The Big, Bad Wolf

and the Rational Market:

Portfolio Insurance, the 1987 Crash and the

Performativity of Economics

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ABSTRACT

This article distinguishes two meanings of the performativity of economics, a thesis advanced by Michel Callon: 'generic' performativity, according to which markets and other economic relations are not to be taken as given, but as performed by economic practices; and 'Austinian' performativity, in which economics brings into being the relationships it describes. The two versions of performativity are explored by means of an examination of the history of portfolio insurance (a financial-market technique based on the economics of option pricing), of the 1987 stock market crash, and of subsequent efforts to diagnose the causes of the crash and to redesign the market to avoid future catastrophe. The article emphasises the extent to which the financial markets of high modernity are designed entities, and argues that the question of their design is always a political question, even if it is seldom recognised as such.

Keywords: portfolio insurance; 1987 crash; economic sociology; Callon, Michel; performativity

Social-science interpretations of the financial markets and of human behaviour within them are divided into two antagonistic camps. One interpretation is that of 'orthodox', rational, neoclassical, financial economics. Its central pivot is the efficient market hypothesis, the view that prices in the mature capital markets of high modernity reflect all available information. The hypothesis fits well with the 'rational expectations' revolution in economics in the 1960s and 1970s, according to which economic agents can be modelled as if they form their expectations of future events according to the best available economic theory or econometric analysis.[i] For the efficient market hypothesis to hold, however, it is not necessary for *all* investors to be rational, but at least a subset of them, arbitrageurs†, must be rational and must be able to borrow money and securities to exploit and thus close any price discrepancies that temporarily appear. The efficient market hypothesis is supported by a considerable body of empirical evidence and is not just a general analysis. Add to the hypothesis some further assumptions, for example about the stochastic dynamics of asset prices, and precise, elegant and empirically successful mathematical models can be developed. A prime example is the Nobel-prize-winning analysis of option† prices by Black and Scholes (1973) and Merton (1973). [Definitions of terms marked † can be found in the glossary in table 1.]

The second camp in the interpretation of financial markets is currently represented most prominently by 'behavioural finance', though other perspectives, such as Marxist analyses or many analyses rooted in economic sociology, can also be seen as falling in this camp. For members of this camp, claims of market efficiency are empirically false (there are, for example, persistent anomalies in stock prices that are hard to account for in efficient-market terms) and – a Marxist would add – ideological: a way of justifying the hegemony of financial markets. Investors respond not just to new information but to irrational fads, fashions and fears. The price of stocks or other securities can rise far beyond the present value of the rationally expected future income stream from those securities, and such 'bubbles' can end in catastrophic 'crashes'. The capacity of arbitrageurs to eliminate anomalies and bubbles is limited (Shleifer and Vishny 1997). The mathematical models prized by orthodox financial economists are unjustifiable idealizations of the imperfect psychological and institutional realities of markets. Those whose trading activities rely too much on these models will be punished for their naiveté and hubris by practical failure (Lowenstein 2000).

This article does not seek to adjudicate this entrenched debate, but to suggest a different way of approaching the underlying issues. Instead of treating orthodox, neoclassical finance theory as true (or false), it suggests treating it as (a) historically variable in its verisimilitude; (b) dependent for its verisimilitude on institutional and technological conditions; and (c) implicitly a historical project, incorporated into efforts to transform its object of study, the financial markets. Points (a) and (b) are, in one sense, self-evident,[ii] but they nevertheless require emphasis because debate about the efficient market hypothesis (e.g.

Shleifer 2000) is often curiously ahistorical, and because neoclassical finance abstracts away from institutional (Merton and Bodie 2002) and technological matters. Point (c) is less evident: only two of the major finance theorists, William F. Sharpe (Sharpe 1990) and Robert C. Merton (see Merton and Bodie 1995: 20-22 and, especially, Merton 1992: 470) have come close to viewing the theory as a historical project in any sense similar to that intended here.

The view of economics as a historical project can be found, for example, in Daniel Miller's theory of 'virtualism', though the latter's roots in Miller's work on consumption has led him, in my view mistakenly, largely to exclude finance from virtualism's scope (Miller 1998: 210). However, the existing theoretical debate to which this article has the closest connection is that sparked by the work of Michel Callon (Callon 1998; see also Barry and Slater 2002, the subsequent papers in the May 2002 issue of *Economy and Society*, and Fine 2003). Callon's work has virtues that his critics have missed, but the aim of this article is not to recapitulate or directly to take part in this debate, nor to assess the relative merits of Callon's and Miller's accounts.[iii] Instead, the article offers a conceptual clarification and (in contrast to the so far largely abstract debate about Callon's work) an empirical case-study.

The clarification concerns the notion of 'performativity', which is at the heart of Callon's work. This can mean (at least) two things. The first one might call generic performativity, because it is all-pervasive both as a phenomenon and now as a notion. Performativity in this sense points to the fact that the categories of social life (gender is the prototype)[iv] are not self-standing, 'natural', or to be taken as given, but are the result of endless performances by human beings and (an actor-network theorist such as Callon would add) by non-human entities and artefacts as well. The economy, Callon points out, is performed by economic practices, including marketing and accountancy, and by the all-pervasive practices of metrology (the bringing of disparate and what could be regarded as qualitatively distinct entities within standardized systems of quantitative comparison, such as weights and measures).

In this meaning, 'performativity' is at the most general level entirely obvious. For example, even prior to the Enron and WorldCom scandals, it was a matter of simple observation that profit figures – corporate earnings – were generated by accountancy practices. The self-evident nature of the point does not, however, rob it of empirical interest or substantive importance. We cannot, for example, hope to understand the corporation, especially in its contemporary relationship to the financial markets, without understanding how earnings figures are in practice constructed, but an empirical 'ethnoaccountancy' of profit (MacKenzie 2003a) of this kind is in its infancy.

Except in areas such as sex and gender where social categories might be read as natural, generic performativity is a weak claim (could matters be otherwise?), but still empirically important. A second meaning of performativity is less universal but stronger. This I call 'Austinian performativity', because it is closer to the meaning of the term in the work of the coiner of the word 'performative', the philosopher J.L. Austin. A 'performative utterance' is one that 'makes itself true', that brings into being that of which it speaks, as when an absolute monarch designates someone an 'outlaw', an appropriate authority designates a couple husband and wife, a ship is authoritatively named, and so (Austin 1962).

Although the dominant notion of performativity in Callon's work is generic, it sometimes approaches the Austinian meaning, as when Callon discusses *homo œconomicus*, the rational, egoistical individual posited by much economic theory:

> yes, *homo economicus* does exist, but is not an a-historical reality; he does not describe the hidden nature of the human being. He is the result of a process of configuration (Callon 1998: 22).

What makes it hard for an actor-network theorist fully to embrace the Austinian notion of performativity is perhaps that it seems to invoke a distinction between speech and that which is spoken about. In the context of finance theory, however, it does so in only a modest, proximate sense. To ask whether a model in financial economics is performative in the Austinian sense is to ask, amongst other things, whether the effect of the practical use of the model is to change patterns of prices towards greater compliance with the model. Asking that question does not imply that prices are brute facts somehow standing outside of speech or of the complex networks of human beings and artefacts that constitute markets.

It is also important not to extrapolate too literally the simple, paradigmatic Austinian performatives like 'outlaw'. The U.S. 'discount rate' – the rate the Federal Reserve charges banks for loans – is set by the Federal Reserve and is close to an example of a simple performative: the rate is whatever the Federal Reserve says it is. Many other utterances by which market participants offer prices or interest rates and conclude deals are also performative. However, finance theory addresses not these 'micro' phenomena of market interaction, but overall patterns, for example patterns of prices. In that respect, most situations of interest lack a single, centralized authority with the capacity to bring directly into being that of which it speaks. Only in rare circumstances, therefore, will the propositions of finance theory be simple performatives.

I suggest that instead of expecting simple performativity we examine the effect of the practical adoption of a theory or model on its verisimilitude. At the cost of some oversimplification,[v] let me distinguish three possibilities. The first is that adoption increases verisimilitude, improving the fit between model and 'reality'. It is this situation that can reasonably be called 'Austinian performativity'.[vi] For example, in earlier work with Millo (MacKenzie and Millo 2003) I have suggested that the effect of Black-Scholes-Merton option pricing theory on the market for options in the U.S. was to shift both market conditions and patterns of prices towards those posited by the theory.

A second possibility is that adoption of a model has no effect upon its verisimilitude. That is how we ordinarily think of theories or models: that they depict (with varying degrees of success) economic processes and patterns of prices that existed before the models were formulated and would exist even if the models did not, just as astrophysicists' models of the nuclear reactions within stars have, as far as we are aware, no significant effect on those reactions. There is, however, also a third possibility, one that is my focus in this article: the possibility that adoption reduces verisimilitude. An advantage of distinguishing the Austinian sense of performativity from the generic sense is that it highlights this possibility, which is, for example, not explicit in Callon's framework.[vii] A theory or model can be *counterperformative*: its widespread adoption can undermine the preconditions of its own empirical validity.

