

Long-Term Capital Management and the sociology of arbitrage

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Abstract

Arbitrage is a key process in the practice of financial markets and in their theoretical depiction: it allows markets to be posited as efficient without all investors being assumed to be rational. This article explores the sociology of arbitrage by means of an examination of the arbitrageurs, Long-Term Capital Management (LTCM). LTCM's 1998 crisis is analysed using both qualitative, interview-based data and quantitative examination of price movements. It is suggested that the roots of the crisis lay in an unstable pattern of imitation that had developed in the markets within which LTCM operated. As the resulting 'superportfolio' began to unravel, arbitrageurs other than LTCM fled the market, even as arbitrage opportunities became more attractive, causing huge price movements against LTCM. Three features of the sociology of arbitrage are discussed: its conduct by people often personally known to each other; the possibility and consequences of imitation; and the limits on the capacity of arbitrage to close price discrepancies. It is suggested that by 1998 imitative arbitrage formed a 'global microstructure' in the sense of Knorr Cetina and Bruegger.

Keywords: arbitrage; economic sociology; imitation; Long-Term Capital Management (LTCM); globalization; risk.

Introduction

Of all the contested boundaries that define the discipline of sociology, none is more crucial than the divide between sociology and economics. Despite his synthesizing ambitions, Talcott Parsons played a critical role in reinforcing this divide. The economy, argued Parsons and Smelser, is a 'differentiated

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sub-system of a more inclusive social system' (1956: 7). Conventional neoclassical economics could, Parsons believed, quite appropriately be applied to that sub-system. The technical core, so to speak, of the workings of market economies was the business of economists, not of sociologists.

In more recent years, a revived economic sociology has rebelled against this intellectual division of labour, which Stark (2000) calls 'Parsons' Pact'. A range of authors – among them White, Granovetter, Fligstein, Podolny, and Callon – have proposed a variety of ways of conceptualizing social processes not as 'surrounding' economic life but as being at its core.¹ This article seeks to contribute to this post-Parsonian economic sociology by proposing not a new approach but a new (or almost new) topic for sociological investigation: arbitrage. Arbitrage is trading that exploits price discrepancies: for example, differences between the prices of the same asset at different geographical locations or between the prices of similar assets at the one location.

There is a sense in which arbitrageurs are the border guards, in economic practice, of the Parsonian boundary between economics and sociology. Suppose that the prices of two similar financial assets temporarily diverge for reasons that are 'sociological' rather than 'economic': investors' irrational preferences, enthusiasms, or fears; legal constraints (often ultimately moral in their roots: see Zelizer 1979) on market participants such as insurance companies; regulatory impositions (perhaps driven by political ideologies); and so on. Arbitrageurs can then profit by buying the cheaper of the assets and short selling the dearer (financial terminology such as 'short selling' is defined in the glossary in Table 1). Their purchases tend to raise the price of the cheaper asset and their sales to lower that of the dearer, thus helping to restore equality. The consequently plausible assumption that pricing discrepancies will be eliminated by arbitrage allows the development of elegant and influential economic models of markets. Arbitrage-based reasoning is, for example, central to the work that has won Nobel Prizes in economics for three of the five finance theorists so far honoured: Merton H. Miller, Robert C. Merton, and Myron S. Scholes.²

Arbitrage is thus seen by economists as making it possible for financial markets to be efficient even in the presence of investor irrationality and other social or psychological 'factors':

Neoclassical finance is a theory of sharks [i.e. arbitrageurs] and not a theory of rational homo economicus. . . . [A]rbitrageurs spot [price discrepancies], pile on, and by their actions they close aberrant price differentials. . . . Rational finance has stripped the assumptions [about the behaviour of investors] down to only those required to support efficient markets and the absence of arbitrage, and has worked very hard to rid the field of its sensitivity to the psychological vagaries of investors.

(Ross 2001: 4)

Furthermore, finance theory is itself drawn on by modern arbitrageurs, so arbitrage is a key issue for the 'performativity' of economics: the thesis that economics creates the phenomena it describes, rather than describing an already

existing ‘economy’ (Callon 1998).³ To the extent that arbitrageurs can eliminate the price discrepancies that finance theory helps them to identify, they thereby render the theory performative: price patterns in the markets become as described by the theory.

Table 1 Financial terminology

<i>Arbitrage</i>	trading that seeks to profit from price discrepancies.
<i>Basis point</i>	a hundredth of a percentage point.
<i>Future</i>	a contract traded on an organized exchange in which one party undertakes to buy, and the other to sell, a set quantity of a particular asset at a set price on a given future date.
<i>Haircut</i>	when money is borrowed to buy securities such as bonds, and these are pledged as collateral for the loan, the haircut is the difference between the amount of money lent and the market price of the securities.
<i>Implied volatility</i>	the <i>volatility</i> of a stock or index consistent with the price of <i>options</i> on the stock or index.
<i>Libor</i> (London interbank offered rate)	the average rate of interest at which banks with the highest credit ratings are prepared to lend each other funds.
<i>Option</i>	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 on, or up to, a given future date (the ‘expiration’).
<i>Short selling</i>	selling an asset one does not own, e.g. by borrowing it, selling it, and later repurchasing and returning it.
<i>Swap</i>	a contract to exchange two income streams.
<i>Swap spread</i>	the difference between the fixed interest rate at which interest-rate <i>swaps</i> can be entered into and the <i>yield</i> of a government bond of equivalent maturity denominated in the same currency.
<i>Value-at-risk</i>	a method of estimating the exposure of a portfolio of assets to potential losses.
<i>Volatility</i>	the extent of the fluctuations of a price, conventionally measured by its annualized standard deviation.
<i>Yield</i>	the yield of a bond is the rate of return it offers at its current market price.

Despite the centrality of arbitrage, there has been little empirical study of it by economists and, for all the flowering in recent years of the sociology of the financial markets,⁴ almost none by sociologists. The only extant sociological study focusing directly on arbitrage is Beunza and Stark (2002), which – in the tradition of the actor-network theory of Callon and Latour (see, e.g., Callon

1998; Latour 1987, 1999) and the distributed cognition approach of Hutchins (1995) – explores ethnographically how economic models, computer systems, price feeds, inter-personal interactions, whiteboards, and the like are brought together in the practice of arbitrage.

Beunza and Stark's study is descriptive: it does not, for example, investigate the capacity of arbitrage to eliminate price discrepancies and thus maintain the boundary between 'the social' and 'the economic'. That investigation, in contrast, is the goal of this paper. It focuses on the hedge fund, Long-Term Capital Management (LTCM).⁵ LTCM was highly skilled: it emerged from the celebrated arbitrage group at the investment bank Salomon Brothers, a group headed by John Meriwether, by common consent the most talented bond trader of his generation. LTCM, set up and led by Meriwether, had available to it the best of finance theory: among its partners were the Nobel laureates Merton and Scholes. It was hugely successful: at its peak, it deployed what is almost certainly the largest single concentration of arbitrage positions ever. And yet, in August and September 1998, in one of the defining moments of the economic history of the 1990s, adverse price movements drove LTCM to the brink of bankruptcy (it was recapitalized by a consortium of the world's leading banks, co-ordinated by the Federal Reserve Bank of New York).

LTCM's crisis has provoked widespread comment – for example, books by Dunbar (2000) and Lowenstein (2000) – and even features in a novel (Jennings 2002). Typically, popular commentary advances two accounts:

- 1 The partners in LTCM were guilty of greed and gambling (consciously reckless risk-taking);
- 2 LTCM's partners had blind faith in the accuracy of finance theory's mathematical models.

More informed discussion (e.g. President's Working Group on Financial Markets 1999) avoids blaming individuals' alleged character flaws, and instead advances a third hypothesis:

- 3 LTCM was over-levered – too high a proportion of its positions were financed by borrowing, rather than by LTCM's own capital.

This third hypothesis, however, explains at most LTCM's vulnerability to the events of August and September 1998: it does not explain those events. The most common explanation of them is:

- 4 On 17 August 1998, Russia defaulted on its rouble-denominated bonds and devalued the rouble. This triggered a 'flight-to-quality' in the financial markets – a sudden greatly increased preference for financial assets that were safer (less prone to default) and more liquid (more readily bought and sold).

That there was a flight-to-quality in August and September 1998, and that the Russian default triggered it, cannot be denied. The hypothesis of this article, however, is that superimposed on the flight-to-quality, and sometimes cutting against it, was a process of a different, more directly sociological kind:

5 LTCM's success led to widespread imitation, and the imitation led to a 'superportfolio' of partially overlapping arbitrage positions. Sales by some holders of the superportfolio moved prices against others, leading to a cascade of self-reinforcing adverse price movements.

This article draws upon sources of information of four kinds. First is a set of 'oral history' interviews conducted by the author with partners in and employees of LTCM.⁶ These initial interviews were then followed up by further exchanges in person, by electronic mail, and by telephone. The second source of information is interviews conducted with other key individuals, not affiliated with LTCM, who were also active in the markets within which LTCM operated.⁷ These interviews give additional insight into the market processes surrounding LTCM, and make it possible to check for any 'exculpatory' bias in the views of LTCM insiders.⁸ These first two sources then permit reliable published sources on LTCM to be distinguished from unreliable ones (the only consistently reliable, detailed source is Perold 1999), and these form the third source of data drawn on here. The fourth source is the price movements of key parts of LTCM's portfolio in the months of its crisis, August and September 1998.⁹

The exploratory nature of this study needs emphasizing. LTCM was deliberately chosen for this research because a brief earlier study (MacKenzie 2000a; see also MacKenzie 2000b, 2001a) suggested that what happened to LTCM revealed theoretically interesting aspects of arbitrage. Clearly, then, no claims can be made that the episode discussed here is typical: plainly it is not. If, however, one's interest is in the limits of arbitrage (as mine is), then a breakdown of arbitrage is an appropriate event to examine.

