FIRMS, FINANCE AND THE WEATHER: THE UK WEATHER DERIVATIVES MARKET

by

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Abstract:

The spectre of climate change is motivating businesses to evaluate the weather sensitivity of their operations and earnings. Persistent changes in day-to-day weather, such as a warmer than average winter, may prove very costly for businesses and since 1997 a new financial market has grown up around the mitigation of these day-to-day weather risks. This weather derivatives market has expanded from being a small US energy product to become a $45.2 billion industry by 2006. In the process this commodification of weather indexes is re-valuing meteorological data, forecasts and expertise, as well as changing the ways in which firms have traditionally considered weather as unmanageable. This thesis presents an empirical examination of the weather derivatives market, particularly focusing upon the UK, drawing upon in-depth interviews with market participants. Setting this within the context of current theories in human geography and science studies, the research also illustrates the material and discursive implications weather derivatives are having not just on firms and meteorology, but also climate change policies.

Contents:

Glossary of Acronyms

ANT	-	Actor-network theory
CBOE	-	Chicago Board Options Exchange
CBOT	-	Chicago Board of Trade
CDDs	-	Cooling Degree Days (=average temperature - 18°C)
CME	-	Chicago Mercantile Exchange
CO_2	-	Carbon Dioxide
EKT	-	Entergy-Koch Trading (now part of Merrill Lynch)
ETS	-	European Emissions Trading Scheme
GCMs	-	General Circulation Models
Gw h	-	Gigawatts hour
HDDs	-	Heating Degree Days (= 18°C – average temperature)
IPCC	-	Intergovernmental Panel on Climate Change
ISDA	-	International Swaps and Derivatives Association
ISD2	-	The EU Directive on Financial Instruments Markets
LIFFE	-	London International Financial Futures and Options Exchange
NAIC	-	National Association of Insurance Commissioners
NASD	-	National Association of Securities Dealers
NOAA	-	National Oceanic and Atmospheric Administration
NWS	-	National Weather Service (US)
NYMEX	-	New York Mercantile Exchange
OTC	-	Over the counter (trading)
ROCs	-	Renewable Obligation Certificates

SRES	-	IPCC produced Global Emission Scenario Reports
SSTs	-	Sea Surface Temperatures
STS	-	Science and Technology Studies
WPI	-	Wind Power Indices, specifically as patented by EKT
WRMA	-	Weather Risk Management Association

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CHAPTER 1: INTRODUCTION

1.1. OPENING NOTES

In Thomas Hardy's novel *The Mayor of Casterbridge* (Hardy, 1994), Michael Henchard, a farmer, plots to beat his rival Farfrae with a gamble on the prices of wheat. Located in mid 19th century Casterbridge (Dorchester), when meteorology was less scientifically institutionalized (Burton, 1983), Henchard visits a weather prophet called, behind his back, Wide-oh for forecasts of the harvest weather. Wide-oh also specialized in such activities as charming away warts and curing the evil. The weather prophet was held in ill esteem as one that practiced a black art, albeit that five other farmers had already visited him for the harvest forecast (Hardy, 1994: 213-214). Dependent upon Wide-oh's prediction of an autumn more like 'Revelations' than England, Henchard bought grain expecting a poor harvest when he would be able to sell his grain back into the market at an inflated price, thereby making a profit for himself and forcing Farfrae to pay higher prices. Yet "[w]hen his granaries were full to choking, all the weathercocks in Casterbridge creaked and set their faces in another direction" (*ibid*: 215) as the weather turned warm and sunny. The price of grain "... rushed down" (*ibid*: 215) in expectation of a good harvest. As Henchard had been so extensive in his dealings, and with the expectation that grain prices would fall further, the Bank requested that he sell some of the grain at the new lower prices. These financial losses took place without him even seeing much of the corn, let alone having moved it from its original ricks (*ibid*: 216). "Henchard had backed bad weather and … lost" (*ibid*: 216), and gambled as readily "… upon the square green fields … as upon those of a card room" (*ibid*: 216). Three days into the harvest the air became like "... damp flannel" (*ibid*: 218) and the ingathering would prove to be far less successful. Henchard feels as though he has been cursed (*ibid*: 219) as the weather prophet's forecast comes to pass. As he states "... you can never be sure of weather till 'tis past" (*ibid*: 217).

The weather has been a critical factor throughout history, whether in aiding agricultural production or in destroying military campaigns (Durschmied, 2000). Managing the vagaries of the weather has been a recurring theme. Though financial markets in agricultural and other products have integrated weather risks within the prices of goods, as the gamble by farmer Henchard illustrates, it is only since 1997 that weather indexes became financial products to be bought and sold as easily as coffee, grain, soya beans or oil.