As will be seen, the spectre of counterperformativity haunts the episode to be discussed here. That episode – and the case-study offered by this article as a contribution to an empirical foundation for the debate around Callon's work – is the development of 'portfolio insurance' and its involvement in the 1987 stock market crash. Portfolio insurance was an application of Black-Scholes-Merton option pricing theory. Its large-scale adoption was widely regarded at the time as having exacerbated the crash, and such claims persist (e.g. Jacobs 1999). Were the claims correct, the 1987 crash would indeed be an instance of counterperformativity. The crash was a grotesquely unlikely event on the log-normal† model of stock price movements underpinning Black-Scholes-Merton option pricing theory – indeed, the crash involved substantial, discontinuous, downward price movements, not the continuous random walk of the log-normal model – and it led to the apparently permanent emergence of a phenomenon at variance with classic option pricing theory, the volatility skew† (Rubinstein 1994; see Mackenzie and Millo 2003). The crash fits poorly with any standard model of the stochastic dynamics of stock prices: 'No study so far has been able to explain the [crash] as a "reasonable" draw from a distribution that also describes the price dynamics during more normal times' (Timmermann 1995: 19).

More generally, the crash is a frequently-cited counter-example to finance theory's claim that stock price movements are the result of the impact of new information on rational expectations of future returns from those stocks. In the U.S. stock market, Monday October 19, 1987 (or Tuesday October 20, 1987 in a variety of other markets worldwide) was in percentage terms the largest-ever one-day move in stock prices: the Dow Jones Industrial Average fell 22.6%, the equivalent of well over 2000 points at the market levels of early 2004. Yet it is hard to identify 'new news' over the previous weekend that would rationally justify such a huge, sudden reevaluation of stocks. The crash took place against a background of deteriorating economic conditions, but knowledge of those conditions was not new. Both efficient market theory and a considerable body of empirical evidence suggest that capital markets react almost instantaneously (within minutes, and often within seconds) to relevant news, so earlier events – even events during the previous week – cannot from an efficient-market point of view explain Monday's crash: such information would already have been incorporated into Friday's prices.

Let me not unduly raise the reader's expectations in relation to the charge of counterperformativity. The available evidence, as we shall see, sustains only the Scottish verdict of 'not proven': despite a multitude of econometric and other studies, there seems to be no decisive way of showing that portfolio insurance exacerbated the crash, but equally no unequivocal demonstration that it did not. If this case-study assists discussion of performativity, it can only be in looser ways. The study also has, I hope, modest historical virtues independent of the theoretical interest of performativity. Unlike the Great Crash of 1929, the 1987 crash has within less than a generation vanished almost entirely from popular memory: in contrast to its predecessor, its effects on the 'real economy' were remarkably limited. At most, it is remembered that it happened and that computerized trading 'caused' it.

1987 is, however, too important to forget. Precisely because the crash's causes are not known conclusively, one cannot be sure that it will not be repeated, or that the 'real economy' consequences of a repetition might not be significantly worse. 1987 was the closest postwar financial markets have come to a systemic breakdown. It was in a sense an unplanned equivalent to Harold Garfinkel's famous breaching experiments (Garfinkel 1967): it made the performed nature of economic relations (in the generic sense of 'performativity') evident by disrupting the performance.

In its historical account, this article relies mainly on sources that have been available to earlier writers. The chief exception is oral history interviews conducted by the author with the three key figures in portfolio insurance: Hayne Leland, John O'Brien, and Mark Rubinstein. These are not the first interviews with them (see Norris 1988 and Bernstein 1992), and what my interviews contain is consistent with the earlier ones, but elaborates on it in important ways. Leland, O'Brien and Rubinstein might be expected to deny any role of portfolio insurance in exacerbating the crash, but they do not in fact do so.

This article has seven sections. After this introduction comes a section explaining portfolio insurance, its roots in Black-Scholes-Merton option pricing theory, and the role of index futures† in its implementation. A third section discusses the 1987 crash, focusing in particular on a key aspect: the breakdown of the arbitrage-imposed link between stock and futures markets. The fourth section explains why portfolio insurance was widely viewed as having exacerbated the crash, but also emphasizes the difficulty of establishing a definitive analysis of the latter. Section five outlines both the analysis of the crash given by key figures of portfolio insurance, particularly by Hayne Leland,

and the proposals for 'market redesign' that flowed from their analysis. After a brief penultimate section on the fate of these proposals and of portfolio insurance after 1987, comes a conclusion returning to the issue of the performativity of financial economics.

Portfolio Insurance

Portfolio insurance is the use of option theory to guide trading so as to set a floor below which the value of an investment portfolio will not fall. The idea came to finance scholar Hayne E. Leland of the University of California at Berkeley in September 1976, while, during a sleepless night, he was pondering how to boost his income via consultancy. He recruited the very next day the help of his colleague Mark Rubinstein, who had greater experience of option theory and who had particular expertise in the application of computing to finance (Leland interview; Leland and Rubinstein 1988). An idea similar to Leland's was also developed, independently and indeed slightly earlier, by Michael J. Brennan of the University of British Columbia and his student Eduardo S. Schwartz, who were considering the investment strategy that should be followed by insurance companies that sold investment products with a guaranteed minimum value (Brennan and Schwartz 1976).

It was Leland and Rubinstein, however, who played the critical role in starting the process that led to the widespread adoption of portfolio insurance. Black, Scholes, and Merton had shown that given certain conditions (to be discussed below) it was possible to mirror perfectly the returns on an option by continuously adjusting holdings or borrowings of the underlying stock and cash (or government bonds). The position in the stock and cash thus replicated the option: it was what we now call a 'replicating portfolio'. Black, Scholes, and Merton had used the idea of the replicating portfolio to work out what options ought to cost. Leland and Rubinstein (and also Brennan and Schwartz) focused on the replicating portfolio itself.

A floor below which the value of an asset cannot fall is, in effect, a put† option on the asset: an option to sell the asset at the guaranteed price level. So, in principle, the value of a portfolio can be insured by buying a put with strike† price equal to the desired floor. However, although organized options exchanges had been established in the U.S. from 1973 onwards, the options they traded were short-term, there were limits on the size of position that could be accumulated, and they were unsuitable in other ways for the insurance of the value of large, diversified portfolios. For example, in the 1970s and at the start of the 1980s the exchanges traded options only on individual stocks, not on stock indices such as the Standard and Poor's (S&P) 500. Market regulators, in particular the Securities and Exchange Commission (SEC), were suspicious of derivatives† such as options, fearing that they would be used for destabilizing speculation, and the abstract nature of a stock index raised a legal barrier. It would be clumsy in the extreme for the exercise of an index option or the settlement of an index future to require the delivery of the stock of dozens or hundreds of corporations, yet futures contracts that could be settled only in cash were considered wagers in U.S. law (MacKenzie and Millo 2003). In 1978, the SEC rejected a proposal from the Philadelphia Stock Exchange to trade index options, despite an 'economic justification' written by Mark Rubinstein, because of 'the gambling aspect' (Rubinstein interview).

What Leland had seen, however, was that although suitable actual puts were not available, a pension fund or other investor which wished portfolio insurance could use option pricing theory to 'manufacture' a synthetic put. Qualitatively, what was needed was to shift between stocks and cash (or government bonds) as stock prices fluctuated, buying stocks as prices rose and selling them as the value of the portfolio fell towards its floor. Option pricing theory provided the quantitative guidelines such that these shifts would replicate the desired put precisely.

Leland's idea did not meet quick or easy acceptance. From 1976 to 1978, Leland and Rubinstein set portfolio insurance largely aside. They feared it would be redundant if the SEC approved index options, and were wary of disseminating the idea too widely because it seemed in the 1970s as if the design of a financial product could not be protected by a patent (Rubinstein interview).[viii] In 1979, Leland gave talks on the idea at several banks, 'went home and eagerly awaited for the phone to ring. It never did' (Leland and Rubinstein 1988: 6). In 1980, however, the two academics' idea sparked the enthusiasm of John O'Brien, an experienced practitioner who had spent over a decade putting finance-theory ideas into practice: his many contacts knew 'I wasn't just another flim-flam man' (O'Brien interview). In February 1981 the trio established Leland O'Brien Rubinstein Associates, Inc. (LOR) with 'two part-time secretaries, one computer, and no clients' (Leland and Rubinstein 1988: 7).

More was involved in turning portfolio insurance from an idea to a product than recruiting a credible product-champion, critical as O'Brien was. Black-Scholes-Merton option theory was based upon a set of assumptions about markets. For example, as noted above, the probability distribution of stock price changes was assumed to be log-normal. Short selling† (selling borrowed stock) was assumed to be possible without financial penalty, and cash could be borrowed or lent at an identical riskless† rate of interest. The volatility† of the underlying stock was taken to be known and constant, and it was also assumed that '[t]here are no transaction costs in buying or selling the stock or the option' (Black and Scholes 1973: 640).

Leland, O'Brien, and Rubinstein knew they did not live in what Leland called 'a Black-Scholes world' (Leland 1980: 580), a world in which market conditions were as posited by option theory. As portfolio insurance was moulded from idea to product, the underlying theory was developed to incorporate some of reality's imperfections. Rubinstein was already involved in the development of an approach to option pricing theory (Cox, Ross, and Rubinstein 1979) that could be used to model price distributions other than the log-normal. Leland provided a mathematical analysis of the replication and pricing of options in a world with non-zero transaction costs (Leland 1985) and found a practical solution to the problem that 'even a cursory familiarity with the behavior of stocks, as well as stock indexes' showed that constant volatility was 'not a realistic assumption' (Leland and Rubinstein 1988: 5). Instead of trying to insure a portfolio for a fixed period of time (which was unrealistic because of fluctuations in volatility), LOR offered to insure it for a given number of stock price moves, for example 'five moves (any combination of ups and downs) of 5 percent' (Leland and Rubinstein 1988: 6).

