist* opines that

> derivatives are simply another financial and managerial tool which financiers and managers need to use properly. True, some of those instruments are too

> powerful for inexperienced or unsupervised hands. Their innards can sometimes be complicated. But then the same could be said for the motor car, and few people would advance that as an argument for more traffic lights.
>
> (quoted in Tickell 2000: 89)

As Adam Tickell argues in an insightful article about derivatives and the regulatory challenge of financial liberalization, *The Economist*'s analogy is a bad one, since global derivatives trading potentially threatens not just single institutions or even countries, but rather the entire global financial network (Tickell 2000). A wild driver might take out a few pedestrians, but is unlikely to demolish the entire interstate highway system. Still, however, this version of the story of derivatives – derivatives as technique, and technique as a closed black box, under the hood of the car, as it were – seems in need of analysis.

Critical writings, however, also leave the black box of technique closed, while assuming derivatives to *index* something else. Such writings generally take as their starting point the phenomenal increase in derivatives trading worldwide since the 1980s, and the increasingly explosive effects such trading seems to have had.[4] For example, scholars argue that derivatives index (1) contingent articulations of politics and economics (Tickell 2000); (2) the valorization of a culture of risk-taking (Green 2000); (3) an increased rationalization and socialization of risk that produces a new monetary imaginary (Pryke and Allen 2000); (3) a semiotic shift that abolishes the myth of anteriority, which is the presumed basis of numerical and linguistic referentiality (Rotman 1987); (4) a near-total separation of exchange from production in 'speculative tournaments' built on meta-fetishization and a competitive ethos (Appadurai 1986).[5]

I borrow the term 'index' from linguistic anthropology (via the nineteenth-century American pragmatist, Charles S. Peirce), which makes a distinction between referential terms and indexical terms. Referential terms are words that refer to things. Indexical terms are words that refer to the aspect, or truth-value, or spatio-temporal co-ordinates of the things that other words refer to, such as 'that' or 'here' (Silverstein 1976: 25). Critical writing on derivatives often elides the distinction between referentiality and indexicality precisely because derivatives themselves call into question the referentialist categories of language. Consider Brian Rotman's (1987) discussion of derivatives at the end of his account of the semiotics of zero. The figure zero, Rotman argues, unsettles the metaphysical claim that 'things' precede the 'signs' humans create to account for them. This referentialist logic is belied, in the domain of number, by zero's non-referentiality. Zero is a sign (of 'nothing'). In that capacity, however, it is a sign about signs, indicating the absence of the other signs that belong to its sign system. Thus, zero is also a meta-sign that indexes the potentiality of enumeration, the whole sign-system of number and the subject who counts. It is the meta-sign, and not the presence of countable 'things', that enables enumeration.

Rotman carries his account of zero through the development of the algebraic variable, the vanishing point in perspectival art and imaginary money – money redeemable only for another copy of itself instead of gold or silver (see also Shell

1982). This self-referential character of imaginary money, Rotman argues, is taken to another level in contemporary currency trading that relies on derivatives. Futures in currencies concoct the *medium* of exchange – money – as a *good* to be exchanged. In doing so, they disrupt money's presumed ability simply to index the 'value' of exchangeable goods and services. There is no distinction between the prior things and the signs that represent things, a referentialist paradox that becomes even more pronounced when money's current value, its signifying capacity, is determined by its potential future states: when currency derivatives dependent on future expectations and values determine present configurations of value, risk and profit. The 'scandal'[6] of imaginary money in the nineteenth century was that it could be increased by fiat without backing by inconvertible specie such as gold or silver. It created itself out of nothing. The 'scandal' of what Rotman calls 'xenomoney', or money concocted by derivative instruments of the late twentieth and early twenty-first century, 'is the fact that it is a sign which creates itself out of the future':

> any particular future state of money when it arrives will not be something 'objective,' a referent waiting out there, determined by 'real' trade forces, but will have been brought into being by the very money-market activity designed to predict its value. The strategies provided by options and futures for speculation and insurance against money loss caused by volatility of exchange and interest rates become an inextricable part of what determines those rates.
>
> (Rotman 1987: 96)

The myths of anteriority and referentiality – that there are things prior to the signs that represent them – are revealed in their irrevocable loss, their utter deconstruction.

Rotman's analysis, however, depends on precisely the referentialist metaphysics he debunks. In a telling passage, Rotman effects a separation of the 'real' from the 'semiotic' that rests on his bracketing of the mathematics of derivatives, the technique, in order for him to make claims about derivatives' own indexicality, their pointing towards a semiotic shift in signs and meta-signs. 'A realistic description of the workings' of phenomena of contemporary international finance, he writes, 'lies far outside the scope of this book' (Rotman 1987: 88). Indeed, 'the phenomena themselves . . . are operationally simple' (ibid.). For Rotman's purpose, which is 'interested in identifying changes in money as a *sign*, *only their semiotic characteristics* need be explicated' (ibid., emphasis added). Leaving aside the operational aspects, leaving out 'description' of technique itself in favour of 'semiotics', conjures a world of 'real' practices and 'signifying' practices. It permits the false separation of description from interpretation and explanation. Rotman, in leaving the 'phenomena themselves' inside a black box, represses the 'real(istic)' and at the same time grants it an inordinate amount of power to destabilize his own analysis and the sign systems that form his object.

Consider also Stephen Green's (2000) account of the culture of modern risk in contemporary finance. Green is not interested in semiotic aspects of derivatives so

much as 'cultural' and 'intersubjective' aspects. To disrupt standard economic narratives, Green wants to get ' "beneath" the formal architecture of finance to the ideational and cultural principals [sic] which are constitutive of the modern financial order' (Green 2000: 77). He is interested in the ways participants in modern financial markets are socialized into valorizing certain kinds of risk-taking, and focuses on the 'highly intersubjective and reflexive' nature of financial markets that prevents them from 'being completely comprehended by risk calculations' (ibid.: 87). Like Rotman, Green brackets the mathematical technique of risk calculation itself. As he puts it, 'I take a step back from the amazing array of mathematical energy, institutional resources, and technological weaponry currently deployed to "manage" risk and ask the question of how and why "risk" itself is constructed as the central coordinating social mechanism for financial actors' (ibid.: 78). Taking such a step back, however, leaves the mathematical energy and technological weaponry (calculators and computers) as somehow beyond culture, beyond the intersubjective arena that interests Green, reinstating the same referentialist fallacy that Rotman falls into: the distinction between certain 'real' practices – here, mathematical and technological – that are beyond interpretation and 'cultural' or 'intersubjective' practices.