An economist might object that a study of LTCM is not really a study of arbitrage. In finance theory, arbitrage is conceived as involving no risk and demanding no capital (it can be performed entirely with borrowed cash and/or securities). These are, indeed, precisely the assumptions that make arbitrage's capacity to close price discrepancies unlimited. LTCM's activities, in contrast, involved risk (even in 'normal' times, not just in 1998), and demanded at least modest amounts of capital. The response to this economist's objection is simple (see Shleifer and Vishny 1997): much 'real-world' arbitrage involves risk and demands capital. Certainly, there is a spectrum in this respect – there are some arbitrages, typically of evanescent 'mispricings', that are very low risk – but LTCM's activities are reasonably characteristic, in terms of their risks and their capital demands, of a large class of arbitrage trades, including some of great theoretical significance, such as the arbitrage that enforces Black-Scholes-Merton option pricing, the single most influential model in finance theory (MacKenzie and Millo, forthcoming).

Readers from sociology, even from economic sociology, may find some of what follows rather 'economic' and 'technical'. For this, I make no apology. Fully to breach 'Parsons' Pact' requires demonstration of the social character of the most technical of economic processes. The flowering in the last thirty years of the sociology of science began when it started to open the 'black box' of

scientific knowledge, the contents of which had previously been held not to be appropriate subject matter for the sociologist. It is this article's contention that the continued flowering of economic sociology will require a similar opening of the black boxes of the economy, especially of the financial markets.

This article has five parts. After this introduction comes a section describing LTCM's arbitrage trading and its risk management. Then comes a section on LTCM's 1998 crisis, which, after briefly discussing the other explanations, draws on the interview data to flesh out the 'superportfolio' explanation. In the fourth section, this explanation is tested quantitatively against the main serious alternative, the flight-to-quality, and there is also a brief discussion of the contrast between 1998 and the aftermath of September 11, 2001. In the conclusion, I return to more general issues of the sociology of arbitrage and its bearing upon the relations of 'economy' and 'society'.

Long-Term Capital Management

LTCM, which began trading in February 1994, was a hedge fund based in Greenwich, Connecticut. It also had an office in London and a branch in Tokyo, and its primary registration was in the Cayman Islands. Its offices were not ostentatious (its Greenwich head office, for example, was a modest, low-rise suburban office block), and, in terms of personnel, LTCM was of limited size: initially, eleven partners and thirty employees; by September 1997, fifteen partners and around 150 employees. These people, however, managed a considerable body of assets: in August 1997, LTCM's assets totalled \$126 billion, of which \$6.7 billion was the fund's own capital. While most hedge funds cater for rich individuals, they were the source of less than 4 per cent of LTCM's capital, which came mostly from financial institutions, particularly banks (Perold 1999: A2, A22).

LTCM's basic strategy was 'convergence' and 'relative-value' arbitrage: the exploitation of price differences that either must be temporary or have a high probability of being temporary. Typical were its many trades involving 'swaps': by the time of LTCM's crisis, its swap book consisted of some 10,000 swaps with a total notional value of \$1.25 trillion.¹⁰ A swap is a contract to exchange two income streams: for example, fixed-rate and floating-rate interest on the same notional sum. Swaps are a recent invention – they date only from the early 1980s – but they have become vitally important financial derivatives, widely used to manage the risks of interest-rate fluctuations. At the end of December 2001, interest-rate swaps with a total notional principal of \$59 trillion were outstanding worldwide (almost \$10,000 for every human being on earth).¹¹

The 'swap spread' is the difference between the fixed interest rate at which swaps can be entered into and the yield of a government bond with a similar maturity denominated in the same currency. Swap spreads can indicate arbitrage opportunities because the party to a swap which is paying a floating rate of interest while receiving a fixed rate is in the same situation as someone who has

borrowed money at a floating rate and used it to buy a bond which pays a fixed amount of interest. If there is sufficient discrepancy between the terms on which swap contracts can be entered into and on which positions in bonds in the same currency and of similar maturities can be financed, arbitrage may be possible: a typical LTCM swap-spread arbitrage is described in the appendix to this paper.

Several features of swap-spread arbitrage go to the heart of LTCM's strategy. First is leverage. LTCM's swap-spread trades were highly levered: that is, were constructed largely with borrowed capital. In the trade discussed in the appendix, LTCM's position amounted to \$5 billion. The capital required by LTCM to construct this position was, however, only around \$100–\$125 million: around \$50 million 'haircut' (see the glossary in Table 1) and \$50–\$75 million 'risk capital' (provision for adverse price movements). The leverage ratio of the trade (the ratio of the total position to the amount of LTCM's own capital devoted to the trade) was thus of the order of 40: 1 to 50: 1. While not all the fund's positions were as highly levered as that, its overall leverage ratio between June 1994 and December 1997 fluctuated between 14: 1 and 31: 1 (Perold 1999: A22, C12).

High levels of leverage, however, did not necessarily imply huge risk (as much subsequent commentary suggested). The risks of swap-spread trades are rather limited. Bond prices and the terms upon which swaps are offered fluctuate considerably, particularly as interest rates vary. LTCM, however, almost always neutralized that latter risk by constructing 'two-legged' trades, in which the effects on one 'leg' of a change in interest rates would be cancelled out by its equal-but-opposite effect on the other 'leg' (the trade in the appendix is an example). The chief 'market risk' of swap-spread trading is of the spread temporarily moving in an unfavourable direction, but if that were to happen the arbitrageur can simply continue to hold the position and wait until such time as it became profitable to liquidate it. Indeed, if necessary the position can be held until the bond matures and the swap expires. That feature was the essence of convergence arbitrage: if held to maturity, a convergence arbitrage position *has* to make a profit, whatever the market fluctuations along the way. Any 'credit risk' – risk of default – associated with the trade is small. The risk of the US government defaulting on its bonds is regarded as negligible; bond futures contracts are guaranteed by the clearing house of the Chicago Board of Trade; and LTCM's swap contracts were typically with major banks. Even major banks may fail, but because the principal sum in a swap is not exchanged, it is only notional and is at no risk: the credit risk involved is only of loss of future net differences between fixed-rate and floating-rate interest.

If the risks were limited, the profits from LTCM's swap-spread trading were impressive. The trade described in the appendix earned a profit of \$35 million, which was a return of 28–35 per cent achieved in eight months or less. Nor was this untypical. Between February and December 1994 LTCM's returns before fees were 28.1 per cent (unannualized); after management and incentive fees were deducted, investors received 19.9 per cent (unannualized). Gross returns in 1995 were 59 per cent, and returns after fees 42.8 per cent; in 1996, the corresponding figures were 61.5 per cent and 40.8 per cent.¹²

Although LTCM was active in the US and Japanese markets, it also had particularly heavy involvement in European markets. In the 1990s, financial deregulation in Europe proceeded apace, but arbitrageurs such as LTCM initially found much less competition than in the US or Japan: ‘the Japanese banks . . . were the ones who were terribly interested in setting up proprietary desks. The European banks were still a bit hesitant’ (Kaplanis interview). LTCM scrutinized the ‘yield curves’ for European government bonds (see Figure 1), along with the corresponding swap curves, looking for the ‘bulges’ and other anomalies that might indicate arbitrage opportunities. If LTCM was confident it understood the reasons for anomalies – frequently they were matters such as regulatory requirements on insurance companies to purchase bonds of particular maturities – it would seek to exploit them by trades carefully constructed to neutralize the risks of interest-rate fluctuations or of changes in the overall steepness of the yield curve.

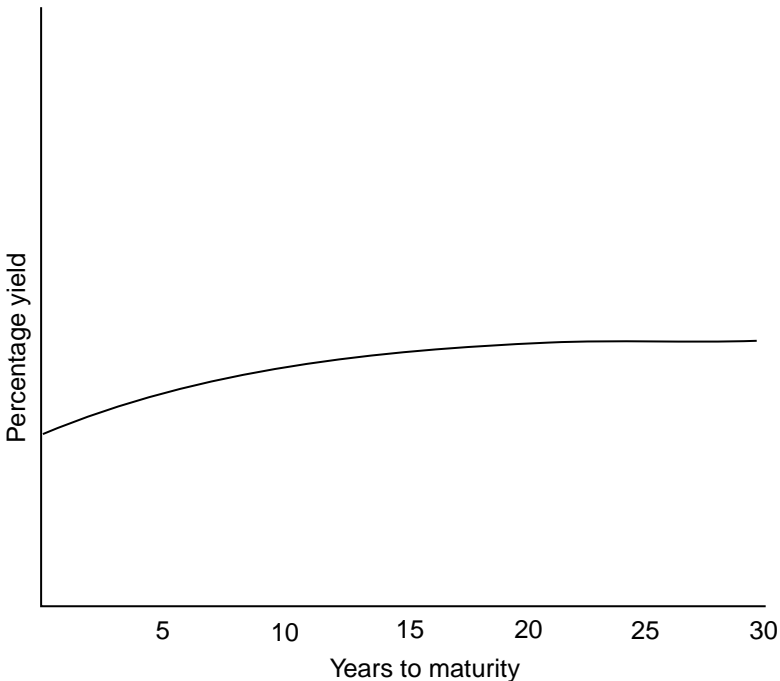


Figure 1 A hypothetical example of a yield curve (highly schematic). Yield curves usually (but not always) have the upward slope shown here