During the early 1980s, a growing number of institutional investors contracted with LOR to provide them with instructions to buy or to sell stock in such a way as to replicate a put and thus provide portfolio insurance. Those investors' individual fund managers sometimes resented these instructions as outside interference with their investment strategies. In April 1982, however, the Chicago Mercantile Exchange launched a futures contract on the S&P 500 index, the benchmark most widely used by portfolio managers. The cultural and legal barriers to cash-settled futures contracts had been undermined by lobbying by the Chicago exchanges, by the gradually growing legitimacy of derivatives, and by changes in the political climate crystallized by the 1980 election of Ronald Reagan. The introduction of index futures provided LOR with a far simpler way of implementing portfolio insurance, one that did not require interference with fund managers' holdings.

The possibility of arbitrage[†] between the stock market and the market for index futures means that buying or selling futures is close to equivalent economically to buying or selling the stocks comprising the index. The profit or loss on an index futures contract is determined by the level of the index at the contract's expiry. The purchaser of such a contract receives returns similar to those received by a holder of the underlying stocks: the main differences are that the futures contract does not require one to put up the cash to buy the stocks (so one can therefore earn interest on the cash), but one foregoes dividends from the shares. In consequence, the theoretical value of an index futures contract is given by a simple equation[ix] that can be written informally (Martin 1988: 139) as:

Futures value = Index price + Interest on index price – Index dividends.

If the price of index futures deviates from this theoretical value, arbitrage profits can be made. For example, if the price is higher than the theoretical value, one can sell index futures contracts, cancel out the risk of index level fluctuations by buying an equivalent amount of the underlying stocks, and realize a sure profit when the future expires. Index arbitrage thus creates an *objective* link between index futures and stocks: the theoretical value of the former has nothing to do with opinions as to whether the price of the latter would rise or fall; it is a value imposed by arbitrage. Though transaction costs create a price zone within which arbitrage profits cannot be earned, the growing presence of arbitrageurs in the early and mid-1980s kept discrepancies between futures prices and theoretical value limited in size. For example, the average such discrepancy for three-month S&P index futures between June 1983 and mid-August 1986 was 0.32% (Hill, Jain, and Wood 1988: 24), and index arbitrageurs would typically move in whenever discrepancies grew to 0.5% (anon. 1988b).

This close link made it possible to implement portfolio insurance by buying and selling the Mercantile Exchange's index futures, rather than by buying and selling stocks, at least so long as the portfolio to be insured was highly correlated with the S&P 500, as well-diversified U.S. stock portfolios would be. LOR's customers provided it with access to capital typically amounting to around 4% of the value of the portfolio to be insured (Mason et al. 1995: 772), and in return for a management fee LOR would use this capital to create and then adjust a position in the futures market designed to produce the desired synthetic put. LOR would begin by selling the quantity of index futures necessary to create the desired initial hedge. If index levels then fell, LOR would sell more futures; if they rose, it would buy futures. Futures traded in large volumes and could readily be bought and sold with low transaction costs, making 'the protection of very large [portfolios] feasible for the first time. ... As of the end of 1986, roughly 80 percent of the dollar value of LOR accounts was protected using futures' (Leland and Rubinstein 1988: 8).

During the mid-1980s portfolio insurance became big business. By the autumn of 1987, the portfolio insurance programmes of LOR and its licensees covered $50 billion of stock (Mason et al. 1995: 786) with perhaps almost as much again covered by insurers not affiliated with LOR (Voorhees 1988: 57). This success, however, began to cause Leland and Rubinstein to have misgivings. Although they had coined the term 'portfolio insurance', they had reservations about it, preferring the broader and more neutral phrase 'dynamic asset allocation'. They knew that for all their technical innovations they had not freed themselves completely from the assumptions of a Black-Scholes world. '[The] analogy with insurance breaks down', they warned, if stock prices 'gapped' downwards, plunging discontinuously: there would not be 'sufficient time to adjust the replicating portfolio' (Rubinstein and Leland 1981: 72). Discontinuities were excluded, mathematically, from the Black-Scholes log-normal random walk, but could not be ruled out in practice. So LOR added an 'override' check to the Black-Scholes strategy. 'Every day we would say "if we were to take all the money out of the market and put it in cash and hold it through the expiration date, would we be able to deliver the floor?"' (Rubinstein interview). For certain clients – such as the Aetna Life Insurance Company, which was literally, not just figuratively, insuring portfolios – LOR added 'jump protection', working out whether the above override check would be passed if markets fell by a set amount (around 6%) so quickly that the portfolio could not be adjusted at all (Rubinstein interview).

It was accepted by all involved that, at least in the absence of jump protection, portfolio insurance would fail if a dreadful external event caused the market to fall discontinuously – if, as Leland warned pension fund officials, 'one morning, we learn that the Russians have invaded Iran and all the mid-east oil supplies are being cut off' (Leland interview). What gradually became more salient, however, was a risk 'internal' to the markets. In a Black-Scholes world, adjustment of the replicating portfolio did not affect the price of the underlying stock, the market for which was implicitly taken to be large, liquid, and efficient: the Black-Scholes option pricing equation 'assumes that you can't affect either stock or options prices, by placing orders', wrote Fischer Black (1990: 13). When portfolio insurance was small-scale, the assumption that the stock and futures markets were external 'things' in which prices would not be affected significantly by the insurers' purchases or sales was plausible enough, especially given that such purchases or sales were 'informationless': they reflected mechanical hedging, not information relevant to the value of stocks. But what if portfolio insurance was adopted widely? In January 1983, after attending an LOR presentation, Bruce Jacobs of the Prudential Insurance Company of America wrote in a memo to his employers (reproduced in Jacobs 1999: 301-4) that 'if a large number of investors utilized the portfolio insulation technique, price movements would tend to snowball. Price rises (falls) would be followed by purchases (sales) which would lead to further price appreciation (depreciation)'.

Jacobs was to become portfolio insurance's most persistent critic. The fear about portfolio insurance's possible positive feedback effect, its amplification of price movements, was, however, shared by the three men at its heart, Leland, O'Brien, and Rubinstein. '[F]rom the very first day I thought of portfolio insurance I said "Well what if everyone tries to do it?" I didn't like the answer I came up with' (Leland interview). By June 1987, the portfolios 'insured' by LOR and its licensees were sufficiently large that Leland was pointing out that 'if the market goes down 3%, which, in those days, would have been a very large one-day move, we could double the volume [of trading] in the New York Stock Exchange' (Leland interview). (Although by then LOR's portfolio insurance was implemented primarily with futures, index arbitrage would transmit selling pressure from the futures to the stock market.) 'We had one client come to us who had a huge pension plan', says Rubinstein. 'We wanted to tell that client that was too much money for us to handle. We were just too worried about the impact that the trading would have on the markets'. If LOR refused the client's business, however, 'he'd go somewhere else', to one of the growing number of other firms also offering portfolio insurance. 'It was as if Pandora's box had been open[ed]' (Rubinstein interview): 'we could shut our doors, but that wasn't going to stop anything' (O'Brien interview). LOR's principals did not envisage a catastrophic crash - they assumed, as had Jacobs, that 'savvy investors' (Jacobs

1999: 303) would step in to exploit and thus limit the mispricings induced by positive feedback – but they knew that market volatility could be increased. 'If that's what people want to do [purchase portfolio insurance]', they thought, 'then the market *should* be more volatile. There's nothing necessarily bad about it' (Rubinstein interview).

Rubinstein's concerns were, however, brought into focus by a sharp market decline on September 11 and 12, 1986. On September 11, the Dow fell 4.6%, its largest one-day fall for nearly a quarter of a century (SEC 1987: 1). The Securities and Exchange Commission (SEC) investigated, and 'concluded that the magnitude of the September decline was a result of changes in investors' perception of fundamental economic conditions, rather than artificial forces arising from index-related trading strategies'.[x] Rubinstein believed (but could not prove) that the SEC was wrong, and that the pressure of futures selling by portfolio insurers had been critical. He told the SEC, but did not publish his concerns: 'for the first time in my career I had a conflict of interests. ... I wasn't sure about it and I didn't want to stick my neck out and do a thing that would have hurt the business' (Rubinstein interview).

The Crash

The events of September 1986 were followed by another sharp decline on January 23, 1987, but those falls seemed minor reversals in a prolonged international bull market that saw the S&P 500 index almost triple between 1982 and September 1987, with similar rises in London and an even greater rise in Tokyo. The demons of the 1970s – rampant inflation, oil shocks, trade union power – seemed to be receding, banished by liberalized markets, monetarism, Reaganism, Thatcherism, and the new breed of aggressive financial management, exemplified by the audacious 'junk bond' acquisitions by 'asset stripping' corporate raiders.

