The Material Production of Virtuality: Innovation, Cultural Geography, and Facticity in Derivatives Markets

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Abstract:

In the existing literature, the 'virtual' nature of financial derivatives is often commented upon, but how these products are brought into being has seldom been examined in any depth. This article analyzes the development since 1970 of organized financial-derivatives trading in the U.S. and U.K. (in particular, of derivatives exchanges and of the British financial spread-betting industry), with the goal of examining the 'material production of virtuality'. The article explores the similarities and differences between technological innovation and innovation in derivatives; discusses the role of the 'internal' cultures of financial markets and of the wider culture (in particular, the legal traces of hostility to gambling); and analyzes the requirement of 'facticity' for the measure underlying a cash-settled derivative, focusing in particular on the most important such measure, British Bankers' Association LIBOR (London interbank offered rate).

Key words: financial derivatives; financial innovation; social studies of finance; spread betting; LIBOR (London interbank offered rate).

A dominant feature of the massive changes in global financial markets since 1970 has been the huge growth in trading of financial derivatives: contracts or securities the value of which depends on the price of another 'underlying' security or on the level of an index, an exchange rate or an interest rate. The financial-derivatives trading that existed at the start of the 1970s was limited in volume by today's standards, and was primarily ad hoc, conducted either in the interstices and/or on the fringes of stock markets, or else 'over-the-counter': by direct negotiation, especially between banks. In January 1970, no organized financial-derivatives exchange existed anywhere in the world.

At the end of June 2006, exchange-traded derivatives totalling $84.4 trillion (the equivalent of around $13,000 for every human being on Earth) were outstanding worldwide, and the total was growing fast, having increased roughly six-fold over the previous eight years (figure 1). Many of these contracts will have been entered into to offset the risks of other derivatives (so an unknown proportion of the total is thus in a sense self-cancelling), but the change from 1970 is nonetheless striking.

Economists have focused primarily on the pricing of derivatives, although there is a more 'institutional' literature in economics on financial innovation (see Tufano 2003) and some useful work on why some derivatives succeed and others fail (e.g., Black 1986). Recently, the attention paid to derivatives by human geographers, anthropologists and sociologists has increased sharply: see, for example, Tickell (1998 & 2000), Pryke and Allen (2000), Maurer (2001 & 2002), LiPuma and Lee (2004 & 2005) and Arnoldi (2004).

A common theme in this more sociological literature is 'the strangely imaginary ... or virtual character of derivatives' (Arnoldi 2004: 23). All financial securities are 'virtual' in the sense that their value lies not in their physical substance as paper certificates or entries in an electronic database but in the claims on future states of the world that they embody: rights to dividends from a corporation, to interest payments from a government, and so on. A derivative of such a security is thus an entity that derives its value from what is already an abstract claim, and so the development of derivatives markets can be seen as a further stage of the abstraction of monetary forms. Derivatives are 'money's "new imaginary"', note Pryke and Allen (2000).

This article focuses not on the overall nature of derivatives (a dominant concern of much of the existing literature) but on how 'abstract' or 'virtual' assets are brought into being and made tradeable. As the developments in computer technology (above all, 'virtual memory')[1] that have given us the modern notion of 'virtuality' remind us, virtuality is always a material effect, indeed an elaborate, sophisticated and expensive one. More generally, it is clear that 'immateriality can only be expressed through materiality' (Miller 2005: 28).

To be sure, one should not reduce materiality to physicality alone. The materiality of financial markets involves physical objects, technological systems and human bodies, but also the legal systems, cultures, procedures, beliefs and social relations that objects and bodies express, make possible, are shaped by, and are enmeshed in. Financial derivatives, abstract though they appear, are particular material configurations (with 'material' read in this broad sense).

However, 'the material production of virtuality' – the way in which those configurations are brought into being, shaped and sustained – has received scant attention in the geographical, anthropological or sociological literature on derivatives (one of the few exceptions is Millo, Muniesa, Panourgias and Scott 2005). In order to help correct this, I explore three issues. The first is the parallels (and also the dissimilarities) between financial and technological innovation. This theme *is* in the literature in economics (e.g. Silber 1981), but the view of technological innovation to be found there is too narrow, excluding for example its political dimension. Viewing derivatives as innovations offers a perspective on the 'performativity' of economics (Callon 1998 and 2007; MacKenzie and Millo 2003; MacKenzie 2004) and highlights issues such as the intellectual property regime within which innovation takes place and the need, if innovation is to be successful, to take into account the interests of intended 'users' and to find a workable compromise between incompatible interests.

The second issue to be explored is the 'cultural geographies' (Thrift 2000) of derivatives. With the exception of Maurer's work on 'Islamic' derivatives (Maurer 2001; see also Maurer 2005), the existing literature is somewhat homogenizing, seeming implicitly to posit a world in which, at least within its metropolitan core, 'place' no longer matters greatly. Spatial and cultural location is still significant, however, even in the metropolitan heartlands. The differing 'internal' cultures of financial markets have left their stamp, as have the different manifestations of a pervasive cultural theme: the relationship between investing and gambling (de Goede 2005).

The third issue to be discussed is 'facticity'. The virtual character of a derivative contract is enhanced if, as is increasingly the case, it can be settled only by

the transfer of cash, with neither party able to demand or impose delivery of an underlying asset. The measure used to determine the amounts to be paid must therefore be a 'fact': it must be an acceptable representation of the reality of which it speaks, and not be subject to manipulation. I focus in particular on how this is achieved for the most important set of facts of this kind: LIBOR, London interbank offered rate.

The article's main empirical focus is the development of financial-derivatives exchanges in the U.S. and U.K. since 1970 and the emergence of the British financial spread-betting industry. The specificity of exchanges and of spread betting builds into the study a bias towards the discovery of heterogeneity: national differences in over-the-counter trading almost certainly exist, but would be harder to identify. That bias, however, is balanced by the choice of the U.S. and U.K. as comparator countries. Their overall financial systems have very similar contours, and in the literature on 'varieties of capitalism' (e.g. Hall and Soskice 2001) they are normally lumped together. The differences found between derivatives trading in the U.S. and U.K. are thus differences between two otherwise similar cases. Greater heterogeneity would likely have been found had the study encompassed the financial-derivatives exchanges now thriving in locations as diverse as Frankfurt, Stockholm, Sao Paolo, and Singapore, or those emerging in many other countries, such as Russia and the People's Republic of China.