For example, LTCM became heavily involved in the Italian capital markets, which became a particularly important site of arbitrage, not just by LTCM but by leading US investment banks, in the late 1990s. Traditionally, the fiscal efficiency of the Italian state was regarded as poor by international (and many local) investors, who would therefore purchase Italian government bonds only at

low prices (and therefore high yields). These yields, in turn, contributed to Italy's budgetary difficulties by making the cost of servicing its government debt high. However, with growing European integration, especially the prospect of Economic and Monetary Union (EMU), arbitrageurs began to believe that Italy's capital-market idiosyncrasies might be temporary. This belief may have been performative, in that the resulting flow of capital into Italian government bonds, and consequent reduced debt-service costs, helped Italy qualify for EMU under the Maastricht criteria.¹³

As well as diversifying geographically, LTCM also diversified from bonds and interest-rate swaps into other asset classes. Some relative-value trades involved pairs of shares, such as Royal Dutch and Shell Transport (see Perold 1999: A9). Shares of Royal Dutch are traded in Amsterdam and the corresponding American Depository Receipts trade in New York, while shares of Shell trade in London, but the two sets of shares represent equivalent rights of ownership of what is essentially a single company (Royal Dutch/Shell). However, they often trade at different prices: for example, because the way dividends are taxed leads investors to prefer one or the other. In a situation like this, arbitrage can be attractive if the difference between the prices of the two sets of shares is expected to narrow, to widen, or to change direction. LTCM could profit from an expected change in relative value while being protected from overall stock-market fluctuations, from industry-specific factors such as the oil price, or, in the Royal Dutch/Shell case, even the performance of the firm involved.

Another equity-related position, taken on in 1997, responded to an anomaly developing in the market for equity index options with long expirations (see Table 1 for the meaning of 'option'). Increasingly, banks and other financial companies were selling investors products with returns linked to gains in equity indices but also a guaranteed 'floor' to losses. Long-maturity options were attractive to the vendors of such products as a means of hedging their risk, but such options were in short supply. The price of an option is dependent upon predictions of the volatility of the underlying asset, and market expectations of that volatility ('implied volatility') can be deduced from option prices using option pricing theory. In 1997, however, the demand for long-expiry options had pushed the volatilities implied by their prices to levels that seemed to bear little relation to the volatilities of the underlying indices. Five-year options on the S&P 500 index, for example, were selling at implied volatilities of 22 per cent per annum and higher, when the volatility of the index itself had for several years fluctuated between 10 per cent and 13 per cent, and the implied volatilities of shorter-term options were also much less than 20 per cent per annum. LTCM therefore sold large quantities of five-year index options, while hedging the risks involved with index futures and sometimes short-expiry options (Perold 1999: A7–A8).

Not all LTCM's trades were successful: for example, 'We lost a lot of money in France in the front end [of the bond yield curve]', says LTCM's Eric Rosenfeld (interview). Nevertheless, as noted above, extremely attractive overall

returns were earned, and the volatility of those returns was reassuringly low. Most of LTCM's positions were almost completely insulated from broad market movements. The firm had only limited involvement in areas where the chance of default was high, such as in high-yield ('junk') corporate bonds or 'emerging markets', such as Russia, Thailand, and Argentina. Risks were carefully calculated and controlled using the 'value-at-risk' approach standard in the world's leading banks (Meriwether interview). In the case of the dollar swap spread, for example, historical statistics and judgements of likely future values led LTCM to estimate that the spread had an 'equilibrium value' of around 30 basis points, with a standard deviation of about 15 basis points per annum (Rosenfeld interview). Using those estimates, it was then possible to work out the relationship between the magnitude of possible losses and their probabilities, and thus the 'value-at-risk' in the trade.

When a firm holds a large number of positions, the estimation of the probabilities of loss in individual positions is less critical to overall value-at-risk than estimates of correlation between positions. If correlations are low, a large loss in one position is unlikely to be accompanied by large losses in others, so aggregate value-at-risk levels will be modest. In contrast, if correlations are high, then, when one position 'goes bad,' it is likely that other positions will also do so, and overall value-at-risk will be high. LTCM's positions were geographically dispersed, and in instruments of very different kinds: see Table 4 below for a typical example of the range of its major positions. At the level of economic fundamentals, little if anything connected positions such as on the spread between US government bonds and mortgage-backed securities, on the difference between the prices of the shares of pairs of companies such as Royal Dutch and of Shell, on the idiosyncrasies of the Italian bond market, on the bulges in the yen yield curve, on the chances of specific mergers failing, and so on. LTCM was aware that its own and other arbitrageurs' involvement in these diverse positions would induce some correlation, but nevertheless the observed correlations, based on five years of data, were very small: typically of the order of 0.1 or lower.

The standard deviations and correlations that went into LTCM's aggregate risk model were, however, not simply the empirically observed figures but deliberately conservative estimates of their future values. The observed standard deviation of the US dollar swap spread, for example, was around 12 basis points a year, while, as noted above, the risk model assumed it would be 15 (Rosenfeld interview). Past correlation levels, likewise, were 'upped' (Meriwether interview) to provide a safety factor: despite observed correlations being 0.1 or less, LTCM was 'running analyses at correlations at around 0.3'. The consequence of this conservatism was that, while the firm's risk model suggested that the annual volatility (standard deviation) of its net asset value would be 14.5 per cent, in actuality it was only 11 per cent (Meriwether interview). Both figures were considerably less than the risk level of 20 per cent that investors had been told to expect (Perold 1999: A11).

Of course, such statistical analyses of risk assumed the absence of

catastrophic events in the financial markets. LTCM's key members were well aware of the possibility of such events. David W. Mullins, Jr, who joined LTCM after serving as vice chair of the Federal Reserve and Assistant Treasury Secretary, had been Associate Director of the Presidential task force that produced the key report on the 1987 stock market crash (Brady Commission 1988); LTCM's Gérard Gennotte had co-authored an insightful academic analysis of the crash (Gennotte and Leland 1990); and Meriwether's group at Salomon were heavily involved in trading at that time. LTCM was born into the midst of the bond market turmoil of 1994, when sharp interest-rate rises after a period of relative stability caused large losses to many investors (including the bankruptcy of Orange County, California, which had taken large, unhedged positions in interest-rate derivatives: see Pryke and Allen 2000). So LTCM also 'stress tested' its portfolio, investigating the consequences of hypothetical events too extreme to be captured by statistical value-at-risk models, events such as a huge stock market crash, bond default by the Italian government, devaluation by China, or (particularly salient given its European involvement) failure of EMU. As well as investigating the consequences of such events for market prices and for LTCM's risk capital, it also calculated – and set aside – the funds necessary to cope with a sudden increase in 'haircuts' in a situation of stress. When an event could have particularly catastrophic consequences, LTCM either turned to insurance – it bought insurance against bond default by the government of Italy – or balanced its portfolio to minimize consequences, as in the case of EMU failure.

The crisis of 1998

The partners in LTCM, therefore, believed themselves to be running the fund conservatively, and in the modest volatility of its returns they had evidence for the correctness of this belief. After the fund's crisis, it was commonly portrayed as wildly risk-taking, but I have found almost no one inside or outside LTCM who can be proved to have expressed that view prior to the crisis. Gambling – consciously reckless risk-taking – does not explain LTCM's 1998 disaster. Nor does the second hypothesis advanced in the commentary: blind faith in mathematical models. Models were much less critical to LTCM's trading than commonly thought. Many of the pricing anomalies it sought to exploit (such as the swap-spread example discussed in the appendix) could be identified without sophisticated modelling, and, although models were important in how its trades were implemented and in assessing the risks involved, all those involved knew that models were approximations to reality and a guide to strategy rather than a determinant of it. LTCM's traders had often themselves developed the models they used: no one was more aware than they of the models' likely deficiencies. The way in which the standard deviations and correlations in the most important model of all – LTCM's overall risk model – were increased by explicitly judgement-based 'safety factors' is indicative of that.

The third posited explanation of LTCM's crisis – over-leverage – is almost tautologically correct. If LTCM had been operating without leverage, or at low levels of leverage, the events of August and September 1998 would have placed it under much less strain. However, a number of provisos are in order. First, leverage was intrinsic to the kind of arbitrage performed by LTCM. As can be seen in the example in the appendix, unlevered rates of return are typically paltry. Only with leverage does arbitrage of the kind practised by LTCM become attractive. Second, LTCM's pre-crisis leverage ratios were not, in fact, egregious when compared, for example, to those of investment banks. In the early months of 1998, the leverage ratio was 27:1 (Perold 1999: C11–C12); 27:1 was the *average* ratio of the five biggest investment banks at the end of 1998 (President's Working Group on Financial Markets 1999: 29).

Blaming LTCM's crisis on leverage is like attributing a plane crash to the fact that the aircraft was no longer safely in contact with the ground: it identifies the source of overall vulnerability but not the specific cause. That cause was the financial crisis of August and September 1998, and in particular the way in which the adverse price movements of those months exceed LTCM's, or anyone else's, expectations. Conventionally, the 1998 crisis is regarded as a 'flight-to-quality': an increased relative preference for assets with low risk of default and/or an increased preference for more liquid assets, in other words those that can more readily be bought and sold at or near prevailing market prices.¹⁴ The interviews drawn on here, however, suggest a rather different, more directly sociological process. Meriwether's group at Salomon and at LTCM earned remarkable profits, and were *known* to have earned those profits. This encouraged others – in other investment banks, and increasingly in other hedge funds – to follow similar arbitrage strategies. Others were being told: 'LTCM made \$2 billion last year. Can't you?' (Meriwether interview). For example, LTCM's success meant that it rapidly became largely closed to new investors, and in January 1998 a new fund, Convergence Asset Management, 'raised \$700 million in a single month purely from disgruntled investors denied a chance to buy into LTCM' (Dunbar 2000: 197).

