Second Draft

Risk, Financial Crises, and Globalization: Long-Term Capital Management and the Sociology of Arbitrage

Donald MacKenzie

March, 2002

Author's address:
School of Social and Political Studies
University of Edinburgh
Adam Ferguson Building
George Square
Edinburgh EH8 9LL
Scotland
D.MacKenzie@ed.ac.uk

Word counts: main text, 16,883 words; notes, 1,657 words; appendix, 142 words; references, 1,400 words.

Risk, Financial Crises, and Globalization: Long-Term Capital Management and the Sociology of Arbitrage

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). It describes LTCM's roots in the investment bank, Salomon Brothers, and how LTCM conducted arbitrage. LTCM's 1998 crisis is analyzed 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 resultant "superportfolio" began to unravel, arbitrageurs other than LTCM fled the market, even as arbitrage opportunities became more attractive. The episode reveals limits on the capacity of arbitrage to close price discrepancies; it suggests that processes of imitation can involve professional as well as lay traders; and it lends empirical plausibility to the conjecture that imitation may cause the distinctive "fat tails" of the probability distributions of price changes in the financial markets.

Introduction: The Sociology of Arbitrage

Of all the contested boundaries that define the discipline of sociology, none is more crucial than the divide between sociology and economics. As Granovetter (1990) and Stark (2000) amongst others, have argued, the work of Talcott Parsons, for all its synthesizing ambitions, solidified the divide. "Basically," says Stark (2000:2), "Parsons made a pact ... you, economists, study value; we, the sociologists, will study values." The technical core, so to speak, of the workings of market economies was the business of economists, not of sociologists: "The proper division of labour, Parsons urged, was for economics to concentrate on the part of the means-ends chain involving rational adaptation of scarce means to alternative ends, and sociology on that part of the chain involving ultimate values" (Granovetter 1990: 91; see also Camic 1987).

More recent economic sociology, perhaps most prominently White (e.g. White 1981; White 2001) and Granovetter (e.g. Granovetter 1973; Granovetter 1985), has been framed above all by the aim of transcending the Parsonian boundary between the two disciplines. Particularly interesting, in this respect, has been the emergence – rapid in recent years – of the sociology of the financial

markets,[1] for those markets plainly lie close to the core of the economy; indeed, in Anglo-American countries, they arguably now *are* its core.

This article seeks to advance the research agenda of post-Parsonian economic sociology by means of an explanatory study of the sociology of arbitrage. If the financial markets are the core of many high-modern economies, so at their core is arbitrage: the exploitation of discrepancies in the prices of identical or similar assets. Arbitrage is pivotal to the economic theory of financial markets. It allows markets to be posited as efficient without all individual investors having to be assumed to be economically rational (see, e.g., Ross 2001). Suppose the prices of two sufficiently similar assets diverge for reasons that potentially lie on the sociological side of the Parsonian boundary: investors' irrational preferences, enthusiasms, or fears; legal constraints (perhaps 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 buy the cheaper of the two similar assets, and short sell the dearer (financial terminology such as "short sell" is defined in the glossary on pp. 67-71 below). Their purchases raise the price of the cheaper asset, and their sales lower that of the dearer, thus tending to restore

[1] 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; forthcoming); Lépinay and Rousseau (2000); Muniesa (2000a; 2000b); Podolny (1993); Smith (1999); Zuckerman (1999).

equality. The consequently plausible assumption that pricing discrepancies will be eliminated by arbitrage allows the development of powerful, elegant and influential theoretical models of markets. Crucially, in standard models arbitrage involves no risk and demands no outlay of capital (that is, it can be performed entirely with borrowed cash and/or securities), so there are no limits on its capacity to eliminate discrepancies (Shleifer and Vishny 1997). The assumption that it will do so 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] To put it simply, arbitrageurs are, in market practice, the border guards of the Parsonian dichotomy: arbitrage is the key mechanism keeping prices at, or close to, their values as posited by economic theory.

Despite the practical and theoretical centrality of arbitrage, there has been little empirical study of it by economists and almost none by sociologists. The only extant sociological study focusing directly on arbitrage is Beunza and Stark

[2] See Modigliani and Miller (1958), Miller and Modigliani (1961), Black and Scholes (1973), Merton (1973). Modigliani is also a Nobel laureate, but primarily for more general contributions to economics; Black died before the award of the Prize to his colleagues Scholes and Merton. The no-arbitrage assumption is less central to the work of laureates Harry Markowitz and William Sharpe.

(2002).[3] Their work is an ethnography of a trading room of a major investment bank which houses traders specializing in forms of arbitrage such as risk arbitrage and statistical arbitrage (see glossary). In the tradition of the actor-network theory of Callon and Latour (see, e.g., Callon 1998; Latour 1987; Latour 1999), and the distributed cognition approach of Hutchins (1995), Beunza and Stark explore how economic models, computer systems, price feeds, inter-personal interactions, whiteboards, and the like are brought together in the practice of arbitrage. An epilogue to Beunza and Stark (2002) illuminatingly examines the contingencies of reconstructing this practice following the forced relocation of the trading room after the atrocities of September 11, 2001.

The study reported here is complementary to that by Beunza and Stark. It examines a different group of arbitrageurs: that led by the celebrated bond trader John W. Meriwether, first within the investment bank Salomon Brothers and then in the hedge fund[4] Long-Term Capital Management (LTCM) and its successor JWM Partners. Unlike the group examined by Beunza and Stark (which focused on equity arbitrage), Meriwether's group's roots were in the market for U.S. government bonds. As the financial markets were transformed by deregulation

[3] Arbitrage is amongst the activities of some of the traders in financial markets studied by economic sociologists such as Baker (1981, 1984a, 1984b), Abolafia (1996, 1998) and Godechot (2001), but the focus of this sociological work has not typically been on arbitrage.

[4] See glossary. 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.

and by globalization, so the group's activities enlarged. It expanded into bond derivatives (see glossary); into Japan, Europe, and elsewhere; into "bond-like" instruments such as mortgage-backed securities; and into particular parts of the international stock markets and related derivative markets. In so doing, the group drew not just upon its wealth of practical experience, but on the developing corpus of finance theory: amongst LTCM's partners were Nobel laureates Merton and Scholes.

The Salomon/LTCM group is of interest not just because of its prominence in arbitrage and the intertwining of its fortunes with the processes of globalization. In August and September 1998, turmoil in the markets within which LTCM operated caused it severe losses, which would have led to its bankruptcy had it not been for a recapitalization by a consortium of the world's leading banks orchestrated by the Federal Reserve Bank of New York. The episode has been the focus of a host of commentary in the press and by official bodies such as the President's Working Group on Financial Markets (1999), and of two books by journalists (Dunbar 2000; Lowenstein 2000). Much of this commentary has been inaccurate and speculative, and in particular it has often looked for the roots of the crisis within LTCM itself – for example in alleged blind faith in mathematical models, reckless risk-taking and other claimed character flaws in its partners – rather than in the market processes surrounding it.

Those market processes are of considerable interest for four reasons. First, they represent a failure of arbitrage (in a specific sense of "failure" to be defined

below), and thus a breakdown, albeit a temporary one, of the central theoretical mechanism of modern financial economics.[5] Second, I shall argue that this arbitrage failure had its roots in a distinctively social form of market behaviour: as the success of the Salomon/LTCM group became known, its strategies were imitated by others. The consequent large, overlapping arbitrage portfolios formed an unstable structure – a "superportfolio," I shall call it – that unravelled disastrously following the bond default and devaluation by Russia in August 1998 (an event to which LTCM itself had only a modest exposure). To sociologists, imitation is an elementary and familiar process, but its presence and its consequences in the financial markets have been too little studied (though see, e.g. Orléan 1998). I shall suggest, for example, that imitation may be an underpinning of distinctive statistical patterns in securities prices.

Third, the unstable pattern of imitation around LTCM is an instance of what Knorr Cetina and Bruegger (forthcoming) call a "global microstructure." It linked both geographically disparate markets and diverse asset types. It thus undermined the protection that flowed from the central precept of the management of financial risk: diversification. Fourth, the unravelling superportfolio posited here would be expected to have effects on price movements analytically distinguishable from those to be expected on conventional accounts of financial crises as flights to "quality" (that is, to assets

[5] This feature of the episode is highlighted, rightly, by Shleifer (2000:107-111): see below. Shleifer's remarks on LTCM are, however, schematic rather than detailed.

that have low default risk and/or are highly liquid). While most work in the sociology of the financial markets has been qualitative,[6] in this case effects of social processes on prices can therefore be tested quantitatively.

This article draws upon sources of information of four kinds. First is a set of "oral history" interviews conducted in 1999 and 2000 with partners in and employees of LTCM.[7] From these, it was possible to discover the roots of LTCM, how it operated, and how its crisis was perceived by those who lived through it. These initial interviews were then followed up by further exchanges in person, by electronic mail, and by telephone. I am particularly grateful to those involved in LTCM for their co-operation in this respect, especially given that the publicity surrounding its crisis meant that the group I was studying could not, realistically, be granted normal sociological anonymity. 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.[8]

---

[6] Amongst the work listed in note 1, only the studies by Baker, Podolny, and Zuckerman demonstrate effects on pricing.

[7] 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 experience in 1998. All intended quotations were reviewed by the interviewee being quoted. In certain cases they requested amendments, which have been incorporated.

[8] 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

These interviews, which form part of a wider study of the modern financial markets that will be reported elsewhere, 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. These first two sources then permit reliable published sources on LTCM to be distinguished from unreliable ones (the only consistently reliable source is Perold 1999), and these form the third source of data drawn on here. Fourth are 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. While Beunza and Stark's ethnography is of the normal practice of arbitrage (the physical effects of September 11 aside), LTCM was deliberately chosen for this research because an exploratory study (MacKenzie 2000a, see also MacKenzie 2000b and 2001a) suggested that what happened to LTCM revealed theoretically interesting limits of arbitrage. Clearly, then, no claims can be made that the episode

---

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, unlike LTCM, its focus is statistical arbitrage in the equities markets.

[9] At my request, members of JWM Partners provided me with the often specialized market data drawn on below. 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.

discussed here is typical: plainly it is not. Because my focus is a specific set of events, not any typical process, my methodology is largely akin to the historian's reconstruction of historical episodes: I make no attempt to search for bases for generalization such as representative samples of respondents. My quantitative analysis of price movements, though it serves as a test of interview-based conclusion, has no claims to sophistication. Nevertheless, I trust that this article shows that the sociology of arbitrage is of interest to economic sociologists, to those studying globalization, and to those concerned with the analysis of the "risk societies" of high modernity (q.v. Beck 1992).

After this introduction comes a section discussing bond arbitrage as it was practised at Salomon Brothers. The third section of the paper turns to LTCM itself, examining a particular example of one of its trades to provide more detailed insights into how it operated, and then more briefly characterizing the range of positions it held and how it measured and managed risk. That section is of some technicality: together with an extensive glossary, that, alas is the price the reader must pay for a breach of the Parsonian boundary! The fourth section moves to the wider market processes surrounding LTCM, and in particular to the causes of its crisis. After reviewing other explanations of LTCM's crisis, the fifth section of the paper examines the bearing of price movements of 1998 on the previous section's explanation of the crisis. The sixth section concludes.

Bonds, Derivatives, and Arbitrage

The core of the group that formed LTCM came together at the investment bank Salomon Brothers in the 1980s. Founded in 1910, and for decades excluded from Wall Street's informal "Establishment," Salomon developed a reputation for robust competitiveness and expertise in underwriting and trading in bonds (Sobel 1986). The bonds of governments such as those of the U.S., U.K., France and Germany are regarded as the safest of investments: the chance of default is conventionally regarded as zero. However, the safety of such bonds does not preclude trading opportunities. Bond prices are intimately related to the general level of interest rates (because bonds typically offer fixed "coupons," or interest payments, when general interest rates go up bond prices go down, and vice versa), and there is a complex relationship between the price of bonds and the time remaining to maturity (repayment of the capital sum), a relationship usually summarized by the "yield curve" (see figure 1). If one can predict the future course of interest rates better than others can, then there will be money to be made, though in an efficient market like that in U.S. Treasury bonds genuine opportunities of this kind are rare.