Before turning to the main body of the article (which has five sections: this introduction; sections on each of innovation, cultural geography and facticity; and the conlusion), it may be helpful to have a brief introduction to the main organizations covered, the relevant chronology and the sources of information I have drawn on. The

initial modern effort to begin organized financial-derivatives trading was the currency futures launched by the New York International Commercial Exchange in 1970. (A 'future' is a standardized, exchange-traded contract that is equivalent economically to one party committing itself to buy, and the other to sell, a set quantity of a given asset at a given price at a set future time.) That effort failed, but currency futures launched by the Chicago Mercantile Exchange's International Monetary Market in 1972 succeeded, as did the Chicago Board Options Exchange, spun off by the Chicago Board of Trade in 1973. (An option gives the right, but unlike a future does not impose the obligation, to buy – or in an alternative form of the contract, to sell – an asset at a set price on, or up to, a given date.) The Chicago Board of Trade itself, and a number of other U.S. exchanges, also began trading financial derivatives in the mid-1970s.

The International Commercial Exchange, Chicago Mercantile Exchange and Chicago Board of Trade had all originally been agricultural commodities exchanges. In the U.K., the eventually most successful financial-derivatives exchange – LIFFE, the London International Financial Futures Exchange – was an entirely new development, established in 1982. In 1978, the London Stock Exchange set up a Traded Options Market, which merged into LIFFE in 1992. In 1991, the London Futures and Options Exchange, as the London Commodity Exchange was then known, launched property and housing derivatives; it too merged into LIFFE, in its case in 1996. (Property derivatives are of particular interest because housing, commercial property and land account for wealth comparable in magnitude to the totality of stocks or bonds, yet the market in derivatives of them is still small. The failure of derivatives in the sphere of property throws their success in other spheres into an analytically interesting light.)

Financial spread betting began with bets on the FT(Financial Times)-30 share index offered by the bookmaker Joe Coral, and gained momentum with the establishment in 1974 by Stuart Wheeler of IG (Investors Gold) Index. In 1981, IG Index began to offer spread bets on the FTSE(Financial Times-Stock Exchange)-100 and Dow Jones indices. Another firm, City Index, began offering financial spread bets in 1983, and others such as Cantor Index have joined the industry more recently.

In analyzing these developments, the article draws upon four sets of sources. The first is existing histories of the Chicago Board of Trade (Falloon 1998), Chicago Mercantile Exchange (Tamarkin 1993; Melamed and Tamarkin 1996) and LIFFE (Kynaston 1997). The second is the trade press, which is often valuable in particular for revealing failed initiatives in derivatives trading. The third is a set of 27 oral-history interviews conducted by the author between 1999 and 2005 with people central to the development of financial derivatives exchanges in the U.S. and U.K. and of financial spread betting in the U.K. The fourth is a further set of 12 interviews, conducted in 2005-06, which focused on the London interbank market, on the role of brokers in that market and on LIBOR, and were accompanied by brief observation of brokers' offices, bank dealing rooms and the process by which LIBOR is constructed. Interviewees are anonymous except in the case of those who played the most important personal roles in the developments under discussion.

Innovation

The vast bulk of today's financial-derivatives trading is in products that did not exist in 1970. These products, especially those traded on organized exchanges, did not

simply ‘evolve’. They were *invented*. Indeed, today’s financial-derivatives exchanges, especially the freshly-established ones such as LIFFE, are the result of conscious, deliberate processes of design. Innovation in finance and in physical technology is not the same – three key differences are discussed below – but the comparison is analytically productive.

Let me begin with similarities between financial and technological innovation. Prior to the nineteenth century, what we now think of as ‘science’ played little role in technological innovation, but that role has now grown considerably. So too with finance. The academic discipline of economics had little effect on derivatives trading before 1970, but since then its role has been major (MacKenzie 2006).

A widespread understanding of technological innovation is the ‘linear model’ in which science ‘discovers’ truths, technologists ‘apply’ science by working out its practical implications, and the resultant products ‘diffuse’ unchanged to users. Though still influential in public discussion, the linear model has been discredited by the modern literature on technological innovation (e.g., Barnes and Edge 1982; Fleck 1994; Sørensen and Williams 2002; Oudshoorn and Pinch 2003). Instead, that literature suggests that science and technology interact not as disembodied knowledge but as embodied expertise (often via the circulation of people); that science is a resource that engineers draw on creatively, rather than simply applying; that careful attention to users’ needs and to ‘local practical knowledge’ (Fleck 1994) is necessary for successful innovation; and that much innovation – Fleck calls it ‘innofusion’ – takes place in what is conventionally regarded as ‘diffusion’.

All of these aspects of technological innovation also characterize innovation in derivatives: as Callon now puts it, the 'performativity of economics' is a 'coperformance' involving 'economists in the wild' – lay as well as professional – rather than just 'confined' (laboratory or university) economists (Callon 2007). Academic economics has underpinned derivatives trading both technically and by providing legitimacy, especially against the charge of gambling (MacKenzie 2006). However, key innovations in exchange-traded derivatives have involved economists who left academia to work in the markets, such as Richard Sandor, who left the University of California at Berkeley for the Chicago Board of Trade, and his Mercantile Exchange counterparts Fred Arditti and Rick Kilcollin.

These economists in the wild did not simply 'apply' economics. They found themselves involved in processes of innovation that involved close interaction with the three main categories of users of derivatives: hedgers, who are concerned to protect their organizations against a risk such as currency or interest-rate fluctuations; speculators, who hope to profit by correctly anticipating those fluctuations; and market makers, who stand ready both to buy and to sell the product in question, earning the difference between the 'bid' and the 'ask' (the prices at which they are prepared to buy and to sell).