LTCM tried hard not to reveal its trading positions. For example, it would avoid using the same counterparty for both 'legs' of an arbitrage trade. However, as one trader and manager not connected to LTCM put it, '[t]he arbitrage community . . . are quite a bright lot, so if they see a trade happening – and the market gets to find out about these trades, even if you're as secretive as Long-Term Capital Management – they'll analyse them and realize there's an opportunity for themselves' (Wenman interview). LTCM's basic strategy – convergence and relative-value arbitrage – had to be disclosed to potential investors and thus could not be hidden, and others seeking to follow that strategy would often be led to take similar positions to LTCM's. It 'doesn't take a rocket scientist' to discover the kinds of arbitrage opportunities being pursued (Rosenfeld interview), especially when discovering one leg of an LTCM trade through being a counterparty to it would greatly narrow the range of possible other legs. Some of LTCM's trades were well known to market insiders before LTCM

became involved: the Royal Dutch/Shell trade, for example, was the ‘classic European arbitrage trade’ (Wenman interview), and the relationship between Royal Dutch and Shell shares had even been discussed in the academic literature (Rosenthal and Young 1990).

As a result of conscious and unconscious imitation, many of LTCM’s positions became ‘consensus trades’ (Kaplanis interview). Of course, the growing number of arbitrage traders in investment banks and hedge funds did not sit down together in a room to identify good arbitrage opportunities. Rather, ‘the arbitrage philosophy . . . had been disseminated, well disseminated by August ’98; it was there in quite a few hedge funds, it was there in quite a few firms. So Salomon [and LTCM] lost their uniqueness in doing these things. There were many, many others that could do them.’ There was *some* communication: ‘if you talk[ed] to another arb. trader in the street they’d say, “Oh yes, I have this as well, I have that as well”’ (Kaplanis interview). But, even had there not been communication, many traders would still have identified the same opportunities. ‘And what happened by September ’98 is that there was a bunch of arb. trades that . . . became consensus. People knew that the UK swap spreads was a good trade, people knew that US swap spreads was a good trade’ (Kaplanis interview). No other market participant had the same portfolio as LTCM – many arbitrageurs were restricted to particular portions of the spectrum of arbitrage trades – but, collectively, much of LTCM’s portfolio of positions was also being held by others.

The initial effect of imitation was probably to LTCM’s benefit. If others are also buying an ‘underpriced’ asset and short selling an ‘overpriced’ one, the effect will be to cause prices to converge more rapidly. However, imitation also meant that when existing trades *had* been liquidated profitably, replacing them was more difficult:

Author: Did you find that, as the years went by with LTCM – ’94, ’95, ’96, ’97 and so on – did you find . . . that the opportunities were drying up a bit?

Rosenfeld: Yes, big.

In the summer of 1998, imitation switched to become a disastrously negative factor because of two decisions, neither of which had anything directly to do with LTCM. In 1997, Salomon Brothers was taken over by the Travelers Corporation, whose famously risk-averse chair, Sandy Weill, was building the world’s largest financial conglomerate, Citigroup (Booth 1998). According to Kaplanis, Salomon’s US arbitrage desk had not been consistently successful since the departure of Meriwether and his group, and in the first half of 1998 it was loss-making: by June, ‘US was down about [\$]200 [million]. . . . So Sandy [Weill] . . . closed it [Salomon’s US arbitrage desk] down’ (Kaplanis interview), a move that was announced on 7 July. Though Kaplanis, promoted to head of global arbitrage for Salomon, advised against it, the decision was taken to liquidate the US arbitrage desk’s portfolio as quickly as possible, and responsibility for the liquidation was passed to Salomon’s US customer desk. Since the latter was ‘not accountable for the losses generated as a result of the liquidation,

the speed of the latter was faster than would otherwise have been the case'. This caused losses not just to Travelers/Citicorp but also to all of those who had similar positions: 'not only did we lose money as the positions went against us as we were selling them, but all the other funds that also had these consensus trades also started losing money' (Kaplanis interview).

If the liquidation of Salomon's arbitrage positions was a background factor in the problems of the summer of 1998, the immediate cause of the 1998 crisis was Russia's 17 August default on its rouble-denominated debt. That Russia was in economic trouble was no surprise: what was shocking was that it (unlike previous debtor governments) should default on debt denominated in domestic currency. 'I was expecting them [the Russian government] to just print money' to meet their rouble obligations, says Kaplanis (Kaplanis interview), and he was not alone in this expectation. True, some investors in rouble-denominated bonds had hedged against the risk of Russia defaulting by short selling Russian hard-currency bonds (Shleifer 2000: 108). For those investors, however, even the good news of 17 August – Russia's avoidance of a hard-currency default – was damaging, because it meant their hedge failed fully to protect them.

Initially, the Russian default seemed to be an event of only modest significance. Robert Strong of the Chase Manhattan bank told analysts that he did 'not view Russia as a major issue' for the banking sector. Investors more generally seemed to share his viewpoint: on 17 August, the Dow Jones rose nearly 150 points (Lowenstein 2000: 144). In the days that followed, however, it became increasingly clear that the default had triggered what Kaplanis calls an 'avalanche'. The default was combined with a devaluation of the rouble and a three-month ban on Russian banks complying with forward contracts in foreign exchange (Dunbar 2000: 200–1). Since Western investors used these contracts to hedge against the declining value of the rouble, widespread losses were incurred. LTCM itself had limited exposure to the Russian market, and suffered only modest losses, but Credit Suisse, for example, incurred losses of around \$1.3 billion. Arbitrageurs carrying losses incurred in Russia began liquidating other positions to meet the demands of their counterparties. A hedge fund called High-Risk Opportunities, which had a large position in rouble-denominated bonds, was forced into bankruptcy, owing large sums to Bankers Trust, Credit Suisse, and the investment bank Lehman Brothers. Rumours began to circulate that Lehman itself faced bankruptcy. For weeks, Lehman 'went bankrupt every Friday' according to the rumour mill. Though the bank survived, its stock price suffered badly.

In a situation in which the failure of a major investment bank was conceivable, there was indeed a flight-to-quality. Though there are exceptions, the significance of which will be discussed below, convergence and relative-value arbitrage typically involves holding the less liquid of a pair of similar assets. In August and September 1998 the prices of illiquid assets fell sharply and those of liquid ones rose. By 18 September, the 'long bond' – the thirty-year maturity US Treasury bond, often seen as the safest of safe havens – had risen to such an extent that its yield was lower than for three decades (President's Working Group on Financial

Markets 1999: 21). The consequence of the flight-to-quality triggered by the Russian default was, therefore, a shift in prices the typical effect of which was to cause losses to convergence and relative-value arbitrageurs.

LTCM had known perfectly well that a flight-to-quality could happen and that this would be its consequence. Indeed, it was of the very essence of convergence and relative-value arbitrage that spreads could widen – prices could move against the arbitrageur – before a trade finally converged. For that reason, LTCM had required investors to leave their capital in the fund for a minimum of three years: it was this restriction that made the fund *Long-Term Capital Management*. If spreads widened, however, it was assumed that arbitrage capital would move in to exploit them, and in so doing restrict the widening (Rosenfeld interview). Indeed, once spreads had become wide enough, the actions of ordinary investors were expected to reduce them.

The configuration of the markets by August 1998, however, was that the widening of spreads was self-feeding rather than self-limiting. As arbitrageurs began to incur losses, they almost all seem to have reacted by seeking to reduce their positions, and in so doing they intensified the price pressure that had caused them to make the reductions. In some cases, senior management simply became ‘queasy’ (Rosenfeld interview) at the losses that were being incurred, and unwilling to incur the risk of further, possibly larger, losses before trades turned profitable. In the United Kingdom, for example, Salomon, LTCM, a large British clearing bank, and others had all taken positions in the expectation of a narrowing of sterling swap spreads. As those spreads widened, the senior management of the clearing bank decided to exit:

[The bank] of course never had a tradition of risk taking. [It] is a household conservative name. So they were the first . . . to start getting out of positions in [the] UK swap spread; that hurt us [Salomon], LTCM as well. And that was a situation probably that was sparked by the fact that they never had a tradition . . . in arb. trading . . . There were losses . . . some manager didn’t like the idea of [the British clearing bank] having these big positions that were showing this big volatility, and they decided to bail out. . . . [The] UK swap spread is one of those trades that you know that if you hold the [position] until its maturity you’re probably going to make money. But, if there are managers out there that can’t stand the daily volatility and probably don’t understand the nature of the trade, then that’s when you’re in trouble.

(Kaplanis interview)

In some circumstances, such a decision by management might even be anticipated by the traders: ‘you know that if . . . your manager sees that you’re down \$10 million . . . the likelihood that he will ask you to get out of this position is very high. It’s not a formal stop-loss but . . . it’s there’ (Kaplanis interview).

In the case of hedge funds, the issue was investor rather than manager queasiness. Most funds did not have LTCM’s long capital lock-up:

they knew that investors were starting to drain money if they saw more than 15 per cent [loss] or whatever. . . . [T]hey knew that if they showed big losses

a lot of investors would want to get out. They wouldn't wait until they lost 80 per cent of their money . . . so that was the behavioural constraint that led to people unwinding positions even though they knew that those positions had value in the long run. They just had no choice.

(Kaplanis interview)

Furthermore, as market prices moved against hedge funds, they had to transfer collateral to their counterparties or to exchange clearing houses, and that might also require them to raise cash by liquidating positions.