More subtly, however, anomalies can arise in the pricing of bonds, and these anomalies sometimes become large enough that sophisticated traders can exploit them profitably. For example, the market in newly-issued ("on-the-run") U.S. Treasury bonds is more liquid than that in less recently issued ("off-the-run") bonds: many off-the-run bonds are in the relatively static portfolios of investors such as insurance companies. Investors concerned with liquidity are therefore prepared to

pay a premium for the on-the-run bonds. With the passage of time, however, an on-the-run bond will inevitably become off-the-run, so there may be money to be made by buying bonds with, for example, $29\frac{1}{2}$ years to maturity, and shortselling newly-issued 30-year bonds. Their yields can be expected to converge, and, crucially, one is insulated from the effects of general rises or falls in interest rates because such changes will affect the prices of both bonds roughly equally. There may also be anomalies in other parts of the yield curve. Generally the curve is expected to be reasonably smooth, as in figure 1, so if there were "bulges" (for example, the yield on bonds with 5 years to maturity being greater than the yields on either 3-year or 7-year bonds), an arbitrage opportunity might again exist.

Amplifying the arbitrage opportunities offered by the government bond market are a variety of closely-related markets that have emerged in the last three decades. One is in mortgage-backed securities. To improve the supply of mortgage funds, especially in a situation in which the traditional savings and loan institutions were encountering increasing difficulties, the U.S. government started in the late 1960s and 1970s to provide implicit guarantees for bond-like securities backed by pools of mortgages. The prices of these securities also have a tight relationship to interest rate movements, a relationship influenced in their case also by the risk of mortgage prepayment, which replaces a predictable stream of future interest payments by a sudden, unpredictable return of the capital lent. So, despite the involvement of the Federal government, mortgage-backed securities trade at a discount to (or, to put it in other words, offer higher yields than) government bonds.

Typically, the yield of mortgage-backed securities is around a percentage point higher than the yield of government bonds (a difference that in part reflects the prepayment option), and there can, for example, be arbitrage opportunities if that difference widens or narrows for temporary reasons.

From the mid 1970s onwards, the arbitrage opportunities offered by bonds and mortgage-backed securities were expanded by the emergence of markets in derivatives of these securities. A particularly key role here was played by the Chicago Board of Trade. Originally an agricultural futures exchange, the Board began in the 1970s to diversify into financial derivatives (its first effort in this direction, in equity options, is discussed by MacKenzie and Millo, forthcoming). In October 1975 the Board began trading futures on mortgage-backed securities, and in August 1977 U.S. Treasury bond futures (see Falloon 1998: 229-259). In January 1976, the Board's historic rival, the Chicago Mercantile Exchange, began trading futures in Treasury bills. While these futures are contracts traded on organized exchanges, large markets also developed in "over-the-counter" (direct, institution-to-institution) derivatives, such as bond options and swaps (see glossary).

The proliferation of financial derivative products offered both greater complexity and greater trading opportunities. At the heart of Salomon Brothers' New York headquarters was "The Room": a huge double-level sales and trading floor (see, e.g., Sobel 1986: 116-117 and 160-161). It was a tradition of the bank that its Managing Partner – Bill Salomon from 1963 to 1978, and then John Gutfreund – managed the firm largely from a desk in the midst of The Room. Complementing

this trading focus was a group of researchers who focussed above all on the bond market, particularly Sidney Homer (see, e.g., Homer 1978), Henry Kaufman (e.g., Kaufman 2000) and Martin Leibowitz (e.g., Homer and Leibowitz 1972; Leibowitz 1992). Traditionally the core of Salomon was "roughneck traders who grew up in the back office, with great instincts, skill set" (Meriwether interview), but in the late 1970s and 1980s, there was an increasing emphasis on recruitment of staff who combined trading instincts with academic training.

Amongst such recruits were the key future principals of LTCM: first John Meriwether, and then – largely hired by Meriwether – Larry Hilibrand, Richard Leahy, Victor Haghani, Eric Rosenfeld, Greg Hawkins, and Bill Krasker. The group's core activity was arbitrage. To begin with, they focused on simple arbitrage trades like on-the-run / off-the-run, but increasingly they performed more sophisticated trades. These required not just the instincts of a "roughneck" trader but also mathematical sophistication. To exploit arbitrage opportunities involving mortgage-backed securities, for example, one has to adjust the spread to take into account the mortgage holders' prepayment option, and to work out how to hedge the prepayment risk, for instance by purchasing interest-rate options.

It is this growing complexity of arbitrage that explains the increasing connection between Salomon's proprietary trading and finance theory. Initially, much of that theory focused on stocks and stock options: this is where the Nobel Prizes were largely won (see Bernstein 1992). Stock prices have the mathematical

virtue that their movements can with some plausibility be modelled relatively simply as lognormal random walks (though see below on the limits of this model). Bonds, however, have the complications that there is no equivalent canonical model of interest rate fluctuations; that the value of a bond at maturity is a deterministically fixed, not a stochastic, sum of money; and that yield curves are both complex and subject to radical changes in shape. Nevertheless, theoretical progress began to be made in the modelling of bond prices (see, for example, the key early paper by Vasicek 1977) and Cox, Ingersoll, and Ross (1985: but available in preprint form at the end of the 1970s).

As bond derivatives developed beyond bond futures to encompass an increasingly complicated variety of bond options, the skills of those trained in finance theory became an increasingly important resource. However, it is important not to follow popular accounts of the Salomon/LTCM groups (Dunbar 2000; Lowenstein 2000) in overstating either the sophistication of the application of theory or the criticality of particular models. In 1984, for example, Meriwether recruited to Salomon Eric Rosenfeld, an assistant professor at the Harvard Business School whose PhD had been supervised by future Nobel laureate Robert C. Merton. As well as doing arbitrage trades between the cash and futures markets in bonds, Rosenfeld helped a group selling bond options to design and to price their products. He developed simple empirical models of the yield curve, and priced bond options simply by assuming that the probability distribution of the price of the bond at the expiry of the option was log-normal,

and “sometimes we’d assume normal just to make it even more simple.” Rosenfeld’s academic work had been much more sophisticated, but there would have been little point in carrying over this sophistication. “[W]e used so much simpler models than I had been used to. ... And you know what, I don’t think it mattered. We weren’t out in a region where the particular specification of the model mattered” (Rosenfeld interview).

Initially, the arbitrage activities of the Salomon group had been focussed exclusively on the United States, but as other countries also began to deregulate their financial systems, arbitrage opportunities began to appear in capital markets overseas. Japan, for example, partially liberalized its financial system in the 1980s, and Salomon became heavily involved in convertible arbitrage (see glossary) in the Japanese markets: the bank made almost $1 billion in two years of this kind of arbitrage trading in Japan (Meriwether interview). As time passed, however, large and obvious arbitrage opportunities diminished, first in the U.S. and then elsewhere. Realizing that greater sophistication was going to be necessary to keep ahead of the competition, by 1985-1986 Meriwether had developed “a pronounced game plan to interact with academia,” indeed to “evolve into a quasi-university environment” (Meriwether interview). He assigned Salomon staff to visit universities and to attend the conferences of the American Finance Association. By the late 1980s, for example, Eric Rosenfeld and his colleagues were no longer modelling the yield curve by empirical curve fitting but were making use of the more sophisticated

models that were beginning to appear in the academic literature (Rosenfeld interview).

The use of mathematical models by Meriwether's group, however, played only a limited part in his growing reputation as the finest bond trader of his generation. At least equally important was his understanding of the institutional structure of the bond market: its "embedding," as the Granovetterian tradition in economic sociology would put it. A successful arbitrage trader had to attend not only to mathematical models but also to the institutional determinants of supply and demand for bonds; who held which bonds and why; which bonds were readily available and which might suddenly be in short supply, and so on. The mere existence of a price discrepancy was not sufficient to persuade Meriwether to put a trade on: he had to feel satisfied that he knew *why* the discrepancy existed. Amongst the reasons this kind of institutional understanding was necessary was the possibility of a "short squeeze." Typically, one leg of a bond arbitrage trade is constructed by short selling a particular class of bonds, frequently government bonds of long maturity. Especially if others have the same or similar trades on, keeping being able to borrow the requisite bonds can become difficult and expensive,[10] wiping out the profit from the trade and possibly forcing it to be liquidated at a loss. Such "squeezability" might not

[10] The funds from a short sale are normally held by the lender as security against default. Lenders can take advantage of a favorable market situation by refusing to pass on any of the interest earned by these funds.

appear as a feature of mathematical models, but was an ever-present risk of which one had to be aware. "Mathematics was helpful," says Meriwether, but the kind of understanding of the institutional structure of the market that comes only from experience was – precisely as the Granovetterian tradition would predict – "more important" (Meriwether interview).

As important as understanding risks arising from the institutional structure of the bond market were financing and obtaining the necessary positions. Arbitrage trading involves trying to profit from pricing discrepancies that often correspond to a difference in yields between similar assets of a fraction of a percentage point. It therefore inherently involves leverage: use of borrowed capital to increase rates of return to the point at which they become attractive. In bond trading, the key form of leverage is "repo" (see glossary). In Rosenfeld's judgement, "a major thing that John [Meriwether] did was making [repo] an integral part of our business" (Rosenfeld interview). It was critical to know what could be "repoed" and at what terms: typically, lenders impose a modest "haircut" (of the order of 1% or 2%) to protect themselves against the risk of borrowers defaulting in a situation in which the market value of the loan's collateral has fallen, but in critical situations haircuts can leap upwards. Repo was not a prominent or high-prestige business: "in the 70's and 80's, it wasn't done by the top people at the firm, it was done by, you know, almost like a clerk's job." Rosenfeld and his Salomon colleagues "always spent a lot of time with those guys and that was very important to us." Equally important was discovering what bonds could be borrowed for short sale, and on what terms.

Meriwether's group kept in close contact with others at Salomon who knew "if they had any bonds that ... looked like they were going to be there for a long time that we could borrow. And then we'd sell them and buy the cheap assets against it" (Rosenfeld interview).

As Salomon's arbitrage activities began to expand overseas, Meriwether – good practical economic sociologist as he was – 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 (Meriwether interview). 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).

Long-Term Capital Management

Salomon's proprietary trading, the core of which was Meriwether's bond arbitrage group, was strikingly successful. Between 1990 and 1992, for example, it generated $3 billion in pre-tax profits for Salomon, when in each of those years

the bank's other businesses made a net loss (Perold 1999:A2). There was, accordingly, considerable investor interest when Meriwether, key former members of his group at Salomon, along with finance theorists Myron Scholes and Robert C. Merton, and bond trader James J. McEntee, established Long-Term Capital Management, which began trading in February 1994.[11]

LTCM's primary registration, like that of many hedge funds, was in the Cayman Islands. Its headquarters were in Greenwich, Connecticut, and it also had a substantial office in London and a branch in Tokyo. Like that of most funds, LTCM's management group was of limited size: initially, 11 principals and 30 employees. By September 1997, however, it had grown to 15 principals and around 150 employees (Perold 1999:A2). Three respects of LTCM were distinctive. First, its fees were high: its management fee was 2% and its incentive fee 25%,[12] when hedge fund fees had traditionally been 1% and 20%. Second, because LTCM knew that arbitrage positions could incur substantial losses before they became profitable, it required that investors leave their capital in the

[11] Later accounts tended to make much of the academic prestige of Merton and Scholes, but in 1994 they were not yet Nobel laureates, and the only substantial published account of LTCM in its early years (Spiro 1994) focussed much more on Meriwether and his ex-Salomon team than on Merton and Scholes, though it did note that "some believe [Scholes] will win the Nobel Prize in economics for his work on the pricing of options"(Spiro 1994:50).