Finally, consider Michael Pryke and John Allen's (2000) essay on money's 'new imaginary'. Pryke and Allen reflect on Rotman's observations about money's futurity and its loss of anteriority. They argue that derivatives call forth a new kind of 'monetized time-space [that] presuppose[s] a particular rationalization of money and risk' (ibid.: 265). Money's new imaginary involves a monetization and quantification of time-space, rendering the future 'calculable' (ibid.: 270, following Simmel 1990). The new monetary imaginary is spatial, too, for derivative instruments make present economic returns dependent not just on the future, but on the 'future performance of distant spaces' – as, for instance, when a pensioner's income is determined in part by 'Japanese inflation rates and general economic performance in twelve months' time' (ibid.: 273). Like Rotman and Green, Pryke and Allen also bracket the mathematical technique of calculating that future performance of distant spaces. They admit that 'the judgement about the pricing of the future is supposedly based on a financial model' but insist upon '*[l]eaving to one side the intricacies of the model*' (ibid.: 272, emphasis added).[7] Flagging with the word 'supposedly' the important point that the mathematical model does not necessarily actually price the future, Pryke and Allen later in their essay still fall into the referentialist fallacy by accepting the 'apparent transformation of the randomness of distant events into the near-to-hand statistical, intensive, 'accelerated transport' of information' (ibid.: 281, reference omitted). That apparent transformation into near-to-hand statistical information occurs through mathematical techniques that Rotman, Green and Pryke and Allen all 'lay outside', 'take a step back from' and 'leave to one side of' their analytical focus.

My main argument in this paper is that derivatives can take on the indexical power they do in critical and neo-liberal accounts only if their operational, mathematical technique is left in the black box, shut away, bracketed or repressed.

I am not making a mathematical claim that the technique actually functions the way some might say it does – that it actually determines the price of a derivative contract. I am also not making a sociological claim that derivatives traders even use the mathematical technique when they price derivatives. They might not. Rather, I am claiming that, regardless of the mathematical technique's use or efficacy, its being 'left aside' allows it to maintain a very privileged status in any account of contemporary derivatives. I am further arguing that its repression, exclusion, bracketing from analytical and neo-liberal scrutiny does a certain kind of work that allows derivatives to take on their putative stability as financial *entities*[8] and also to take on the peculiar *indexical power* with which they have been invested, especially since the 1980s and 1990s as they have become more important to world financial markets and more visible – the power to point towards big changes afoot, to the aspect, state or truth-value of other phenomena. As we know from Freud, that which we repress always comes back to haunt us. I shall argue that derivatives' indexical power in critical and neo-liberal accounts alike is a symptom of the trauma that led to the repression of mathematical technique from discussions of derivatives.[9]

The Freudian conception of trauma holds that a founding act of violence or an originary wound, while covered over in its immediate occurrence, returns as symptom. And it does so repeatedly, playing out the dynamics of subject-constitution that the originary trauma permitted, reiterating them and thus stabilizing them – to the extent that traumatic repetition could be called 'stable' – in regular symptomatologies. In *Moses and Monotheism*, Freud provided the following illustration:

> It may happen that someone gets away, apparently unharmed, from the spot where he has suffered a shocking accident, for instance a train collision. In the course of the following weeks, however, he develops a series of grave psychical and motor symptoms, which can be ascribed only to his shock or whatever else happened at the time of the accident. He has developed a 'traumatic neurosis'.
>
> (Freud 1939: 84)

What might be the founding traumatic event that causes the repression of the mathematical technique for derivatives? What follows is a partial attempt to answer this question. It involves opening up the black box of the mathematical technique, and listening to number without forcing it to refer to anything other than itself. Like Freud, I shall argue that the founding trauma here institutes a theology. Specifically, I shall show that the founding trauma is the separation of religion from the technical procedures of mathematics, the stochastic models that give form to derivatives trading. Derivatives' indexical power is a symptom of this trauma of separation, and the symptomatology, like the images in dreams, an unconscious misrecognition. In addition, each of the sections that follow begins with a quotation from the business and popular press. These quotations, presented in chronological order and headed by the titles of the articles in which they appeared, document the rise and spectacular fall of Long Term Capital

Management, a venture based on derivatives trading and founded by two of the men central to the development of the mathematical technique behind it. Taken on their own, these titles and quotations chart their own theology, a casuistry of and for the divine, and provide a glimpse perhaps of the founding trauma behind it.

The Black-Scholes formula and efficient markets theory

> *'Formula for Success'*
> The chaps behind the formula [Myron Scholes, Fischer Black and Robert Merton] hit upon it on an autumn afternoon in 1969. . . . It took them four years and several rejections to get their formula published. Today, every MBA candidate it taught the formula. Any joint projects between [Scholes and Black] in the works? 'Not while we're at Goldman and Salomon, I suppose,' laughs Black.
>
> (Kripalani 1991: 203)

In 1973, Myron Scholes and Fischer Black published a formula for the pricing of options in the *Journal of Political Economy* (Black and Scholes 1973). The formula was developed with the assistance of Robert Merton.[10] It fostered a tremendous expansion of the options market, because it seemed to allow a sure method for options pricing and an investment strategy based on using options to hedge against risk. Prior to the Black-Scholes formula, options pricing relied on a combination of broker experience and guesswork. The advent of the formula allowed traders to compare the price of stocks on the market with the predictions of the Black-Scholes model as they developed their investment and risk-hedging strategies, so that options trading could become a win-win situation. As the Federal Reserve Bank of St. Louis put it in an article aimed at corporate managers:

> Knowing the trading strategy means that the model is not only someone's best guess; it is also possible to profit if the model is wrong. If the model price is lower than the price in the economy, we can sell the option, [and] pocket the excess over the model price. . . . If the model price is higher than the price in the economy, we follow the hedging strategy in reverse. [In other words] buying or selling the option and following either the trading strategy or the reverse of the trading strategy will make money!
>
> (Dybvig and Marshall 1997: 9–10)

The Black-Scholes formula is based on formulas from particle physics, and, although that fact is not mentioned in the original Black and Scholes publication, it became fodder for the business press and the textbooks that teach the formula to armies of MBA students (e.g. Hull 1993). The formula is a partial differential equation for dealing with random processes. It is virtually identical to those used in physics for understanding Brownian motion, the random behaviour of small particles bumping against each other in a solution or a gas, and the subject

of one of Einstein's earliest papers (Einstein 1926). Intriguingly, the model of Brownian motion created by Einstein was anticipated in a 1900 dissertation about options pricing, written by Louis Bachelier (1900). There is no evidence that Einstein or any other physicist or mathematician read Bachelier's work, although Bachelier himself seemed to think his model would apply to some problems in physics (Dimand 1993). This convergence is itself symptomatic of the trauma I am attempting to sketch out: that someone interested in the foundational building blocks of the universe and someone interested in, of all things, finance, would hit on the same mathematical formula to model their objects.

