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Managing Dispersed Knowledge in Global Finance

Abstract. This paper considers the ways in which foreign currency trading is managed within multinational financial service companies. At issue is the management of risk by firms over time (24 hours) and space (around the world) with reference to foreign exchange transactions. We distinguish between risk management as an issue of incremental adaptation within known parameters and risk management as an issue of innovation and response to unexpected market movements. How these modes of risk management are institutionally organised around the world on a 24 hour basis not only affects the performance of such firms as investment managers but may also affect the volatility of global financial markets themselves. We pay particular attention to the apparently mundane issues of from where the management process is centred, the actual mechanics of handing trading books on from market to market within the firm, and the calculation and communication of risk profiles from one market to the next. The paper emphasizes the problem of the management of dispersed information within the firm and relies upon both published empirical research on the patterns of foreign exchange volatility and a detailed study of the management processes of one global financial house.

Key words: foreign exchange, time and space, management, bureaucracy

JEL codes: F31, G15, G24

1. Introduction

In the public mind, the paraphernalia of international finance are well-known: the trading floor full of shouting, brightly coloured bodies, the dealing room full of macho adrenaline addicts, periodic financial crises signalled by serious-looking commentators standing outside the headquarters of a financial institution, and so on. It would be fair to say that these kinds of images are foremost in many academic minds as well as the underlying processes that they are assumed to represent: a frantic search for profit, the hyper-speed of communication driven by remorseless technological advance, and the crisis-prone nature of capitalism.

First amongst exemplars of these developments is the global foreign exchange (FX) market. Lone traders hunched over their desks secretly trading enormous amounts of other people's money around the world in the search for personal wealth is a recurrent image. By many accounts, these traders are cowboys (at best) or renegades (at worst) putting in play not only the fortunes of their banks, but also the stability of national currencies and the entire financial world. Respectable versions of much the same idea are found in commentaries on the role and status of financiers like George Soros, and the hedge fund industry that has followed in his wake and is now deeply embedded in the global investment strategies of the largest institutional investors. At the limit, FX trading is the *deus ex machina* of 'hot money' undermining the stability of whole countries and regions, thereby cementing the well-worn prejudices of critics concerning the tyranny of global finance and financialization in general.

In this paper, we suggest that these kinds of accounts are both problematic in their own terms and historically outdated in a number of key aspects. We argue that the freest of free markets, which foreign exchange markets are often presumed to represent, is more accurately represented as a bureaucratic process of risk management that is dependent upon assessing dispersed knowledge about market conditions and response within the firm and across the globe. As such, its purposes are really quite mundane and are characteristic of many firms and industries in which knowledge management and recursive learning are core components of competitive strategy (Nooteboom 2001). Perhaps more than in many other firms and industries, this kind of bureaucratic process is essential to corporate financial integrity and performance; indeed, these kinds of activities may also be essential to global financial stability given the apparent less-attractive alternatives (see generally Stiglitz 2002).

The paper is in four main parts. The next part sets out a series of four myths that continue to beset social commentaries on international financial markets, drawn from the experience of the 1980s, and the combination of forces that have now called them in to question. We seek to dispel these myths through close study of the global foreign exchange market. In the subsequent part of the paper, we introduce the foreign exchange market and consider its contemporary mechanics.[1] We show that FX trading is a continuous but time-sensitive process and is a global but also a spatially-sensitive process. Understanding the time and space of FX markets is vital in understanding how the FX trading process and its attendant risks are institutionally managed. Thereafter, we go on to document and explain how private financial institutions manage the trading process on a 24 hour basis around the globe. In developing this account, we are conscious of the need to understand both the routine management of currency trading and the responsiveness of private institutions to events within the 24 hour cycle of markets opening and closing one after the other.

At the core of the paper is a basic proposition: global FX trading is a deliberate process of managing *dispersed* knowledge so as to account for and control total institutional risk exposure. While individual greed is always present, seeking-out unrecognised black spots in the management process, we contend that the real issue is institutional coordination and management and especially the maintenance of bureaucratic procedures that control trading exposures across time and space. The penultimate part of the paper considers the growth of bureaucratic procedures in large international financial services firms. This growth is associated with increased technological sophistication, new systems of risk management, and ever more demanding regulatory requirements regarding compliance. Thus, modern FX corporate trading floors are nearer to process-regulated accounting machines than entrepreneurial bear pits. Finally, we provide a summary of our argument and its implications.

The paper utilises three main sources of evidence. The first source is published quantitative research on global trading patterns and volatilities. The second source consists of insights gleaned from our own detailed interviews taken from a study of the foreign exchange operations of one global banking operation. We believe this operation to be representative of the large commercial organizations that now encircle the globe.[2] The third source is our

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[1]/. Here, we are particularly interested in institutional investors, recognising their importance in the FX trading process (Chinn 2003; Davis and Steil 2001). We do not consider their clients in any detail.

[2]/. At the end of 2001, this institution had approximately $13.9 billion in revenues, $10 billion in equity and $406 billion in assets. It operated in 77 locations across more than 36 countries and was involved in a variety of activities including securities underwriting, sales and trading services, investment banking, private equity,

knowledge of the internal structures of large multinational financial institutions drawn from our own interaction with the international financial sector over twenty years or more (see, for example, Clark, Thrift and Tickell 2004). In any event, our paper is deliberately exploratory as much as it is designed to report evidence and findings from close dialogue.[3]

2. Leaving behind the 1980s

Much of the critical literature on international financial markets is predicated on a set of myths for our time that retain a strong grip on the imagination. One myth finds its wellspring in a particular historical period being based on studies carried out in the 1980s, the high-noon of a particular set of entrepreneurial practices and representations. This was the time of Thatcher's 'big bang' in the City of London described in Churchill's (2002) *Serious Money*, and Reagan's Wall Street boom brought compellingly to life in Tom Wolfe's (1990) *Bonfire of the Vanities* and Auletta's (2001) *Greed and Glory on Wall Street*. It was the time of 'greed is good', of red ties and braces, of champagne and oysters, of barrow-boy traders and star bosses, of unlimited masculinity and its accompanying sexism. It laid down a particular set of interpretations of international finance which haunt us today (reinforced, of course, by the TMT (technology, media and telecommunications) boom of the 1990s and the related activities of analysts in the Wall Street based financial institutions). These interpretations even have grip within international finance: some of its participants would have us believe that this is still the swashbuckling world to which they belong.[4]

A second myth takes it that the world of international finance lurches from boom to bust, from unbridled optimism to scandal and to irrational pessimism This myth is usually framed as a moral lesson about the iniquities and necessary failures of neoliberal capitalism. Whether it is Orange County derivatives, the LTCM crash, a rogue trader bringing down a bank, or some other manifestation, all are grist for the moral mill. The result is that

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financial advisory services, investment research, venture capital, correspondent brokerage services and asset management.