[12] The latter was calculated on the difference between the fund's "net asset value" at the end of a year and its highest net asset value at the end of previous years (Perold 1999:A2).

fund for a minimum of three years: it was this feature that "Long-Term" signalled.[13] Third, less than 4% (Perold 1999:A2) of the capital invested in the fund came from the traditional mainstay of hedge funds, rich individuals. The vast majority of the investment came from financial institutions, particularly banks, especially from outside the U.S.

LTCM's basic strategy was the convergence and relative-value arbitrage (see glossary) with which Meriwether's group had been so successful. It sought, however, to break with the traditional situation in which arbitrageurs specialized in one asset type, such as bonds, or one form of arbitrage, such as convertible arbitrage. It intended, for example, to expand into equity arbitrage and to be more heavily involved in mortgage-backed securities than had been possible at Salomon, which had different groups responsible for those areas (Meriwether interview). The overseas banks which invested in LTCM hoped for more than a financial profit: from involvement with Meriwether and his group they hoped to learn some of the art and science of arbitrage. One of the key ideas in the creation of LTCM was that of "strategic investors," to whom LTCM's management team would give general forms of advice, and from whom LTCM hoped to gain "local knowledge" (Meriwether interview) of non-U.S. markets.

To understand LTCM's strategy it is necessary to consider an example of one of its trades in more detail: I draw the example from Perold (1999:A4-A6), although

[13] LTCM later permitted phased withdrawals of set portions of capital (Perold 1999:A14).

my account is also influenced by discussion of it and similar trades with LTCM principals. The trade involves taking a position on the "swap spread." The party to a swap (see glossary) which is receiving a fixed interest rate while paying a floating 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 coupon. 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, an arbitrage opportunity appears.

At this point, my account necessarily becomes somewhat technical, and the reader may, skip forward to p. 23. On February 8, 1997, twenty-year U.S. dollar interest-rate swaps could be entered into at "6.94% versus Libor."[14] In other words, one party would undertake to pay 6.94% per annum for 20 years, while receiving from the other dollar Libor (see glossary). That day, the yield on U.S. Treasury bonds maturing in around 20 years was 6.77%. The "swap spread" – the difference between the fixed interest rate at which swaps can be entered into and the yield on government bonds of equivalent maturity – was thus 6.94% - 6.77%, or 17 basis points. The interest rate at which an institution like LTCM can use repo to borrow money to buy bonds is called the "repo rate." Because the bonds are held by the creditor as collateral, and because the "haircut" protects against the consequences of default, repo is typically available at a

[14] These and other data in the following paragraphs are taken from Perold (1999:A4-A6), supplemented by an interviewee's estimate of risk capital requirements.

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%, financed at repo rate, and paying fixed interest in a swap while receiving Libor in return. The position would earn 6.77% + Libor, while the outgoings would be repo rate + 6.94%. As Perold (1999:A4) notes, the net annual cash flow would be:

(Libor – repo) + 6.77% - 6.94%

= (Libor – repo) – swap spread

= 20 basis points – 17 basis points

= 3 basis points.

Clearly, a profit of 0.03% per annum is not enticing! LTCM could construct the position by borrowing all but a "haircut" of 1%, which raised the return on the capital devoted to the haircut to 3%, 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.[15] (LTCM's trades were generally governed by two-way mark-to-market – see glossary – so those fluctuations could temporarily drain capital from the fund even in the case of positions that eventually had to be profitable.) Crucially, however, a swap spread of 17 basis points was low:

[15] 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 model (see below).

between May 1994 and February 1997 the 20-year U.S. dollar swap spread had fluctuated between 17 and 32 basis points. If it widened again, the value of the bonds bought by LTCM would increase relative to that of its swap contract, and the fund could then make additional profit – perhaps substantial – by liquidating its position: selling the bonds, and entering into a swap contract "cancelling out" the original. As had been the case with Meriwether's group at Salomon, LTCM would not enter into such a position without an understanding of why an apparently attractive opportunity had opened up. In early 1997, LTCM believed that there were clearly identifiable, but temporary, reasons why the swap spread had narrowed.[16] 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.

[16] 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 U.S. banking regulations had also prompted U.S. 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).

Several features of this swap spread trade are worth considering, for they go to the heart of LTCM's strategy, of its success, and of the misconceptions about it. First is the issue of leverage. A common theme in much of the commentary upon LTCM is the extent to which it employed leverage – that is, borrowing – in constructing its positions. LTCM's position amounted to $5 billion. The capital required by LTCM to construct it was, however, only around $100-$125 million (around $50 haircut or futures margin requirement and $50-$75 million risk capital requirement). The leverage ratio (see glossary) of the trade was thus of the order of 40:1 to 50:1. While by no means 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 and C12). This large leverage, however, did not necessarily imply huge risk (as much subsequent commentary suggested). The risks of the swap-spread trade, for example, were rather limited. Bond prices and the terms upon which swaps can be entered could of course fluctuate considerably, particularly as interest rates varied. Much of that risk was, however, neutralized: what mattered was not the absolute level of bond prices or bond yields, but only the difference between such yields and the fixed interest rate in swaps, along with the difference between Libor and repo rate. The chief "market risk" of the trade was of the swap spread continuing to narrow rather than to widen as predicted, but if that were to happen LTCM could simply continue to hold the position, earning the positive carry, and wait until such time as it became profitable to liquidate the

position. Indeed, if necessary the position could simply be held until the bond matured and the swap expired. That feature was the "essence" of convergence arbitrage: if held to maturity, a convergence arbitrage position *had* to make a profit in excess of the risk-free rate of interest, whatever the market fluctuations along the way. Any "credit risk" – risk of default – associated with the trade was even more limited. The risk of the U.S. government defaulting on its bonds was negligible; bond futures contracts are guaranteed by the clearing house of the Chicago Board of Trade; and the swap contracts would typically be with major banks.[17]

If the risk was limited, the profit on the swap-spread trade was impressive. A profit of $35 million was a return of 28-35% earned in eight months or less (in addition to which unused risk capital would also earn interest). Nor was this untypical of LTCM's returns. Between February and December 1994 its returns before fees were 28.1% (unannualized); after management and incentive fees were deducted, investors received 19.9% (unannualized). Gross returns in 1995 were 59.0%, and returns after fees 42.8%; in 1996, the corresponding figures were 61.5% and 40.8%.[18] Some of those

[17] 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.

[18] The 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).

returns, as in the swap-spread example, were earned from the traditional hunting ground of Meriwether's group at Salomon: the market in U.S. government bonds, and the derivative markets associated with it. Some came from the Japanese market, where Salomon, as noted above, had also been strikingly successful at the end of the 1980s: for example, large profits were made by LTCM in 1995-96 on a yen swap-spread trade similar to the above dollar example (Perold 1999:A7).

A facet, however, that distinguished LTCM's strategy from that of Meriwether's group in Salomon was LTCM's heavy involvement in European markets. The wave of financial deregulation that began in the U.S. in the 1970s and 1980s also hit Europe, albeit significantly later: for example, repo and reverse repo, crucial to the operation of a fund such as LTCM, were permitted for most participants in the British gilt (government bond) market only in January 1996.[19] As the European markets were liberalized, attractive arbitrage opportunities opened up, and there was less competition than in either the U.S. or Japan: "the Japanese banks ... were the ones who were terribly interested in setting up

[19] Prior to that, "only Gilt Edged Market Makers (GEMMs) and discount houses were allowed to go short of gilts, which they could borrow from end-investors via specialised intermediaries, Stock Exchange Money Brokers (SEMBs). The GEMMs funded part of their long position in gilts by placing these as collateral with the SEMBs. In this earlier system, the wider secured sterling money market was effectively confined to secured deposits with the discount houses. It is now universal" (Chaplin, Emblow, and Michael 2000:97-98).

proprietary desks. The European banks were still a bit hesitant" (Kaplanis interview). Core to Meriwether's view of LTCM was that its members' experience and analytical skills would give it a comparative advantage in Europe (Meriwether interview). LTCM scrutinized the yield curves for European government bonds, especially those of the U.K., France and Germany, 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, such as regulatory requirements on insurance companies to purchase bonds of particular maturities, it would seek to exploit them, for example by "butterfly" trades. Thus, if yields were anomalously low (that is, bond prices high) in a particular segment of the yield curve, LTCM could short sell bonds in that segment, hedging by buying bonds with both shorter and longer maturities and wait for the passage of time to make it possible to liquidate the trade at a profit.[20]

LTCM became particularly heavily involved in the Italian capital markets, which had idiosyncrasies that LTCM expected to diminish with European integration and growing market efficiency. For example, restrictions on many Italian banks meant that they had to hold Italian government short-maturity

[20] In practice, LTCM would often implement such trades with swaps, not bonds, and would adjust the relative sizes of its positions so that the overall trade "had exposure neither to a uniform rise or fall in yields, nor to a typical steepening or flattening of the yield curve" (Perold 1999:A7).

bills, *Buoni Ordinari del Tesoro* (BOTs), which were therefore expensive and had yields significantly lower than lira Libor. LTCM expected this difference to reduce in size. Accordingly, it entered into swaps in which it paid lira Libor in return for receiving BOT-Libor (the yield at auction of BOTs, which LTCM expected to increase relative to Libor) plus an increment of around 40 basis points (Perold 1999:C6-C7; interview data).

As well as diversifying geographically, LTCM also diversified from bonds into other asset classes. Most closely similar to its bond arbitrage trades were relative-value trades involving stock, such as one involving Royal Dutch and Shell Transport. 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. The two sets of shares represent equivalent rights of ownership of the Royal Dutch / Shell group of oil companies, but they often trade at significantly different prices, for example because the way dividends are taxed leads investors to prefer one or the other. In a situation like this, arbitrage could be attractive if the difference between the prices of the two sets of shares was expected to narrow, to widen, or to change direction. LTCM could take a short position on one, a long position on the other, and profit from the expected change in relative value while being protected from overall stock-market

fluctuations and even from the effects of the specific performance of the firm involved.[21]

Another equity-related position, taken on in 1997, responded to an anomaly developing in the market for equity index options with long expirations. Investors were increasingly being sold 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 were unlikely. Five-year options on the S&P index, for example, were selling at implied volatilities of 22% per annum and higher, when the volatility of the index itself had for several years fluctuated between 10% and 13%, and the implied volatilities of shorter-term options were also much less than 20% per annum. LTCM therefore sold large quantities of five-year index options, while

[21]Thus LTCM expected that an impending change in U.K. tax structures would diminish the relative attractiveness of Royal Dutch shares and that there was a possibility that Royal Dutch/Shell would convert to single listing. LTCM implemented its short position in Royal Dutch, and long position in Shell, via a "total return swap" rather than outright holdings or short sales of the shares: see Perold (1999:A9).

hedging the risks involved with index futures and sometimes short-expiry options (Perold 1999:A7-A8).

Perhaps the greatest departure from the Salomon group's traditions was diversification into risk arbitrage (see glossary). It is an "information-sensitive" business, the classic terrain of allegations of insider trading: the activities in the 1980s of risk arbitrageurs such as Ivan Boesky gained considerable public notoriety. LTCM certainly did not indulge in insider trading, and indeed it had no advantages at all in terms of access to information. It concentrated on those cases where the chance of a merger failing was low, and regarded involvement in this area as justifiable because of the low correlation between the risks involved and those of its other positions (see below for the reason why this mattered) and because it could use "total-return swaps" to implement these trades at low transaction costs (Perold 1999:A8-A9).