The analogy between stock prices and particles in Brownian motion requires two key assumptions. First is an assumption about randomness, or stochastic processes. As Black and Scholes put it in their original article, assuming 'ideal conditions' in the market, 'The stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of positive stock prices at the end of any finite interval is log-normal. The variance rate of the return on the stock is constant' (Black and Scholes 1973: 640). The outcome of randomness of stock prices and particle motion, in other words, is a regular distribution – plot prices or particle positions as points, take the log of the points on the curve and you get a classic normal distribution bell curve, given enough time and enough points in the universe.

It follows that a key variable for predicting the position of a particle or the price of a stock after a specified interval of time $t+n$ is the position of the particle or the price of the stock at time t. In other words, because the distribution of stock prices is log-normal at time $t+n$, all you need in order to predict probability of a price rising or falling is the position or price at time t. Since an option is a bet against the future price of a stock, then the key to determining the value of an option is the price of the stock at time t and the temporal interval to time $t+1$. As Black and Scholes wrote, 'the value of the option will depend only on the price of the stock and time and on variables that are taken to be known constants' (ibid.: 641).

Second is an assumption about the market. In order for the model to work, we need to know that the price at time t is the 'correct' price. This went unstated in Black and Scholes's original paper but was elaborated by Scholes in a later lecture. Today's stock price cannot be the result of, say, an accountant's irresponsible fib or a government's interventionist inflation of a particular industry's assets. The market must be 'efficient' in that it is allowed to operate without constraint, and trading must be free and fair, so that 'the best estimate of the value of a security is today's price' (Scholes 1998: 352). Bachelier summarized: 'At a given instance, the market believes in neither a rise nor a fall of true prices. . . . Clearly the price considered most likely by the market is the current true price: if the market judged otherwise, it would quote not this price, but another price higher or lower' (Bachelier 1900: 26).

Stochastic processes and the weight of divine argument

> *'Dream Team: John Meriwether's Brain Trust Made Billions at Salomon. Can They Do It On Their Own?'*
> [John Meriwether has] hired experts in mathematics, computer science, economics and stock trading [namely, Myron Scholes and Robert Merton], in the hopes that his [new] company will become a leader in computer-assisted bond trading.
>
> (Spiro 1994: 50)

The Black-Scholes formula, as a probability function, is a product of what Philip Mirowski has termed the 'probabilistic counter-revolution' in neoclassical economic theory (Mirowski 1989a). Mirowski has traced the rise of probability theory in economics to a repudiation of strictly determinist models and an elaboration of statistical procedures designed to deal with real-world numbers and to 'eventually achieve numerical results' (Schumpeter 1954: 962). Stochastic procedures were a key component in the twentieth-century transformation of neoclassical economics.

Such procedures entered into economics as the discipline tracked changes in physics for its own model building. In a quest to achieve scientific status, economics in the late nineteenth and early twentieth centuries borrowed heavily from deterministic energy concepts in physics (Mirowski 1989b). By the 1920s, however, physics itself turned towards probabilistic models via the new field of quantum mechanics. Economics at first was reluctant to abandon determinism. But 'by the 1930s, any culturally literate layperson could not turn around without bumping into some denunciation of determinism and praise of stochastic concepts' (Mirowski 1989a: 219). As Eddington wrote of physics in 1935, in a particularly rich passage:

> [classical determinism] was the gold standard in the vaults; [statistical laws were] the paper currency actually used. But everyone still adhered to the traditional view that paper currency needs to be backed by gold. As physics progressed the occasions when the gold was actually produced became rarer until they ceased altogether. Then it occurred to some of us to question whether there still was a hoard of gold in the vaults or whether its existence was a mythical tradition. The dramatic ending of the story would be that the vaults were opened and found to be empty. The actual ending is not quite so simple. It turns out that the key has been lost, and no one can say for certain whether there is any gold in the vaults or not. But I think it is clear that, with either termination, present-day physics is *off the gold standard*.
>
> (Eddington 1935: 81, in Mirowski 1989a: 219)

Neoclassic economics was wedded to a vision of utility as potential energy and a vision of explanation as causal and deterministic. It could not escape mechanistic models without abandoning stasis assumptions and without adopting time series data. The new field of econometrics imported stochastic models from the

new physics and began the task of not merely explaining the mechanisms of the economy but forecasting economic processes (Mirowski 1989a).

What did it mean for physics – and, later, economics – to go 'off the gold standard'? It meant, up to a point, an embrace of indeterminacy and an anti-necessitarian world-view. But only up to a point: neither Einstein nor the econometricians abandoned realism, embraced radical contingency or deconstructed referentiality.[11] The introduction of temporal variables explicit in stochastic problems did not cause either field to leave causality by the wayside. Physical and economic entities were held to 'have a continuous, objective, observer-independent existence', and the introduction of temporality meant 'event-by-event causality' – x happens because a_1, then z happens because a_2, then y happens because a_3 – and a commitment to 'locality', or the idea that the variables effecting a process are not separated from the process by great distances of space or time (Cushing 1998: 352). In sum, then, the variables introduced through a recognition of stochastic processes were assumed (a) to be real variables in the world; (b) to be located at a particular point in space; and (c) to be moving along a temporal trajectory. The fact that variables were assumed to be real variables in the world also meant a very particular and traumatic reading of probability theory. The normal distribution 'bell curve' had to be taken as a real reflection of the characteristics of nature, whether that nature be physical, social, biological or informatic.

Abraham de Moivre, the early eighteenth-century inventor of the bell curve, devised his model to account for errors of measurement – for instance, measure a desk 100 times and use the model to militate against errors in order to obtain a reasonably accurate measurement (Langley 1971). The purpose of the normal distribution model, for de Moivre, was akin to the hypothetical desk-measuring problem. De Moivre was interested in the distribution of 'error'. He had a particular kind of error in mind, believing that, in modelling errors in 'nature', he would be 'determining the frequency of irregularities from the Original Design of the Deity' (Pearson 1924: 404). Furthermore, against the charge that his book – made up almost entirely of examples drawn from gambling and games of chance – would encourage 'play', de Moivre wrote that 'so far from encouraging Play', the book was 'rather a Guard against it' (de Moivre 1773:, 'Dedication'). His 'doctrine of chances', de Moivre believed, would lead people away from their belief in Luck and toward an appreciation of God: 'the Doctrine of Chances may likewise be a help to cure a Kind of Superstition, which has been of long standing in the World, viz. that there is in Play such a thing as Luck, good or bad' (ibid.: iii). He continued, 'we may learn, in ma[n]y Cases, how to distinguish between Events which are the effect of Chance, from those which are produced by Design' (ibid.: v). And Design always wins any bets placed against Chance.