[3]/. This kind of inductive process of both empirical analysis and theoretical speculation is increasingly important in the social sciences, and is characteristic of recent developments in economic geography and finance (see Clark 1998, Thrift 1997, and Wrigley, Currah and Wood 2003). But it is also a vital research tool in finance and economics in helping to build a better understanding of the behavioural structures underpinning global financial markets (see Shiller 2000; 2003).

[4]/. It is instructive to pick one of the above mentioned books and view its contents on web sites like bn.com and amazon.com. These sites often list the related books bought by consumers who purchased one of those listed. There is a veritable market for the guts and gore of global financial malfeasance.

exceptional events are written about to a much greater degree than the ordinary but vital day-to-day operations of international finance. The mechanics of everyday reproduction are ignored or lost in a rush to demonise the unruly nature of financial capitalism.

The third myth centres around speed. According to many commentators, international finance has become a set of continuously moving markets, sustained by the seamless spread of information and the increasing speed of modern communications technology. Mythically, the world of international finance has become a uniform landscape over which money flows like mercury in response to the slightest variation in expectations. And the future holds out the promise of more of the same: it is supposed that each and every financial market which does not operate on this basis will gradually be forced to accommodate the imperatives of global integration. It may be a myth, but it is also a claim made about the functioning of financial markets now (O'Brien 1992) and in the future (Shiller 2003).

The fourth myth centres on the presumed ubiquity of information. And yet, commentators point to a paradox: on one side, the power of privileged forms of information exchange that still rely on unmediated communication whether these be the buzz of dealing floors or the power of gossip retailed in pubs and wine bars. On the other side, an environment characterised by more and more mediated electronic communication from the telephone to the screen, from instant messaging to electronic data display etc. At the limit, this myth would have it that it does not matter where in time and space we are located - we can all trade in the global marketplace on equal terms not withstanding the evidence to the contrary (see Clark and Wojcik 2004 on related commentaries regarding the value of trading location in pricing the integration of European capital markets).

In this paper we seek to show through a detailed case study of global foreign exchange trading that each of these four myths is suspect. They persist because of a curious lack of attention to changing circumstances, a tendency to hyperbole instead of empirical analysis, and a large dollop of technological determinism. In particular, we wish to show how four forces have become so intertwined to produce a global foreign exchange market rather different from the one commonly found in the critical social science literature if not in the expert studies of market performance.

The first and most obvious of these forces is the gathering global recession accentuating competitive pressures and scale. Since the burst of the TMT bubble at the end of 2000, the world's financial markets have been subject to a marked slowdown in the growth of transactions. Coupled with declining demand for advanced financial products and traded securities, the slowing rate of growth has introduced great pressure on the cost structures of international financial firms. In turn, this has been particularly problematic for smaller firms that do not have the operational reach or depth of liquidity to participate fully in

markets where very large sequential trades across the globe are used to pick up the slightest of profits from the smallest differences of a few basis points.

The second force is technological efficiency. Since the 1980s, information technology has continued to grow in scale, effectiveness, and price. In turn, firms must now operate at much the same electronic speeds, have access to many of the same products (and, if they do not have them, be able to catch up more quickly than in the past), and have access to much the same information and expertise. Even though the set-up or sunk costs associated with market position have greatly increased in significance, competitive edge is much more difficult to have and to hold. Similarly, markets are less likely to be characterized by systematic inefficiencies than in the past. High levels of information flows and the application of advanced technology have ironed-out arbitrage opportunities, making for fewer of those opportunities while reducing the size of pay-offs when such opportunities arise.

The third force is increasing market concentration. The largest international financial firms dominate global market trading and dominate many developed domestic markets. Furthermore, market concentration measured in terms of the share of all transactions held by the largest firms is remorselessly increasing within and between capital markets and is especially apparent in the US and Europe (Davis and Steil 2001). These firms are not the swashbuckling entities of folklore. They are very large and complex bureaucracies which depend on highly-articulated hierarchies of control, management, and the flow of information. Their best interests are served by knowing what every one of their traders are doing on a near to continuous basis.

The fourth force is regulation. The intrusion of regulation on firms' operations is much greater than is often realised and is growing - the product of the crises of the 1990s and the concern of multilateral and national institutions charged with global financial stability. Not only do the requirements of regulatory compliance strengthen the bureaucratic impulse of corporate managers, not least by strengthening the hand of back-office oversight, it also produces its own bureaucratic layers with their own agendas outside of trading and making an immediate profit. In other words, regulation has become a corporate force in its own right, a point that, like the others, we use in subsequent sections of the paper.

3. Foreign exchange markets

Foreign exchange trading is reckoned to be a vital cog in the global economy. It is essential for cross-border business transactions, trade and commodity exchange, and the flow of portfolio and direct foreign investment. It is also essential for governments of all political

persuasions, and is especially important when offering sovereign debt. No national economy is immune from its effects.[5] At a most mundane level, and usually unnoticed by most people, FX trading greases the wheels of vacation travel and the like. In all, the unadjusted foreign currency cross-border assets of banks reporting to the Bank for International Settlements in September 2002 were just over $7 trillion (compared with $6.5 trillion in December 2001) (BIS 2003, Table 5A, p. A16). Average daily turnover on traditional foreign exchange markets is of an order of magnitude larger: the latest confirmed data were $1.2 trillion per day for April 2001 (BIS 2002; compare Roberts 1995 with Harris 2002). Large numbers indeed.