Hedging, speculating and market making are categories of activity rather than of people and organizations: market makers, for example, often hedge their positions or deliberately take speculative positions, while some well-publicized derivatives fiascos have resulted from organizations starting out by hedging but slipping into speculating. Nevertheless, the categories of 'hedger' and 'speculator' are part of the

'lay sociology' that participants in derivatives exchanges deploy, and 'market maker' is a designated role with specific responsibilities.

Innovative exchange-traded derivatives need to be shaped in such a way as to be attractive to all three categories of user. For example, the International Commercial Exchange's currency-futures trading overlapped with the start of the break-up of the Bretton Woods system of fixed exchange rates, a favourable time because volatility encourages derivatives trading by giving hedgers, speculators and market makers incentives to participate. However, insufficient effort seems to have been devoted to designing and marketing contracts that satisfied the needs of hedgers. '[T]he contract specifications had to be attractive to bank traders and corporate treasurers. ... Successful futures contracts need, at a minimum, 20 to 25 percent commercial participation. You cannot have a market just for speculators' (Melamed and Tamarkin 1996: 174; see also Black 1986).

Exchange-traded derivatives are standardized products, so their specifications need decided in advance. These include how big a single contract is to be; the 'tick size' (the minimum increment in price); the limits (if any) on daily price moves and on the size of position any one trader can accumulate; the requirements for 'margin' (the sums participants in an exchange have to deposit with the exchange clearinghouse when they first buy or sell a derivative, and then have to adjust as prices fluctuate); the expiration dates of contracts; and the procedures for delivery of the underlying asset or for cash settlement.[2]

Successful choice of the specifications of derivatives contracts involves careful attention to sometimes-conflicting interests: of hedgers and speculators; of

exchange members and external customers; and of 'the 'longs' who have bought a derivative and the 'shorts' who have sold it. These interests are neither easy to determine – extensive research often seems to be necessary to elicit them, giving contract design something of the flavour of economic experimentation (q.v. Muniesa and Callon 2007) – nor fixed. Indeed, a major entrepreneurial activity of financial-derivatives exchanges is to persuade both external customers and exchange members that it is in their interests to trade a new derivative (see MacKenzie 2006: 154-55 and 173-74 for examples from the history of the Chicago Mercantile Exchange and Chicago Board Options Exchange).

The potential for interests to conflict, even after they have been elicited and 'translated' (Latour 1987) in this way, makes contract design – like technological design (Winner 1980) – an inherently political problem. It is one that cannot be solved simply by fiat (overly favouring the interests of one group will likely be fatal, because others will then not participate in trading), but requires balance and compromise. Richard Sandor, for example, noted that the delivery procedure he designed for the Chicago Board of Trade's first financial derivative, futures on mortgage-backed bonds, 'is complicated and cumbersome. It appears to cause difficulties for both the longs and the shorts. It is in that sense fair, and may be the reason it has been successful' (Sandor and Sosin 1983: 267).

Design, marketing and the encouragement (often via face-to-face meetings) of participation are pressing matters, especially in the early days of a new contract, because exchange-traded derivatives are subject to 'virtuous' and 'vicious' circles akin to those identified in technological innovation by Arthur (1984) and David (1992). The archetypal example is the QWERTY keyboard. It is not demonstrably

optimal for electronic word-processing – its original motivation was to reduce the chances of the levers of a mechanical typewriter sticking together by minimizing the frequency with which adjacent keys were struck in succession – but QWERTY is 'locked in' to the English-speaking world's keyboards, and its rivals 'locked out': none has a realistic chance of displacing it.

Lock-in results from the advantages that sometimes flow to an incumbent technology or derivatives exchange simply by virtue of being incumbent. QWERTY's advantages are the familiarity of millions of users with that key-lay and the difficulties they would face in the first few weeks of using a different layout. The internal combustion engine's advantages include the century of intensive research and development effort that has been devoted to it (and not to its rivals), and the huge infrastructure of fuel supply and maintenance that a rival would have to create afresh.

In the case of derivatives exchanges, business tends to flow to where existing volumes of trading are high, because high volumes mean liquidity (even large transactions can be conducted quickly, easily, and without a large impact on price), low transaction costs and a robust market price. Conversely, low volumes mean illiquidity, high costs and unreliable prices. So an exchange that gains an established position in a particular derivative becomes, like QWERTY, hard to challenge (Silber 1981: 132). LIFFE, for example, found that the currency futures it launched in competition with those of Chicago Mercantile Exchange were not successful, despite London's overall prominent role in foreign exchange (Kynaston 1997: 95-96 and 126-27; Leslie and Wyatt 1992: 91). Instead, LIFFE's survival and success came to rest on derivatives that had no well-established rivals, notably FTSE-100 futures and U.K. and German bond futures.

There are, however, also differences between financial and most technological innovation. The tax treatment of derivatives is more critical to their success than in the case of most physical technologies. For example, the appeal of the London Traded Options Market to customers was initially limited by the way in which options were treated until September 1980 in U.K. tax law as 'wasting assets', which had the consequence that capital gains tax liabilities could be incurred on loss-making as well as on profitable trading (Steen 1982). In contrast, a large part of the appeal of financial spread betting is that in the U.K. customers' winnings are free from tax. Spread-betting firms incur tax liabilities as bookmakers, but these are modest and absorbed into the spread between the prices at which the firms buy and sell contracts.

Financial innovations are easier to 'reverse engineer' than most technologies (Tufano 1989: 230; Allen and Gale 1994: 53). To minimize the risk of dispute and litigation, the specification of derivatives has to be made as explicit as possible. Trading derivatives, pricing them and hedging their risks may require tacit knowledge, but their design is easy to copy. Innovative technologies (especially those that *are* easily copied, such as pharmaceuticals) are protected from imitation by intellectual property law, particularly patenting. In contrast, the legal protection of innovative financial products (and, for example, derivatives pricing models) has been limited, at least until very recently. In the U.S., for example, financial products and models were presumed to fall within the 'business method' and/or 'mathematical algorithm' exemptions from the possibility of patenting. The general shift of intellectual property law from a presumption of open access – to which *patents* were the exception – towards a presumption in favour of private property (Merges 2000) has only quite recently encompassed financial innovations.