By the autumn of 1987, however, doubts were growing as to whether the apparent successes of 'Reaganomics' (Brady Commission 1988: I-11) were sustainable. The U.S.'s trade deficit had ballooned, as had its public debt, the dollar was under pressure, and there were fears that interest rates would have to rise. On Wednesday October 14 disappointing U.S. trade figures, and moves by the Ways and Means Committee of the House of Representatives to remove tax advantages that had contributed to the mergers and acquisitions boom, led to what was then the largest ever number of points lost in a single day by the Dow Jones average. Thursday October 15 was again highly volatile, and Wednesday's fall was exceeded by an even worse one on Friday October 16, with the Dow falling 4.6%. That Friday 'was living history', one trader told the *Financial Times*. 'We have young traders out here with their eyes popping out of their heads at this sight', said another (anon. 1987a). Markets internationally also fell, and in

Britain even nature seemed to echo the human turmoil. On the night of October 15-16, the worst storm for over a century caused widespread damage across southern England, leaving British markets effectively shut on the Friday.

Friday's falls were, however, quickly to pale into relative insignificance. On Monday October 19 the London market fell some 11% (anon. 1988a: 52), and in New York – where the trading day is several hours later than London's, because of the time zone difference – the Dow fell 22.6%. It was, as noted above, its largest one-day fall ever, worse even than its worst individual days in the Great Crash: the 12.8% fall on October 28, 1929, and 11.7% fall on October 29, 1929 (Schwert 1990; Brady Commission 1988: 1). As alarming as the size of the crash were the breakdowns in markets that accompanied it. For prolonged periods on October 19 and October 20 the stocks of great U.S. corporations such as IBM and General Motors – normally the most readily traded of all private securities – simply did not trade at all, as the New York Stock Exchange's specialists† could not match buyers with sellers and feared bankruptcy if they stepped in to remedy the imbalance (as their regulatory obligations said they should). The printers at the specialists' booths could not keep up with the waves of sell orders arriving through the semi-automated DOT (Designated Order Turnaround) system, and there were also network delays and software problems (Brady Commission 1988: 48 and VI-47). Those who tried to sell via telephones often found they could not get through. Some brokers simply left their telephones to ring unanswered; others tried to respond but could not cope with the volume of calls. One NASDAQ broker-dealer reported that 'his phone board looked like a disco with every light flashing all day long and even after bringing in additional help from off the trading desk it was just impossible to answer them all' (Brady Commission 1988: VI-15). The two most important U.S. stock-derivatives exchanges, the Chicago Board Options Exchange and Chicago Mercantile Exchange, came under huge strain, with widespread fears that clearing systems, and thus the exchanges, would collapse under a ramifying chain of bankruptcies (Brady Commission 1988: 51-52; MacKenzie and Millo, 2003).

Critically, the trading disruptions in New York broke the link that arbitrage established between the stock and futures markets (and thus made visible the sociotechnical performance of that link in 'normal' times). The S&P and other indices were recalculated virtually continuously: as each New York stock traded, exchange employees completed cards and fed them via optical character recognition readers into the exchange's Market Data System, and computer systems at firms such as Bridge Data and ADP updated index values (Blume, Mackinlay and Terker 1989). If significant component stocks in the index were not trading, however, the calculated index value rapidly became 'stale': its relationship to market conditions became indeterminate. Even under normal circumstances, gaps between successive trades of individual stocks and delays in data entry and processing meant that the S&P 500 was 'typically about five minutes old' (Rubinstein 1988: 39), and that could be consequential economically for an index arbitrageur. On October 19 and 20, however, the disruption of trading meant that the gap between the index and the market it was meant to represent grew dauntingly large.

Furthermore, even if one had the confidence to perform index arbitrage it was not clear on October 19 and 20 that one actually could. Because index arbitrage requires trading not just individual stocks but large baskets of them, it was normally implemented via the automated DOT system, which allowed member firms of the New York Stock Exchange to identify in advance a basket of up to 500 stocks and then enter buy or sell orders for the entire basket (SEC 1988: 1-6). On October 19 and 20 there were serious network delays, and at 9.30 a.m. on October 20 the Exchange imposed what was in effect a prohibition on use of DOT for index arbitrage (Brady Commission 1988: III-22). In addition, the ends of the automated chain were human beings: the specialists on the floor of the New York Stock Exchange. It was they who had to turn an index arbitrageur's DOT order, arriving on printers at all the specialists' posts at which S&P 500 stocks were traded, into a completed transaction. As noted above, on October 19 and 20 many were unable or unwilling do to so.

The breakdown in arbitrage permitted futures prices to plunge far below the theoretical values implied by the apparent level of the index: on 19 October, the S&P 500 index fell 20%, while the price of S&P 500 two-month index futures fell 29% (Jackwerth and Rubinstein 1996: 1611). The arbitrage that the discrepancy should have evoked was to buy futures and short sell the underlying stocks. As noted above, however, it was quite unclear whether that arbitrage could successfully be completed. For example, Edward Thorp, co-founder of the arbitrageurs Princeton Newport Partners, recalls great difficulty in getting his firm's trader even to attempt the trade. He was able to persuade him only by threatening to do it on his own account and telling him 'I'm going to hang you out to dry' because the firm would then get no share of the profit. The trader was able to make only around 60% of the short sales Thorp had instructed, but Thorp had anticipated this by telling him to attempt twice the theoretical quantity (Thorp interview).

The fact that futures prices plunged far below even the huge falls on the stock market exacerbated fears on the latter, because they were taken as indicative of further declines yet to come. It also caused portfolio insurers to face a difficult dilemma. The price discrepancy could imply that the price of futures was artificially low because of the failure of arbitrage, and insurers should therefore not attempt the enormous sales demanded by put replication. Alternatively, it could mean that the index itself was not an accurate reflection of the state of the stock market, that the even greater fall in Chicago was the more valid measure, and huge sales of futures were the correct response.

Different portfolio insurers reacted differently to the discrepancy. On the morning of Monday October 19, Leland and Rubinstein flew down from their

Bay Area homes to LOR's Los Angeles headquarters. The New York Stock Exchange had just opened as Leland boarded his early morning flight, and the flight crew told the passengers the Dow had fallen by a serious, but less than catastrophic, 60 points. After the short flight, Leland 'asked the cab driver to put on the stock report and the market was down like 300 points at that time. I just said "Oh God"' (Leland interview): that fall would be the equivalent of a drop of around 1,400 points at the market levels of early 2004. At LOR's offices, the trader who handled futures's sales warned his bosses 'if I try to put on all the contracts ... I'm convinced the market will go to zero'. The fear of 'driv[ing] the markets to closure' (Leland interview), together with the growing discrepancy between the price of futures and their theoretical value, led LOR to slow futures sales. In contrast, Wells Fargo Investment Advisers, another leading portfolio insurer and LOR licensee, ignored the price discrepancy and kept selling futures aggressively (Voorhees 1988: 58).

Despite these difficulties, portfolio insurers performed quite credibly in protecting their clients' 'floors' in the exceptional market conditions of October 19 and 20, 1987. Although slow futures sales meant LOR was 'underhedged by 50 percent' on October 19, it 'still met its floor for 60 percent of its clients' with the rest of its accounts suffering 'floor violations that ranged between 5 and 7 percent' (Voorhees 1988: 57). The clients of other portfolio insurers typically were down '6% or 8% if the maximum targeted loss is 5%' (Anders 1987). Given the much larger falls in the overall market, 'It was better to have it [portfolio insurance] than not to have had it', said one client, Robert Mall of the Honeywell pension fund (quoted in Voorhees 1988: 57).

The problem, however, was that many portfolio insurance accounts were then 'stopped out': they were in effect completely in cash (the futures sales had been equivalent to the entire insured portfolio), and the only way in which LOR or the other portfolio insurers could continue to guarantee the 'floor' was to leave them in that condition (see, e.g., Rubinstein 1988: 40). This meant that unless clients were prepared to accept an *ad hoc* downward revision of their floors they had entirely to forego the benefits of subsequent stock price rises, and that turned out to be a significant cost.

Explaining the Crash

For portfolio insurers, however, the question of the benefits and costs to their clients was quickly joined by a more fundamental question: was portfolio insurance implicated in the crash of October 19? The most authoritative of the clutch of official reports on the crash was by a Presidential Task Force on Market Mechanisms led by investment banker Nicholas Brady, soon to serve both Reagan and George H.W. Bush as Secretary of the Treasury. It placed considerable weight in its account of the crash on 'mechanical ... selling' by portfolio insurers (Brady Commission 1988: v).

The questions of whether portfolio insurance exacerbated the crash, and if so to what extent, are immensely hard to answer conclusively. The Brady Commission and critics of portfolio insurance could point to a plausible set of mechanisms: initial price declines causing portfolio insurers to sell stocks and futures; index arbitrage transmitting sales pressures from the futures to the stock market; an 'overhang' of uncompleted portfolio insurance sales over the weekend of October 17-18; well-informed traders realizing further sales were inevitable and anticipating them by selling ahead of them; price declines causing further sales by portfolio insurers, and so on. Detailed analysis by the Brady Commission found that on October 19 portfolio insurers directly sold almost $2 billion in stock (nearly 10% of New York Stock Exchange volume) and also sold futures equivalent to stock worth $4 billion, more than 40% of externally-generated futures volume (Brady Commission 1988: 36).