FX trading comprises a series of markets which are usually bundled up together. Not only does it consist of standard trades between currencies (so-called vanilla) but it also takes in a series of more specialised sub-markets. For example, in the large financial institution we studied, there were dedicated teams involved in fixed income and various kinds of exotics ranging from vanilla FX options to far more complex options which involved several varieties of derivatives and spread betting. Each of these markets had their own range (for example, exotics were rarely traded in more than seven or eight currencies), skills (for example, exotics typically demand much higher levels of quantitative expertise to both develop and run), tempo, and spatial distribution.6

By contrast, much of the academic research devoted to FX is about long-term macro-economic fundamentals such as relative money supply or relative velocity of circulation. However, of late, more and more research time has been devoted to analysing and modelling the microstructure of FX markets, recognising that the management of information and the behavioural responses to information are vital elements in all financial markets (Wilhelm and Downing 2001). This paper focuses on short-term volatility in currency exchange rates, being conscious of the fact it is short-term volatility rather than long-term trends that preoccupies FX traders around the world. Further, and like Knorr-Cetina and Bruegger (2002a, 2002b), our contribution to understanding FX trading is focused on the management of the trading process, even if we conclude that bureaucracies

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[5]/. To illustrate, consider the November issue of the OECD's (2002) *Financial Market Trends*. Therein, after a page devoted to broad trends and prospects, the report looks in detail at FX markets before considering recent developments in interest rates, equity and bond markets, and the management of global market volatility. Financial stability, domestic and international, is driven in part by FX markets.

[6]/.The latest confirmed data on FX derivatives trading indicated that daily average turnover was in the order of $1.4 trillion for April 2001 (BIS 2002).

and teams are more important than sole traders (perhaps the product of our particular focus).

Another contribution of the paper is our argument that the management process is both systematic and is characterised by deliberate attempts at fostering intra-bank learning within and between related *teams* operating in markets over time, an issue dealt with by many analysts including Nooteboom (2002). Individuals are, of course, assessed in terms of their own performance. But, despite all the furore sparked by the large salaries and bonuses generated by some individual traders, the overall performance of FX trading within international financial institutions is much more a function of the formal and informal mechanisms of fostering teamwork and managing the shared knowledge and expertise that teams corporately generate and own (while recognising that there are also substantial competitive pressures between individuals in teams and between teams; see Ackerman, Pipek and Wulf, 2002). Without the collaborative support of team members, all would be the poorer.

3.1 Global FX market structure

Over the 1980s and 1990s, Western industrialised countries deregulated their currency exchange markets. Previous attempts at fixing exchange rates were shown to be problematic amongst the developed economies; witness the experience of Great Britain with the European exchange-rate mechanism (ERM) during the early 1990s. More recently, successive regional crises (in Asia, Russia, and Latin America) have also shown that nation-state attempts at global currency management are extremely difficult in the face of enormous financial flows around the world, notwithstanding the fact that many countries outside the OECD use administrative systems to dampen currency inflows and outflows.

At its core, the global FX currency market is a private market that uses the US dollar as the reference currency. Evans (2002) characterised the structure of the FX market as follows. It is a decentralised, multi-dealer market with three types of FX trading: direct inter-dealer trading, brokered inter-dealer trading, and non-bank customer-dealer trading. The FX 'market' is actually a virtual set of sequentially-related regional markets linked together by high-speed electronic systems (the Reuters system dominates all other systems). Being a system of exchange, it allows for simultaneous bids, offers, and trades wherein dealers 'call' one another for quotes on pairs of currencies with the expectation of acceptance or decline of those bids within seconds. In sum, the market is open 24 hours-a-day and 365 days a year, and is in theory accessible to traders from virtually any location in space and time. But, of course, most traders are the employees of large financial institutions just as the

overwhelming volume of FX transactions come from those institutions rather than individuals trading on their own account.

The academic literature has focused upon currency exchange rates, being concerned about long-term macro-economic trends in the value of individual countries' currencies in relation to the US dollar and the other core reference currencies, including the British pound, the Japanese yen, and the Euro. Over the long term, it is arguable that exchange rates should reflect nation-state comparative advantage in the trade of commodities and services (Sarno and Taylor 2000). Thus long-term exchange rates should reflect nation-state economic growth potentials including expected rates of economic growth, labour productivity, and innovation. Indeed, much of the literature on national rates of economic growth and comparisons between national growth potentials assume there is no FX effect on those fundamentals. In other words, FX rates are assumed to be the medium through which national growth potentials are priced. For example, recent debate about the relative growth prospects of the US economy in relation to its European competitors suggests that the price of the US dollar in relation to the Euro fully reflects its potential.7

To illustrate, Figure 1 displays daily closing exchange rates for three pairs of currencies: the Euro in relation to the US dollar, the British pound in relation to the US dollar, and the Japanese yen in relation to the US dollar. This is a useful way of representing longer-term trends, recognising that the daily closing price at London is just a moment in time. Therein, we can easily discern for the Euro and the British pound the slow discounting of both currencies in relation to the US dollar over the last phases of the boom and bubble in TMT stocks. Thereafter, we can also discern the slow discounting of the US dollar against the Euro and the British pound as investors came to terms with the cost and consequences of the TMT bubble in the United States. Over this same period of time, it is apparent that the Japanese yen was less dominated by long-term expectations and more often affected by shorter-term shifts in expectations as Japanese government policy has failed time and again to deal with the stagnation slowly enveloping Japan. Other interpretations are possible, and may be adjudicated by reference to macroeconomics assuming a relationship between observed short-term patterns and long-term fundamentals (Sarno and Taylor 2000).