A pivotal case was *State Street Bank & Trust Co. v. Signature Financial Group*.[3] It concerned U.S. Patent 5,193,056 (9 March 1993), assigned to Signature, which covered a data processing system for calculating asset values and allocating expenses in a 'hub and Spoke'™ system in which mutual funds share the ownership of a common investment portfolio. State Street had sought to have the patent ruled invalid, but in July 1998 the Court of Appeals for the Federal Circuit, which enjoys 'nationwide jurisdiction' over patent cases,[4] found in favour of Signature. State Street sought to appeal to the Supreme Court, but in January 1999 the latter denied it leave to do so (Lerner 2002: 903).

It is remarkable that, at least until *State Street*, financial derivatives, central as they are to the global capitalist system, developed in a legal regime with only limited intellectual property rights. Did that regime (a) slow innovation by reducing incentives, or (b) enhance innovation by facilitating copying and adaptation in a context in which QWERTY-like 'first mover' advantages were an adequate incentive? That question points to a familiar debate about patenting that cannot be entered into here, but the extraordinary pace of derivatives innovation might incline one to (b). What is, however, clear is that copying was indeed easy. Specific derivatives have frequently been imitated without, at least until recently, fear of litigation. IG Index would, likewise, have been unable to prevent other firms offering analogous spread-betting contracts. Indeed, there is a sense in which entire exchanges have been imitated. LIFFE, for example, was more closely modelled on the Chicago exchanges, particularly the Mercantile Exchange, than on any British precedent (Kynaston 1997; Leslie and Wyatt 1992: 91).

Cultural Geography

The establishment of LIFFE highlights a theme prominent in ethnographies such as Abolafia (1996): trading is a cultural as well as an economic activity. The Chicago financial derivatives markets inherited from their parent agricultural futures exchanges a tradition of often-frenzied open-outcry trading conducted in 'pits' (stepped amphitheatres), accompanied by frequently jostling and occasional fist-fights. Chicago's was a trading culture quite different from that of the New York Stock Exchange. There was no equivalent amongst Chicago's competing market makers of New York's 'specialists', who enjoyed what in Chicago was often perceived to be unfairly privileged access to the 'book' of unfilled orders (in return for an obligation to maintain an orderly market, in particular to trade with their own capital if there was a temporary imbalance between orders to buy and to sell).

There was an even greater gulf between Chicago's rough and tumble and the 'gentlemanly capitalism' (Thompson 1997) that played a dominant role in London until the early 1980s (the 'Big Bang' deregulation of 1986 was a key moment in its demise). It is easy to stereotype – to forget that an urbane self-presentation is perfectly compatible with dedication, financial acumen, and even hard-edged dealing – but nevertheless the elite of London's financial sector formed something of a 'status group' in Weberian terms. David Steen, a key figure in the development of the London Traded Options Market nicely expressed in my interview with him (21 June 2001) the difference that he saw between London's ethos and that prevalent in the U.S.:

> They [Americans] are much keener to make money than [we] are here ... When I was young, if you'd been to a public school, and particularly if you'd been to Oxford or Cambridge, you really didn't need to worry much more about anything else as far as social status was concerned. You could go anywhere and you'd be accepted anywhere. You knew where you were.

Established social standing made it possible to disdain small-minded pursuit of pecuniary advantage, which was sometimes called 'tizzy snatching' ('tizzy' was nineteenth-century English slang for sixpence): as Steen put it, 'people trading and taking a snatch at profit of sixpence a share'. In Chicago, in contrast, the equivalent of a tizzy was considered well worth snatching energetically.

LIFFE plumped unequivocally for Chicago culture over gentlemanly capitalism, opting symbolically for Chicago's brightly-coloured trading jackets rather than the dark suits and black shoes traditional in the City. (LIFFE drew the line only at Union Jack jackets, fearing they 'would be seen on television selling the pound down the river' [Kynaston 1997: 73].) LIFFE's traders were often defiantly East End or 'Essex boys' (Zaloom 2003 and 2006) rather than gentlemen.

The London Traded Options Market (LTOM) was far more ambivalently placed than LIFFE. Its inspiration too was Chicago (in its case, the success of the Chicago Board Options Exchange, although the immediate spur to its establishment was the threat that options on London shares might be traded in Amsterdam), but LTOM's London Stock Exchange parentage was too strong for it fully to embrace the more flamboyant aspects of Chicago trading culture. One market maker who moved from Chicago to LTOM in 1986 recalls that he 'was booed off the floor first day

because I had brown shoes on'. His colleagues were no doubt teasing, but he found the attempt to translate Chicago attitudes and practices to London sometimes uncomfortable.

Tracing the economic consequences of differences of this kind is difficult. The spreads between LTOM's market makers' 'bid' and 'ask' prices in the late 1970s and early 1980s were large (Gemmill and Dickins 1986), far bigger than those in Chicago, and it is tempting to attribute this to the way in which Chicago's ethos of fierce competition between market makers failed to survive the translation to what was in some respects still a gentlemanly world. However, that may not be correct, for there are other possible explanations of large spreads.[5] For example, there were economically consequential tensions between LTOM and its parent, the London Stock Exchange. In particular, stock-exchange 'jobbers' (market makers) valued their right under exchange rules not to disclose large transactions for 90 minutes, because it made it easier to handle big blocks of shares. Delayed disclosure caused difficulties to London's options market makers (no equivalent right to delayed disclosure existed in the U.S.), because it meant they could never be entirely confident of the price at which they could hedge an options position. Wide bid-ask spreads can thus be seen as helping insulate them from the risks attendant on the difficulty of hedging.