Another factor may paradoxically have been modern risk management practices, particularly value-at-risk. This allows senior management to control the risks incurred by trading desks by allocating them a risk limit, while avoiding detailed supervision of their trading. When a desk reaches its value-at-risk limit, it must start to liquidate its positions. Says one trader, 'a proportion of the investment bank[s] out there . . . are managed by accountants, not smart people, and the accountants have said, "Well, you've hit your risk limit. Close the position"' (Wenman interview). An international change in banking supervision practices increased the significance of value-at-risk. Banks are required to set aside capital to meet the various risks they face, and in 1996 they began to be allowed to use value-at-risk models to calculate the set-aside required in respect to fluctuations in the market value of their portfolios (Basle Committee on Banking Supervision 1996). The change was attractive to banks because it reduced capital requirements, but it had the consequence that, as market prices move against a bank and become more volatile, it has to raise more capital to preserve its trading positions, a slow and often unwelcome process. Even when banks *were* managed by 'smart people' – sophisticated managers who understood the nature of arbitrage trading – there were thus considerable pressures to liquidate positions in the face of adverse price movements and increased volatility (Dunbar 2000; Meriwether interview).

The consequences for LTCM of these processes went beyond losses on individual trades. '[A]s people were forced to sell, that drove the prices even further down. Market makers quickly became overwhelmed, where the dealers, who would [normally] be willing to buy or sell those positions were simply unwilling to do it, and they either said "Just go away. I'm not answering my phone" or set their prices at ridiculous levels' (Shaw interview). The simple fact that the crisis occurred in August, the financial markets' main holiday month and thus typically the worst time to try to sell large positions, may have exacerbated the effects on prices. Certainly, price movements were huge. In a single day, 21 August, LTCM lost \$550 million as swap spreads in the US and UK widened dramatically and the merger between Ciena Corporation and Tellabs, Inc., in which LTCM had a large merger arbitrage position, was cancelled (Perold 1999: C2–C3).

Crucially, correlations between the different components of LTCM's portfolio leapt upwards from their typical level of 0.1 or less to around 0.7 (Leahy interview).¹⁵ Suddenly, a whole range of positions – hedged, and with little or nothing in common at the level of economic fundamentals – started to incur

losses virtually across the board. LTCM's losses were stunning in their size and rapidity: in August 1998, it lost 44 per cent of its capital. However, though massive, and far greater than had seemed plausible on the basis of LTCM's risk model, this loss was not in itself catastrophic. LTCM still had 'working capital' of around \$4 billion (including a largely unused credit facility of \$900 million), of which only \$2.1 billion was being used for financing positions (Perold 1999: C3). LTCM was, it seemed, a long way from being bankrupt.

At this point a social process of a different kind intervened: in effect, a run on the bank. 'If I had lived through the Depression,' says Meriwether, 'I would have been in a better position to understand events' in September 1998 (Meriwether interview). Unlike investment banks, which report their results quarterly, LTCM and other hedge funds report monthly. On 2 September, Meriwether faxed LTCM's investors its estimate of the August loss. Quite reasonably, he told LTCM's investors that the large spreads that had appeared in August represented an excellent arbitrage opportunity, and his fax (reproduced in Perold 1999: D1–D3) invited further investment:

the opportunity set in these trades at this time is believed to be among the best that LTCM has ever seen. But, as we have seen, good convergence trades can diverge further. In August, many of them diverged at a speed and to an extent that had not been seen before. LTCM thus believes that it is prudent and opportunistic to increase the level of the Fund's capital to take full advantage of this unusually attractive environment.

Meriwether's fax, intended to be private to LTCM's investors, became public almost instantly: 'Five minutes after we sent our first letter . . . to our handful of shareholders, it was on the Internet' (Merton interview). In an already febrile atmosphere, news of LTCM's losses fed fears of the fund's imminent collapse. These fears had two effects. First, they had an immediate effect on the prices of assets LTCM was known or believed to hold. It held, for example, a relatively small amount of 'hurricane bonds', securities which permit insurers to 'sell on' the risks of hurricanes. On 2 September, the price of hurricane bonds fell 20 per cent, even though there had been no increase in either the probability of hurricanes or the seriousness of their consequences. Assets that LTCM was believed to hold in large quantity became impossible to sell at anything other than distressed prices. Beliefs about LTCM's portfolio were sometimes far from accurate: after the crisis LTCM was approached with an offer to buy six times the position it actually held in Danish mortgage-backed securities (Meriwether interview). Nevertheless, presumptions about its positions were accurate enough to worsen its situation considerably, and, as September went on and LTCM had to divulge more information to its counterparties, those presumptions became more accurate.

The second effect upon LTCM of fears of its collapse was even more direct. Its relationship to its counterparties typically was governed by 'two-way mark-to-market': as market prices moved in favour of LTCM or its counterparty, solid collateral, such as government bonds, flowed from one to the other. In

normal times, in which market prices were reasonably unequivocal, it was an eminently sensible way of controlling risk by minimizing the consequences of default. In September 1998, however, the markets within which LTCM operated had become illiquid. There was ‘terror’ that LTCM was going to liquidate, says Meriwether (interview). The loss caused to a counterparty if that happened could be mitigated by it getting as much collateral as possible from LTCM before liquidation, and this could be achieved by ‘marking against’ LTCM: choosing, out of the wide spectrum of plausible market prices, a price unfavourable to LTCM, indeed predicated upon the latter’s failure (Merton interview; Meriwether interview). LTCM had the contractual right to dispute unfavourable marks: in its index options contracts, for example, such a dispute would have been arbitrated by getting price quotations from three dealers not directly involved. These dealers, however, would also be anticipating LTCM’s failure, so disputing marks would not have helped greatly.

The outflows of capital resulting from unfavourable marks were particularly damaging in LTCM’s index option positions, where they cost the fund around \$1 billion, nearly half of the September losses that pushed it to the brink of bankruptcy (Rosenfeld interview). In the 1998 crisis, stock market volatility did indeed increase. But to this increase was added the results of anticipation of LTCM’s likely demise. As the prices of the options that LTCM had sold rose (in other words, as their implied volatilities increased), LTCM had to transfer collateral into accounts held by its counterparty banks. If LTCM failed, those banks would lose the hedge LTCM had provided (in other words, they would be ‘short volatility’) but they would now own the collateral in the accounts. So it was in their interest that the implied volatility of the index options LTCM had sold should be as high as possible. One banker whose bank had bought index options from LTCM says:

When it became apparent they [LTCM] were having difficulties, we thought that if they are going to default, we’re going to be short a hell of a lot of volatility. So we’d rather be short at 40 [at an implied volatility of 40 per cent per annum] than 30, right? So it was clearly in our interest to mark at as high a volatility as possible. That’s why everybody pushed the volatility against them, which contributed to their demise in the end.

(quoted by Dunbar 2000: 213)

LTCM kept its counterparties and the Federal Reserve informed of the continuing deterioration of its financial position. On 20 September 1998, staff from the Federal Reserve Bank of New York and Assistant Secretary of the Treasury Gary Gensler met with LTCM. By then, it was clear that without outside intervention bankruptcy was inevitable. In the words of William J. McDonough, President of the Federal Reserve Bank of New York:

Had Long-Term Capital been suddenly put into default, its counterparties would have immediately ‘closed out’ their positions. . . . [I]f many firms had rushed to close out hundreds of billions of dollars in transactions simultaneously . . . there was a likelihood that a number of credit and interest rate

markets would experience extreme price moves and possibly cease to function for a period of one or more days and maybe longer.

(McDonough 1998: 1051–2)

If ‘the failure of LTCM triggered the seizing up of markets’, said Alan Greenspan, it ‘could have potentially impaired the economies of many nations, including our own’ (Greenspan 1998: 1046).

McDonough brokered a meeting of LTCM’s largest counterparties, which concluded that a recapitalization of LTCM would be less damaging to them than a ‘fire sale’ of its assets. Fourteen banks contributed a total of \$3.6 billion, in return becoming owners of 90 per cent of the fund. LTCM’s investors and partners were not ‘bailed out’: they were left with only \$400 million, a mere tenth of what their holdings were worth not long previously. The recapitalization did not immediately end the crisis: many feared that the consortium that now owned LTCM might still decide on an abrupt liquidation. On 15 October 1998, however, the Federal Reserve cut interest rates without waiting for its regular scheduled meeting, and the emergency cut began to restore confidence. It also gradually became clear that the consortium was intent on an orderly, not a sudden, liquidation of LTCM’s portfolio, which was achieved by December 1999.

The flight-to-quality and the superportfolio

If the ‘superportfolio’ explanation is correct, then superimposed upon the flight-to-quality should be distinctive price movements reflecting the unravelling of the positions held by LTCM’s conscious and unconscious imitators. The composition of the superportfolio is not known with any precision, but if the imitation-based explanation is correct, LTCM’s portfolio should be a reasonable proxy, and its main components *are* known, from Perold (1999) and from interviewees’ testimony. The hypothesized specific characteristic of September 1998 – ‘run on the bank’ declines in the prices of assets believed to be held by LTCM – is identical in its predicted consequences to the ‘unravelling superportfolio’ explanation.