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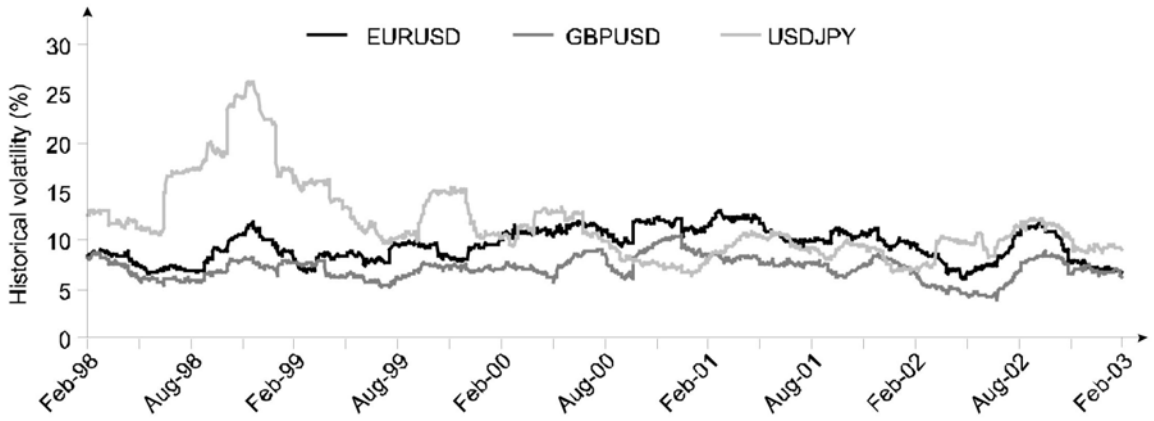
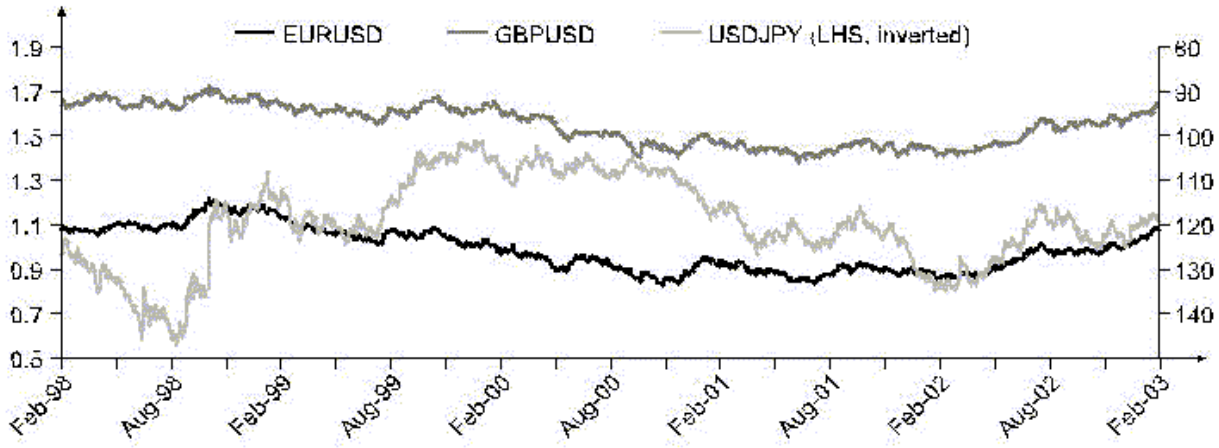
[7]/. This is the lifeblood of global investment banks. There is a premium for informed commentaries on the relative value of the US dollar compared to the Euro, GBP, and Japanese Yen which mix together current issues like the prospects and consequences of war with the productivity effects of the new economy and labour and capital market flexibility in the United States. See the recent reports by Quinlan and McCaughrin (2002), and McCaughrin et al. (2002) from Morgan Stanley Dean Witter (New York) on these issues and more.

Figure 1: *Exchange rates: Euro, Sterling, Yen daily closing prices vs. US $ (Source: Credit Suisse First Boston)*



One step further, however, takes us to Figure 2 which displays exchange rate volatility for the same pairs of currencies. Again, this figure is based on daily closing prices using a 60-day moving average to smooth the observed patterns. Most notably, the Euro and sterling experienced very similar levels of volatility compared with the volatility of the Japanese yen in relation to the US dollar. In simple terms, Table 1 presents estimates of these similarities and differences as measured by the standard deviation and variance for the three sets of currencies. Since volatility is measured in percentage terms, underlying differences in exchange rate value are removed from the picture. Consequently, comparing volatility for the three currency pairs, it is apparent that there is far greater volatility in the Japanese exchange rate than the other two European currency exchange rates. Again, it is possible to think of reasonable theoretically-informed explanations of these long-term trends in volatility. But we must be cautious not to exaggerate the significance of theoretically-referenced long-term trends, whether in terms of exchange rates or their volatility.

Figure 2: *Exchange rates: Euro, Sterling, Yen (60 days rolling period looking backward. Source: Credit Suisse First Boston)*



In fact, the available evidence suggests that much of the observed variance in exchange rates is short-term rather than long-term and is to be found within the day rather than between days, weeks, months and years. Furthermore, it is widely conceded that theoretical models based on economic fundamentals are very poor predictors of short-term exchange rates and are virtually irrelevant to the question of exchange rate volatility.[8] It is not possible to work backwards from long-term patterns in exchange rates to predicting intra-day exchange rate volatility. Whereas most theoretical models are focused upon exchange rates, the volatility of intra-day exchange rates is the issue that dominates the trading process. Not surprisingly, then, stochastic time series models clearly out-perform econometric models when intra-day data is taken into account. As a consequence, there is increasing interest in the micro-economic and behavioural processes that drive global day-to-day FX operations.

[8]/. See Sarno and Taylor (2000, 136) who conclude their review of the value of theoretical models of long-term exchange rates with the observation that "empirical work on exchange rates has not produced models that are sufficiently statistically satisfactory to be considered reliable and robust".