In the absence of a model of the underlying economic processes it is hard to assess the significance of such figures. The total value of the stock of U.S. corporations before the crash was of the order of $3.5 trillion (Gennotte and Leland 1990: 999), so portfolio insurers' $6 billion sales on October 19 amounted to less than 0.2% of the total holdings of stock. It might seem a tiny proportion, incommensurate with generating such a huge drop in prices. Overall, though, only just over 1% of the U.S. market's total capitalization (stocks worth $39 billion) changed hands during the crash, and that small percentage change in ownership *was* associated with a price decline of over 20%.

If positive feedback had taken place, if price declines had been amplified by insurers' mechanical sales, one might expect prices to rebound as investors realized that an 'artificial' mechanism had led stocks to be undervalued. A brief rebound on the morning of Tuesday October 20 was overwhelmed by another wave of selling and serious market disruption – in two and a quarter vertiginous hours, index futures prices fell 27% (Brady Commission 1988: 40) – but prices did indeed rebound in a more sustained fashion on the afternoon of October 20 and on Wednesday October 21, when they rose 9.1%, the seventh-largest one-day percentage rise since 1885 (Schwert 1990: 80). About half of Monday's decline was thus recovered by the close on Wednesday, so perhaps positive feedback accounts for roughly 50% of the crash? That argument is, however, inconclusive: it is, for example, greatly affected by whether one includes the previous week's declines as part of the crash and whether one takes somewhat later, lower prices, rather than Wednesday's rebound, as the benchmark. Both these alternatives would considerably reduce the proportion of the crash that was later 'corrected'.

Another way of examining the role played by portfolio insurance in the crash is international comparison. By 1987, the technique was beginning to be adopted outside the U.S., but nowhere else had it achieved anything like its scale in the U.S.[xi] Since all major stock markets internationally crashed, by amounts similar to or even worse than in the U.S. (Roll 1988), specific features of the U.S. market such as portfolio insurance might seem to be incidental. The problem, however, is that price movements in stock markets internationally were highly correlated. 'Eyeballing' charts of price movements to see whether the U.S. led other markets down does not produce unequivocal results,[xii] and formal tests of causality only partially disentangle the chain of events.[xiii] The crash was an international event, but the available evidence does not rule out the possibility (though equally does not demonstrate) that its extent outside the U.S. was exacerbated by what happened in the U.S.

Portfolio insurance is not the only possible candidate cause of the 1987 crash. 'Behavioural' finance scholar Robert Shiller conducted a mail survey of investors directly after the crash: his first pilot survey was dispatched before 5 pm. on October 19. He found that while 5.5% of institutional investor respondents employed portfolio insurance, almost as many again were using simpler forms of 'stop-loss' strategy in which stocks are sold when prices fall below a set threshhold, and 10% of wealthy individual investors also had stop-loss strategies (Shiller 1988: 291). The effects of such strategies would have been similar to those of portfolio insurance: stocks would have to be sold as prices fell.

There had also been widespread speculation prior to October 19 that the stock price rises of the 1980s would end in a crash akin to 1929. J.K. Galbraith, historian of the Great Crash, contributed an article to the *Atlantic Monthly* (Galbraith 1987) on 'The 1929 Parallel'. The October issue of the magazine, on America's newsstands as the crash began to unfold, warned that 'America has let its infrastructure crumble, its foreign markets decline, its productivity dwindle, its savings evaporate, and its budget and borrowing burgeon. And now the day of reckoning is at hand' (Peterson 1987: 43; see Shiller 1988: 292). On the morning of October 19, the *Wall Street Journal* published a chart with the movements of the Dow Jones Industrial Average in the 1980s superimposed on those of the 1920s. The article's text was reassuring: 'Wall Street analysts ... argue that much has changed in the intervening decades to make the stock market – and the economy – more stable' (anon. 1987b). However, any reader that Monday morning who extrapolated 1987's prices using the 1929 graph would have been led to expect a crash remarkably similar to what was going to take place in the hours to come (Koning n.d.).

To the extent that fears of a crash had been widespread in the months prior to October 1987 – and Shiller's survey suggests they were – they would help explain the growing popularity of portfolio insurance, and also add an element of self-fulfilling prophecy to the October events: large numbers of investors who feared a crash responded to price declines by all running for the exit and finding 'it was large enough to accommodate only a few' (Brady Commission 1988: 57). The Brady Commission concentrated its attention on large sales by big investors, notably by portfolio insurers, but the breakdown of the technical mechanisms of the markets – swamped telephone lines and the failures of the DOT system, for example – 'came from urgent selling by the large number of smaller investors rather than from the small number of larger investors' (Bernstein and Bernstein 1988: 176).

Given the lack of conclusive evidence, and the presence alongside portfolio insurance of other strategies and a broader mindset that would be similar in their effects, it is therefore difficult to improve on Hayne Leland's admirably candid and properly tentative judgement. Portfolio insurance 'certainly didn't start a crash', he says, 'because we were a reactive strategy, but we may well have contributed in some degree to the size of the fall. The "some degree" was a 3% contribution or a 60% contribution. I'm not sure' (Leland interview).

It is also perfectly possible that to inquire into the causes of the *crash* is to ask the wrong question. The fundamental challenge posed by the October events to efficient market theory is to explain why relatively minor new information apparently caused such large price movements. From this viewpoint, it may be the rebound in the afternoon of October 20 and on October 21 that is more challenging to explain than the price declines on October 19, for which reasonably plausible explanations, broadly compatible with economic orthodoxy, can be found.[xiv] Wednesday October 21, however, has received almost no analytical attention (the Brady Commission's analysis, for example, stops with October 20), presumably because it is sharp declines, not sharp rises, that are regarded as undesirable and in thus need of explanation. How participants behaved on the Tuesday and Wednesday was of course affected by their beliefs as to the cause of Monday's events. Thorp, for example, 'went home that night [October 19] to think about it. ... thinking through the numbers, knowing how much portfolio insurance was on and how much selling had to be due to portfolio insurance being adjusted. It was a very large number. ... I realized what had happened ... [it] was portfolio insurance'. This analysis gave him the confidence to undertake the arbitrage, described above, that others did not attempt. '[W]hen the disconnect [between the futures and stock markets] was understandable it wasn't quite so fearsome. You could see it was going to go away again' (Thorp interview).

It is also possible that the search for the *causes* of the crash is mistaken. For example, Timmerman's verdict, quoted above, on the difficulty of explaining October 19 'as a "reasonable" draw' may reflect exploration of too limited a class of stochastic processes. Perhaps 'wilder' forms of randomness account for sudden, huge price discontinuities interrupting prolonged periods of limited fluctuation – a possibility advocated above all by 'chaos' theorist Benoit Mandelbrot (see, e.g., Mandelbrot 1997), who was moved to return to the study of finance, after many years on other topics, by the 1987 crash (Mandelbrot interview). 'Think of a ruler held up vertically on your finger', suggests geophysicist-turned-finance-scholar Didier Sornette. To ask which hand movement or gust of air causes its collapse is to miss the point. 'The collapse is fundamentally due to the unstable position; the instantaneous cause of the collapse is secondary' (Sornette 2003: 4).

Changing the World

Given the ambiguity of the evidence and the depth of the underlying issues, it is interesting that the key figures in portfolio insurance do not take the easy option of denying that it had a significant role in the 1987 crash. Leland and Rubinstein are both broadly 'orthodox' economists and efficient market theorists (see, e.g., Rubinstein 2001). How do they reconcile this with their acceptance that it 'isn't ridiculous to say that portfolio insurance was a significant factor in the market crash' (Rubinstein interview)?

From the viewpoint of this article, the most relevant explanation is Leland's, first presented in a December 1987 typescript (Leland 1987)[xv] and then developed with postdoctoral researcher Gérard Gennotte (Gennotte and Leland: 1990).[xvi] Its bearing on the theme of performativity is that it is an analysis directly tied to the question of how to 'design the market' so that 'crashes can be avoided' even in the presence of large-scale portfolio insurance (Leland 1987: n.p.). Apart from one feature (to be discussed below), Gennotte and Leland's model is a 'rational expectations' model: it posits investors who have a correct understanding of the price dynamics presumed in the model. The model is of the determination by supply and demand of the price, p_0, of a single risky asset, which can be 'interpreted as the stock market portfolio' (Gennotte and Leland 1990: 1006). Part of the supply of the asset results from the activities of portfolio insurers, who sell increased quantities of it as its price falls. That supply is $\pi(p_o)$, a deterministic, decreasing function of p_o. Part of the demand for the asset comes from 'uninformed investors ... who observe only p_o', in other words whose only source of information about the future price of the asset is by inference from its current price (Gennotte and Leland 1990: 1002).

Because portfolio insurance can create positive feedback – there will be more portfolio insurance sales as price falls – 'price discontinuities or "crashes" can occur' (Gennotte and Leland 1990: 1008). The key factor determining their likelihood in Gennotte and Leland's model is whether or not $\pi(p_o)$, the function describing the extent of portfolio insurers' sales at different price levels, is known to the economic agents posited by the model. (The possibility that $\pi(p_o)$ is known to no participant is the key departure from a full rational expectations model.) Sales of the asset by portfolio insurers will lead to lower prices, but if $\pi(p_o)$ is not known – in other words, if investors do not know the proportion of sales that are 'mechanical' responses to lower prices – price falls will be greater 'as a consequence of investors inferring information from prices. A supply shock leads to lower prices, which in turn (since the shock is unobserved) leads uninformed investors to revise downwards their expectations. This limits these investors' willingness to absorb the extra supply and causes a magnified price response' (Gennotte and Leland 1990: 1001).