Convergence and relative-value arbitrage as practised by LTCM and its imitators typically involves short selling an asset with low default risk and/or high liquidity while holding a similar asset with higher default risk and/or lower liquidity. In many cases, therefore, the price movements predicted by the flight-to-quality and ‘superportfolio’ explanations are identical. In cases of two types, however, the predictions of the two explanations differ. First is where there is a range of similar spreads or implied volatilities in only some of which LTCM had positions. The ‘superportfolio’ explanation would then predict greater increases in the spreads or implied volatilities in which LTCM had positions than in those in which it did not.¹⁶ If the spreads or implied volatilities genuinely are similar, the flight-to-quality explanation would, in contrast, predict similar movements of them all. Second is the minority of arbitrage positions in which LTCM held the

more liquid instrument and was short the less liquid one (the swap spread example discussed in the appendix is an example of this kind of situation). There, the flight-to-quality interpretation predicts a rising spread; the superportfolio explanation predicts a more slowly rising, or possibly even a falling, spread.

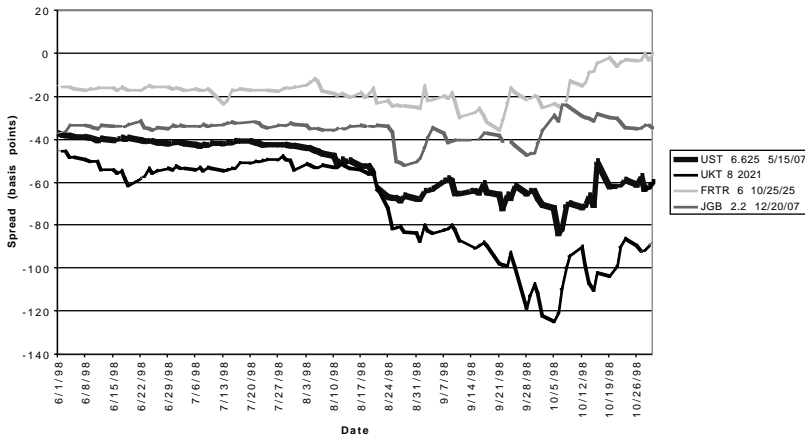
Several of the major positions held by LTCM in the summer of 1998 fall into one or other of these two categories. Consider, for example, the two sets of positions that, together, were responsible for around two-thirds of LTCM's losses (Lewis 1999): equity index options and swap spreads. Equity index options are in the first category of case. LTCM had sold large amounts of long-dated index options on all the major stock market indices listed in Table 2, except the Japanese NK225. The implied volatilities of all rose, but the increase in NK225 implied volatilities was much smaller than in the case of the other indices. Since there was, as far as I am aware, no flight-to-quality reason for increased relative confidence in the future stability of the Japanese stock market, this is evidence for the superportfolio hypothesis.

Table 2 Average implied volatilities (annualized) of five-year options on major stock-market indices

	<i>June/July 1998</i>	<i>September 1998</i>	<i>Increase (percentage points)</i>
S&P 500 (US)	23 per cent	30.3 per cent	7.3
FTSE 100 (UK)	22.9 per cent	32.4 per cent	9.5
CAC (France)	25.8 per cent	32.9 per cent	7.1
SMI (Switzerland)	26.1 per cent	35.5 per cent	9.4
DAX (Germany)	26.5 per cent	35.5 per cent	9
NK225 (Japan)	25.6 per cent	30.3 per cent	4.7

Source: market data provided by JWM Partners

Swap spreads fall into both the first and second categories. Because the market in swaps is less liquid than that in government bonds, and because a crisis may prompt fears of bank failures (and did so in 1998), a flight-to-quality should increase swap spreads. Figure 2 and Table 3 contrast the behaviour of swap spreads in France, where LTCM was long the swap spread in 1998 (that is, had a position akin to that described in the swap spread example in the appendix, which would increase in value if the spread rose); in the US and UK (where LTCM was short the swap spread in the summer of 1998); and in Japan (where LTCM had two offsetting positions that left it neutrally placed with respect to overall widening or narrowing of the spread).¹⁷ In the US and UK (and also Sweden, where arbitrageurs also had large short positions), swap spreads widened markedly. In contrast, in France and Japan, swap spreads widened only modestly over the weeks of the crisis; that was also the case in Germany, where LTCM had a long position akin to that in France.¹⁸ I know of no plausible flight-to-quality explanation of these international contrasts, while they are precisely as predicted by the superportfolio explanation.



Source: market data provided by JWM Partners

Note

Bonds are as listed in the legend to Table 3

Figure 2 Swap spreads of US, UK, French and Japanese bonds

Equity volatility, US swap spreads and European differential swap spreads are three of the thirteen major positions held by LTCM in the summer of 1998 (see Table 4). A further two of its positions also fall into type 1 or type 2, with another six doing so to some extent. The overall pattern in Table 4 is clear. In all the cases for which data are available, the relative price movements of the crisis are consistent with the ‘superportfolio’ explanation, while in five cases they are inconsistent (and in a further four, possibly inconsistent) with the flight-to-quality explanation. A flight-to-quality *did* take place in August and September 1998, but these data do indeed suggest that overlaying it (and sometimes acting in contradiction to it) was an unravelling superportfolio.

Table 3 Average swap spreads (basis points) against selected government bonds, June–September 1998

	June/July 1998	September 1998	Increase
France	17	23	6
US	41	64	23
UK	52	92	40
Japan	34	41	7

Source: market data provided by JWM Partners

Notes

France 6 per cent coupon, maturing 25 October 2025

US 6.625 per cent coupon, maturing 15 May 2007

UK 8 per cent coupon, maturing August 2021

Japan 2.2 per cent coupon, maturing 20 December 2007.

Table 4 LTCM's thirteen major positions in August 1998 classified by relationship to flight to quality/superportfolio explanations

	<i>Type of case</i>	<i>Relation of Aug/Sept '98 price movements to superportfolio(s) and flight to quality (q) explanations</i>
1 Equity volatility	Type 1	Consistent with <i>s</i> ; inconsistent with <i>q</i> : see text
2 US swap spreads	Type 2 in France and Germany; type 1	Consistent with <i>s</i> ; inconsistent with <i>q</i> : see text
3 European differential swap spreads	Comparison of US and UK with Japan	
4 Commercial mortgages	Type 1	Consistent with <i>s</i> ; inconsistent with <i>q</i> : note a
5 Deutschmark/euro swap options	Type 1 and type 2	Consistent with <i>s</i> ; inconsistent with <i>q</i> : note b
6 BOTLibor vs. Libor	Element of type 2	Consistent with <i>s</i> ; possibly inconsistent with <i>q</i> : note c
7 Yen differential swap spread	Possible type 2	Consistent with <i>s</i> ; possibly inconsistent with <i>q</i> : note d
8 Residential mortgages	Neutral	Data not available
9 Sterling differential swap spread	Possible type 1	Data not available
10 Merger arbitrage	Possible type 1	Consistent with <i>s</i> ; possibly inconsistent with <i>q</i> : note e
11 Corporate capital structure	Unclear	Data not available
12 European equity pairs	Partial type 1	Consistent with <i>s</i> ; possibly inconsistent with <i>q</i> : note f
13 Japanese bank preference shares	Possible type 2	Data not available

Source: Perold (1999: C6–C7); market data from JWM Partners.

Notes

bp = basis points.

Type 1: comparison of similar spreads/implicit volatilities.

Type 2: LTCM long more liquid or lower default risk instrument.

Neutral: predictions of flight to quality/superportfolio identical.

a AAA commercial mortgage-backed bonds* widened vs. Libor by 23 bp; AA (greater default risk) corporate bonds widened 3 bp; AAA (similar default risk) Federal National Mortgage Association debentures (e.g. 5.75 per cent coupon maturing 15 February 2008) narrowed versus Libor swaps by 3 bp.

b Deutschmark/euro swap option* implied volatility fell (should rise in flight to quality); dollar swap option volatility unchanged.

c Italian government bonds generally seen as somewhat riskier than lira Libor swaps, so BOTLibor (the yield at auction of BOTs: see note 13) should rise relative to lira Libor in crisis, but fell.

d LTCM long yen swap spread at six-year maturity vs. short swap spread at nine-year maturity. In flight to quality, some expectation that shorter-maturity swap spreads will widen more; in fact, nine-year spread widened more.

e Largest-ever drop in 'Merger Fund' (risk arbitrage fund) price; interviewees suggest drop three times level accountable for by merger breaks. However, perceived risk of latter does rise during market falls.

f Royal Dutch premium over Shell* rose. Relationship to flight to quality explanation affected by extent to which premium reflects greater Royal Dutch liquidity, which is unclear.

* indicates an asset in which LTCM had a long position.

A simpler piece of evidence in favour of the superportfolio hypothesis is the contrast between the market reaction to the August 1998 Russian default and to the attacks of September 11, 2001, which also sparked a flight-to-quality. LTCM's successor fund, JWM Partners, was active then too, but its capital base was smaller and its leverage levels lower, so its arbitrage positions were considerably smaller (Silverman and Chaffin 2000). The amount of capital devoted to convergence and relative-value arbitrage by other market participants such as investment banks was also much smaller (interviewees estimate possibly only a tenth as large in total). There was thus no significant superportfolio in 2001. With a flight-to-quality, but no superportfolio, there was no equivalent crisis. While LTCM had been devastated in 1998, JWM Partners' broadly similar, but much smaller, portfolio emerged unscathed from September 2001: the partnership's returns in that month were 'basically flat'.

Conclusion

What, then, might a sociology of arbitrage consist in, and how does the case of LTCM bear upon it? Three key points emerge. Arbitrage has a 'Granovetterian' sociology (see Granovetter 1985, 1990): it is an activity conducted not by anonymous, atomistic economic agents, but by people who are often personally known to each other. Second, included in the possible forms of interaction among these people is imitation, and this has particularly dangerous consequences (as in the more general economic sociology models of White and Fligstein). Third, for this and other reasons the capacity of arbitrage to insulate 'the economic' from 'the social' is limited: indeed, the interweaving of the economic and the social is too intimate to be captured even by notions of imperfect insulation.