Table 1: *Summary statistics: Euro, Sterling and Yen exchange rate and volatility statistics (based on 5 years sample of daily data. Source: Credit Suisse First Boston)*

	Currency Pairs					
Statistics	EURUSD	GBPUSD	USDJPY	EURUSD Vol	GBPUSD Vol	USDJPY Vol
Mean	0.9887	1.5467	119.6273	9.5025	7.1887	11.7122
Median	0.9817	1.5649	120.1125	9.5993	7.3029	10.5879
Standard Deviation	0.0955	0.0911	9.9867	1.6528	1.1867	3.9536
Sample Variance	0.0091	0.0083	99.7346	2.7316	1.4084	15.6306
Kurtosis	-1.0154	-1.4631	-0.3474	-1.0735	0.1405	2.6153
Skewness	0.3064	-0.0945	0.3250	-0.0600	-0.0940	1.5921
Range	0.3878	0.3465	45.6950	6.8643	6.5916	19.8191
Minimun	0.8271	1.3733	101.4850	6.0832	3.8985	6.4652
Maximum	1.2149	1.7197	147.1800	12.9476	10.4901	26.2844

3.2 Temporal and spatial trading patterns

At the same time, it should be recognised that there *is* detailed information on both the temporal and geographical structure of FX trading patterns. In fact, recent statistical studies can provide us with a clear characterisation of the various components that make up intra-day FX volatility; see Andersen et al. (1998, 1999, 2000), Evans (2002), and many others for further details. Most importantly, such characterisations depend a great deal upon knowledge of the opening and closing as well as their moments of overlap of the three core global FX markets: in order of GMT, Tokyo, London, and New York. To illustrate, Andersen et al. (1998, 221) characterised the spot DM-US dollar market in the following terms: "a 24-hour market composed of sequential and partially overlapping trading in regional centres worldwide, so it has no definite closures, except those generated endogenously by the market. This allows for the study of the volatility process over periods that would be non-trading intervals under centralised market structures...".

Evans (2002) showed that in each of these markets the 'home' currency is the most traded currency in relation to the US dollar, recognising that London is both the centre for trading in sterling and the Euro. In describing FX trade over the course of a day, he suggested that it can be characterised as 'triple-humped'. Beginning about 1am GMT in Tokyo, the first hump is relatively low volume. That is followed by the opening at about 7am GMT in London

for trade in sterling and the Euro which records the highest volume of trade over the day, which is followed in turn at about 12:30pm GMT by the opening of New York at a lower volume of trade than London. In terms of the management of the trading process within many FX companies, the close of trade in New York effectively closes the book for that day on FX operations.[9] This is customary practice for many such firms in the industry and around the world. We noted above that trade is anonymous in the market, and that the volume and volatility of trading is closely associated with the entry and exit of market traders by region. In fact, although trading can be continuous second by second, minute by minute, and hour by hour throughout the 24 hour cycle it is commonly observed that trade peaks at the opening and closing of each of the three markets.

Notice that London has an especially important place in the 24-hour cycle of FX trading. This is partly because of its historical role as a centre of calculation collecting diverse market interests from around the world, and providing an unmatched depth of liquidity and range of risk preferences (Clark 2003). The role of London has also been important in recent financial history, being particularly associated with the 'big-bang' in the 1980s, the subsequent float of major European currencies, and the introduction of the Euro. Furthermore, London is very important as a switching point between Asia and Europe and Europe and North America being a place where financial deals can be packaged and priced in terms of their currency exposure. As has been suggested many times in interview, if London didn't exist it would have to be invented at much the same place in time and space between Tokyo and New York.[10] It could be in Paris or Frankfurt, but for all these reasons, reinforced by the concentration of related banks and trading talent, flexibility and technological capacity, London remains the dominant international financial centre.[11]

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[9]/. In fact, in our global financial institution, close of play was taken to be 1615 EST with all subsequent trades going on to the next day. The situation is even more complicated because common books are not really passed on in the way depicted in many accounts. In our global financial institution, each region still had its own books even if positions were passed on between markets.

[10]/. It has also been suggested that London is important because the Pacific Ocean is too wide (in time). If it were narrower, presumably New York would be able to bridge the gap thereby being able to compete directly with London. Geography in this sense is a marvellously simple idea.

[11]/. We would suggest, moreover, that the traditional virtues associated with London as being a place of gossip and face-to-face contact is less relevant than often assumed, given the significance of electronic linkages and networks on a second-by-second basis. In any event, like Cheung, Chinn and Marsh (2000) we have not found any discernable firm-specific or market-specific collective view about the significance or otherwise of the determinants of long-term trends.

Considerable research has focused upon the role of information flow and sources in driving trading volume and volatility on an intra-day, daily, weekly, and calendar-basis. Anticipated public disclosures of relevant macro-economic and monetary information have an impact upon FX trading by region. In some cases, especially those associated with news from New York, the impact of this kind of news can be distributed in time over the day. However, it has also been observed that anticipated public news has a limited temporal and spatial impact upon trading intensity even if public news may have an immediate and significant affect on the FX market concerned (Galati and Ho 2001). This type of information is thought to underpin long-term patterns embedded in observed short-run high-frequency volatility. Even so, since such announcements are regular, they are also, more often than not, anticipated in terms of their likely effects upon regional markets as well as the turnover between markets. Expectations are an essential ingredient in FX trading especially if there are marked differences between markets in the meaning attributed to anticipated announcements.

On the other hand, it appears that unanticipated private information has the biggest impact upon trading volume and intensity in FX markets. For Evans (2002), this is because of the apparent anonymity of FX markets and the fact that FX trades cannot be directly observed by third parties not involved in those trades. As a consequence, at any point in time there is a distribution of exchange rates and an intensive search by traders for an approximate reference point in making subsequent trades. In other words, just as there is a distribution of FX prices at any point in time and space that distribution is itself partially dependent upon previous distributions of FX prices. More technically, it is observed that FX markets are characterised by informational asymmetries, by heterogeneous expectations, and by an ever-present need to trade when others trade so that current conditions are revealed to traders by sequential pairs of currency trades. By this logic, traders cannot afford to 'sit-out' the market awaiting new information that would propel local market traders to an expected equilibrium point in the relationship between currencies.