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 Rosenfeld (interview). Nevertheless, extremely attractive overall returns were earned, as noted above. What is perhaps most striking about these returns was the modest volatilities that accompanied them. Most of the fund's positions were almost completely insulated from broad market movements. The firm had minimal involvement in areas where the risk of default was high, such as in high-yield ("junk") corporate bonds or "emerging markets," such as Russia, Thailand, Argentina, etc. Though the firm's positions were large, the risk involved in them

was carefully calculated and controlled. The methodology for doing this employed by LTCM was essentially the "value-at-risk" approach (see glossary) which has become standard in the world's 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 probabilities of losses and their magnitudes.

When a firm holds, as LTCM did, a large number of different positions, the estimation of the probabilities of loss in individual positions is less critical than estimates of the correlation between the positions. If the correlations are close to zero, then 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 be bad, and overall value-at-risk would be high. LTCM's positions were geographically dispersed, and in instruments of very different kinds. At the level of economic fundamentals, little if anything connected the spread between U.S. government bonds and mortgage-backed securities, the difference between the prices of the shares of Royal Dutch and of Shell, the idiosyncrasies of the Italian bond market, the bulges in the yen yield curve, 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 correlation coefficients, 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 estimates of their future values. Quite consciously, LTCM sought to be conservative in these estimates. The observed standard deviation of the U.S. 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: 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%, in actuality it was only 11% (Meriwether interview). Both figures, it is worth noting, were considerably less than the risk level of 20% that investors had been told to expect (Perold 1999:A11).

Of course, such analyses assumed the absence of catastrophic events in the financial markets. LTCM's key members were well aware of the possibility of such events. For example, 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 it (Gennotte and Leland 1990); and Meriwether's

group at Salomon were heavily involved in trading at that time. LTCM itself, 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). So LTCM also tried as best it could to "stress test" 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 European Economic and Monetary Union (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 "event" risk was deemed to be too high, LTCM bought insurance, as in the case of an Italian default, or balanced its portfolio to minimize the risk, as in the case of EMU failure. Furthermore, though a crisis may initially be damaging to a fund following LTCM's strategies, crises subsequently often produce arbitrage opportunities. Meriwether's team's bond arbitrage had profited considerably from the volatility subsequent to the 1987 stock market crash; the fund made impressive gains during the 1994 turmoil, and its 1997 profits were little affected by the financial crisis engulfing many of the Asian economies.

LTCM's principals, therefore, believed themselves to be running the fund conservatively, and in the modest volatility of its performance 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.[22] Why, after all, should LTCM's principals have wished to take reckless risks? They were nearly all, by any ordinary standards, substantially wealthy. With their stakes in LTCM constituting most of that wealth, why should they place the entirety of those stakes in jeopardy, especially when they were in the situation in which the marginal utility of increases in their wealth was surely diminishing fast?

Gambling – conscious, reckless risk-taking – does not explain LTCM's 1998 disaster. Nor does the other main candidate explanation 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 above) could be identified without sophisticated modelling at all, and although models were important in how its trades were implemented and in assessing the risks

[22] There are those who retrospectively claim to have been aware of large risk, but in only one case (Seth Klarman, manager of a different set of hedge funds) does there seem to be documentary evidence of warnings issued prior to August 1998: see Lowenstein (2000:59-60).

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 them 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.

Paradoxically, the real roots of LTCM's crisis seem to lie not in gambling nor in blind faith in models, but to a significant extent in its very success. Meriwether's group at Salomon, and then 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). 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 was careful not to reveal its trading positions. For example, it would avoid using the same counterparty for both "legs" of an arbitrage trade. For instance, in a swap-spread trade, the bond repo or reverse repo deal would be struck with one investment bank, and the swap contract made with another.

Sometimes, the effort at secrecy was to no avail. 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 analyze them and realize there's an opportunity for themselves" (Wenman interview). Furthermore, LTCM's basic strategy, of convergence and relative-value arbitrage, could not be hidden, and others seeking to follow that strategy would often be led to take similar positions to LTCM's, even if they were entirely ignorant of the latter: it "doesn't take a rocket scientist" to discover the kinds of arbitrage opportunities pursued by the Salomon group and by LTCM (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, indeed, had been 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). To the extent that LTCM had an "edge" over its competitors, it lay in the sophistication with which arbitrage trades were implemented, in the efficiency with which they were financed,[23] in the

[23] As noted above, LTCM's equity positions were largely created by the use of "total return swaps," which could be constructed at much lower costs than those of going directly long and

consequent large size of positions that could be adopted, and in its degree of diversification, both geographical and across instruments and markets of different kinds. Others, however, had equally sophisticated models, and no less ability to identify arbitrage opportunities.

In consequence, many of LTCM's positions became what Costas Kaplanis, involved in arbitrage not for LTCM but for Salomon, calls "consensus trades" (Kaplanis interview). He does not mean that the growing number of arbitrage traders in investment banks and hedge funds sat 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 of the separate traders would still have identified, and sought to exploit, many of 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 U.K. swap spreads was a good trade, people knew that U.S. swap spreads was a good trade, or off/on-the-run" (Kaplanis interview). No other market participant had the same

---

short in stock themselves. In one case, "We talked to Merrill [Lynch] for two years," before finally being able to obtain sufficiently efficient financing (Rosenfeld interview).

portfolio of trades as LTCM – many arbitrageurs were still restricted to small portions of the spectrum of arbitrage trades – but the consequence of conscious and unconscious imitation was that, collectively, much of LTCM's portfolio of positions was also being held by others.

Though one cannot be certain, it seems likely that the initial effect of the imitation of LTCM's positions was to the fund's benefit. If others are also buying an "underpriced" asset, and also short selling an "overpriced" asset, the effect of their purchases and sales will be to cause prices to converge more rapidly than they would otherwise have done, and thus to allow positions to be liquidated at a profit more quickly, and so at a higher rate of return. The existence of widespread imitation, however, also meant that when existing trades *had* been liquidated, 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.

It was becoming harder to find productive employment for the growing amount of capital accumulating in LTCM. This, together with the persistent "undershooting" (Leahy interview) of anticipated risk levels, led LTCM's principals in September 1997 to a significant decision: with the fund's net asset value having risen to $7.5 billion, they decided to reduce its capital base by returning $2.7 billion to investors. We "thought we'd done the right thing for

investors" (Leahy interview), because the return on marginal capital was very low, but the consequence of the decision, visible only in retrospect, was the removal of a "cushion" of capital that might well have been large enough to allow the fund to survive the events of August and September 1998.[24]

The ultimate causes of those events lie not in LTCM itself, but in the indirect and unanticipated consequences of the widespread conscious and unconscious imitation of its strategies. Imitation, having first probably helped LTCM, and then reduced its opportunities, suddenly 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 chair, Sandy Weill, was building a huge, consciously low risk, banking concern, Citigroup (Booth 1998). According to Kaplanis, Salomon's U.S. 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, "U.S. was down about [$]200 [million]. ... So Sandy [Weill] ... closed it [Salomon's U.S. arbitrage desk] down" (Kaplanis interview), a move that was announced on July 7. Though Kaplanis, promoted to head of global arbitrage for Salomon, advised against it, the decision was taken to liquidate the U.S. arbitrage desk's portfolio as quickly as possible, and responsibility for the liquidation was passed to Salomon's U.S.

[24] Though this $2.7 billion was less than the $3.6 billion recapitalization that saved the fund from bankruptcy (see below), its presence might have prevented the "run on the bank" phenomena of September 1998.

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). In May and June 1998, LTCM had suffered significant losses (6.7% and 10.1% respectively; see Perold 1999:C1), for reasons that remain unclear. In the first three weeks of July, much of those losses was recouped, but in the final days of the month those gains were entirely reversed, almost certainly because of the effects of the liquidation of the Salomon positions.

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 the decision of the Russian government on Monday, August 17 to default on its ruble-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. Past experience had suggested that if default occurred, it would be on debt denominated in hard currencies. "I was expecting them [the Russian government] to just print money" to meet their obligations, says Kaplanis (Kaplanis interview), and he was not alone in this expectation. True, some investors in ruble-denominated bonds had hedged against the risk of Russia defaulting on them by taking an offsetting short position in Russian hard-currency

bonds (Shleifer 2000:108). For those investors, however, even the good news of August 17 – Russia's avoidance of a hard-currency default – was damaging, because it meant their hedge failed 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: "I do not view Russia as a major issue." He was talking about the banking sector, but investors more generally seemed to share his viewpoint: on August 17, 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 ruble and a month's ban on Russian banks complying with forward contracts in foreign exchange (Dunbar 2000: 200-201). Since western investors used these contracts to hedge against the declining value of the ruble, 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 had to begin liquidating other positions to meet the demands of their counterparties. A hedge fund called High-Risk Opportunities, which had a large position in ruble-denominated bonds, was forced into bankruptcy, owing large sums to Bankers Trust, Credit Suisse, and, crucially, 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: at one point, it was trading at a 37% discount to the value of the assets it held.

In a situation in which the failure of a major investment bank was conceivable, there was a widespread move by investors to shift funds from risky, illiquid assets to safer, more liquid ones, even if the latter offered much lower rates of return. Though there are exceptions, the significance of which will be discussed below, convergence and relative-value arbitrage typically involves holding illiquid assets and short-selling liquid ones. In August and September 1998 the prices of the former fell sharply and those of the latter rose: by 18 September, the "long bond" – the 30-year maturity U.S. 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 this would be the consequence of a "flight to quality" of this kind. Indeed, it was of the very essence of convergence and relative-value arbitrage that prices could move against the arbitrageur, perhaps considerably, before the trade finally converged: that was the reason for the restriction on capital withdrawal 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, unleveraged, investors were expected to reduce them. Says one interviewee: "you're looking for people to start selling government bonds and to buy bonds issued by the World Bank of AAA or Asset-Backed bonds,[25] or whatever, when the spread gets to be too wide, because neither one of those instruments is going to default. The 100 basis points difference between the AAA bonds and government bonds is not reflective of a 1% chance per year of default, it's reflective of supply and demand at a point in time. And so that substitution will happen and spreads should come in."

The configuration of the markets by August 1998, however, was that the widening of spreads caused by Salomon's withdrawal and the consequences of the Russian default was self-feeding, rather than self-limiting. As convergence and relative-value arbitrageurs in investment banks and hedge funds 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. They did so for a variety of reasons. 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

[25] That is, the bonds of international banks with the highest credit rating or mortgage-backed or similar securities.

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] U.K. 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] U.K. 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, and if large

losses were encountered, investors would withdraw funds: “they knew that investors were starting to drain money if they saw more than 15% [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% 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 would have to transfer collateral to their counterparties and / or meet margin calls from exchanges. Funds with limited capital might quickly find themselves in a position in which they were having to liquidate positions in order to generate the cash needed to meet these demands.

Another factor, in addition to management queasiness and the pressures upon hedge funds, was, paradoxically, modern risk management practices, particularly the methodology of value-at-risk. This allows senior management to control the risks incurred by trading desks, while avoiding detailed supervision of their trading, by allocating them a risk limit. When a desk reaches that limit, it must liquidate positions to reduce value-at-risk. 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 limits. In 1996, the ultimate regulatory body, the Basle Committee on Banking Supervision,

permitted banks to use value-at-risk models in their calculations of the amount of capital they have to set aside. 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, the bank has to set aside more capital to preserve its trading positions, an expensive and 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.[26]

The consequences for LTCM of a "flight to quality" and concerted efforts by those with similar positions to reduce those positions 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, may have exacerbated the effects on prices of the multiply-caused efforts to reduce positions. With market liquidity at what would in any case have been an annual trough, the effects of position reductions were that much greater. In a

[26] This point is discussed in particular by Dunbar (2000), but the existence of the mechanism was also suggested, for example, by John Meriwether (interview).

single day, Friday 21 August, LTCM lost $550 million as swap spreads in the U.S. and U.K. widened dramatically (by then, LTCM's position in the U.S. was the opposite to that in the trade discussed earlier, and it was expecting spreads to narrow) and the merger between Ciena Corporation and Tellabs, Inc., in which LTCM had a large risk arbitrage position, was cancelled (Perold 1999:C2-C3).