After de Moivre, the normal distribution curve was also found sometimes to describe patterns of natural variation. It soon became used to predict and explain natural variation. In a quick survey of introductory college statistics textbooks, I found that some were careful to stress the distinction and to warn the

short-cut-seeking undergraduate against throwing out data points from an experiment simply to produce the coveted bell curve. Most, however, especially most of the more recent books, were not. At a general level, the model has become a fetish, taken merely to describe and reflect real-world variables, rather than to be a model helpful for predicting or explaining them for the purposes of a particular argument. The fetishization of the model is particularly apparent in Black-Scholes.

Consider a variable in stochastic econometrics as an arrow shot from an archer's bow with the winds influencing its trajectory – stable entities whose motion is affected by local forces inflecting their movement through space over time. The word stochastic derives from the Greek *stokhastes*, meaning archer, but also diviner; *stochos* refers to an archer's target, but also a stable-state or equilibrium. The etymology of the term stochastic recalls the connection in the history of ideas between games of chance and divination. Florence Nightengale David (1962), in her *Games, Gods and Gambling*, even argues that gambling may have been the first human invention (see Hacking 1975: 1).[12] Yet, while all cultures seem to use randomizers like tali, dice, chicken innards and so forth, to read the intentions of the gods and to gamble against the gods' plans for the future, nevertheless, '*theories* of frequency, betting, randomness and probability appear only recently' (Hacking 1975: 2, emphasis added). Rather than speculating on this apparent lack, I follow Ian Hacking, who interrogates the 'preconditions for the emergence of probability', which, in turn, 'determined the space of possible theories about probability' (ibid.: 9).[13]

The family of words derived from the Latin *probabilis* originally had no connection to the concept of randomness. That connection emerged in the 1600s. Previously, probable meant something like 'worthy of approbation' – a 'probable doctor' was a 'medical man who could be trusted' (Hacking 1975: 18). It is not until the ascendance of mathematical concepts of probability that the link between probability and approval transmuted into something else.

This is not to suggest, however, that the older conception of probability is of no relevance here. Far from it. That conception figured centrally in religious debates over the status of knowledge and opinion. The probable, where opinion was concerned, derived from the position of the person offering it. For Aquinas, for instance, probability did not refer to something supported by 'evidence', but rather something approved of or accepted by 'intelligent people' (ibid.: 22) – an 'opinion commended by authorities', one which may in fact be incorrect but still, by this definition, probable (ibid.: 22–3). Opinion in this sense was not knowledge, for knowledge had to do with universal truths beyond accepted opinion, and was therefore not part of the domain of medieval probability. Instead, opinion had to do with degrees of belief based on the weight of an argument. Since opinion occupied a different epistemological and moral space from that of knowledge, then whence opinion?

Medieval opinion depended upon the citing of authority, and theologians' debates centred on which authorities to rely on and when to rely on certain authorities as opposed to others. Suffice to say 'evidence' did not have a place in

these decisions. For the Jesuits, authority derived from a process of weighing the moral consequences of following one or another authoritative opinion. For the Jansenists, authority derived from scripture and natural reason alone. The Jansenists won the theological debate, and Blaise Pascal's *Provincial Letters* represented an attack on the casuistry of the Jesuits and a defence of natural reason (ibid.: 25). What was the nature of this 'natural reason'?

One of Hacking's chief contributions is to demonstrate that the medieval conception of opinion and probability derived not from medieval 'high sciences' like physics, but from the 'low sciences' like alchemy. In a world where the authority of theologians was no longer a valid source for opinion, but where one had to rely on scripture and one's natural reason, natural reason had to look for 'signs' of nature to gauge the probable. The notion of the sign here derived from alchemical conceptions of the universe, a universe authored, animated and marked by the Author of Nature with signs of resemblance so that Man may come to know God's mind (Collier n.d.). Medieval alchemists relied on the testimony of things, not people, to arrive at their conclusions about the order of the cosmos. Things testified through relations of similitude – a liver-shaped leaf must bear some relationship to the liver in the body, for instance (Foucault 1973; Hacking 1975: 44). Hacking shows how similitude concocts 'evidence' as a new sort of object about which new knowledges may be made possible. These are knowledges of probability, not in the sense of weight of argument but in the sense of the inductive evidence of things. Arguments were still probable based on the authorities backing them, but the authorities now were the signs of nature, which, more often than not, guaranteed at least the semblance of correct predictions about observable phenomena. Alchemists were a small step away from the notion of probabilistic knowledge derived from statistical frequencies based on the evidence of the world.

In Hacking's account, the dual nature of probability – weight of argument or degrees of belief, on the one hand, and processes productive of stable long-term statistical frequencies, on the other – was stitched together to form modern conceptions of probability in the work of Blaise Pascal in the late 1600s. Pascal's wager in favour of acting as if God existed depended on the weight of argument on the epistemological side of the coin. His correspondence with Fermat, on how to divide the stakes in a game of chance that has been interrupted before its completion, depended on the aleatory side of the problem. On the epistemological side, Pascal was concerned with the nature of God, who may or may not exist. On the stochastic or aleatory side, Pascal was concerned with the God of Nature, who has placed signs in the world and sets the world into motion along a temporal trajectory with a Beginning and an End. Hacking's achievement is to show that, despite the ascendance of the stochastic side of probability after Pascal, the epistemological side remains, albeit often hidden, repressed.[14] Contemporary probability is thus a moral argument. The argument now involves the traumatic sundering of stochastic from epistemological process, and the repression of the latter.

Efficient markets, equilibrium and the fall of man

> *'The Right Option: The Nobel Prize for Economics'*
>
> Economists may sometimes seem about as useful as a chocolate tea-pot, but as this year's Nobel prize for economics shows, it isn't always so. On October 14th, the $1m prize was awarded to two Americans, Robert Merton, of Harvard University, and Myron Scholes, of Stanford University [Fischer Black having died since the development of the formula in 1973]. Their prize-winning work involves precisely the sort of mind-boggling mathematical formulae that usually cause non-economists either to snooze or scream. That is too bad, for it ranks among the most useful work that economics has produced.
>
> (*The Economist* 1997: 75)

The stochastic move in economics did not count among its adherents some of the era's most prominent figures. John Maynard Keynes and, after him, Joan Robinson fervently argued against the statistical conception of probability and in favour of the epistemological conception. Robinson both cleverly articulated the logical errors of neoclassical economics' marriage to stochastic probability theory and delightfully exposed its repressed theological underpinnings.