Interviewee David Wenman's use of the phrase 'arbitrage community' (p. 360 above) is not happenstance: arbitrageurs often know each other and are affected by each other. 'Community' does not imply harmony. For example, one interviewee at LTCM suggested that it had generated resentment among Wall Street investment banks (for instance, by pressing hard to reduce 'haircuts') and that others 'were, I think, jealous of the money we made'. Resentment and jealousy, however, are indicative that those involved were not atomistic individuals, but mutually aware and mutually susceptible. Positive forms of this awareness and susceptibility were also evident: I was struck, especially during the process of getting interviewees' permission for quotation, how exercised they often were not to give offence to each other.

These issues of mutual susceptibility are not matters incidental to the 'real business' of arbitrage, because that real business depends upon mundane forms of social interaction with personally known others. To perform its arbitrages, the Salomon/LTCM group had to borrow money (via what participants call 'repo', in which the borrowed money is used to buy securities that are pledged as collateral for the loan) and also had to borrow bonds (for short sale). Others of

its trades, for example the Royal Dutch/Shell arbitrage, were implemented by arranging 'total return swaps' with banks. All these were wholly legitimate activities, but getting the best possible repo, bond borrowing, and swap terms was critical to the profitability of arbitrage exploiting small price discrepancies. It could be done better among personally known people, rather than by anonymous commercial interaction. In the 1970s and 1980s, for example, 'repo . . . wasn't done by the top people at the firm: it was . . . almost like a clerk's job', and Rosenfeld and his Salomon and future LTCM colleagues 'always spent a lot of time with those guys and that was very important to us' (Rosenfeld interview).

The emphasis in commentary on LTCM on its use of mathematical models has diverted attention from the extent to which its arbitrage activities (and also those of its predecessor group at Salomon) rested upon a Granovetterian, institutional understanding of the embedded nature of markets. Meriwether's reputation as a trader in the US bond market rested less on mathematical sophistication than on his understanding of matters like who held which bonds and why. 'Mathematics was helpful', he says, but understanding the institutional structure of the bond market was 'more important' (Meriwether interview). As Salomon's arbitrage activities began to expand overseas, Meriwether realized that it would not be enough simply to send Americans, however sophisticated mathematically, into overseas markets. 'Knowing the culture was more important than just quantitative knowledge', he says. Typically, Salomon would seek to recruit people brought up overseas, train them in New York, and then send them back to the markets in the countries in which they were raised. The head of Salomon's trading activities in Japan, the legendarily successful Shigeru Miyojin, for example, is an instance. Someone who did not know Japanese would be at a disadvantage, and in Japan (as elsewhere) the price discrepancies that were of interest to arbitrage would typically be 'driven by the tax and regulatory framework'. An outsider would often find that framework hard to comprehend in sufficient depth (Meriwether interview).

The Granovetterian sociology of market embedding is thus evident in the normal practice of arbitrage. In the case of LTCM, however, that embedding took a very specific form, imitation, and this is the second aspect of the sociology of arbitrage that needs emphasizing. The underlying general point is well known to economic sociology, and has been emphasized, for example, by White (1981, 2001) and Fligstein (1996, 2001). Firms do not choose courses of action in isolation: they monitor each other, and make inferences about the uncertain situation they face by noting the success or failure of others' strategies. When this leads to diversity – to firms selecting different strategies and coming to occupy different 'niches' – a stable market structure can result. But, if firms imitate, each choosing the same strategy, disastrous 'crowding' (q.v. White 2001: 139–44) occurs. That is what took place in global arbitrage in the 1990s.

The effects of imitation run deep: it can, for example, affect the statistical distributions of price changes, causing distributions to become dangerously 'fat-tailed' (that is, the probability of extreme events is far higher than implied by standard normal or log-normal distributional assumptions). That imitation can

affect statistical distributions in this way was shown in theoretical work by Lux and Marchesi (1999); the case of LTCM appears to show it happening in practice. The unravelling of the imitative superportfolio caused 'fat tailed' price changes far beyond those anticipated on standard models.¹⁹

Imitation led to extreme price movements and to disaster because of a third feature of the sociology of arbitrage: the possibility of 'arbitrage flight', the risk that arbitrage positions that, if held for long enough, have to be profitable may nevertheless have to be abandoned.²⁰ This possibility was expressed to me, separately, by two partners in LTCM who used the same analogy. Suppose they had been vouchsafed a little peek into the future: that they knew, with absolute certainty, that at a particular point in time the stock price of company X would be zero (these conversations took place during the dot.com bubble). Could they, they asked me, make money with certainty from this knowledge? Their question was rhetorical: they knew the answer to be no. Of course, they could sell the stock short. *If* they could hold their position until the stock price became zero, they could indeed profit handsomely. But an unpredicted rise in price in the interim could still exhaust their capital and thus force them to liquidate at a loss. That was in essence what happened to LTCM. Many of the positions in its 1998 portfolio have gone on to converge profitably precisely as expected,²¹ but it was driven to the brink of bankruptcy before that took place.

The consequence of this third feature of arbitrage, when conjoined with the second feature (imitation),²² is that arbitrage's capacity to 'insulate' the economic from the social is limited. This constitutes, for example, a limit on the performativity of economics: under some circumstances, arbitrage may be unable to eliminate what economic theory regards as pricing discrepancies. Ultimately, the metaphor of 'insulation', the Parsonian view of the economy as a differentiated subsystem, is itself inadequate. The financial markets are not an imperfectly insulated sphere of economic rationality, but a sphere in which the 'economic' and the 'social' interweave seamlessly. In respect to arbitrage, the key risks may be 'social' risks from patterns of interaction within the financial markets, rather than shocks from the 'real economy' or from events outside the markets. That, at least, is what seems to be suggested by the contrast between 17 August 1998 (the Russian default, a relatively minor economic event, triggered a disastrous unravelling of an imitative superportfolio) and September 11, 2001 (a dramatic external shock that failed to trigger dangerous internal social processes).²³

The interweaving of 'the economic' and 'the social' is not simply a matter of analytical interest. It affects the technical practices of risk management, because imitation of the kind evident in 1998 can undermine the protection flowing from the basic precept of such management: diversification. The most important way in which LTCM's successor, JWM Partners, has altered its predecessor's risk model to take account of the lessons of 1998 is that all the fund's positions, however well diversified geographically and unrelated in asset type, are now assumed to have correlations of 1.0 'to the worst event' (Meriwether interview). In an extreme crisis, it is assumed that diversification may fail completely: all the

fund's positions may move in lock-step and adversely, even those positions (the type 2 cases discussed above) where the fund holds assets that should rise in relative value in a crisis.

One way of expressing the forms currently taken by the inextricable interweaving of the 'economic' and the 'social' is via Knorr Cetina and Bruegger's notion of 'global microstructure'. The financial markets are now global in their reach, but interaction within them still takes the form of 'patterns of relatedness and coordination that are . . . microsocal in character and that assemble and link global domains' (Knorr Cetina and Bruegger 2002: 907). In a sense, it was globalization that undid LTCM: 'Maybe the error of Long-Term was . . . that of not realizing that the world is becoming more and more global over time', says Myron Scholes (interview). Of course, no one was more aware than LTCM's principals of globalization *as a general process* (they had surfed globalization's wave, so to speak), but what caught them unawares were the consequences of the global microstructure created by imitative arbitrage. What happened in August and September 1998 was not simply that international markets fell in concert (that would have had little effect on LTCM), but that very particular phenomena, which at the level of economic 'fundamentals' were quite unrelated, suddenly started to move in close to lock-step: swap spreads, the precise shape of yield curves, the behaviour of equity pairs such as Royal Dutch/Shell, and so on. The 'nature of the world had changed', says Meriwether, 'and we hadn't recognized it' (Meriwether interview). LTCM's wide diversification, both internationally and across asset classes, which he had thought kept aggregate risk at acceptably modest levels, failed to do so, because of the effects of a global microstructure.

Since September 1998, this particular microstructure has dissipated as arbitrage capital has withdrawn from the markets. The failure of the shock of September 11, 2001, to ramify and amplify through the markets is testimony to the way in which market linkages driven by imitative arbitrage have been very much weaker subsequently. Of course, such linkages may well return, albeit most likely in different forms. But that, indeed, may precisely be the point. Globalization is not a once-and-for-all event, not a unidirectional process, not something that can be stopped, but a composite of a myriad microstructures, often contradictory, waxing and waning.

Appendix: a typical swap-spread arbitrage trade

On 8 February 1997, twenty-year US dollar interest-rate swaps could be entered into at '6.94 per cent versus Libor'.²⁴ In other words, one party would undertake to pay 6.94 per cent per annum for twenty years, while receiving dollar Libor from the other party. That day, the yield on US Treasury bonds maturing in around twenty years was 6.77 per cent. The 'swap spread' – the difference between the fixed interest rate at which swaps can be entered into and the yield of government bonds of equivalent maturity – was thus 6.94 per cent – 6.77 per

cent, or 17 basis points. The interest rate at which an institution like LTCM can use repo to borrow money to buy bonds is called 'repo rate' (technically, the typical contract is a repurchase agreement, hence 'repo'). Because the bonds are held by the creditor as collateral, and because a 'haircut' protects against the consequences of default, repo is typically available at a discount to Libor: 20 basis points at the time we are discussing. A tiny positive cash flow (a positive 'carry') could thus be obtained by buying bonds yielding 6.77 per cent, financed at repo rate, and paying fixed interest in a swap while receiving Libor in return. The position would earn 6.77 per cent + Libor, while the outgoings would be repo rate + 6.94 per cent. As Perold (1999: A4) notes, the net annual cash flow would be:

$$\begin{aligned} & (\text{Libor} - \text{repo}) + 6.77 \text{ per cent} - 6.94 \text{ per cent} \\ & = (\text{Libor} - \text{repo}) - \text{swap spread} \\ & = 20 \text{ basis points} - 17 \text{ basis points} \\ & = 3 \text{ basis points.} \end{aligned}$$

Clearly, a profit of 0.03 per cent per annum is not enticing. LTCM could construct the position by borrowing all but a haircut of 1 per cent, which raised the return on the capital devoted to the haircut to 3 per cent, but even that was not in itself attractive, particularly when prudent management of the trade required LTCM to set aside risk capital equivalent to around 1 or 1.5 times the haircut to protect against market fluctuations.²⁵ Crucially, however, a swap spread of 17 basis points was low: between May 1994 and February 1997 the twenty-year US dollar swap spread had fluctuated between 17 and 32 basis points. If it widened again, LTCM's bond position would be worth more than its swap position, and it could make additional profit – perhaps substantial – by selling the bonds and entering into a swap contract 'cancelling out' the original.