When the various parameters in Gennotte and Leland's model are set to values roughly corresponding to the U.S. stock market in 1987, the effects of whether or not $\pi(p_o)$ is observed are dramatic: 'the unobserved hedging which created a 30-percent crash in market prices, would have less than a 1-percent impact on prices if it were observed by all investors' (Gennotte and Leland 1990: 1016). For Leland, then, the key factor in the 1987 crash was not portfolio insurance, *per se*, but lack of awareness of the true extent of portfolio insurance's 'mechanical' sales. '[I]f everybody knows that we're uninformed traders, then people don't revise their expectations downward when the price falls. They just say things are on sale. Then they will take the other side [i.e. buy] more willingly. If everyone thinks the price is falling because somebody has information, then they won't take the other side' and the price fall will be much larger (Leland interview).

Leland and Gennotte's explanation, in other words, is that mechanical sales were misinterpreted as implying that 'something terrible was happening ... that there was something fundamentally wrong' (Leland interview). That process could account for developments in the U.S. and could also explain the extent to which price falls were transmitted from the U.S. to other markets, as investors in those markets inferred gloomy economic prognoses from declines in the U.S. It is an explanation consistent with widespread reports of investor fear. Shiller's questionnaire asked respondents whether during the crash they experienced 'symptoms of anxiety' such as 'sweaty palms' or 'tightness in chest'. A fifth of individual investors, and two fifths of institutional investors, reported experiencing such symptoms on October 19 (Shiller 1989: 388-89). Almost all were aware of falling prices during that day – Shiller's institutional respondents 'checked the prices of stocks' an average of 35 times on October 19 (1989: 388) – and those falls provoked emotion consistent with there being 'something fundamentally wrong'.

'[T]here was panic', reports John O'Brien: '[in] my observation ... people were as panicked in brokerage houses as they were two weeks ago [September 11, 2001]' (O'Brien interview). Had investors understood that sales were mechanical and known how large they were going to be – LOR heard rumours that 'suggested portfolio insurance trading was going to be three or four times larger than in fact it was' (Norris 1988: 28) – they might have felt less afraid. Recall Thorp's testimony that the disconnect between the futures and stock markets 'wasn't quite so fearsome' once he understood it to be the effect of portfolio insurance. But investors in general did not have the knowledge Thorp had of the likely proportion of sales that had been portfolio insurance. Such investors may well have believed 'the big, bad wolf was there ... that some catastrophe would befall America that the smart people were on to' (O'Brien interview).

Leland and Gennotte's explanation of the role of portfolio insurance in the 1987 crash improves on looser discussions of the topic (for example, by the Brady Commission) in that it involves an explicit economic model. Ultimately, however, it is no more provable (or disprovable) than other explanations. Its particular relevance here is its explicit link to a means of banishing the big, bad wolf from the rational market: 'sunshine trading'. The idea predated the crash: it had emerged from a conversation between John O'Brien and futures broker Steven Wunsch of Kidder Peabody. O'Brien and Wunsch were discussing the problem that LOR's futures trades were large and that they *had* to be made: 'if the market drops this much, we have to trade. It's not a matter of us saying "well, gee, this is not a good time to trade"'. Says O'Brien: 'What Steve [Wunsch] and I devised was something [for which] we then came up with the name "sunshine trading". We said, what we'll do, we'll go down to the floor of the futures exchange, we'll announce an hour beforehand that we're going to sell $10 million of futures at 11 o'clock' (O'Brien interview).[xvii]

The obvious objection was that a sunshine trader would be 'front run' – others would sell futures ahead of them, in order to profit from a decline in price brought on by the preannounced sale. However, if news of the intended sale was disseminated widely, competition amongst would-be front runners would tend to eliminate the adverse price effects of front running. Indeed, sunshine trading can in a sense be seen as an attempt to free portfolio insurers from the dense, information-rich social structures of Chicago's open outcry pits. In a pit, matters such as body language convey useful messages. For example, Chicago Mercantile Exchange trader Lewis J. Borsellino recalls: 'As I walked into the S&P pit [on October 22, 1987] a few minutes before the opening bell, I noticed the brokers who filled customer orders seemed nervous and edgy. I had been an order-filler myself. ... I remembered well the nervous anticipation of having a big order to fill at the opening. That's what I saw across the pit that morning. I could see it in the way their eyes darted around them and the uneasy fidgeting. ... They were sellers, I decided at that moment' (Borsellino 1999: 6). In that instance, it took to the following day for the seller's identity to become known via the Chicago rumour-mill (it was speculator George Soros), but the activity of regular, predictable customers such as portfolio insurers would quickly be identifiable via local knowledge of which brokers acted for them, giving floor traders 'an advantage because they know something that nobody else does' (Leland interview).

LOR's pre-crash experiments with sunshine trading were successful: 'We made 13 large trades this way ... and it was our belief that, on average, we got better prices' (Rubinstein interview). The goal at that point was to reduce LOR's transaction costs, but after the crash Leland and O'Brien saw sunshine trading as attractive for another reason. Instead of pre-announcing just one trade, portfolio insurers could make known, 'the table of trades that we would make at various market levels' (O'Brien interview), in effect publishing Gennotte and Leland's $\pi(p_0)$. If Gennotte and Leland's account of the crash were correct, that would greatly reduce the risk of portfolio insurance sales destabilizing the market. With $\pi(p_0)$ not known, large sales produced 'shock ... nobody knowing how big ... how much more would be coming'. In contrast, with $\pi(p_0)$ known the market could 'prepare itself' for portfolio insurers' informationless trades and 'clear ... just fine' (O'Brien interview; see also Grossman 1988: 278-9).

Sunshine trading, in other words, could be seen as an attempt to repair the Black-Scholes world, to create a world in which the mere placing of 'informationless' orders did not affect prices. Another attempt at repair – a more ambiguous one – was advocacy of a shift away from continuous stock trading via New York's specialists, trading which had broken down so disastrously on October 19 and 20, and of a move to discrete stock auctions, perhaps four times daily. In these auctions, in O'Brien's words (quoted by Norris 1988: 26), 'all the buy and sell orders [would] be congregated in one place and adjusted by the people who are putting these orders in to a point that they can be cleared at a single price, and all buyers and sellers receive that price'. The key advocate of single-price auctions was Wunsch, but the suggestion was also supported by Leland and O'Brien. Its ambiguity in relation to a Black-Scholes world is that this world assumes trading that is continuous in time, but what was more important to portfolio insurers was continuity in price: the avoidance of large, discontinuous gaps.

New York's specialists were supposed to provide price continuity, but had failed to do so. Perhaps the moment at which the markets came closest to disaster was the morning of Tuesday October 20, when a sudden, brief rebound gave way to another precipitous fall. The initial rebound was based on very partial information, says Leland: 'there were very thin orders left. If the [specialists'] book [of buy and sell orders] had been public, I am convinced those prices would not have opened up with as much of a gap as they actually did'. In contrast, a 'single price auction essentially allows everyone to see the full sets of supply and demand'. From a portfolio insurer's viewpoint, 'it is sort of like sunshine trading, in the sense that we would put in our entire order demand, and everybody would see that' (Leland, quoted by Norris 1988: 28).

After the Fall

Neither sunshine trading nor single-price stock auctions were successful reforms in the U.S. (see Muniesa 2003 for the contrasting case of France). Sunshine trading foundered on the objections of Chicago floor traders, who claimed that its preannounced trades would be 'prearranged' trades, which were illegal. Despite the failures of 1987, the basic structure of the New York Stock Exchange remained unchanged (only now, in 2004, is it coming under fundamental threat following allegations of malpractice), although small specialists' firms were largely taken over by investment banks and other bigger, better-capitalized institutions. Wunsch helped set up the Arizona Stock Exchange, based around electronically-conducted, discrete auctions rather than continuous trading via specialists, but the Arizona Exchange was eventually unable to compete successfully with its entrenched rivals.

So LOR's proposals to redesign markets so as to minimize the unwanted effects of portfolio insurance came to little. That mattered less than it might have, because after October 1987 the market for the type of portfolio insurance sold by LOR, its licensees and its competitors dwindled rapidly. In part that was because the costs of portfolio insurance in situations of high volatility (foregone gains and risks of being 'stopped out') became evident, but it may also have been because the managers of 'respectable' institutions such as pension funds wished to avoid overt pursuit of a strategy that was 'tainted' by its association with the crash. That does not mean that the desire for what portfolio insurance promised – a floor to losses – vanished. Instead, those who wished such a floor seem to have turned from portfolio insurance's synthetic puts to actual puts. Such puts were purchased either 'over-the-counter' (by direct institution-to-institution negotiation) from investment banks or bought on organized options exchanges.