More clear-cut is the effect upon derivatives markets of one aspect of the wider culture in which they are embedded: the trace left in the legal system of hostility to gambling. For example, section 18 of the U.K. Gaming Act of 1845 laid down 'That all Contracts or Agreements ... by way of gaming or wagering, shall be null and void', rendering gambling debts unrecoverable in law. The U.S. went further, with

most states (including, crucially from the viewpoint of the Chicago derivatives markets, Illinois) outlawing gambling.

Although organized exchanges dedicated to the trading of derivatives of financial assets are recent, such derivatives have long been traded in ad hoc ways, and exchanges dedicated to derivatives of agricultural commodities (grain futures, for example) have existed since the nineteenth century. The issue of how to draw the legal distinction between a legitimate derivatives contract and a wager is thus long-standing, and it is not straightforward: a derivative can indeed seem to resemble a bet on the movement of the price of the underlying asset. If it were ruled that a derivative was a wager, derivatives trading would have been illegal in the U.S. It would have been legal in the U.K., but the contracts involved would not have been enforceable.

In eighteenth-century English legal doctrine, the overall distinction between a legitimate contract and a wager was informed by what O'Malley calls a 'materialist theory of exchange', in which 'the act of exchange must include some element of material value or title to [material] value' (2003: 239-40). The 'abstract' or 'virtual' nature of derivatives – which, as noted, is a main theme of recent theoretical discussion of them – is thus in fact their most longstanding legal drawback. A doctrine according to which legitimate exchange has to involve the transfer of title to material value endangers the legality of options on securities, which are at two removes from material value, being at best a claim on a title of ownership. Nor was the problem restricted to derivatives of securities. A grain future might seem unequivocally to involve eventual transfer of ownership of a material asset, but in practice futures contracts on grain or other commodities were normally settled by cash

payments. Delivery of grain (or even of the elevator receipts that were the main form of evidence of ownership of grain: see Cronon 1991) was rare.

For reasons that have yet to be explored in detail, nineteenth-century legal doctrine, in both England and the U.S., became less 'materialist' and more favourable to derivatives. The distinction between a legitimate contract and a wager was redrawn around what became known as the 'intent test' (Swan 2000: 212-13): if the parties to a contract intended the delivery of the asset in question, then the contract was not a wager and was legal and enforceable, even if delivery did not actually take place. To agrarian critics of agricultural futures exchanges, 'intent' could seem 'an empty legal fiction' (O'Malley 2003: 243), since it was easy for futures traders to claim that they had intended to deliver the commodity involved, and had failed to do so simply because circumstances had changed. Nevertheless, critics' efforts to restore 'the eighteenth-century principle of material exchange' failed (O'Malley 2003: 244).

Trading of futures on physical commodities and of stock options passed the intent test (stock options could be settled by handing over share certificates, and that had come to count as delivery). However, the test created problems for more sophisticated financial derivatives precisely because of their more abstract nature. A stock index, for example, is a mathematical abstraction (it is not the price of any single entity, but is an average of prices), so by far the simplest way to construct a future on an index is to make it settleable by cash payment alone. But claiming intent to deliver would then be impossible, and the contract would as a result be liable to be ruled to be a wager. In consequence, although the Chicago exchanges had wished to introduce futures on stock indexes from the late 1960s onwards, they were unable to

do so until 1982. (How the necessary legal and regulatory changes were brought about is discussed in MacKenzie 2006.)

In England, LIFFE faced the intent test and the 1845 Gaming Act (still on the statute book), initially in regard to interest-rate futures based upon LIBOR. Again, the issue was that LIBOR, being an average interest rate, was not deliverable. LIFFE devised what it hoped was a legally adequate hybrid: cash settlement, but with the 'long' having the right to demand delivery of a deposit similar to a loan in the interbank market (the market that LIBOR 'summarizes' in the way discussed below). In July 1982, LIFFE obtained Counsel's opinion that 'such a contract is not a wager in law' (Kynaston 1997: 58). In 1984, a similar hybrid was devised for LIFFE's new FTSE-100 futures, with 'buyers and sellers [able to] nominate shares they might wish to receive or deliver', again because of the fear that 'Gaming Act implications might preclude cash-only settlement' (Kynaston 1997: 131).

The issue of gambling was resolved decisively in the U.K. only in 1986, when, Kynaston reports, LIFFE's 'traditionally good relationship' (1997: 155) with the Department of Trade and Industry led to the inclusion in the Financial Services Act of a provision (section 63) laying down that no contract that constituted investment business within the meaning of the Act could be rendered 'void or unenforceable' on the grounds that it was a wager. The provision removed the barrier to derivatives that could be settled only in cash. They might still fail the intent test and thus be classed as bets, but they were now legally enforceable.

The 1986 provision had, however, an inadvertent consequence: it rescued the nascent British spread-betting industry (which has subsequently grown to compete

with LIFFE for the business of individual customers) from the consequences of the 1987 stock market crash. Because gambling remained legal in the U.K., IG Index had been able to turn the analogy between derivatives trading and gambling from a problem (as it had been in the U.S. and for LIFFE) into a resource: making a derivative into a bet confers the tax advantage noted above.

The standardized contracts that IG Index and its competitors offer their customers are analogous to futures (the main difference is that the contracts are directly with the spread-betting firm, rather than between customers). In the case of FTSE-100 contracts, for example, firms quote a price at which customers can 'buy' the index, and a lower price at which they can 'sell' it. (As with market makers on exchanges, the firms' profits come mainly from the spread between the two prices.) A customer who believes the index will rise will buy the index, staking a certain amount (typically of the order of £5) per index point, hoping that the index will have risen by more than the spread by the time he or she sells the index back to the firm. A customer who believes the index will fall will begin by selling the index, and close the bet by buying (see, e.g., Vintcent 2002).

As with exchange-traded futures, spread bets thus offer the potential that a limited initial 'margin' deposit can become a much larger gain or loss. Spread-betting firms hedge any large resultant exposure to market movements by taking a position similar to that taken by the aggregate of their customers (often using futures on LIFFE or other exchanges). Until 1986, however, it was impossible legally to recover sums customers owed the firm. IG Index controlled that risk by requiring a deposit large enough to cover likely losses, but calculating that deposit involved estimating the size

of plausible market movements; demanding too big a deposit would put customers off.