Robinson voiced exasperation with one of the fundamental tenets of efficient markets theory: the principle of equilibrium. This tenet is today perhaps the most commonsensical of all economic theories. It simply states that price tends towards the equilibrium of supply and demand. Robinson is short and devastating: equilibrium theory in economics 'uses a metaphor based on space to explain a process which takes place in time' (Robinson 1953: 255). Consider a pendulum swinging back and forth: over time, it will achieve equilibrium and stop moving. Robinson writes, 'If you give your bodies time, they actually do get into equilibrium. Time will help you with space' (ibid.: 256). Economic processes, such as the relationship between supply and demand, however, unfold over time, and the purported equilibrium point towards which things are 'tending' is a projected point of time in the future, and not, as with a pendulum, a resting place in space. 'Take as much space as you like,' Robinson notes, '– how is that going to help you with time' (ibid.)?

Equilibrium theory fails, for Robinson, because it fails to take account of the role of the past and the future in phenomena of the present. It is the wrong tool for the job, for the job demands good arguments, not collections of 'facts'. In the *Treatise on Probability*, Keynes argued that probability was about the weight of arguments, not statistical frequencies (Keynes 1921; Maurer n.d.). It appeared to him that, before even attempting to assess frequencies of phenomena in the world, one needed to know, in a literal sense, what one was talking about. The argument was about logic and language. Economistic conclusions in equilibrium models, for Keynes, ignored the temporal contingency of social life and thus had less 'weight' than conclusions based on epistemological probabilistic claims. As Rotheim points out:

> words such as tendency, if used in an equilibrium framework, only have meaning if the concept of equilibrium exists, *a priori*. One cannot move in time when the language emanates from an equilibrium system, because in the latter we start with an equilibrium, define the appropriate premise structure, and then rest assured that we will return to the equilibrium unscathed.
>
> (Rotheim 1988: 98)

He continues:

> When we move into a framework of time, we start with the premises and move forward as we interact along the way causing us to change our premises and change our path. The two thought processes reflect different, incompatible language structures; between those based on atomistic systems where probabilistic statements are valid, and those which are organic, where uncertainty prevails, and where knowledge of the real, social world evolves in an interactionist configuration.
>
> (Rotheim 1988: 98)

Robinson, inimitably, states this same point more directly, in a passage that is worth quoting at length:

> Never talk about a system *getting into* equilibrium, for equilibrium has no meaning unless you are in it already. By thinking of a system *being* in equilibrium and having been there as far back as Adam and you find it useful to go:
>
> Fall of Man $\rightarrow$ E
>
> so that every *ex ante* expectation about today ever held in the past is being fulfilled today. And the *ex ante* expectation today is that the future will be like the past.
>
> (Robinson 1953: 262)

Contingencies of fact and value

> *'Crony Capitalism'*
> Alan Greenspan patted himself on the back before the Senate Budget Committee on September 23, declaring the successful creation of 'a very efficient and very effective global economic financial system' with derivatives under careful control of banks. Greenspan might as well have been smashing a champagne bottle over the prow of the Titanic as it slid down the ramp into the harbor. Only hours later the New York Fed was orchestrating the $3.65 billion bailout of Long-Term Capital Management, the Greenwich, Connecticut-based hedge fund started by Nobel Prize-winners [Myron Scholes and Robert Merton] and star traders. LTCM's portfolio was estimated in the New York Times as having been worth $1.25 trillion some weeks ago – or more than China's annual economic output.
>
> (*The Nation* 1998: 3)

I am arguing, essentially, that the separation of stochastic probability and epistemological probability was a traumatic event, and that the repressed epistemological side returns to haunt contemporary accounts of financial derivatives. When critical analysts of derivatives 'leave to one side' the black box of the mathematical model, the repressed returns in terms of a symptomatology that grants derivatives indexical power, the power to point towards and refer to the truth-value of some other phenomena. Truth-value becomes a positive statement about the empirical world, not a moral statement within a language game. This is a misrecognition of the model's power as a moral argument. The model is a deontology of the way things 'ought' to be, not an ontology of the way things 'are'.

Probability theory, emerging from 'low' sciences, came into being around a particular problem about the status of knowledge and opinion – the problem of the existence and nature of God. The fetishization of the normal distribution curve makes a certain sense in this context. If it is taken as a prediction and explanation of reality, it reveals an order to the signs of nature, the writing animating the universe. Even the 'errors', the outcome of chance events, fall into the familiar bell-shaped pattern and thereby prove divine Design (In the Beginning was the Normal Distribution). The fetishization of equilibrium in economics makes the same kind of sense. Joan Robinson's point is that equilibrium is theology, an assumption about totality together with the hubris to deny that that totality is unattainable. M. Ali Khan makes much the same argument, in his re-reading of Samuelson's reflections on economics as language. Equilibrium in economics 'does not correspond to any object that it itself has not already projected through its tropes' (Khan 1993: 795), yet it is taken for granted as a telos and a 'tendency' (compare MacKenzie 2001).

The awkward relationship between games of chance and monotheistic conceptions of divinity also begins to make sense. Divination techniques based on randomizers are equivalent in form to gambling, the only difference being intention: casting lots = playing craps, with the minor inflection that in craps you are betting against God, not merely trying to deduce his intentions. It is in this sense that the stochastic side of the coin is also inseparable from religion, and contemporary invocations of Lady Luck in Las Vegas and grain futures on the Chicago Mercantile Exchange are merely variations on the character of the unknowable. Stochastic models are bad at doing what they are supposed to do: they do not really help us deal with radical contingency – the flow of temporality unwritten by divine hand, the accident of luck non-personified. The fetishization of the bell curve and equilibrium supposedly renders predictable the unpredictable, but just as often fails. If it were successful, statisticians would have had no need of the concept of the 'outlier', and undergraduate statistics students would not be tempted to fudge their data.

The same issue of the *Journal of Political Economy* in which Black and Scholes's options pricing formula appeared contains an obituary and several short, commemorative essays for the economist Frank Knight. Best known for his book, *Risk, Uncertainty and Profit* (1921), which clearly laid out the distinction and relationship between quantifiable and epistemological probability,

Knight also authored a lesser-known work, 'Liberalism and Christianity' (1945). The latter, published together with an essay by Thornton Merriam, is a defence of liberalism. It is also a defence of the epistemological conception of probability. 'Recognizing that truth is a value means recognizing that it is a social category,' he wrote. 'Truth is known, tested, and practically speaking defined, by agreement in some community of discourse' (Knight 1945: 49). Furthermore, 'real problems of fact are problems of the worth of evidence' – Knight considered the use of 'utilitarian application of positive science' to be 'the worst form of original sin, rationally defined' (ibid.). He concluded his essay with a strong statement against methodological individualism (ibid.: 101). As noted in his obituary, Knight believed that 'a multiplicity of principles and conceptual frameworks are necessary if we are to know much about human society and hence of ourselves as the "social animal"; and it was accordingly necessary to surmount what he saw as a sort of original sin – the human propensity to be simpleminded' (Wick 1973: 514). As Knight himself put it, 'The position we have to combat seems to rest on the inference, characteristically drawn by the "best minds" of our race, that since natural objects are not like men, men must be like natural objects' (ibid.). One might also state that the position we have to combat rests on the inference that the things 'men' make – like contracts and stock markets – must be like natural objects, and even that natural objects must be like the models of natural objects in positive science, models that rest on a repression of the moral contingencies of the human.