The use of real rather than synthetic puts might seem to make little difference, because the vendors of such puts have to hedge the risks involved in their sale, and this may involve constructing the same replicating portfolio as needed for a synthetic put. Three factors, however, may have mitigated the effects of this. First, investment banks need hedge only a small portion of their apparent exposures, for reasons to be discussed below. Second, total sales of different classes of option on organized option exchanges are published, and those versed in option theory can then estimate the resultant hedging sales and purchases: LOR's goal of a publicly-known $\pi(p_0)$ is thus indirectly achieved, at least where exchange-traded puts are concerned. Third, the price of index puts has been high, substantially higher than it would be in a Black-Scholes world (this is the 'volatility skew' referred to above), and the price has to be paid explicitly and 'up-front' rather than primarily by foregone gains, as in portfolio insurance. These 'up-front premium' costs could cause 'sticker shock' (Voorhees 1988: 58), limiting the scale of the purchase of puts, and consequently the extent of any destabilizing effects of hedging. On October 13, 1989, for example, U.S. markets again crashed. Though the 7% fall was only a third of that two years previously, it sparked renewed anxious analysis. This analysis, however, showed that 'insurance' uses of puts had been small compared to portfolio insurance in 1987. Portfolios worth only of the order of $2 billion had been protected by over-the-counter puts, a mere fraction of portfolio insurance's $60 - $90 billion coverage (SEC 1990: 25; Voorhees 1988: 57).

Conclusion

The 1987 crash shows the importance of 'generic' performativity. The way in which economic relationships, including those posited by finance theory, were performed by mundane sociotechnical practices was made evident when those practices were disrupted. The breakdowns of DOT and other communication systems, the collapse of the arbitrage-mediated link between the futures and stock markets and the growing discrepancy between the prices of futures and their theoretical values, the unwillingness or incapacity of specialists to maintain price continuity (or even to facilitate any trading at all), the near failure of clearing systems and thus of the underlying exchanges – all these amounted to the most serious crisis faced by the U.S. financial markets since the Great Crash. The present-day structure of financial markets in the U.S. cannot be understood without grasping how much of that structure is the result of conscious redesign in response to 1987's trauma (see, e.g., Lindsey and Pecora 1998). At the Securities and Exchange Commission, for example, the trauma became known as the 'market break' (e.g. SEC 1988). The phrase needs read in the sense of 'breakdown' as well as of 'discontinuity'. In October 1987, the market broke, albeit partially and temporarily, and much of what has happened since – a host of changes to capital adequacy rules and to clearance, settlement and margining systems, the provision of 'circuit breakers' (planned rather than ad hoc trading halts), new testing regimes for the markets' technological systems, and so on – has been an effort to make sure it never happens again.

What of performativity in the narrower, Austinian sense: finance theory making a world in its own image? There is at least an aspect of that in the history of portfolio insurance. To begin with, models were adapted to markets: an example is Leland's research on how to modify option pricing theory to reflect the world of non-zero transaction costs. But as portfolio insurance grew in scale, and the possibility of it having undesired effects on markets became more evident, thought had to be given to reshaping markets, via sunshine trading and single-price auctions. This was not because of any abstract commitment to a model-compliant reality, but because those who were pursuing a strategy based, however loosely, on a Black-Scholes world had, for reasons of self-interest if nothing else, to tackle threats to that world's verisimilitude. At its most mundane, they had an interest in reducing transaction costs, the most pervasive discrepancy between the Black-Scholes world and reality, but they also had an interest in eliminating the possibly counterperformative, self-undermining effects of portfolio insurance when practised on a large scale.

The extent in this instance of finance theory's Austinian performativity should not be exaggerated. Sunshine trading and single-price stock auctions were not successful innovations in the U.S. Much of the last three decades' growing fit between theory and model is simply because of the way technological change has speeded up trading and reduced its costs. Another factor has been the generic influence of free-market economics, but that is only an attenuated form of performativity. More specific forms, however, do exist (see MacKenzie 2003c). One has been the way in which Black-Scholes-Merton option pricing theory and its many subsequent developments enable investment banks to trade derivatives almost as if they enjoyed zero transaction costs and are thus in that respect the economic agents posited by the theory. The theory allows such banks mathematically to decompose the risks they face. When that is done, they typically discover that many of these risks are mutually offsetting, so the residual risk that needs explicit hedging is quite limited in proportion to those banks' overall portfolios, and the cost of such hedging is thus relatively small (Merton and Bodie 2002: 8). The pivotal position of the major investment banks – Goldman Sachs, Morgan Stanley, Merrill Lynch, etc. – in the global economy is in part the result of the economic advantages for other agents of transacting via the investment banks rather than directly, and some of those advantages come down to this matter of transaction costs.

In highlighting the possibility of finance theory's Austinian performativity, I do not want to imply that this performativity is simple or complete. It is one factor in a world of many other factors, and these include political power and the tendency for entrenched positions of advantage to replicate themselves. For example, the world's major financial exchanges (especially the New York Stock Exchange, the single most influential exchange) are political actors in their own right, and the liquidity their scale offers is a powerful disincentive to trading elsewhere. It is factors such as this, I would conjecture, that led to the failure in the U.S. of sunshine trading and single-price stock auctions, not any intrinsic difficulty in implementing those ideas: as Wunsch noted, 'marketmakers are not likely to voluntarily give up their monopoly on mediating between buyers and sellers' (Wunsch 1987: 4). More generally, the redesign of U.S. financial markets in response to 1987 owed relatively little to finance theory, which was largely excluded from politically key fora such as the Brady Commission (see Mirowski 1994). 'Circuit breakers', for example, are a measure that most finance theorists would view as likely to be counterproductive.

Nor is finance theory – even 'orthodox' finance theory – unitary. There are competing strands within it (see MacKenzie 2003c), and increasing the fit of reality in one respect may worsen it in others. Portfolio insurers' desire that their supply schedule, $\pi(p_0)$, be public knowledge could in a sense be seen as an attempt to make reality more compliant with a rational expectations model: to give all actors an awareness of the processes forming market prices, rather than have informationless sales be mistaken for evidence of bad news. As we have seen, however, the effort in this way to banish the 'big, bad wolf' of fear, and thus to repair the rational market, pushed the key figures in portfolio insurance towards discontinuous auctions – and thus away from the continuous trading (and associated sophisticated 'Itô calculus' mathematical apparatus) that is the hallmark of much of modern finance theory, especially that influenced by the work of Robert C. Merton (e.g. Merton 1992). Furthermore, theoretically-inspired proposals for market design have to contend with an alternative tradition in economics based upon experimentation with laboratory markets, a tradition begun above all by recent Nobel laureate Vernon L. Smith. For example, along with the efforts of Steven Wunsch, the experimental work of Smith, who was then at the University of Arizona, was the inspiration of the Arizona Stock Exchange (Smith 1994: 116; Muniesa 2003: 104-5).

In addition, there is a sense in which the mathematical relationships posited by finance theory may only ever hold 'in the limit', as mathematicians put it. These relationships are imposed, above all, by arbitrage: if they are violated, arbitrageurs step in to profit from, and in so doing reduce, the violations. Arbitrageurs do not do this as a public service: they do it only if there are profits to be made. The existence of such profits is dependent on the relationships in question *not* holding, at least not all the time. Even in this narrow respect, then, one cannot posit a smoothly-performed world, but a world in tension – a tension that is exacerbated if successful arbitrage undermines its own conditions of possibility by attracting dangerously many imitative arbitrageurs (MacKenzie 2003b).

These issues are of more than esoteric interest because the financial markets of high modernity are to a significant extent designed entities, and their design is a political question. Only occasionally does this become explicit: a recent example is the campaign for a 'Tobin tax', a small, globally-imposed tax – perhaps of the order of 0.5% – on financial transactions, especially foreign-exchange transactions. Such a tax could raise large sums and throw 'sand in the wheels of international finance' (Eichengreen, Tobin and Wyplosz 1995). It would, of course, also unmake significant aspects of the world posited by finance theory, because transaction costs of 0.5% are economically a very long way from zero for those who transact with any frequency.

The Tobin tax is unusual in being debated outside financial-market circles. There are, however, other 'market design' issues with potentially important consequences that have not received a proper public airing: sunshine trading and single price auctions are only examples. Of potentially considerable significance is the asymmetry in the design of the U.S. (and many other) stock markets, whereby 'positive' opinions on, or information about, stock valuations are much easier to 'register' than negative opinions. Virtually any individual or institution with the requisite funds can 'register' a positive opinion by buying stock. Registering a negative opinion or negative information by short selling stock is much harder and much rarer.[xviii] Many institutions are legally prohibited from short selling, and in the U.S. short sales are legal only if made on an 'uptick' (that is, after an upward movement of the price of the stock in question). It can be hard to borrow stocks and the cost of doing so can be high. There is the risk of a 'short squeeze', in which it becomes impossible or too expensive to keep borrowing stock, which thus has to be purchased and returned, sometimes at high cost.

The result of the asymmetry, together perhaps with a tendency for negative information to remain 'bottled up' within corporations for longer than positive information, may be that the efficiency of the incorporation into prices of negative information (for example, the gradually increasing knowledge that many of the corporate earnings figures being reported in the late 1990s and early 2000s were inflated: see Partnoy 2003) is sometimes less than the efficiency of the incorporation of positive information. If that were so, one might expect an intermittent upwards 'bias' to stock prices punctuated by occasional steep falls as 'pessimistic information ... largely hidden from other investors, particularly after a market rise, because of constraints on short sales' becomes apparent as the 'market [begins] to fall' and 'pessimistic investors fail ... to materialize as buyers' (Rubinstein 2001: 26, summarizing a preprint version of Hong and Stein 2003). The mechanism would, for example, explain the dangerous tendency for stock market falls to be much more rapid than rises, and Rubinstein believes it may be part of the explanation of the 1987 crash (Rubinstein interview).