As noted in MacKenzie (2004), the 1987 crash involved a market move far greater than seemed likely, and it left many of IG Index's customers with liabilities exceeding their deposits. At that time, the firm was nowhere near as well-financed as it is today and it could easily have become insolvent. Because its customers were in aggregate 'long', it too was long, and huge price declines meant it owed large sums to its brokers, which had to be paid immediately. However, many of its customers (who thought they knew gambling debts to be unenforceable) refused, or were unable, to pay what they owed IG Index. Fortunately from its viewpoint, IG Index was able to point them to section 63 of the Financial Services Act, which meant they had to pay (interview with Stuart Wheeler, 1 March 2005).

Facticity

'Culture' is thus not simply 'the context' within which derivatives trading takes place. Via matters such as the law of gambling, it shapes and is intermeshed with the detailed mechanics of this trading. Another crucial aspect of those mechanics is the nature of the asset or rate underlying a derivative.

For agricultural futures exchanges – which were, as noted, the sites from which modern financial-derivatives exchanges sprung – the most pressing issue in this respect was standardizing the underlying asset to an extent sufficient for claims on it to be tradeable without reference to any *specific* physical entities. In Chicago grain trading, standardization seems to have been an emergent property, co-evolving with

futures trading (Cronon 1991). Later, standardization was an explicit part of the planning for a new contract, such as the Chicago Board of Trade's futures on mortgage-backed bonds or its futures on Treasury bonds, introduced in August 1977 and 'the exchange's most successful contract ever' (Falloon 1998: 251; the fine ethnography by Zaloom 2006 is of the Board of Trade's bond-futures trading). Bonds themselves could not plausibly be standardized, so in both cases the tricky problem of making different issues of bonds commensurable had to be tackled. The solutions found were a little elaborate but robust, though sudden shortages of the 'cheapest-to-deliver' bond (sometimes the result of a deliberate 'squeeze') are a recurrent problem of which all bond-derivatives traders must be wary.

A derivatives contract that can be settled only in cash avoids such problems, and cash settlement also facilitates the development of derivatives on entities that cannot straightforwardly be delivered: first of all stock indexes, and now a much wider range of entities including, for example, weather and human longevity.[6] However, cash settlement raises a difficulty of a different sort (one quite distinct from the legal vulnerability arising from the 'intent test'). The measure used to determine cash settlement sums – whether it be a price, an index level, an interest rate or a measurement of weather, longevity or other entity – must be a *fact*.

One aspect of facticity is adequacy of representation. The measure used for cash settlement must be believed genuinely to express conditions in the market or process underlying the derivative, so that someone using the derivative to hedge risk can be sure that (if conditions are unfavourable) the gain they will make from the derivative will cancel out the losses they will incur in the underlying market or from the underlying process.

Problems of adequacy of representation may, for example, have been one factor in the failure of the London Futures and Options Exchange's property futures (Patel 1994). The measure used for its housing futures was the Nationwide Anglia house price index, but that was based only on transactions in which Nationwide Anglia was the lender. It was only one of several candidate measures of the overall state of the U.K. housing market (even today, different indexes often offering markedly different estimates of the rate of change in house prices). Furthermore, the average countrywide condition of the housing market was less relevant to hedgers – such as developers concerned that the houses they were building would not fetch the anticipated prices – than local conditions, which in the housing market can often vary markedly. (In 2006, the Chicago Mercantile Exchange launched housing futures and options, using indexes that are specific to particular and cities and based on identifying repeat sales of the same properties, but it is too early to tell how successful these contracts will be.)

In contrast, LIBOR is an example of a measure that *is* taken as an adequate representation of the underlying market. It is the basis both of important exchange-traded derivatives contracts, such as the Chicago Mercantile Exchange's Eurodollar contract or LIFFE's Short Sterling interest-rate contract, and also plays the central role in the over-the-counter interest-rate swaps market. (In a typical swap, party A pays party B a rate of interest that is fixed for the contract's duration, while B pays A a floating rate, most commonly LIBOR.) The swaps market is the largest of all derivatives markets – it dwarfs even the huge markets in exchange-traded derivatives – with the consequence that contracts totalling around $200 trillion (about $30,000 for every human being on Earth) are indexed to LIBOR.[7] Given that, it is surprising that

LIBOR has never, to my knowledge, been the object of a social-science study (the only detailed source on it is unpublished: Mason 1999).

LIBOR is the interest rate at which major banks can borrow funds from other banks in the London interbank market in a particular currency for a given period of time. (Because a range of currencies and time periods are involved, LIBOR is a set of numbers – six-month U.S. dollar LIBOR, for instance – not a single number. Why the most crucial facts are a set of 'London' rates, not 'New York' rates is a intriguing question in the cultural and political geography of financial markets that unfortunately cannot be discussed because of space constraints.)

To understand how LIBOR is constructed requires a brief discussion of the interbank market. A key role in it is played by 'voice brokers'. Such brokers sit at desks in rooms that resemble banks' trading rooms, but are more crowded, noisier and more raucous. On each broker's desk is a 'voice box' (consisting of a microphone, loudspeaker and switches), which is connected by a dedicated telephone line to a similar voice box at the desks of each of the broker's clients in bank dealing rooms.

Sometimes interbank deals are struck directly, but more often a bank's dealer who wishes to place or to receive an interbank deposit will use his or her voice box to tell a broker, who will then do one of three things: (a) use his or her voice box to try to find a counterparty; (b) shout out the order to his or her colleagues; or (c) ask a 'board boy' (as they are still called) to write the order on one of the large whiteboards that surround the brokers' desks.