Conclusion: derivatives' unconscious and the traumatic separation of God from number

> *'The Unbearable Lightness of Finance'*
> Academic financial economists, unsurprisingly, still stand up for the science. Rene Stulz, who edits the profession's top research publication, the Journal of Finance, says, in a new book he is writing, that LTCM's only impact will be as 'a nice case study.' Most academics hint that LTCM's downfall had nothing to do with the financial models of [Myron Scholes and Robert Merton,] the two Nobel laureates (an argument that rather irks those Wall Street firms persuaded to invest in the hedge fund precisely because it was using their models).
>
> (*The Economist* 1998: 83)

The separation of stochastic from epistemological probability, like the separation of facts from interpretations, things from signs, history from memory, is a moral problematic. It is foundational in Western world makings that delineate sacred and profane, and animate liberalism and secularism by separating and excluding the religious even as they depend on the religious (see Asad 1993). Indeed, if we view the separation of stochastic from epistemological probability as a traumatic event in the Freudian sense, then the very metapragmatics of statistics hinges upon the reiteration of practices of purification that render number

referential, and things prior to numbers (see Latour 1992; Daston 1994; Poovey 1998). Yet the deontological character of number, number as moral argument, asserts itself in its return as statistical 'power'. Cathy Caruth is instructive on this point:

> The experience of trauma, the fact of latency, would . . . seem to consist, not in the forgetting of a reality that can hence never be fully known, but in an inherent latency within the experience itself. The historical power of the trauma is not just that the experience is repeated after its forgetting, but that it is only in and through its inherent forgetting that it is first experienced at all.
>
> (Caruth 1991: 187)

Furthermore, I am not merely suggesting that mathematical procedure, as Caruth says of history, 'is always a matter of distortion, a filtering of the original event through the fictions of traumatic repression, which makes the event available at best indirectly' (Caruth 1991: 185). Rather, attending to the founding and impossible separation of fact from value compels knowledge to confront its limit. What is knowable, here following Caruth's reading of Kant, is not knowledge of objects as such, things-in-themselves, but knowledge's *relation* to its objects.[15] 'To know [philosophy's] limits is to know that its knowledge of an object is always relational, a relation between the object and itself' (ibid.: 19). Yet even Caruth's conception of knowledge is inadequate to our object here, for, as Marilyn Strathern has argued, the very notion of *relation* was 'directly enabling of the kind of secular inquiry fuelled by the enlightenment conviction that the world (nature) is open to scrutiny. For relations are produced through the very activity of understanding when that understanding has to be produced from within, that is, from within the compass of the human mind and without reference to divinity' (Strathern n.d.: 14). We are left in a place where subjects, objects and relations deconstruct in the wake of the decomposition of fact and sign, anteriority and referentiality. This poses a problem not just for our objects but for any forms of knowing that would be adequate to them.

The idea of the fact 'before' it becomes enumerated and entered into the statistical formula demands the traumatic separation of words from things, deracinated particulars from moral commitments and the repression of that separation – or, better, the re-territorialization of that repression into the familiar (Western, bourgeois) separation of subjects from objects and into the commodity form, the form of the fact, the neatly purified world of words and the things to which they refer (Deleuze and Guattari 1983). Hence my equivocation at the beginning of this essay over whether derivatives are subjects or objects. And hence my worry over whether they index anything at all. The mathematical black boxes of financial derivatives are a moral argument. Bringing the repressed to consciousness will not necessarily get rid of the symptom, the repeatedly enacted desire to grant to statistical reason all the powers of argument. But it may give us other grounds to transform the weight of that argument.

Acknowledgements

A very early (and rather remarkably different) version of this paper was presented at the 1999 annual meetings of the American Anthropological Association. I should like to thank Nicholas Blomley, Tom Boellstorff, Saba Mahmood, Richard Perry, Elizabeth A. Povinelli, Annelise Riles and Katherine Verdery for their comments on that paper. I am especially grateful to Hiro Miyazaki for an incredibly close and critical reading, as well as for the suggestion of some key sources. I am also thankful for having the chance to discuss some of the ideas developed here with Roger Lee, Susan M. Roberts, Richard Schein and Adrian Smith. Research has been supported by the Program in Global Peace and Conflict Studies at the University of California at Irvine, and National Science Foundation grant, SES-9818258, Law and Social Sciences Program, 'Alternative Globalizations: Community and Conflict in New Cultures of Finance'. Writing was supported by the Department of Anthropology at the Research School of Pacific and Asian Studies and by the Centre for Women's Studies, both at the Australian National University. Any errors or inconsistencies are my responsibility alone.

Notes

1 Derivatives have cropped up in critical social scientific accounts of the breakdown of the Bretton Woods system of capital controls and fixed exchange rates (Cerny 1994; Helleiner 1994), the rise of 'flexible' modes of accumulation (Harvey 1989), the increasing dominance of exchange over production (Appadurai 1986), new monetary imaginaries and new forms of identification (Pryke and Allen 2000; Allen and Pryke 1999) and the emergence of mechanisms of governance modelled on insurance (see, e.g., O'Malley 2000; Rose 1996). For the purposes of this paper, I lump together futures and options, for they seem to function in the same manner in the discursive dynamics I examine here.

2 In the interests of full disclosure, I first became interested in derivatives pricing formulas in the course of research on Islamic banking and finance – a worldwide effort to create financial products that avoid interest and speculation, deemed religiously unacceptable in Islam. While the permissibility of derivatives from an Islamic standpoint is a topic of great debate (see Kamali 1996, 1997, 1998; Maurer 2001), some Islamic financiers employ derivatives pricing formulas in a manner that makes explicit their moral problematic. They use them to determine the proportion of a mutual fund's return that is derived from interest or interest-based activities. That amount can then be filtered out and given to charity, thus 'purifying' the fund. Using the formula this way belies its putative referentiality altogether.

3 Contrast this with John Maynard Keynes's famous assertion that the democratization of the stock market would be potentially disastrous: 'It is usually agreed that casinos should, in the public interest, be inaccessible and expensive. And perhaps the same is true of Stock Exchanges' (Keynes 1936: 159).

4 The Bank for International Settlements values the total volume of outstanding derivative contracts at the end of June 1999 at US$98.7 trillion, or, as Donald MacKenzie (2001: 122) notes, $16,000 for every man, woman and child on the planet.