There is, therefore, a case at least for public discussion of the wisdom of removing barriers to short sales.[xix] (Many of these barriers arise from the fear that short sales contribute to crashes, while if the above analysis is right it may be the barriers themselves that are the problem.) It is, furthermore, only one of a number of issues in market design that might benefit from a more prominent place in the policy agenda.[xx] However infrequently such issues become explicit, the design of financial markets is always implicitly political: it influences who will perform which transactions with whom and with what effects.

The notion of performativity as applied to financial markets has its limitations: generic performativity is, at the most general level, obvious; Austinian performativity may be relatively rare. The concept has, however, two virtues. It focuses attention not just on the overall features of financial markets but on the critical role of apparent detail: transaction costs of all kinds (not just taxes), constraints on short selling, regulatory frameworks, clearing systems, technological networks, order-matching algorithms (Muniesa 2003), and so on. And it prompts a question: what sort of a world do we want to see performed?

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List of interviews

William L. Fouse, San Francisco, June 14, 2000.
Hayne Leland, Berkeley, Calif., June 12, 2000.
Benoit Mandelbrot, Djursholm, Sweden, May 25, 2002.
Merton Miller, Chicago, November 5, 1999.
John O'Brien, Newport Beach, Calif., October 3, 2001.
Mark Rubinstein, Berkeley, Calif., June 12, 2000.
Edward O. Thorp, Newport Beach, Calif., October 1, 2001.

Arbitrage; arbitrageur	trading that seeks to profit from price discrepancies; a trader who seeks to do so.
Black-Scholes	the canonical ***option*** pricing model, based upon the assumption that the underlying stock price follows a ***log-normal*** random walk.
Derivative	a contract or contractual instrument (such as a ***future*** or ***option***), the value of which depends upon that of another 'underlying' asset, index or interest rate.
Future	a contract traded on an organized exchange in which one party undertakes to buy, and the other to sell, a set quantity of an asset at a set price on a given future date.
Implied volatility	the ***volatility*** of a stock or index consistent with the price of ***option***s on the stock or index.
Log-normal	a variable is log-normally distributed if its logarithm is normally distributed.
Option	a contract that gives its purchaser the right, but not the obligation, to buy ('call') or to sell ('put') an asset at a given price (the 'strike price') on, or up to, a given future date (the 'expiration').
Put	see ***option.***
Riskless rate	the rate of interest paid by a borrower who creditors are certain will not default.
Short selling	selling an asset one does not own, e.g. by borrowing it, selling it, and later repurchasing and returning it.
Skew	a pattern of ***option*** prices in which ***implied volatility*** is not independent of strike price (as it should be on the ***Black-Scholes*** model).
Specialist	on the New York and other U.S. stock exchanges, an exchange member who maintains the 'book' of buy and sell orders for the stocks for whom s/he is responsible, matches such orders, and trades with her/his own capital if there is an imbalance.
Strike price	see ***option.***
Volatility	the extent of the fluctuations of the price of an asset, conventionally measured by the annualized standard deviation of continuously-compounded returns on the asset.

Table 1: Glossary

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[i] Those expectations can still be erroneous, but the errors they contain are random not systematic. For a useful review of the different strands of rational expectations theory, see Sent (1998).

[ii] At least limited forms of efficiency can, however, be found in surprisingly early markets: see, e.g., Brown and Easton (1989).

[iii] For a spirited, self-consciously tendentious comparison of Callon and Miller see Holm (2003).

[iv] See, especially, Butler (1990: 136-140); for Butler's thoughts on what I am calling 'Austinian performativity', see Butler (1997). I have been influenced here by discussions with Angus Erskine, but since he would prefer to see the ugly word 'performativity' dropped, I should not foist my views upon him.

[v] The most important qualification is that the 'fit' between an economic model and 'reality' (e.g. empirical prices) is often not a straightforward matter. Econometric tests, for example, are often themselves theory-laden. Thus tests of the efficient market hypothesis often involve models of the relationship between risk and return, such as the Capital Asset Pricing Model. None of this, of course, is surprising – analogous issues to do with the theory-laden character of observation and experiment are commonplace in the sociology of science – and it does in a sense justify the actor-network theorist's reluctance to distinguish speech and that which is spoken about. The resultant issues in relation to economics are, however, deep, and space prohibits their discussion here.

[vi] 'Simple performativity' is then the extreme case in which adoption of a model by a single designated authority generates full compliance with the model. A possible approximation to this situation is the use of finance theory's Capital Asset Pricing Model by the regulators of private utilities (e.g. water companies in England) to set 'appropriate' – i.e. model-compliant – profit rates.

[vii] Counterperformativity could reasonably be construed, as a referee suggested, as a species of what Callon calls 'overflow' (see, e.g., Callon 1998: 18), but even if this is the case counterperformativity is important enough to require specific identification.

[viii] *State Street Bank & Trust Company vs. Signature Financial Group*, 149 F.3d 1368 (U.S. Court of Appeals Federal Circuit, July 23, 1998) has changed the interpretation of U.S. patent law in this respect.

[ix] $F_0 = S_0 e^{(r-q)T}$ where F_0 is the theoretical value of the future, S_0 the current index level, r the (continuously-compounded) riskless rate of interest, q the annualized dividend yield, and T the time remaining until the future's expiry (Hull 2000: 64).

[x] Typescript of remarks of David S. Ruder, chair of the SEC, to the Bond Club of Chicago, October 6, 1987, 13, summarizing SEC (1987). I am grateful to William L. Fouse, Chairman Emeritus, Mellon Capital Management, for this typescript of Ruder's speech and a large collection of other published and unpublished material on portfolio insurance. Fouse's group at Mellon, particularly Jeffrey P. Ricker, was perhaps the most influential set of critics of portfolio insurance prior to October 1987 (Fouse interview)

[xi] In the analysis by Roll, 'computer-designed trading' is judged to have been present in 5 of the 23 national markets examined: Canada, France, Japan, U.K. and U.S. (Roll 1988: 29-30). This judgement, however, masks large differences in scale. For example, the Bank of England reported that 'In contrast to the US markets, the use of stock-related derivative products in the United Kingdom is very limited and the volume of stock-index-related business is very small' (anon. 1988a: 58).

[xii] Compare the opposite conclusions reached in this way by Roll (1988) and Jacobs (1999: 177).

[xiii] Malliaris and Urrutia apply Granger causality tests, in which time series A is deemed to have been a cause of time series B if previous values of A improve predictions of values of B. Examining prices in New York, Tokyo, London, Hong Kong, Singapore and Australia, they conclude that Tokyo played predominantly 'a passive role' (was influenced by changes in New York and elsewhere rather than influencing them) and 'no market led New York during

the crash', but that there were mutual, bi-directional, influences between New York and London and New York and Hong Kong (Malliaris and Urrutia 1992: 362).

[xiv] For example, dividend discount models, in which stock prices are the discounted present value of the expected future income stream to which the stock is a title, are very sensitive to projected rates of dividend growth and choice of risk-adjusted discount rate. A small reduction in the former, and small rise in the latter, can cause a large drop in stock prices (see the example in Miller 1991: 99-100). If the economic 'climate' as well as the weather is persistent (serially correlated), small events – a slight rain shower after a prolonged drought: see Mandelbrot (1966) – can rationally trigger '[r]evisions in risk allowances and/or in long-run growth projections' (Miller 1991: 100). 'What's [serially] correlated is the feeling that these are good times or bad times and if there's a slight chill in the air, it says "look, the good years are over and we're now heading into a period of bad times". Bam! The market will crash and it should, and that's perfect Mandelbrot, although it'll be very hard to show it in specific numbers' (Miller interview). Another possibility is that the events on October 14-16 led to 'a sudden extremely large upward shift' in estimates of future volatility, 'that may have convinced the most risk-sensitive investors to exit the market on Monday' (Rubinstein 2001: 26; see also Black 1988).

[xv] Again, I am grateful to William L. Fouse for a copy of this typescript.

[xvi] While Rubinstein entertains the explanation discussed in the text, he places less weight on portfolio insurance, and suggests mechanisms (discussed in note 14 above and in the conclusion) in which it would not have played an essential role (Rubinstein interview; Rubinstein 2001: 26). Jacklin, Kleidon and Pfleiderer (1992) develop a model similar to Gennotte and Leland (1990) but in which it is earlier portfolio insurance purchases that are misunderstood as being the result of positive information. This is also in principle plausible, but its empirical significance is reduced by the fact that as the market rose prior to October 1987 the clients of portfolio insurers often instructed the latter to raise their floors. This required sales of futures and may have outweighed the purchases necessitated in a rising market by programmes with unchanged floors (Rubinstein interview).

[xvii] See also Fabian Muniesa's interview with Steven Wunsch, quoted in Muniesa (2003: 334).

[xviii] Negative opinions can also be registered by buying puts or selling futures, but this has also encountered barriers. The sale of futures on individual stocks has, for example, only very recently become legal in the U.S.

[xix] After the first draft of this paper was completed, the SEC announced a review of the 'up-tick' rule.

[xx] Although the considerations taken into account are politically narrow, there is a useful discussion in Miller (2002).