Crucially, correlations between the different components of LTCM's portfolio leapt upwards. Their historic level had, as noted above, been 0.1 or less; LTCM had performed its risk analysis at around what it took to the conservative level of 0.3. In the crisis, however, correlations leapt to around 0.7 (Leahy interview). 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 had, as noted above, suffered a significant loss at the end of July, and its positions continued to deteriorate in the first half of August, but the losses in the week of the Russian default were stunning in their size and rapidity. By the weekend after the default, LTCM's net asset value had fallen by almost 40% from its total at the start of the year (Perold 1999:C1). However, though a massive loss, and far greater than had seemed plausible on the basis of LTCM's risk model, it 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" from late August onward (Meriwether interview). Unlike investment banks, which report their results quarterly, LTCM and other hedge funds report monthly. LTCM's practice was to issue an estimate of the fund's performance as soon as the month ended, followed around ten days later by a definitive figure. On September 2, 1998, Meriwether faxed LTCM's investors its estimate of the losses to the end of August: "down 44 percent for the month of August, and 52 percent for the year-to-date" (the faxed letter is reproduced in full in Perold 1999:D1-D3). Meriwether, quite reasonably, told LTCM's investors that the large spreads that had appeared in August represented an excellent arbitrage opportunity, and his fax 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 (Perold 1999:D3).

Meriwether's fax became public almost instantly: "Five minutes after we sent out 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 September 2, the price of hurricane bonds fell 20%, even although there had been no increase in either the probability of hurricanes or the seriousness of their consequences. In the case of markets in which LTCM was believed to have large positions, it became impossible to sell assets that LTCM was believed to hold at anything other than distressed prices. Beliefs about LTCM's portfolio were sometimes far from accurate: there were false rumours that it had a large position in copper, presumably spread by someone who was short copper, and 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. As noted above, 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, would flow 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, in good part because of fears of its collapse. 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 getting as much collateral as possible from LTCM before it did, and this could be achieved by "marking against it," in other words choosing out of the wide spectrum of plausible market prices a price that was unfavourable to LTCM, indeed predicated upon the latter's failure (Merton interview; Meriwether interview). The President's Working Group on Financial Markets (1999:13) noted that by mid-September, "LTCM's repo and OTC [over-the-counter] derivatives counterparties were seeking as much collateral as possible through the daily margining process, in many cases by seeking to apply possible liquidation values to mark-to-market valuations." LTCM had the contractual right to dispute unfavourable marks, and 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 collateral outflows resulting from unfavourable marks were particularly damaging in LTCM's index option positions, where they cost the fund around $1 billion, accounting for nearly half of the losses in September that pushed it to the brink of bankruptcy (Rosenfeld interview). Following the Russian default, and possibly influenced by the then-growing Clinton-Lewinsky scandal, stock market volatility did indeed increase. But to this increase was added the results of anticipation of the consequences of the 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 them with (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 told author Nicholas Dunbar:

> 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 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).

As September 1998 wore on, LTCM's financial position continued to deteriorate. It kept its counterparties and the Federal Reserve, informed of this deterioration. On September 20, staff from the Federal Reserve Bank of New York and Assistant Secretary of the Treasury Gary Gensler met with LTCM in the latter's Greenwich offices. By then, it was clear that without outside intervention bankruptcy of LTCM was effectively 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, they would have been unable to liquidate collateral or establish offsetting positions at the previously existing prices. Markets would have moved sharply, and losses would have been exaggerated. Several billion dollars of losses might have been experienced by some of Long-Term Capital's more than seventy-five counterparties. ... [A]s losses spread ... this would lead to tremendous uncertainty about how far prices would move. Under these circumstances, 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 1998:1051-1052).

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).

Whether or not those dire prognostications would have been confirmed is unclear. 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% of the fund. LTCM’s investors and partners were not in any sense “bailed out.” The “sliver of equity” (Greenspan 1998:1048) that the original investors were left with in September 1998 amounted to $400 million, a mere tenth of what their holdings were worth not long previously.[27] The recapitalization did, however, permit an orderly liquidation of LTCM’s portfolio. The latter was complex, (LTCM’s swap book, for example, consisted of some 10,000 swaps with a total notional value o around $1.25 trillion),[28] and trading conditions remained difficult even after the recapitalization. The heavy losses incurred in 1998 by the investment banks

[27] The large profits earned by LTCM in previous years, and the compulsory return of capital in December 1997, meant that only 12 of LTCM’s 100 investors made a net loss from their involvement, and the median investor even earned the equivalent of 19% per annum (Rosenfeld 2001).

[28] See anon. (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 contract.

persuaded many of them to abandon arbitrage trading almost completely. It took several weeks, and the effects of successive interest rate cuts by the Federal Reserve, to settle the markets' nerves, and in particular to end fears that the consortium of banks that now owned LTCM might decide on an abrupt liquidation. Nevertheless, careful management by the consortium, and the skills of LTCM's partners and staff (many of whom chose, as the consortium had hoped, to remain with the fund) allowed the consortium to recover its investment completely, and indeed to make a modest profit on it before the fund's positions were fully liquidated in December 1999.

Explaining the Crisis

As noted above, neither reckless risk-taking nor blind faith in mathematical models explains the crisis of LTCM. LTCM's principals believed themselves to be managing the fund with an appropriate degree of conservatism, and while blind faith in models plainly is dangerous, there is no evidence of such faith being manifest within LTCM. A third, more plausible, account of the fund's near failure lies in its degree of leverage: this, for example, is the main theme of the President's Working Group on Financial Markets (1999). This explanation, indeed, 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. Before we jump to the conclusion

that we have found the correct explanation of the LTCM's crisis, however, four provisos are in order.

First is the simple point that leverage was intrinsic to the kind of arbitrage performed by LTCM. As noted above, the unlevered rates of return from the kinds of positions it adopted are paltry. Only with leverage does convergence or relative-value arbitrage become attractive. Second, LTCM's pre-crisis leverage ratios were not, in fact, egregious when compared to those of investment banks. As noted above, up to December 1997, LTCM's leverage ratio fluctuated between 14:1 and 31:1. In the early months of 1998, after the return of capital to investors but before serious shrinkage of LTCM's capital base, its 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). True, such banks conduct a wider range of business activities than LTCM did, and have a greater variety of sources of funding available to them, but their assets are on average less liquid and riskier than LTCM's portfolio. Third, the very high levels of overall leverage (of the order of 100:1) reached by LTCM in September 1998 were an effect of, rather than the cause of, its crisis: they reflected the shrinking of the fund's capital base. Fourth, the conventional means of measuring leverage, the leverage ratio, is a poor indicator of the degree of risk.[29] Reducing risk by entering into offsetting positions may well increase

[29]A homely example shows the inadequacy of the leverage ratio considered in isolation. Take a householder who buys a £100,000 property with a 95% mortgage (that is, provides a twentieth of

the leverage ratio, while entering into swap contracts (which, depending on how they are used, may either increase or decrease risk) leaves the leverage ratio unaltered, because these do not appear in conventional asset/liability balance sheets (Perold 1999:A12-A13).

Blaming LTCM's crisis on leverage is rather like attributing a plane crash to the fact that the aircraft was no longer safely in contact with the ground: it identifies a necessary, but in no sense a sufficient, cause. Leverage at best explains the fund's vulnerability to the events of August and September 1998, but does not itself explain those events. LTCM did not choose the sizes of its positions, and thus its leverage levels, arbitrarily: those sizes were determined by, amongst other things, what its risk model indicated would be the resultant volatility level of the fund's returns. Understanding the causes of its near-failure, therefore, becomes the more general problem of understanding the financial crisis of August and September 1998. Why did the adverse price movements of those months exceed LTCM's, or anyone else's, expectations?

---

the purchase price from his/her own funds, while borrowing the remainder) and who has no other assets or debts. His/her leverage ratio is £100,000:(£100,000 - £95,000)

= £100,000:£5,000

= 20:1

Some lenders indeed offer 100% mortgages, and thus infinite leverage!

A home purchase levered 20:1, or even infinitely levered, may, however, be perfectly prudent, while a stock purchase at 20:1 would generally be regarded as very high risk even if it were feasible.

Conventionally, the 1998 crisis is regarded as a "flight to safety" (President's Working Group on Financial Markets 1999:20), "flight from risk," or "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 (see Scholes 2000 for this latter interpretation). However, if the interpretation advanced above 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 imitations. Because of the postulated overlap of these positions, I shall call this the "unravelling superportfolio" explanation. The exact composition of the superportfolio is not known with any precision: interviewees from investment banks and other hedge funds were unwilling to disclose their holdings in 1998. However, if the imitation-based explanation advanced here is correct, LTCM's portfolio should be a reasonable proxy for the composition of the superportfolio, and the make-up of the former *is* 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.

As noted above, convergence and relative value arbitrage 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 "unravelling superportfolio" explanations are identical. In cases of two types, however, the predictions of the two explanations differ, and this allows us to test for the existence of price movements predicted by the "superportfolio" overlaying the flight to quality.

The first type is where there is a range of similar spreads (or, for example, implied volatilities) in some of which LTCM had positions and in others of which it did not. The "unravelling superportfolio" explanation would then predict greater increases in the spreads or implied volatilities in which LTCM had positions than in those in which they did not.[30] If the spreads or implied volatilities genuinely are similar, the flight-to-quality explanation would, in contrast, predict similar movements of them all. The second set of circumstances in which the two explanations yield different predictions 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 detail above 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

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

position which, 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 was short large amounts of long-dated index options on all the major stock market indices listed in table 1, except the Japanese NK225. The implied volatilities of all rose, but the implied volatilities of the other indices rose by around $1^1/_2$ times to twice as much as that of NK225 options (table 1). It is difficult to interpret this difference in a "flight to quality" sense as resulting from increased relative confidence in the future stability of the Japanese stock market.

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, a flight to quality should increase swap spreads. Figure 2 and table 2 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 text, which would increase in value if the spread rose); in the U.S. and U.K. (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).[31] In the U.S. and U.K. (and also Sweden, where arbitrageurs also had large short positions), swap spreads widened markedly. In

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

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 position akin to that in France.[32] In France, for example, the swap spread was only modestly affected for much of the early phase of the crisis; it did widen fairly sharply in mid-September, but then narrowed dramatically, reaching zero by the end of October. An initially sharp widening of the yen swap spread was also corrected fairly quickly, with the spread widening October at almost the same value as it began June, while the larger widening in the dollar and sterling spreads was only slowly and partially corrected. I know of no plausible flight-to-quality explanation of these international contrasts, while they are precisely as predicted by the superportfolio explanation.

Equity volatility, U.S. swap spreads and European differential swap spreads are three of the 13 major positions held by LTCM in the summer of 1998 (Perold 1999: C6-C7). A further two of its positions also fall into type 1 or type 2, with another six doing so to some extent (see table 3). The overall pattern is clear. In all the cases for which data are available, the relative price movements of the crisis are consistent with the "unravelling 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

[32] 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.

overlaying it (and sometimes acting in contradiction to it) was an unravelling superportfolio.

Also supporting the superportfolio hypothesis is the contrast between the market reaction to the August 1998 Russian default and to the terrorist atrocities of September 11, 2001. The latter also sparked a flight to quality, but did so in a situation in which there was no equivalent superportfolio. LTCM's successor fund, JWM Partners, was active then too, but its capital base was much smaller and its leverage levels lower (Silverman and Chaffin 2000); crucially, the amount of capital devoted by others to convergence and relative value arbitrage was also much smaller (interviewees estimate possibly only a tenth as large in total). So the externally-generated crisis of 2001 was not amplified by internal market dynamics as the Russian default had been in August and September 1998. While LTCM's portfolio was 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."