5 These accounts, interestingly, often run parallel to the social studies of finance literature or ethnographies of finance that study the behaviours and baggage of market participants (e.g. Abolafia 1996; Hertz 1996). These studies of finance do open the field's black

boxes by exposing the networks of relations and institutions that make markets. Often, however, they do so by pointing to other forces or features 'outside' the financial realm that structure financial markets, rather than attempting an endogenous critique of the techniques involved in market trades. In this, they take a step initiated by Actor Network Theory but do not necessarily carry it through to the knowledge-objects of finance like the mathematical formulas discussed in this paper. On these points, see Callon (1998) and Latour (1999). What makes MacKenzie's (2001) contribution unique is his attempt to bridge these disciplinary and methodological divides; it is fascinating, in terms of the emerging history of (inter-)disciplinarity for finance studies, that his paper appears in the journal of the Society for Social Studies of *Science*.

6 All quotations here are from Rotman (1987: 96).

7 Similarly, in their fascinating essay on Simmel and Deleuze, Allen and Pryke also invoke derivatives and also neglect their technique: 'it is not the instruments so much that are of concern to us here as the ideas about what they may facilitate and what different groups of people in locations distant from one another imagine themselves to be involved in' (1999: 52).

8 I use 'entity' instead of 'subject' or 'object' to avoid opening a particular can of worms just now; I come back to this at the end of the essay.

9 I see a convergence between my own approach in terms of traumatic repression, and that of MacKenzie (2001) in his brilliant paper on the Black-Scholes formula and what he calls 'S-terms' in finance. Both of our approaches mean to highlight the problems of knowledge and referentiality in financial forms. By S-terms, MacKenzie refers to social-kind terms that operate as performative speech acts and work to create what they name through positive feedback loops. He demonstrates that it was the Black-Scholes formula itself that conjured forth a world after its own image, rather than naming a naturally occurring world of finance 'out there' in advance of the formulation. MacKenzie is leaning on Barnes (1983) and Austin (1962), the latter of which also influences the linguistic anthropology I draw on here. I would like to thank Hiro Miyazaki for drawing my attention to MacKenzie's important paper, the only critical analysis of derivatives I have seen that actually attends in a sustained fashion to the problem of mathematical technique.

10 MacKenzie (2001) provides a rich social history of the formula's creation and effects.

11 One could compare the stochastic revolution in physics at the beginning of the twentieth century to Rotman's 'imaginary money' in the late nineteenth century, when currencies went off the gold standard. Rotman's 'xenomoney' would then map onto more recent theories in physics, such as Bell's Theorem. Bell's Theorem essentially states that you cannot have it both ways: you cannot maintain a commitment to locality and keep realism. The locality postulate held only when physicists assumed the existence of 'hidden variables'. Bell demonstrated that a statistical account of those hidden variables was impossible (Cushing 1998: 325). Derivative pricing techniques, like Bell's Theorem, abandon locality. At the same time, however, they hold to a certain (theological) vision of statistical power, as I demonstrate below, and thus do not quite do away with necessitarianism and empiricism to the extent Bell might have endorsed.

12 On stochastic thinking in the Bible and Talmud, see Sheynin (1998) – although I remain sceptical of his conclusions because he fails to differentiate the use of randomizers like lots or tali from the development of models of random processes.

13 The following argument leans heavily on Hacking, and I refer the interested reader to his *The Emergence of Probability* and other writings for an account of the history of probability theory more nuanced than I can offer here.

14 Moivre and Bayse, and not just Pascal, developed probability theories around the question of the existence of God.

15 Elizabeth Mertz points out to me that it would be a mistake to fall into the false choice of adopting the relativity of vision, on the one hand, or the fixed points of a presumably 'shared' vision of a collectivity, on the other. Rather, she suggests an analytical strategy

involving a 'calculus of relationship and effect' (Mertz, personal communication, 2001) in any attempt to bring trauma into the domain of the thinkable.

References

Abolafia, M. Y. (1996) *Making Markets: Opportunism and Restraint on Wall Street*, Cambridge, MA: Harvard University Press.

Allen, John and **Pryke, Michael** (1999) 'Money cultures after Georg Simmel: mobility, movement, and identity', *Environment and Planning D: Society and Space* 17: 51–68.

Appadurai, Arjun (1986) 'Introduction: commodities and the politics of value', in A. Appadurai (ed.) *The Social Life of Things*, Cambridge: Cambridge University Press, pp. 3–63.

Asad, Talal (1993) *Genealogies of Religion: Discipline and Reasons of Power in Christianity and Islam*, Baltimore, MD: Johns Hopkins University Press.

Austin, J. L. (1962) *How to Do Things with Words*, Oxford: Clarendon Press.

Bachelier, Louis (1900) 'Théorie de la spéculation', *Annales de l'Ecole Normale Supérieure*, 3rd series, 17: 22–86.

Barnes, B. (1983) 'Social life as bootstrapped induction', *Sociology* 17: 524–45.

Black, Fischer and **Scholes, Myron** (1973) 'The pricing of options and corporate liabilities', *Journal of Political Economy* 81(3): 637–54.

Callon, Michel (ed.) (1998) *The Laws of the Markets*, Oxford: Blackwell.

Caruth, Cathy (1991) 'Unclaimed experience: trauma and the possibility of history', *Yale French Studies* 79: 181–92.

Cerny, Philip (1994) 'The dynamics of financial globalization: technology, market structure, and policy response', *Policy Sciences* 27: 319–42.

Collier, George (n.d.) 'Aboriginal sin in the Garden of Eden', unpublished ms., Department of Cultural and Social Anthropology, Stanford University, CA.

Cushing, James T. (1998) *Philosophical Concepts in Physics*, Cambridge: Cambridge University Press.

Daston, Lorraine (1994) 'Marvelous facts and miraculous evidence in early modern Europe', in James Chandler, Arnold Davidson and Harry Harootunian (eds) *Questions of Evidence: Proof, Practice and Persuasion across the Disciplines*, Chicago: University of Chicago Press, pp. 243–74.

David, Florence Nightengale (1962) *Games, Gods and Gambling: The Origins and History of Probability and Statistical Ideas from the Earliest Times to the Newtonian Era*, New York: Hafner.

Deleuze, Gilles and **Guattari, Félix** (1983) *The Anti-Oedipus: Capitalism and Schizophrenia*, Minneapolis: University of Minnesota Press.

Dimand, R. W. (1993) 'The case of Brownian motion: a note on Bachelier's contribution', *British Journal for the History of Science* 26(89): 233–4.

Dybvig, Philip and **Marshall, William** (1997) 'The new risk management: the good, the bad, and the ugly', *Federal Reserve Board of St. Louis Review* 79(6): 9–21.