LTCM would not enter into a trade such as swap spread arbitrage without an understanding of why an apparently attractive opportunity had opened up. In early 1997, LTCM believed that there were identifiable, temporary reasons why the swap spread had narrowed.²⁶ Accordingly, it gradually built its position, buying bonds (and also bond futures), while entering into swap contracts to pay fixed interest. By July 1997, the predicted increase in the swap spread had indeed taken place, and the fund was able over the summer to liquidate its position, with a total net gain of around \$35 million.

Notes

1 See, e.g., White (1981, 2001), Granovetter (1985, 1990), Fligstein (1996, 2001), Podolny (1993, 2001), and Callon (1998).

2 See Modigliani and Miller (1958), Miller and Modigliani (1961), Black and Scholes (1973), and Merton (1973).

3 See Barry and Slater (2002) and the subsequent papers in the May 2002 issue of *Economy and Society*.

4 See, for example, Abolafia (1996, 1998), Adler and Adler (1984), Baker (1981, 1984a,

1984b), Brügger (2000), Godechot (2000, 2001), Hassoun (2000), Hertz (1998), Izquierdo (1998, 2001), Knorr Cetina and Bruegger (2000, 2002), Lépinay and Rousseau (2000), Muniesa (2000a, 2000b), Podolny (1993), Smith (1999), and Zuckerman (1999). Arbitrage is among the activities of some of the traders studied by several of these authors – particularly Baker, Abolafia, and Godechot – but the focus of their work has not been on arbitrage.

5 Strictly, the fund was the investment vehicle (Long-Term Capital Portfolio) that LTCM managed, but to avoid complication I shall refer to both as LTCM. The case-study of LTCM was supported financially by DIRC, the Interdisciplinary Research Collaboration on the Dependability of Computer-Based Systems (UK Engineering and Physical Sciences Research Council grant GR/N13999).

6 There was no fixed interview schedule. Instead, interviewees (listed in the appendix) were led through their careers in finance, with special, but by no means exclusive, attention to their experiences in 1998.

7 Particularly important in this respect are the interviews with Costas Kaplanis and David Shaw. During 1998, Kaplanis was head of global arbitrage for Salomon Brothers, and Shaw heads one of the world's largest and most successful hedge funds. Although the founders of LTCM were largely drawn from Salomon, Kaplanis (who was based in London, not, as they had been, New York) was not part of this group, and indeed differed from it on a number of key issues, such as the applicability of yield curve models based on American experience to the European bond markets (Kaplanis interview). Like LTCM, D.E. Shaw and Co. is a hedge fund manager, but with a quite different focus from LTCM's.

8 Another check is against the interviews with market participants conducted by central bankers for the Committee on the Global Financial Systems (1999: 38–43).

9 At my request, members of JWM Partners provided me with the often specialized market data drawn on here. All of it is also available commercially, albeit at high cost, from industry-standard independent data providers, and readers within the finance industry can thus readily check its accuracy.

10 See Anon. (2000) and, for a broader discussion of derivatives such as swaps, Pryke and Allen (2000). As is standard practice, LTCM typically exited a swap position not by negotiating an end to the contract but by entering a new, equivalent but opposite, swap. As is conventional, swaps are not included in the asset figure of the previous paragraph.

11 Data from Bank for International Settlements, *www.bis.org*. Because many swaps 'cancel out' other swaps (see note 10), and because the replacement cost of a swap is usually much less than the notional principal, this figure overstates the economic importance of swaps. The Bank's estimate of the total replacement cost of interest-rate swaps at the end of December 2001 is \$1.969 trillion. Even that much reduced figure is nonetheless substantial, the equivalent of \$300 for every human being.

12 Figures for total returns are calculated from the data in Perold (1999: A19); the figures for returns net of fees are taken from Perold (1999: A2).

13 A particular idiosyncrasy identified by LTCM was that restrictions on many Italian banks meant that they had to hold Italian government short-maturity bills, *Buoni Ordinari del Tesoro* (BOTs), which were therefore anomalously expensive. LTCM expected this difference to reduce in size and entered into swap trades accordingly.

14 See Scholes (2000) for an interpretation of the crisis in terms of the 'liquidity premium'.

15 See also the data on correlations in Committee on the Global Financial System (1999: table 5).

16 Assuming that, as was in general the case, LTCM held the less liquid instrument or was short volatility.

17 The particular bonds are chosen so as best to represent LTCM's position in the various markets.

18 For Germany, see the data on ten-year swap spreads in chart 57 of the Bank of

England's *Financial Stability Review*, issue 7 (November 1999); data for Sweden from JWM Partners.

19 The dollar swap spread, for example, has a daily volatility (standard deviation) of around 0.8 basis points. Perhaps the single most dramatic event in the crisis of August and September 1998 was the widening of the dollar swap spread in half a day (the morning of Friday, 21 August, five days after the Russian default) of 19 basis points (Perold 1999: C2): a 34σ event. Of course, nothing can safely be inferred from a single event plucked from among many, but it is worth noting that the aggregate movement in price of LTCM's positions in August 1998 (a 44 per cent loss) was a -14σ event in terms of the 3.2 per cent historical monthly volatility of the fund's portfolio and a -10.5σ event on its risk model's 4.2 per cent monthly volatility. Either is wildly unlikely on standard distributional assumptions.

20 This feature has been modelled by 'behavioural' finance specialist Andrei Shleifer (Shleifer and Vishny 1997; Shleifer 2000). Shleifer's work is prescient: the Shleifer and Vishny model captures well one key aspect of 1998, the arbitrage flight that occurs when those who invest capital in arbitrageurs withdraw it prematurely in response to adverse price movements. But, in another respect, even Shleifer preserves the Parsonian boundary around the 'economic'. The Shleifer-Vishny model's arbitrageurs are not influenced by each other, and each has perfect individual knowledge of the true value of the asset they trade. As we have seen, however, a key dynamic leading to the crisis of 1998 was imitation among arbitrageurs. The resultant correlation of prices that were otherwise essentially unrelated economically – the second key aspect of 1998 – is not captured by the Shleifer-Vishny model's single asset market and non-imitative arbitrageurs.

21 Even though the priority of the consortium that took over LTCM was orderly liquidation, it still made a profit: the sale of LTCM's portfolio, although more rapid than optimal from the viewpoint of profit, more than recouped the consortium's investment.

22 Were it not for the risk of imitation-induced correlation, the dangers posed by arbitrage flight could be reduced greatly by holding a large portfolio of diverse arbitrage positions.

23 2002 saw sharp falls in global stock markets, but these were not the direct effect of September 11. After recovering quickly from the initial shock of September 11, stock markets continued to rise for several months before succumbing to the effects of events such as the Enron and WorldCom scandals.

24 This example and the data in this appendix are taken from Perold (1999: A4–A6), supplemented by an interviewee's estimate of risk capital requirements.

25 No precise figure can be given for risk capital because it was calculated as an increment to LTCM's overall risk capital requirement, which was in its turn determined by the partnership's risk analyses.

26 Early in 1997, the yields of corporate bonds were unusually close to those of government bonds, so corporations were taking advantage of favourable rates by issuing large quantities of bonds. To reduce heavy resultant commitments to fixed-rate outgoings, some of these corporations were keen to receive fixed-rate interest in swap agreements. An October 1996 change in US banking regulations had also prompted US banks to heavy issuance of bond-like equity ('Trust Preferred Stock'), and the issuing banks also sought swap contracts to convert the resultant outgoings to floating-rate. The unusually low swap spread, LTCM believed, was the result of these twin, temporary, market pressures driving down the fixed rate at which swap contracts could be obtained (Perold 1999: A5).

List of interviews

Partners in and employees of LTCM:

Victor Haghani, Gérard Gennotte, Fabio Bassi and Gustavo Lao, London, 11 February 2000.

Richard F. Leahy, Greenwich, CT, 31 October 2000.

John W. Meriwether, Greenwich, CT, 14 November 2000.

Robert C. Merton, Cambridge, MA, 2 November 1999.

Eric Rosenfeld, Rye, NY, 30 October 2000.

Myron S. Scholes, San Francisco, 15 June 2000.

This article also draws on a wider set of interviews (numbering sixty in total) conducted by the author with finance theorists and market practitioners, of which those drawn on most directly here are:

Costas Kaplanis, London, 11 February 2000.

David E. Shaw, New York, 13 November 2000.

David Wenman, London, 22 June 2001.

Not all interviewees were prepared to be identified, and some quotations and interview material are therefore anonymous.

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