Imitation, Risk, and Globalization

Arbitrage failed in August and September 1998. Though the losses by LTCM reported by Meriwether's fax of September 2 triggered the "run-on-the-bank," his claim that arbitrage opportunities were extremely attractive was born out by subsequent events. The Royal Dutch-Shell trade, and the BOTLibor-Libor trade, for example, converged precisely as LTCM had predicted (see figures 3 and 4);

equity index implied volatilities returned to "normal" levels.[33] And yet arbitrageurs fled in 1998, and in many markets have remained largely absent subsequently. Such convergence as has taken place has been driven by the actions of ordinary investors, not of arbitrageurs.

Figures 3 and 4 – and the events of 1998 more generally – reveal a phenomenon that causes what one might call the anxiety of the arbitrageur. Before convergence, there was the sharp divergence of the autumn of 1998, and several further adverse movements. Any prudent and well-financed arbitrageur would withstand such movements in any one position, but, as noted above, the critical factor in 1998 was the suddenly enhanced correlation across positions. The result was an aggregate market movement far worse than *anyone* involved (in LTCM, amongst other arbitrageurs, amongst LTCM's many after-the-fact critics) had anticipated. Although he was one of the world's most successful and most sophisticated arbitrageurs, and aware that a process of the kind that marked august and September 1998 could occur, David Shaw was taken aback by the magnitude of it. "I don't think any of us thought there was much chance of it being even a third as large as it turned out to be in 1998" (Shaw interview).

[33] True, U.S. and U.S. swap spreads remained wide, in good part because improving public finances raised bond prices and depressed yields. However, as noted above, a well-financed arbitrageur could simply wait out adverse fluctuations until maturity or the appearance of a profitable time to liquidate.

What arbitrageurs have learned from 1998 was expressed to me, separately, by two partners in LTCM. Suppose they had been vouchsafed a little peek into the future: that they knew, with absolute certainty, that at a particular point 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? They 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 – the analogue of a 1998 event – could still exhaust their capital and thus force them to liquidate at a loss.

Of course, prudent arbitrageurs always knew of that danger, and LTCM went to considerable lengths to avoid it. Its existence, however, reveals that what may, in economic theory, be risk-free arbitrage, requiring no capital, and therefore limitless in its capacity to close price discrepancies, in practice requires the arbitrageur to have substantial capital and always carries some degree of risk, however small. That arbitrage may in consequence fail indicates that its capacity to "insulate" the economic from the social – to maintain the Parsonian dichotomy – is always potentially limited.

Even that formulation, however, is not entirely adequate. 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 "social" risks seem to come from inside the financial markets rather than from outside. This facet of them is expressed in that most important way in which LTCM's successor, JWM Partners, has altered its predecessor's risk model to take account of that lessons of 1998. All the fund's positions, however diverse geographically and unrelated in asset type, are assumed to have correlations of 1.0 "to the worst event" (Meriwether interview). They are all are assumed to move, in an extreme crisis, 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.

It is prudent risk management. (There might be virtues in other market participants also modifying their models in this way, although of course reduction of risk also constrains possible returns.) From the viewpoint of this article, however, the key point is that the risk it mitigates was, in 1998, a risk generated by conscious or unconscious imitation and by the consequent unravelling of a superportfolio.

The work within economics that focuses most directly on the limits of arbitrage is that of "behavioural" finance specialist Andrei Shleifer (Shleifer and Vishny 1997; Shleifer 2000). Shleifer's work in 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 dichotomy. 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 amongst arbitrageurs. The resultant correlation of prices that were otherwise essentially unrelated economically – the other key phenomenon of 1998 – is not captured by the Shleifer-Vishny model's single asset market and non-imitative arbitrageurs.[34]

That imitation is found among skilled, sophisticated, professional traders such as arbitrageurs – and not just among the lay investors in Nasdaq stocks whose mutual susceptibility has been brilliantly described by Pollner (2001), himself one of those investors – may explain one of the most robust statistical findings about financial markets: the fat-tailed nature of the probability distributions of price changes. Extreme events happen with a frequency much greater than predicted by normal or log-normal distributions. The U.S. swap spread, for example, has a daily volatility (standard deviation) of around 0.8 basis points per day.[35] Perhaps the single most dramatic event in the crisis of

---

[34] Thus Shleifer and Vishny (1997:47) essentially accept the conventional intuitive judgement that, as they put it, "if arbitrageurs are at least somewhat diversified, not all of their holdings lose money at the same time." Shleifer (2000:105-6) corrects this, noting the possibility of the emergence of correlation across unrelated asset classes, but his model remains unaltered.

[35] Volatilities scale as the square root of time. With the standard assumption of 252 trading days a year, the swap spread's annual volatility of 12 basis points is equivalent to a daily volatility of $12/\sqrt{252} = 0.76$ basis points, or a half-day volatility of 0.54 points.

August and September 1998 was the widening of the U.S. swap spread in half a day (the morning of Friday, August 21, five days after the Russian default) of 19 basis points (Perold 1999:C2): a 35σ event. Of course, nothing much can be inferred from a single event plucked from amongst many, but it is worth noting that the aggregate movement in price of LTCM's positions in August 1998 (a 44% loss) was a -14σ event in terms of the 3.2% historical monthly volatility of the fund's portfolio and a –10.5σ event on its risk model's 4.2% monthly volatility.[36]

Why are the empirical probability distributions of price changes fat-tailed?[37] A possible explanation is imitation. If traders imitate each other – for example, by seeking to discover and then follow "trends" – then external events that are normal (Gaussian) in their probability distribution can be transformed by internal market processes into price distributions that are fat-tailed and follow a power law (Lux and Marchesi 1999). (Although the analogy is not perfect, some intuition of why this may be so can be gained by imagining a small boat rocked by waves that are seldom large, but in which when a passenger slips towards one side, the others imitate his/her movement.) Lux and Marchesi's paper explores a theoretical possibility, but if this paper's analysis is correct, the

[36] These monthly figures are calculated by dividing the annual volatilities (see above) by $\sqrt{12}$.

[37] LTCM is often accused (e.g. by Lowenstein 2000: 173) of ignoring fat tails. While its risk model was indeed based on standard lognormal distributional assumptions, its practice of "upping" observed standard deviations and correlations in fact had the effect of fattening tails: it just did not do so enough.

consequences of imitation (an unravelling superportfolio) generated, in empirical fact, the observed "fat tail" events of August and September 1998.

What, finally, of globalization? The notion has become a banality and a truism, both in sociological thought and in everyday discourse. There has been too little attention to its detailed mechanisms, and too great a confidence that it is a uni-directional process. No-one has been closer to the heart of the processes of globalization than John Meriwether and his group at Salomon and LTCM: they surfed globalization's wave, so to speak, but in a sense they were also undone by it. They, and all other sophisticated participants and observers, knew that by the final decades of the twentieth century the world's financial markets were interconnected, and that a crisis in one would affect others. The stock market crash of 1987, for example, hit not just markets in the U.S. but markets throughout the world. But the very nature of Salomon/LTCM's convergence and relative-value arbitrage meant that it was insulated from what one might call the "first order" globalization in which a decline, for example, in one stock market (particularly the American market) causes declines in others worldwide.

What caused the crisis of 1998, rather, was what one might call a "second order" globalization, which neither LTCM, nor to my knowledge anyone else, had fully identified. What happened in August and September 1998 was not simply that international markets fell in concert, but that very particular, and at the level of economic "fundamentals" quite unrelated, phenomena 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 recognised it": 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 (Meriwether interview). "Maybe the error of Long-Term was ... that of not realizing that the world is becoming more and more global over time," says Scholes (interview).

The crisis of 1998 was indeed created by globalization. But not globalization as a generic, disembodied, inevitable, or uni-directional process: the "second order" globalization whose effects were manifest in 1998 was a specific, contingent, and reversible process in which a relatively limited number of institutional actors, notably hedge funds and major investment banks, were involved. With banks that once traded within countries, or within regions like North America or Europe, by 1998 trading globally, "there are probabilities that are enhanced that if there's a shock, it will, ... in a market-to-market part of the market ... cause firms to have to adjust their positions because of the risk management technologies [like value at risk and associated stop-loss rules] that every firm has" (Scholes interview). A "global microstructure" (in the sense of Knorr Cetina and Bruegger, forthcoming) had come into being. Its traces were the sudden, fatal correlations of 1998.

Since September 1998, however, this particular microstructure and the specific form of "second order" globalization it induced, have largely been

reversed. The failure of the shock of September 11, 2001, to ramify and amplify through the markets, in the way the Russian default did, is testimony to that. After September 1998, the major investment banks radically scaled down their arbitrage activities, and the remaining hedge funds in the area have not been operating on anything like the pre-1998 scale.

There is therefore a sense in which since 1998 we have been living in a *less* globalized world: the mechanisms of "second-order" market linkage manifest in 1998 have been weaker subsequently. Of course, they may well return, albeit most likely in different forms. But that, indeed, is precisely 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,[38] waxing and waning.

[38] Take al-Qaida: it is globalization's enemy, but also its product.

List of interviews

Partners in and employees of LTCM:

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

Leahy, Richard F., Greenwich, Conn., October 31, 2000.*

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

Merton, Robert C., Cambridge, Mass. November 2, 1999.*

Rosenfeld, Eric, Rye, NY, October 30, 2000.*

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

This article also draws on a wider set of interviews (numbering 60 in total) conducted by the author with finance theorists and market practitioners, of which these drawn on most directly here are:

Kaplanis, Costas, London February 11, 2000.*

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

Wenman, David, London, June 22, 2001.*

Not all interviewees wished to be identified, and some contributions are therefore cited in the text simply as anonymous interview material. * indicates that the interview was tape-recorded.

Glossary

Basis point: a hundredth of a percentage point.

Bill: a government *bond* of short maturity, often paying no coupon.

Bond: a "security evidencing debt" (Moles and Terry 1997, p. 50), issued as a way of raising money by entities such as governments or corporations. Bonds normally commit the issuer to repay a fixed sum on a given date and to pay a *coupon* (make periodic interest payments) until that date. The initial purchaser of bonds can sell them on to others.

Convergence arbitrage: trading that seeks to profit from discrepancies between prices of two assets that must on some future date have an identical price.

Convertible arbitrage: trading that exploits discrepancies between the price of *convertible bonds* and the value of the *option* they contain. Typically, the *Black-Scholes* or another option pricing model is used to identify convertible arbitrage opportunities.

Convertible bond: a *bond* that contains an *option* to be converted into a security of another type, such as the stock of the corporation issuing the bond.

Coupon: see *bond*.

Derivative: a contract or contractual instrument (such as a *future*, *option*, or *swap*), the value of which depends upon that of another asset or interest rate.

Future: a contract traded on an organized exchange in which one party undertakes to buy, and the other party to sell, a set quantity of a particular asset at a set price on a given future date (the future's expiration).

Haircut: the difference between the amount of money lent in a *repo* or similar agreement and the market price of the securities pledged as collateral for the loan.

Hedge fund: a special category of investment vehicle, for example permitting only very large investments and/or a strictly limited number of investors, that is exempt from many regulatory requirements (but is also, for example, typically banned from advertising). Hedge funds are thus free to adopt strategies such as *short selling* and using borrowed funds to enhance returns. Most hedge funds are structured so as to be "private" funds under the terms of the U.S. Investment Company Act of 1940: see President's Working Group on Financial Markets (1999: appendix B).

Implied volatility: the *volatility* of a stock or index consistent with the price of *option*s on the stock or index.

Libor (London interbank offered rate): the average rate of interest at which a panel of banks with the highest credit ratings are prepared to lend funds to each other.

Log-normal: a variable is log-normally distributed if its natural logarithm is normally distributed.

Long position: a portfolio of an asset and / or *derivative* of that asset that will rise in value if the price of the asset rises. Q.v. *short position*.

Mark-to-market: the process of revaluing a trading position as market prices fluctuate.*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"); the seller of the option is obliged to fulfill his / her part of the contract if so demanded.