Brokers supply their bank dealing-room clients with screens that indicate current bid and offer rates for interbank deposits, and those screens are the most important minute-by-minute representation of the interbank market. There is, however, an element of judgement in the rates that brokers display on the screens. Not all banks are equal: their credit ratings differ, and a bank's credit risk department will typically impose a limit on the amount of money that can be on deposit with any particular counterparty bank. So a broker may, for example, choose not to display the most attractive interest rate that he or she knows of, if its source is a bank with a poor credit rating to which many of his or her clients would be unable to lend.

Dealers in banks also exercise judgement in interpreting the rates the screens display. Asked how he estimates LIBOR, one dealer told me:

> ... within say the pool of 16 [banks on a LIBOR Panel: see below] ... you'll probably have three aggressive lenders, so the run-through you get from the broker is where you're going to get the first three lots of money. After that you have to move your price up until it becomes attractive enough for the people that don't want to lend to suddenly think, 'well, this is becoming attractive enough to do it', and that's where this spread ... comes from ...[A LIBOR estimate is] not going to be a mid-market rate, it's going to be the point at which you are likely to get the money.

The judgement thus involved in estimating LIBOR raises another aspect of the facticity of the measure used to cash-settle a derivative: its robustness in respect to attempts to manipulate it. Those with no direct involvement in the market of which it LIBOR is a representation might be guaranteed to be unbiased, but they would lack

the detailed knowledge needed to exercise informed judgement, so there is no practical alternative to reliance on those who may have 'interests' in the outcome.

When the Chicago Mercantile Exchange launched LIBOR-settled Eurodollar futures in December 1981, it thus set up its own daily poll, designed by its chief economist, Fred Arditti. Each of a designated set of banks was asked to give an estimate of LIBOR, but before the average was taken the highest and lowest estimates were eliminated, so no one bank could influence the result by giving a very high or a very low estimate. '[I]n the beginning there [was] some minor grousing', says Leo Melamed, then chair of the exchange, but 'the beauty of the [LIBOR] "fixing" was that it was so overwhelmingly accepted as the "true" price for interest rates'.[8]

In 1985, the British Bankers' Association, membership of which is open to international banks trading in Britain as well as British-domiciled banks, introduced a centralized daily LIBOR 'fixing' (similar in outline to Arditti's) that eventually replaced all other fixings, although other 'LIBORs' are still sometimes quoted. The Foreign Exchange and Money Markets Advisory Panel of the Association selects panels of eight, 12 or 16 banks for each currency on the basis of those banks' 'reputation', 'scale of activity in the London market' and 'perceived expertise in the currency concerned', while 'giving due consideration to credit standing' (Mason 1999: 3-4).

By 11.10 am each business day, each bank on a LIBOR panel reports to Telerate (now part of Reuters) 'the rate at which it could borrow funds ['unsecured', and 'governed by the laws of England and Wales'] were it to do so by asking for and then accepting inter-bank offers in reasonable market size just prior to 11.00' (Mason

1999: slides 8 and 9) in the currency and for the time period in question. The rates are then ranked in order, the top and bottom quartiles are ignored, and the mean of the second and third quartiles is calculated. That mean is British Bankers' Association LIBOR, and by around 11.45 am it is disseminated worldwide via all the main market networks.

The fixing takes inputs that may seem imprecise – 'we ask *them* [the banks on the panel] to tell us what *other people* are offering'; there is no requirement that any loan actually be taken out at that rate; and what constitutes 'reasonable market size' is deliberately not defined exactly (Mason 1999: 4-5, emphases in original) – and from those inputs it produces almost unequivocal facts. The fixing's elegance is that it is *sociologically* robust, so to speak. The banks that produce the inputs will very likely have large derivatives portfolios indexed to British Bankers' Association LIBOR, the value of which will be affected by the final figure, but as well as the latter their inputs are also disseminated. An idiosyncratic, manipulative input would thus be on public display to the market. Furthermore, the exclusion of the top and bottom quartiles means that an overly idiosyncratic input would in any case be thrown out of the calculation.

LIBOR is of course a social-kind (Barnes 1983), performative fact: it *is* the output of the above process. The one significant issue about its facticity has concerned not the integrity of the process but its output's representativeness. As worries grew in the 1990s over the creditworthiness of Japanese banks, the rates at which they could borrow increased with respect to their western counterparts. Their inputs into the LIBOR calculation rose accordingly. In panels with only one or two Japanese banks, that would simply place them in the top quartile and outside the averaging process,

but, for example, in 1999 seven of the 16 banks in the yen panel were Japanese. Concern surfaced about the impact on LIBOR of the 'yen premium' – or, viewed from a Japanese perspective, 'the European discount' (Mason 1999: 6). Wholesale removal of Japanese banks from the LIBOR panels would have been a very damaging vote of no-confidence, but the need for such a measure was avoided by the gradual stabilization of the Japanese banking system and the introduction of netting agreements that reduced the exposure of counterparties to a bank failure.

Conclusion

The more theoretically-oriented of the contributions to the geographical, anthropological and sociological literature on financial derivatives have had a tendency inadvertently to replicate the appearance of the products they discuss: they have formed a rather abstract literature on apparently abstract products. However, a market in these products 'is more than a bright idea', says Leo Melamed, who led the Chicago Mercantile Exchange's move into financial derivatives. 'It takes planning, calculation, arm-twisting, and tenacity to get a market up and going. Even when it's chugging along, it has to be cranked and pushed' (Melamed and Tamarkin 1996: 295).

In emphasizing that calculation, cranking and pushing (for some insight into arm-twisting, see MacKenzie 2006), I hope that this article has exemplified the 'material sociology' (Beunza, Hardie and MacKenzie 2006) characteristic of the emerging field of 'social studies of finance' (for which see, e.g., Knorr Cetina and Preda 2005). The material production of virtuality should matter to those who are interested in the 'big questions' of the theoretical literature – such as the extent and distribution of risk or the scope of globalization and commodification – because well-

grounded answers to those big questions inevitably must involve the apparent detail of material sociology.