The exact temporal and spatial decay function is therefore less important at this juncture than the realisation that the significance of this component also varies by trading intensity. Although the electronic trading system is available for FX trading every second of every day, FX trading is not continuous but marked by identifiable trading peaks and troughs within each day by market. Evans' (2002) observations and arguments provide a compelling rationale for strong intra-day patterns. What is not often realised is that the significance of the 'sampling' component of FX volatility varies in terms of the volume of trading. Whereas it is the dominant component in normal market conditions, it declines in significance when trading intensity is very high suggesting that in these circumstances the distribution of FX

prices narrows and converges towards a shared reference point only to diverge and once again spread as trading intensity declines. There appears to be no *necessary* intra-day temporal pattern of high activity *except* for the fact that all traders are aware of the peaks in trade associated with market opening and closing. Under conditions of uncertainty, traders bunch together at those moments in time and space for more information (characteristic of all securities markets; see Shin 2003).[12]

Added to this problem of managing the 24-hour market structure is the problem of managing speed. It cannot be gainsaid that, under pressure from improvements in information and communications technology, financial markets have tended to demand more and more rapid response, especially in markets like FX which depend on arbitrage to such a degree. But the problems presented by speed should not be overplayed for at least two reasons. First, the markets are only nominally 24 hours. There is still, in reality, a gap of an hour or so in the global 24 hour clock between New York and Tokyo. As well, there is the problem of settlement. We were constantly told that managing 24-hour books 'would be a nightmare'. Like the noonday sight at sea, there has to be a close of business in order to assess net positions. In any event, handing on a book from one market to another takes a considerable amount of time. The process is not instant: it occupies several hours each day, involving regional and global members of the FX team in constant conversation and what can often be a complex series of negotiations (see Table 2).

Table 2: *A typical FX dealing timetable for London*

Time	Action
06.30	Starting to pass the book from Tokyo
07.00	Update volatility curves
07.00-07.30	London and Tokyo make prices together
07.30-08.00	Take deltas (management of spot risk)
08.00	All prices made by London (RISK TRANSFERRED)
12.00-15.30	Same process gone through with New York
15.00	Option expiry time
15.30	London no longer actively involved in trading (RISK TRANSFERRED)
15.30-17.30	Administration

[12]/. In fact, the search for information by sampling others' expectations and positions is reputedly one explanation for the enormous volume of FX trading day in and day out (Harris 2002).

4. Corporate management of FX trading

Having outlined the nature of the FX markets, we can now consider the management problem that this poses for participants. We hope to identify the basic elements of the FX management problem by drawing upon the observations made above about the temporal and spatial patterns apparent in global FX trading. In doing so, we focus upon three kinds of 'agents and institutions': individual traders, their firms, and the markets in which they operate. Most importantly, we focus upon how global financial firms manage time and space on a 24 hour basis by being responsive to anticipated and expected events arising market by market, as well as the unexpected and surprising events that may drive high levels of intra-day market volatility. In the first instance, this requires conceptualising the FX management problem. In the second instance, it allows us to emphasize the *bureaucratic* nature of corporate decision-making.

Of course, bureaucracies have had a notoriously bad press of late. In the face of 1990s management paradigms focused around concepts like networks and communities of practice, hierarchical bureaucracies have often been depicted as shallow and energy-sapping forms of organization, sets of mundane routines that are inimical to the production of enterprising cultures and persons (Leavitt 2003): at odds, one might think, with what is often depicted as the free-wheeling nature of trading. In fact, as we have argued, the FX markets rely on vast swathes of bureaucratic routine to function, from the day-to-day minutiae of settlement and compliance to the larger issues of regulation and general managerial oversight. Further, it is doubtful that bureaucracy is simply useful background for more entrepreneurial activities: most entrepreneurial activities like trading rely on bureaucratic routines for sustenance, whether these are embedded in software packages, organisational knowledge or highly complex logistics. Indeed, du Gay (2000) goes as far as to argue that bureaucracy ought to be seen as a substantial ethical domain in its own right and not just an impoverished set of checks and balances on the real business of entrepreneurial effort.

Yet, in a series of descriptions of financial markets dating from Bagehot and Weber, it has become commonplace to regard financial markets as the very opposite of bureaucracies. As we have tried to show, the scale of the management task of collecting and synthesizing dispersed financial knowledge is now so great that for the main corporate players who constitute so much of the market this no longer amounts to a realistic or even desired description. Large financial firms are highly structured, hierarchical operations that try to impose order and security as well as make a profit (the two by no means being inimical to one another). Though regional FX teams may work quasi-independently, they are all overseen by an inevitably authoritarian management hierarchy whose task is to manage risk

on a global scale in organizations which may have been put together through mergers and acquisitions and therefore may have a mix of quite different cultures and even quite serious rivalries. Thus the managerial imperative is consistently towards a classical nested organisational hierarchy with each team head reporting upwards in a formal fashion to the global manager (see also, and generally, Thompson 2003).

4.1 Managing dispersed knowledge

At the most general level, FX management is a problem of managing dispersed knowledge. This issue has been the subject of increasing research in the management literature, and is the subject of Becker's (2001) seminal paper, and related research by writers like Girard and Stark (2002).[13] In essence, Becker contends that the issue of dispersed knowledge is representative of a most important aspect of modern economies, that being the utilization of knowledge where economic agents are themselves decentralised and coordinated through market exchange. Becker cites the relevant literature and goes on to reference Hayek and his argument to the effect that in market economies characterised by the division of labour knowledge must be organised, codified, and deliberately managed if agents and their institutions are to be competitive with one another. Further, Becker suggests that this issue is now "more salient than ever" (p. 1039). Because many markets and systems of production and exchange are global rather than local, and because networks of communication allow access to markets by people from many more locations in space and time than ever before, dispersed knowledge is now one of the most important management issues preoccupying firms and their managers.