Relative-value arbitrage: trading that seeks to profit from discrepancies between the prices of two assets that are likely, but not certain, to be temporary (qv *convergence arbitrage*).

Repo (repurchase agreement): a contract in which party A borrows money from party B to buy securities such as *bonds* from B. B holds the securities as collateral for the loan, and undertakes to buy back the securities at a given price on a given future date.

Reverse repo: the converse of *repo*, i.e. earning interest by lending money to permit the temporary purchase of securities one owns.

Risk arbitrage: when a takeover of company A by company B is announced, the price of A's shares frequently does not fully reflect the value of B's offer, and the difference may be greater than implied by the risk of the takeover not being concluded. Risk arbitrage seeks to exploit this difference, for example by buying shares in A and *short selling* shares in B.

Risk capital: capital set aside to protect against losses.

Short position: a portfolio of an asset and / or *derivative* of that asset that will rise in value if the price of the asset falls. A short position can, for example, be constructed by *short selling* an asset. Q.v. *long position*.

Short selling: borrowing an asset, selling it, and later repurchasing and returning it.

Statistical arbitrage: trading that seeks to exploit patterns in prices discovered by statistical analysis or other pattern detection techniques.

Swap: a contract to exchange two income streams, e.g. fixed-rate and floating-rate interest on the same notional principal sum.

Swap spread: the difference between the fixed interest rate at which interest-rate *swap*s can be entered into and the *yield* of a government bond of equivalent maturity denominated in the same currency.

Two-way mark-to-market: an agreement between two parties to a securities transaction (e.g. the purchaser and seller of an *option*) that collateral should flow between them as the market value of the securities fluctuate.

Value-at-risk (VAR): a method of estimating the exposure of a portfolio of assets to potential losses. A typical VAR calculation might estimate the level of loss over a given time period that is expected to be exceeded only five percent of the time. Typically, VAR calculations are based on the assumption of a normal or *log-normal* probability distribution of asset price changes.

Volatility: the extent of the fluctuations of a price, conventionally measured by its annualized standard deviation.

Yield: the yield of a *bond* is the rate of return it offers at its current market price.

References

Abolafia, Mitchel Y. 1996. *Making Markets: Opportunism and Restraint on Wall Street*. Cambridge, Mass.: Harvard University Press.

Abolafia, Mitchel Y. 1998. "Markets as Cultures: An Ethnographic Approach." Pp. 69-85 in *The Laws of the Markets*, edited by M. Callon. Oxford: Blackwell.

Adler, Patricia A. and Peter Adler, eds. 1984. *The Social Dynamics of Financial Markets*. Greenwich, Conn.: JAI Press.

Anon. 2000. "Risk Managers of the Year: LTCM Oversight Committee." *Risk* 13(1): 32-33.

Baker, Wayne E. 1981. "Markets as Networks: A Multimethod Study of Trading Networks in a Securities Market." Northwestern University, PhD thesis.

Baker, Wayne E. 1984a. "The Social Structure of a National Securities Market." *American Journal of Sociology* 89: 775-811.

Baker, Wayne E. 1984b. "Floor Trading and Crowd Dynamics." Pp. 107-128 in *The Social Dynamics of Financial Markets*, edited by P. A. Adler and P. Adler. Greenwich, Conn.: JAI Press..

Bank of England. 1999. *Financial Stability Review*. 7 November.

Beck, Ulrich. 1992. *Risk Society: Towards a New Modernity*. London: Sage.

Bernstein, Peter L. 1992. *Capital Ideas: The Improbable Origins of Modern Wall Street*. New York: Free Press.

Beunza, Daniel and David Stark. 2002. "Market Instruments: Arbitrage as Abstraction and Artifacts in a Wall Street Trading Room."

Black, Fischer and Myron Scholes. 1973. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81:637-54.

Booth, Tamzin. 1998. "Why Costas Kaplanis had to sell." *Institutional Investor*: 12-16.

Brady Commission. 1988. "Report of the Presidential Task Force on Market Mechanisms." U.S. Government Printing Office,Washington, D.C.

Brügger, Urs. 2000. "Speculating: Work in Financial Markets." Pp. 229-55 in *Ökonomie und Gesellschaft*. edited by H. Kalthoff, R. Rottenburg, et. al. Marburg: Metropolis.

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

Camic, Charles. 1987. "The Making of a Method: A Historical Reinterpretation of the early Parsons." *American Sociological Review* 52:421-439.

Chaplin, Graeme, Alison Emblow, and Ian Michael. 2000. "Banking System Liquidity: Developments and Issues." *Financial Stability Review* no 9:93-112.

Cox, John C., Jr. Ingersoll, and Stephne A. Ross. 1985. "A Theory of the Term Structure of Interest Rates." *Econometrica* 53:386-407.

Dunbar, Nicholas. 2000. *Inventing Money: the Story of Long-Term Capital Management and the Legends Behind it*. Chicester, West Sussex: Wiley.
Falloon, William D. 1998. *Market Maker: A Sesquicentennial Look at the Chicago Board of Trade*. Chicago: Board of Trade.
Gennotte, Gérard and Hayne Leland. 1990. "Market Liquidity, Hedging, and Crashes." *American Economic Review* 80:999-1021.
Godechot, Olivier. 2000. "Le Bazar de la Rationalité: Vers une Sociologie des Formes Concrètes de Raisonnement." *Politix* 13 (52):17-56.
Godechot, Olivier. 2001. *Les Traders: Essai de Sociologie des Marchés Financiers*. Paris: la Découverte.
Granovetter, Mark. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78:1360-80.
Granovetter, Mark. 1985. "Economic Action and Social Structure: The Problem of Embeddedness." *American Journal of Sociology* 91:485-510.
Granovetter, Mark. 1990. "The Old and the New Economic Sociology: A History and an Agenda." Pp. 89-112 in *Beyond the Marketplace: Rethinking Economy and Society*. New York: de Gruyter.
Greenspan, Alan. 1998. "Statement before the Committee on Banking and Financial Services, U.S. House of Representatives, October 1." *Federal Reserve Bulletin* 84:1046-1050.
Hassoun, Jean-Pierre. 2000. "Trois Interactions Hétérodoxes sur les Marchés à la Criée du MATIF." *Politix* 13 (52):99-119.
Hertz, Ellen. 1998. *The Trading Crowd: An Ethnography of the Shanghai Stock Market*. Cambridge: Cambridge University Press.
Homer, Sidney and Martin L. Leibowitz. 1972. *Inside the Yield Book: New tools for bond market strategy*. Englewood Cliffs, N.J.: Prentice-Hall.
Homer, Sidney. 1978. *The Great American Bond Market: Selected speeches of Sidney Homer*. Homewood, Illinois: Dow Jones Irwin.
Hutchins, Edwin. 1995. *Cognition in the Wild*. Cambridge, Mass.: MIT Press.
Izquierdo M., A. Javier. 1998. "El Declive de los Grandes Números: Benoit Mandelbrot y la Estadística Social." *Empiria: Revista de Metodología de Ciencias Sociales* 1:51-84.
Izquierdo M., A. Javier. 2001. "Reliability at Risk: The Supervision of Financial Models as a Case Study for Reflexive Economic Sociology." *European Societies* special issue on the new economic sociology in Europe.
Kaufman, Henry. 2000. *On Money and Markets: A Wall Street Memoir*. New York: McGraw-Hill.
Knorr Cetina, Karin and Urs Bruegger. 2000. "The Market as an Object of Attachment: Exploring Postsocial Relations in Financial Markets." *Canadian Journal of Sociology* 25:141-168.

Knorr Cetina, Karin and Urs Bruegger. Forthcoming. “Global Microstructures: The Interaction Practices of Financial Markets.” *Under revision for American Journal of Sociology*.
Latour, Bruno. 1987. *Science in Action*. Cambridge, Mass.: Harvard University Press.
Latour, Bruno. 1999. *Pandora’s Hope: Essays on the Reality of Science Studies*. Cambridge, Mass.: Harvard University Press.
Leibowitz, Marin L. 1992. *Investing: The Collected Works of Martin L. Leibowitz*. Chicago: Probus.
Lewis, Michael. 1999. “How the Eggheads Cracked.” *New York Time Magazine* January 24:24-31, 42, 67-68 and 77.
Lépinay, Vincent and Fabrice Rousseau. 2000. “Les Trolls sont-ils Incompétents? Enquête sur les Financiers Amateurs.” *Politix* 13 (52):73-97.
Lowenstein, Roger. 2000. *When Genius Failed: The Rise and Fall of Long-Term Capital Management*. New York: Random House.
Lux, Thomas and Michele Marchesi. 1999. “Scaling and Criticality in a Stochastic Multi-Agent Model of a financial Market.” *Nature* 397:498-500.
MacKenzie, Donald. 2000a. “Fear in the Markets.” *London Review of Books* 31-32.
MacKenzie, Donald. 2000b. “Long-Term Capital Management: a Sociological Essay.” Pp. 277-287 in Okönomie und Gesellschaft, edited by Herbert Kaltoff, Richard Rottenburg and Hans-Jürgen Wagener. Marberg: Metropolis.
MacKenzie, Donald. 2001a. “Physics and Finance: S-terms and modern finance as a topic for science studies.” *Science, Technology & Human Values* 26:115-144.
MacKenzie, Donald. 2001b. *Mechanizing Proof: Computing Risk, and Trust*. Cambridge, Mass.: MIT Press.
MacKenzie, Donald and Yuval Millo. (Forthcoming). “Negotiating a Market, Performing Theory: The Historical Sociology of a Financial Derivatives Exchange.”
McDonough, William J. 1998. “Statement before the Committe on Banking and Financial Services, U.S. House of Representatives, October 1.” *Federal Reserve Bulletin* 84:1050-1054.
Merton, Robert K. 1949. “The Self-Fulfilling Prophecy.” Pp. 179-95 in *Social Theory and Social Structure*. New York: Free Press.
Merton, Robert C. 1973. “Theory of Rational Option Pricing.” *Bell Journal of Economics and Management Science* 4:141-83.
Miller, Merton H. and Franco Modigliani. 1961. “Dividend Policy, Growth and the Valuation of Shares.” *Journal of Business* 34 (1961):411-33.
Modigliani, Franco and Merton H. Miller. 1958. “The Cost of Capital, Corporation Finance and the Theory of Investment.” *American Economic Review* 48:261-297.

Muniesa, Fabian. 2000a. “Performing Prices: The Case of Price Discovery Automation in the Financial Markets.” Pp. 289-312 in *Okönomie und Gesellschaft*, edited by H. Kalthoff, R. Rottenburg, et al. Marburg: Metropolis.
Muniesa, Fabian. 2000b. “Un Robot Walrasien: Cotation Electronique et Justesse de la Découverte des Prix.” *Politix* 13 (52):121-54.
Orléan, Aandré. 1998. “Informational Influences and the Ambivelance of Immitation.” Pp. 39-56 in *Advances in Self-Organization and Evolutionary Economics*, edited by J. Lesourne and A. Orléan. London: Economica.
Perold, André. 1999. *Long-Term Capital Management*, L.P. Boston, Mass.: Harvard Business School Publishing.
Podolny, Joel. 1993. “A Status-based Model of Market Competition.” *American Journal of Sociology* 98:829-872.
Pollner, Melvin. 2001. “Inside the Bubble: Communion, cognition, and Deep Play at the Intersection of Wall Street and Cyberspace.” Typescript.
President's Working Group on Financial Markets. 1999. “Hedge Funds, Leverage and the Lessons of Long-Term Capital Management.”
Rosenfeld, Eric. 2001. “Presentation to AIMR Hedge Fund Management Conference, November 28.”
Rosenthal, Leonard and Colin Young. 1990. “The Seemingly Anomalous Price Behavior of Royal Dutch / Shell and Unilever N.V. / PCL.” *Journal of Financial Economics* 26:123-141.
Ross, Steven A. 2001. “Neoclassical and Alternative Finance.” in *EFMA Meetings*, keynote address.
Scholes, Myron S. 2000. “Crisis and Risk Management.” *American Economic Review* 90:17-21.
Shleifer, Andrei and Robert W. Vishny. 1997. “The Limits of Arbitrage.” *Journal of Finance* 52:35-55.
Shleifer, Andrei. 2000. *Inefficient Markets: An Introduction to Behavioral Finance*. Oxford: Oxford University Press.
Silverman, Garry and Joshua Chaffin. 2000. “Hedge Fund Guru Back in the Game.” *Financial Times* August 21:9.
Smith, Charles W. 1999. *Success and Survival on Wall Street: Understanding the Mind of the Market*. Lanham, Maryland: Rowman & Littlefield.
Sobel, Robert. 1986. *Salomon Brothers, 1910-1985: Advancing to Leadership*. New York: Salomon Brothers.
Spiro, Leah Nathans. 1994. “The Trader.” *Business Week*: 50-60.
Stark, David. 2000. “For a Sociology of worth.”
Vasicek, Oldrich. 1977. “An Equilibrium Characterization of the Term Structure.” *Journal of Financial Economics* 5:177-188.
White, Harrison C. 1981. “Where Do Markets Come From?” *American Journal of Sociology* 87:517-547.