The question of spatiality, for example, demands a nuanced answer. Yes, global financial integration is a very real phenomenon; but no, it has not brought about 'the end of geography' (O'Brien 1992). LIBOR, for instance, is a global fact; but it is also *London* Interbank Offered Rate. Spread betting, to take another example, permits rapidly increasing numbers of residents of the U.K. to use the screens and key-pads of their mobile phones to enter into inexpensive derivatives contract on thousands of global assets: the Nikkei index, Brent crude, gold, carbon emissions permits ...[9] The simple operation involved takes less than ten seconds and the contracts are usually confirmed in as little as five seconds. No fully equivalent experience has been available to residents of the U.S., and such lived experiences of markets are surely consequential. (Currently, there is an attempt to repeat in the U.S. the success of financial spread betting in the U.K. in the form of 'hedgelets', which are similar to spread bets, but are formulated in such a way as to stop them being classed as wagers.)

The material sociology of derivatives has many facets not discussed here: for example, how arbitrage ties the prices of derivatives to their underlying asset (but also how it sometimes fails); the roles in trading of bodies, which are material entities par excellence, and of technologies (the sometimes traumatic shift from open-outcry to electronic trading is discussed by Zaloom 2006); the crucial functions of clearing houses (Millo, Muniesa, Panourgias and Scott 2005); the structuring role of systems of regulation; and so on. It is clearly important to extend the analysis beyond the U.S. and U.K. to the world's many other derivatives exchanges, whether established or

nascent. The issues of innovation, cultural geography and facticity need addressed also in the context of the over-the-counter market, not just exchange-traded derivatives. Nevertheless, I hope that this preliminary analysis indicates at least that the answers to these further questions may be of some interest.

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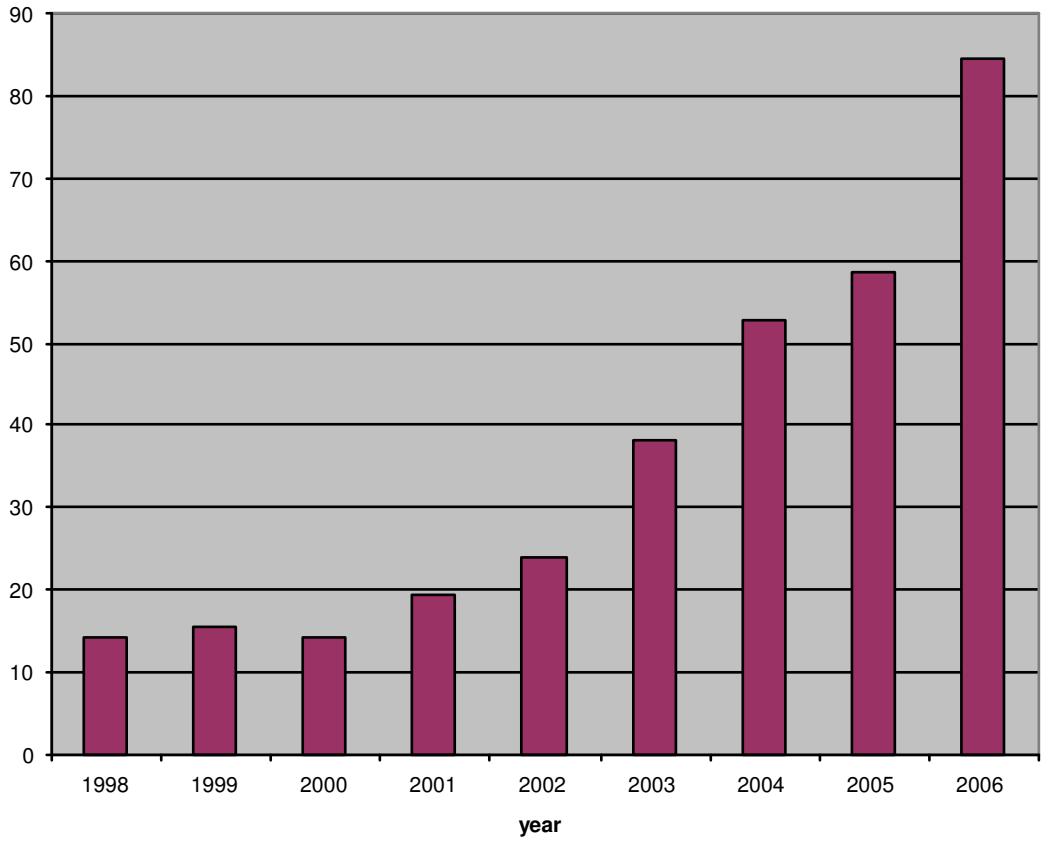
Figure 1: Total amounts of exchange-traded derivatives outstanding at end of June of each year. Source: half-yearly statistics from the Bank for International Settlements (www.bis.org), incorporating later data adjustments.



[1] Most computer systems employ both fast 'main memory' (the contents of which programs can access and modify), which in the early years of computing was expensive and limited in its capacity, and 'secondary storage', which is slower, not directly accessible but larger-capacity. In the late 1950s and early 1960s, computer scientists learned how to design operating systems that automatically transfer data between the two in such a way as to free programs from the limited physical capacity of main memory by giving them access to an 'address space' ('virtual memory') that is much larger.

[2] See, e.g., Sandor and Sosin (1983: 260-67).

[3] U.S. Court of Appeals, Federal Circuit, 149 F.3d 1368.

[4] See http://fedcir.gov/about.html, accessed 4 December 2006.

[5] It is also worth noting that the extent to which Chicago's competitive ethos translated into the actuality of fierce competition was in fact variable, as beautifully demonstrated by Baker (1984 a&b).

[6] On weather derivatives see Pryke (forthcoming). The potential demand for longevity derivatives – still largely in the planning stage – arises from the desire of pension funds to hedge the risk that their members may live longer than anticipated.

[7] Greater precision is unfortunately impossible, because derivatives data from the Bank for International Settlements do not specify the rate underlying interest-rate derivatives.

[8] Leo Melamed, electronic mail message to author, 13 January 2006.

[9] See, e.g., http://www.igindex.co.uk/