Assume that FX trading firms and their employees seek to maximise, respectively, reported profit (by division) and earned income (including yearly bonuses) while minimising firm costs and potential catastrophic losses. Also assume that, given the robustness of firms' reporting practices and monitoring functions, it is difficult for any individual trader to build up over time positions that threaten the financial integrity of their firm. We must assume, however, that firms have an interest in allowing their traders sufficient discretion that firms may benefit from their employees' exploitation of market knowledge, experience, and intuition. In other words, the most important imperative driving the FX trading process is the interest of traders and their firms in making money day after day, week after week, and

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[13]/. We use the term 'dispersed knowledge' because it captures succinctly the geography we wish to analyse. But other related conceptual reference points would work as well including 'cognitive distance' and the 'cycle of discovery' (see Gilsing and Nooteboom 2002).

year after year. In this respect, traders and their institutions cannot afford to sit out market trading in the hope that collecting and organising market knowledge will allow them an opportunity to make 'excess' profit out of a limited set of trades. For any firm seeking to maximize profit from FX trading, achieving this goal is a function of the strategic collection and dissemination of knowledge to and from their own traders located in different markets around the globe. This is an essential management function, and an issue of managerial control. It goes beyond the issue of setting correct incentives to the organisation of the firm itself.[14]

This issue can be characterised in the following ways. With respect to intra-day FX trading, firms must manage the flow of knowledge (1) within each market and between their traders (within the firm), (2) between each market and between their market-based traders (within the firm), and (3) within and between markets with reference to external (non-firm) traders. They must do so in ways that sustain mutual learning between team members and recursive response to changing conditions across the globe. It is a deliberately managed process because the costs of individual discretion and competition between team members are too high, even potentially catastrophic for the firm and the global financial system.

Before carrying out these tasks, firms must decide whether traders trade on their own account or trade as members of market-specific teams, and whether the geographical and temporal segmentation of FX markets should carry over into the accounting structure of the day-to-day performance of the firm itself. For the moment, let us assume that traders trade as members of market-specific teams and that those teams are held to account in terms of their contribution to the day-to-day performance of the firm in foreign exchange currency markets. We will explain how and why this is the case in the next section. All we need suggest at the moment is that knowledge management and integration is more efficient if individual traders have a clear responsibility to their market-specific teams and if each team has a responsibility to the subsequent market team (in time and space). In essence, our experience is that there is an operational hierarchy that culminates in just one FX team in the firm, a team that is global in scope.

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[14]/. By contrast, much of the literature in finance when dealing with similar issues emphasizes the cognitive and behavioural biases apparent in many individuals when dealing with risk and return, the valuation of reward and loss, and the response to time-dependent events. In this respect, the finance literature ignores the institutional management of knowledge and behaviour. It is pre-occupied with 'star-traders' rather than institutional structure (see Clark 2000 on related issues relevant to pension fund and investment decision making).

4.2 Bureaucracy and regulation

This kind of managerial imperative has only been underlined by three further developments which strengthen the hold of hierarchy and general bureaucratic procedure. The first of these is the capacity for technological oversight of each trader and team's performance. The growth of information and communications technology and, much more importantly, the increasing ability to stitch together often quite diverse systems into a functioning whole, has gradually allowed key managers to gain oversight of performance at all relevant points (in time and space) of the firm.[15] Thus, the global FX manager knows the position of every trader at the end of each day and should be able to pick up rogue traders within one day or a few days at most. Whereas some analysts of related phenomenon emphasize the development of trust between related individuals as a crucial social regulatory determinant of information flow, it is clear that this kind of device is fragile at best in the face of temptation.

The second development is the growth of risk management which is meant to constantly monitor and assess risk exposure. All large international financial services firms have large risk measurement and management divisions which usually monitor trading according to limits set by a Senior Management Committee or equivalent. These divisions are hungry for data with which they assess the state of play of the firm at selected points in time and space. They use various software packages to help them achieve this goal, some of which are written in-house and some of which are proprietary. The goal is to speed up the system of monitoring so as to get as close to the close of business as possible. Even so, this has not proved easy. There have been significant problems in handling the flow of data.

The third development is the growth of regulation. The enormous growth in regulatory demands has in large part grown out of periodic financial scandals which have underlined the need for more control, as well as adding new semi-independent layers of bureaucracy. In our case study, trading teams may have acted to an entrepreneurial stereotype but this stereotype was encased in bureaucratic systems of oversight and regulation, much of which the teams themselves seemed to be only partially aware of. What seems clear, however, is that there has been a shift in the balance of power between the front and back office. The back office has become more important, partly because of all the requirements of oversight

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[15]/. This has proved an enormous problem in most international financial services firms. For example, in the firm we studied computer systems had been quite different in different world regions and there were still substantial problems with legacy systems. It is no surprise, then, that very large amounts of effort still go into developing software. Even a small team may have ten people on its IT side. Mainline FX teams may have upwards of 120.

and regulation, partly because front and back offices have become 'closer' through electronic booking, partly because more senior managers have had to take on certain back office functions, and partly because the entrepreneurial ethic, though still valued, has been in part subsumed under the imperatives of safety.