White, Harrison C. 2001. *Markets from Networks*. Princeton, N.J.: Princeton University Press.
Zelizer, Viviana A. Rotman. 1979. *Morals and Markets: The Development of Life Insurance in the United States*. New York: Columbia University Press.
Zuckerman, Ezra W. 1999. "The Categorical Imperative: Securities Analysts and the Illegitimacy Discount." *American Journal of Sociology* 104:1398-1438.

Figure 2 Swap Spreads of US, UK, French & Japanese Bonds

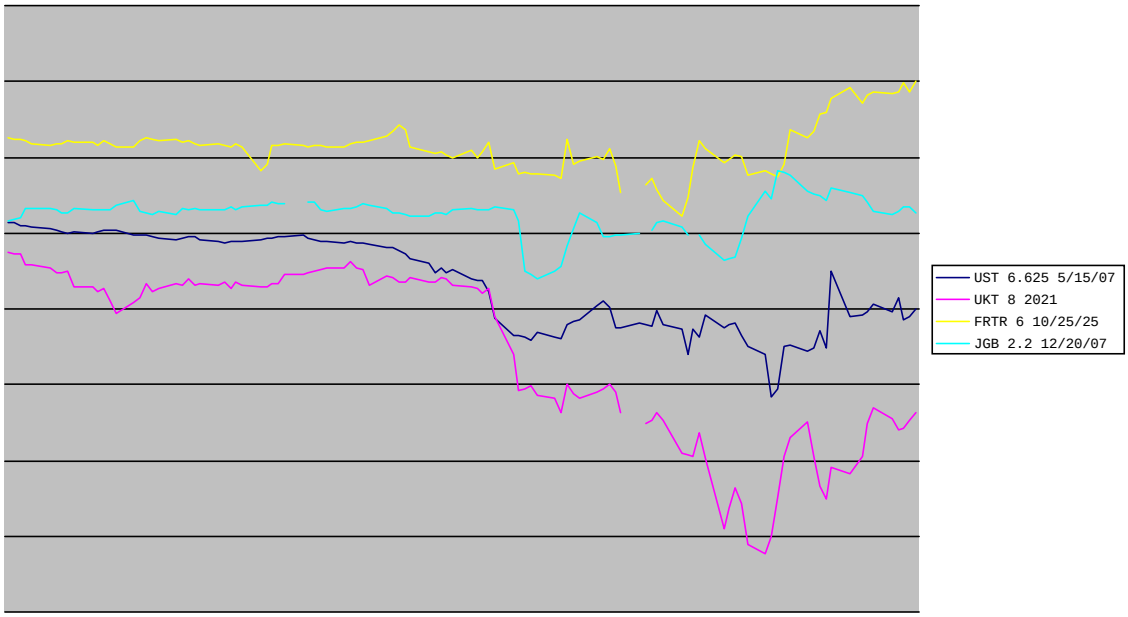


Figure 3 Royal Dutch premium to Shell Transpor

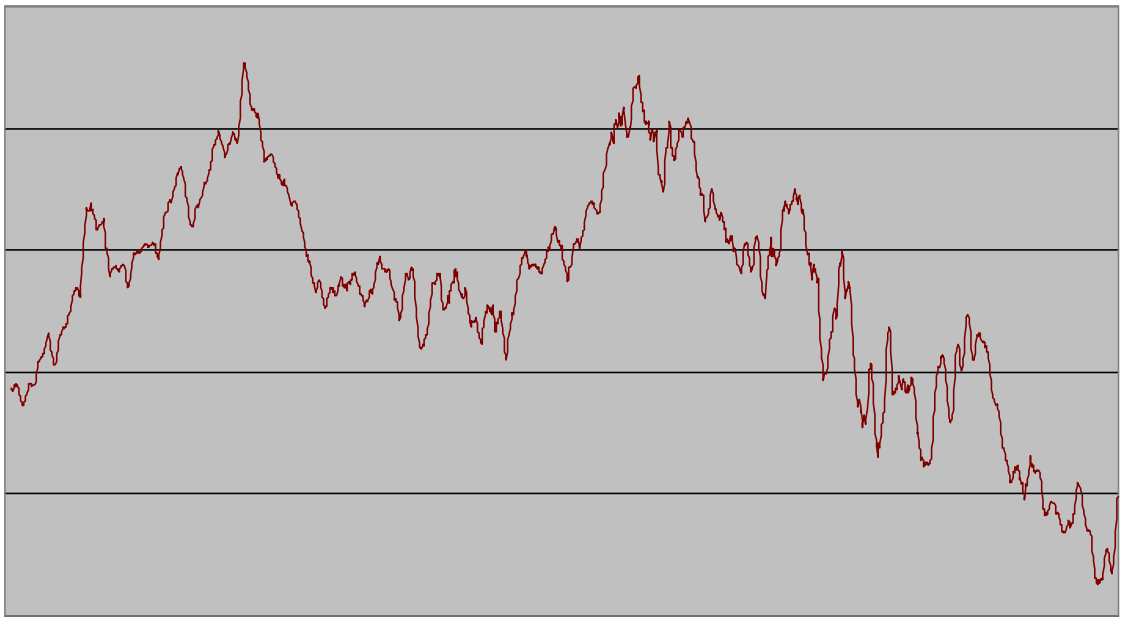
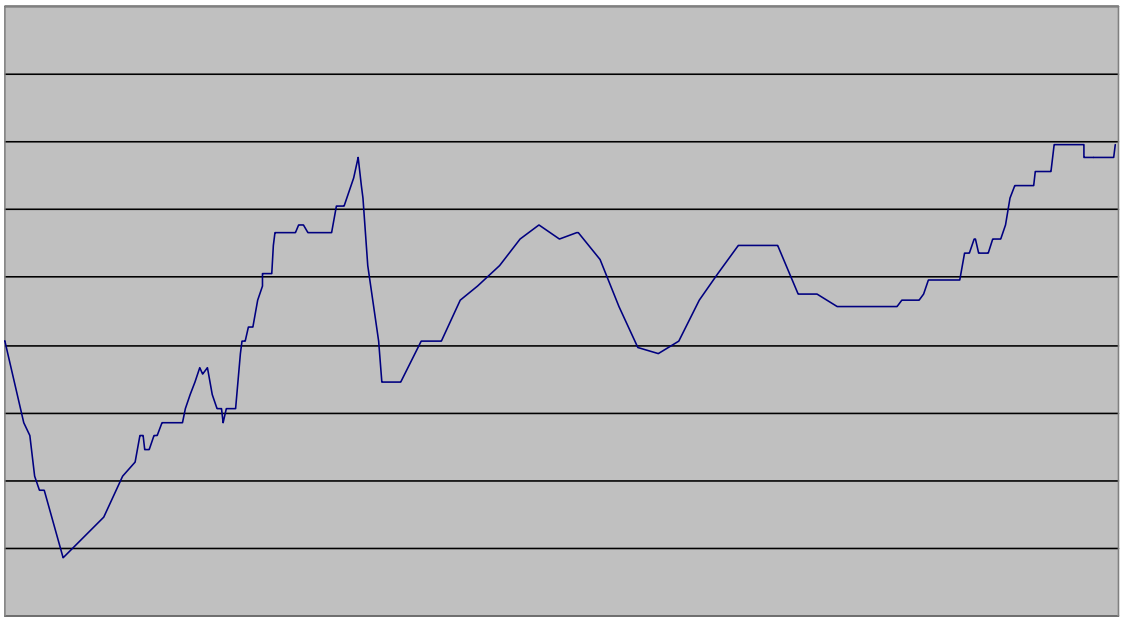


Figure 4 Spread between BOT-Libor and lira Libor (CCT05/03 implied spread to Libo



	June / July 1998	September 1998	Increase (percentage points)
S&P 500 (U.S.)	23%	30.3%	7.3
FTSE 100 (U.K.)	22.9%	32.4%	9.5
CAC (France)	25.8%	32.9%	7.1
SMI (Switzerland)	26.1%	35.5%	9.4
DAX (Germany)	26.5%	35.5%	9
NK225 (Japan)	25.6%	30.3%	4.7

Table 1. Average implied volatilities (annualized) of 5-year options on major stock-market indices.

	June / July 1998	September 1998	Increase
France	17	23	6
U.S.	41	64	23
U.K.	52	92	40
Japan	34	41	7

Table 2. Average swap spreads (basis points) against selected government bonds:

France: 6% coupon, maturing October 25, 2025

U.S. 6.625% coupon, maturing May 15, 2007

U.K. 8% coupon, maturing August, 2021

Japan 2.2% coupon, maturing December 20, 2007.

	Type of case	Relation of Aug/Sept '98 price movements to superportfolio(s) and flight to quality (q) explanations
1 Equity volatility	type 1	Consistent with s; inconsistent with q: see text
2 U.S. swap spreads 3 European differential swap spreads	type 2 in France and Germany; type 1 comparison of U.S. and U.K. with Japan	Consistent with s; inconsistent with q: see text
4 Commercial mortgages	type 1	Consistent with s; inconsistent with q: note a
5 Deutschmark/euro swap options	type 1 and type 2	Consistent with s; inconsistent with q: note b
6 BOTLibor vs. Libor	element of type 2	Consistent with s; possibly inconsistent with q: note c
7 Yen differential swap spread	possible type 1	Consistent with s; possibly inconsistent with q: note d
8 Residential mortgages	neutral	Data not available
9 Sterling differential swap spread	possible type 1	Data not available
10 Risk arbitrage	possible type 1	Consistent with s; possibly inconsistent with q: note e
11 Corporate capital structure	unclear	Data not available
12 European equity pairs	partial type 1	Consistent with s; possibly inconsistent with q: note f
13 Japanese bank preference shares	possible type 2	Data not available

Table 3. LTCM's 13 major positions in August 1998, classified by relationship to flight to quality / superportfolio explanations.

Type 1: comparison of similar spreads / implied 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% coupon maturing February 15, 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 should rise relative to Libor in crisis, but fell: see text pp. 26-27 and figure 3.

d LTCM long yen swap spread at 6-year maturity vs. short swap spread at 9-year maturity. In flight to quality, some expectation that shorter-maturity swap spreads will widen more; in fact, 9-year spread widened more.

e Largest-ever drop in "Merger Fund" (risk arbitrage fund) price; interviewees suggest drop 3 times level accountable for by merger breaks. However, perceived risk of latter does rise during market falls.

f Royal Dutch premium over Shell* rose: see figure 4. 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.

Notes to table 3. bp = basis point(s).