The Economist (1997) 'Finance and economics: the right option: The Nobel Prize for economics', *The Economist* 18 October: 75.

—— (1998) 'Finance and economics: the unbearable lightness of finance', *The Economist* 5 December: 83.

Eddington, A. S. (1935) *The Nature of the Physical World*, New York: Macmillan.

Einstein, Albert (1926) *Investigations on the Theory of the Brownian Movement*, London: Methuen.

Foucault, Michel (1973) *The Order of Things: An Archaeology of the Human Sciences*, New York: Vintage Books.

Freud, Sigmund (1939) *Moses and Monotheism*, London: Hogarth Press.

Green, Stephen (2000) 'Negotiating with the future: the culture of modern risk in global financial markets', *Environment and Planning D: Society and Space* 18: 77–89.

Hacking, Ian (1975) *The Emergence of Probability*, Cambridge: Cambridge University Press.
Harvey, David (1989) *The Condition of Postmodernity*, Oxford: Blackwell.
Helleiner, Eric (1994) *States and the Emergence of Global Finance*, Ithaca, NY: Cornell University Press.
Hertz, Ellen (1996) *The Trading Crowd: An Ethnography of the Shanghai Stock Exchange*, Cambridge: Cambridge University Press.
Hull, John (1993) *Options, Futures and Other Derivative Securities*, 2nd edn, Englewood Cliffs, NJ: Prentice Hall.
Jorion, Philippe (1995) *Big Bets Gone Bad: Derivatives and Bankruptcy in Orange County*, San Diego, CA: Academic Press.
Kamali, Mohammad Hashim (1996) 'Islamic commercial law: an analysis of futures', *American Journal of Islamic Social Sciences* 13: 197–225.
—— (1997) 'Islamic commercial law: an analysis of options', *American Journal of Islamic Social Sciences* 14: 17–39.
—— (1998) 'Prospects for an Islamic derivatives market in Malaysia', *Thunderbird International Business Review* 41(4&5): 523–40.
Keynes, John Maynard (1921) *Treatise on Probability*, in *Collected Writings of John Maynard Keynes*, vol. 8, London: Macmillan.
—— (1936) *The General Theory of Employment, Interest and Money*, New York: Harcourt Brace.
Khan, M. Ali (1993) 'The irony in/of economic theory', *MLN* 108(4): 759–803.
Knight, Frank Hyneman (1921) *Risk, Uncertainty and Profit*, New York: Houghton Mifflin.
—— (1945) 'Liberalism and Christianity', in Frank Knight and Thornton W. Merriam (eds) *The Economic Order and Religion*, New York: Harper & Bros.
Kripalani, Manjeet (1991) 'Formula for success', *Forbes* 28 October: 202.
Langley, Russell (1971) *Practical Statistics for Non-Mathematical People*, New York: Drake.
Latour, Bruno (1992) *We Have Never Been Modern*, Cambridge, MA: Harvard University Press.
—— (1999) 'On recalling ANT', in J. Law and J. Hassard (eds) *Actor Network Theory and After*, Oxford: Blackwell, pp. 15–25.
MacKenzie, Donald (2001) 'Physics and finance: S-terms and modern finance as a topic for science studies', *Science, Technology and Human Values* 26(2): 115–44.
Maurer, Bill (n.d.) 'Redecorating the international economy: Keynes, Grant and the queering of Bretton Woods', unpublished ms.
—— (2001) 'Engineering an Islamic future', *Anthropology Today* 17(1): 8–11.
Mirowski, Philip (1989a) 'The probabilistic counter-revolution, or how stochastic concepts came to neoclassical economic theory', *Oxford Economic Papers* 41: 217–35.
—— (1989b) *More Heat than Light: Economics as Social Physics, Physics as Nature's Economics*, Cambridge: Cambridge University Press.
Moivre, Abraham de (1733) *The Doctrine of Chances, or, a Method of Calculating the Probabilities of Events in Play*, New York: Chelsea Publishing Company, 1967 (reprint of the 1756 edition).
The Nation (1998) 'Crony capitalism', *The Nation* 267(12): 3.
O'Malley, Pat (2000) 'Uncertain subjects: risks, liberalism and contract', *Economy and Society* 29(4): 460–84.
Pearson, Karl (1924) 'Historical note on the origin of the normal curve of errors', *Biometrika* 16: 402–4.
Poovey, Mary (1998) *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society*, Chicago: University of Chicago Press.
Pryke, Michael and **Allen, John** (2000) 'Monetized time-space: derivatives – money's "new imaginary"?', *Economy and Society* 29(2): 264–84.
Robinson, Joan (1953) 'Lecture delivered at Oxford by a Cambridge economist', in *Collected Economic Papers*, vol. 4. Oxford: Blackwell, 1973, pp. 254–63.
Rose, Nikolas (1996) 'The death of the

social? Re-figuring the territory of government', *Economy and Society* 25(3): 327–56.
Rotheim, Roy J. (1988) 'Keynes and the language of probability and uncertainty', *Journal of Post Keynesian Economics* 11(1): 82–99.
Rotman, Brian (1987) *Signifying Nothing: The Semiotics of Zero*, Stanford, CA: Stanford University Press.
Scholes, Myron (1998) 'Derivatives in a dynamic environment', *American Economic Review* 88(3): 350–70.
Schumpeter, Joseph A. (1954) *A History of Economic Analysis*, New York: Oxford University Press.
Shell, Marc (1982) *Money, Language and Thought: Literary and Philosophical Economies from the Medieval to the Modern Era*, Berkeley, CA: University of California Press.
Sheynin, Oskar (1998) 'Stochastic thinking in the Bible and the Talmud', *Annals of Science* 55(2): 185–98.
Silverstein, Michael (1976) 'Shifters, linguistic categories, and cultural description', in Keith Basso and Henry Selby (eds) *Meaning in Anthropology*, Albuquerque: University of New Mexico Press, pp. 11–55.
Simmel, Georg (1990) *The Philosophy of Money*, London: Routledge.
Spiro, Leah Nathans (1994) 'Dream team: John Meriwether's brain trust made billions at Salomon. Can they do it on their own?', *Business Week*, 29 August: 1, 50.
Strathern, Marilyn (n.d.) 'Emergent properties', unpublished ms., Department of Anthropology, University of Cambridge.
Tickell, Adam (2000) 'Dangerous derivatives: controlling and creating risks in international money', *Geoforum* 31: 87–99.
Weber, Max (1978) 'The stock exchange', in W. G. Runciman (ed.) *Max Weber: Selections in Translation*, Cambridge: Cambridge University Press, pp. 374–7.
Wick, Warner (1973) 'Frank Knight, philosopher at large', *Journal of Political Economy* 81(3): 513–15.