Perhaps the best means of symbolizing this change is through what has happened to trading floors. Ten or even five years ago trading floors were often noisy places. Traders existed in a noisy hubbub as information, rumour and mood were passed back and forth as means of finding opportunities for arbitrage. That has now changed. Most trading floors are quiet. Most FX trading takes place through the medium of the screen and electronic booking systems. Most information also comes through the screen – through proprietary services (and especially Bloomberg) or through e-mail and bulletin boards to which all the traders on the floor can contribute[16] – and through telephone conversations on open lines with company dealers in other locations.[17] Rumours no longer have the same place they once had in this world of 'response presence' in which much interaction is at a distance but, through the medium of teams and screens, can be gathered at one 'place' of management and control (see also Knorr-Cetina and Bruegger 2002a). They very rarely move the market because so many of them can be verified as true or false through a combination of the modern media and internal assessment within five minutes of their launch.[18]

The focus is therefore much more on 'sampling' market prices by reference to expected market-specific moments of collectivity and overlap, thereby providing those companies with the most resources (money and management) the opportunity to arbitrage around unexpected events.[19] Of course, speed is still vital on the trading floor. Indeed, given the paucity of opportunities in recession and the accelerating impact of technological change, the discipline of speed on FX trading may have even become greater. But, speed is mediated to a much greater degree than ever before by technological and team backup so that its effects may be rather less than are often envisaged.

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[16]/. One major rite of passage now is inserting information on the very public bulletin board: if it is proved wrong the contributor's credibility obviously declines.

[17]/. Open lines are crucial when, for example, London traders may be spending up to two hours a day on the line to their counterparts in New York and half-an-hour to an hour on the line to their counterparts in Tokyo handing on the book and generally talking business.

[18]/. The focus is therefore much more on set economic events (like interest rate changes) and analyses and arbitrage opportunities around these events.

[19]/. Similarly, it has become much easier to make educated guesses about the sources of activity in the market when relatively few key traders from relatively few financial services firms are making most of the running.

This does not mean there is no role for social glue, of course. But most of that glue is no longer the residue of local boozy nights out; FX traders may just as easily be a part of teams that stretch around the world. A good part of these dispersed teams will not therefore be physically present in the London trading room. Sociality is therefore deliberately engineered. Globally dispersed teams meet-up on a yearly basis and meet one-to-one much more frequently than that in order to talk strategy, swap new expertise, and hone existing communication skills.[20] Thus, at any one time, the trading floor consists of intra- and inter-floor linkages which cannot be separated out. The floor is partly a virtual society but one run on the assumption that teams interact face-to-face on occasion and learn the social assumptions and cues typical of other team members. Team membership is spun out of these assumptions and provides the cues for 'local' decision-making based upon certain well-defined parameters of shared experience (in ways consistent with Nooteboom's 2002 emphasis on managing the costs and consequences of 'cognitive distance').

Thus a crucial point that we want to end this section with is that it is dangerous to concentrate on just the traders and the trading floor, as has become common in a number of recent ethnographies which track the market as it is made. As we have tried to show, the management of these floors is more and more dictated from without by bureaucratic procedure which may or may not be crystallised in technological interfaces like the screen. Knorr-Cetina and Bruegger (2002a, 2002b) make this point but perhaps do not develop it far enough. In stressing the role of individual traders who are partially set apart from the rest of the corporate organization, they may have produced an account which is now historically misleading (Mitchell 2002). Whilst it is clearly the case that traders constitute the market they also increasingly represent corporate goals and organization, either in the form of codified rules of procedure, forms of oversight, and membership of a team which may stretch well beyond local traders code (Thrift and French 2002). There are more and more 'traffic cops' within firms with the result that the boundary between explicit and tacit knowledge of the markets is shifting in the former's direction (Wilhelm and Downing, 2001). In particular, as new metrics are invented and implemented (eg measures of overall corporate exposure), so they have become constitutive of organizations' work and new kinds of information and as new opportunities for control (all the way from new higher management meetings called to consider them to a raft of new additions to the corporate rule book for traders).

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[20]/. For example, the manager of one small team goes to Tokyo at least once a year to meet team members and to New York at least twice a year.

5. Conclusions

In this paper, we have tried to puncture four myths about global financial markets by appealing to a mix of our own observations and existing empirical work. We used the FX market on the grounds that, if it were possible to find counter-narratives in even this fast-moving and in many ways stereotypical financial market, then existing accounts of the pathologies of individual decision-making and market volatility might require considerable adjustment.

What we found was a market which is increasingly co-ordinated by large bureaucracies that attempt to make money by threading a large number of administrative procedures through individual entrepreneurial behaviour. Some of these bureaucratic procedures are activated through the medium of teams which are dispersed around the globe. Others involve overarching corporate organizational structures which are similarly global. In other words, maximising profit and minimising risk involves organising time and space on a global scale which in turn has prompted these organisations to manage how proprietary knowledge of FX markets is dispersed through the organization and then put to best use; dispersed knowledge is both a problem *and* a solution.[21] In the process of dealing systematically and on a global scale with dispersed knowledge and expertise, the balance of power in large international institutions has subtly but inexorably shifted towards bureaucratic procedures of synthesis, oversight, and regulation and away from the kind of untrammelled entrepreneurialism often associated with FX dealers.

Of course, all this can be overdone. Large international financial institutions are still driven by competition, regional divides and at times untrammelled entrepreneurialism is still allowed to let rip. But our argument is that large international financial institutions are learning how to do *global* finance and, as this process continues, so many international financial markets, markets which are so often depicted as the domain of the get rich quick, are becoming the haunt of large bureaucracies. As more and more of the activity of these

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[21]/. Consider, for example, the management 'solution' to this problem implemented at Barclays Global Investors (BGI): "two global co-CEOs-located 5,371 miles apart" (London and San Francisco). When asked about how they divide their responsibilities, one of the CEOs indicated that the divide was functional along "regional and product lines". As for co-ordination, the other CEO responded as follows. "One of (the) things that has helped is that the two of us have worked together for a long period of time and we know each other extremely well…." As for the advantages of such an arrangement, "the business benefits from having the leverage of two people who act as CEOs in different time zones. But it only works if we are joined at the hip in the way in which we are communicating". Reported in the industry newspaper *Pensions & Investments* April 14th 2003, p.14.

markets is taking place within these organizations, so this argument becomes more and more relevant. Though markets are still fast-moving and, at least to a degree opaque, it would not do to over-emphasize these features. International financial markets are not being domesticated but many of them are now moving into a new phase of co-ordination in which the broad contours of activity are understood and subject to the power of bureaucratic routine.

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