It is not difficult to see why a product to manage the costs of 'everyday weather' events, such as a warmer than average winter or a drier than average summer, could be so important[1]. The UK Meteorological Office (hereafter Met Office) suggests that as many as 70% of UK firms are affected by the weather (Met Office, 2001) and their US colleagues concur; as much as $1 trillion of the US economy is weather sensitive (weather2000.com, 2001). Trawling through the business pages of any newspaper would uncover a range of companies blaming their losses on the weather. "Cool weather cools Cadbury's sales," exclaims one headline as sales of their soft drinks disappoint during the cool summer (Anon, 2004a). "Thornton's profits melt in the heat," suggests another as

[1] 'Everyday weather' is a term used in this thesis to define the types of weather risks that weather derivatives are used to mitigate. Everyday weather refers to minor departures from the norm, or in other words relatively small weather events. This is to distinguish these events from extreme weather events such as excessive rainfall (leading to floods), heatwaves and hurricanes.

sales of chocolates in the run-up to Easter fell by 7.4% because of unusually warm weather (MoneyAM, 2004). Many more could be cited.

This thesis provides a specific example of the creation of a new financial product, a weather derivative, to manage these weather costs, costs that arguably will become less predictable with a changing climate. It will examine the material and discursive effects weather derivatives are having upon finance, meteorology, energy companies and climate change policy. It provides the first empirical study of weather derivatives in the UK and addresses how weather could become a financial product traded by a variety of companies in a number of countries worldwide. Drawing together themes in contemporary human geography and science studies, the research presented here illustrates the meteorological and financial networks underpinning the weather derivatives market and how this potentially re-shapes both networks. Though this research is necessarily partial and dated, not least due to the quick turnover in financial markets, it highlights broader concerns raised within the academic literatures. The re-valuing of meteorological expertise, to name but one issue, becomes an important theme in wider debates about the commerce and politics of science. With weather derivatives now a $45.2 billion market (PriceWaterhouseCoopers, 2006) they are clearly becoming an important topic for study.

The following section (1.2.) provides a brief note on meteorological terminology in this thesis. Section 1.3. then outlines the broad aims and questions of this thesis, whilst section 1.4. provides a historical context of derivatives market and defines key derivatives language. Section 1.5. concludes with an outline of the remainder of the thesis.

1.2. A NOTE ON TERMINOLOGY

Terminology in the fields of weather, climate and climate change can be difficult to concretize as meanings often vary by individual and context. Throughout this thesis the word climate will mean the average of weather as expressed over timeframes longer than a season. Weather is changes in the atmosphere at timeframes shorter than a season, whilst seasons are between weather and climate, which in this thesis means anything between ten days and twelve months ahead[1]. This may be somewhat unconventional with seasons often being considered as quarters, but as weather forecasts are generally considered valid only out to ten days (maybe two weeks), beyond which is chaos, this suggests that weather itself only comes into being within a ten-day timeframe. At the same time climate forecasts are generally associated with middle-range or long-distance forecasting. Between weather and climate must therefore be seasonal forecasting, which is important in the weather derivatives market, but is an area often considered highly experimental. This form of season is often invoked in the market where contracts may be written season-ahead to cover the following season[2]. These distinctions are necessary for understanding the different types of products and knowledges being discussed, but it is important to remember that these are categories or orders imposed, not pre-existing realities. The categories used here are consistent with the empirical research and whilst they present a different ordering of the timescales of atmospheric terminology, those categories, regardless, have somewhat fuzzy boundaries.

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[1] There could be an argument that climate does not appear until multiple years to ascertain what an average would be, but the upper limit of the term season is rather less important in the context of a market that operates mostly year-ahead at longest (though there are exceptions), particularly if forecasts are being integrated into pricing models.

[2] A winter seasonal trade is from November through March, whilst the contract may often be written the previous May.

Weather derivatives are contracts that are usually taken out on a seasonal or shorter timeframe. They are designed to protect companies against losses in winter or summer, though the interval months (April, October) do attract some trading. 'Weather derivatives' as a term is interesting, because climate (or maybe seasonal) derivatives may have been more appropriate (see Thornes, 2003). One possible reason for this was to distinguish weather trading from climate trading, the latter normally implying carbon (and other emissions) trading in relation to some objective on climate change. Climate trading is government controlled, weather trading is 'free market' i.e. private. These terminological differences become critical when reflected in the ways in which weather and climate are termed within the weather derivatives market. Past data records come from climate, but future data productions are defined by weather.

If climate is longer than seasonal, then climate change is also long-term change. Climate change is defined by the Intergovernmental Panel on Climate Change (hereafter IPCC) as

> ... any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change where *climate change* refers to a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over compatible time periods.
>
> (Houghton, *et.al.*, 2001: 2, italics in original)

This thesis will use the Framework Convention variant of the term, which has arguably become much more widely interpreted within the media and beyond, namely that climate change is changes in climate as a result of human activity (Pielke, 2005). This is primarily a practical decision as the majority of interviewees use the term climate change to refer to anthropogenic induced change and the climate policies being put into place to prevent it. Others (for example, Byers, 2004) also use the term climate change in a pejorative sense, as a scare concept that is being mobilized to support policies that will have negative implications for the trading abilities of European businesses. Thus to prevent misunderstandings between interviewee quotes and academic writings, the term climate change will have an anthropogenic connotation throughout. The term global warming, likewise, is also used in this thesis, often interchangeably with climate change in interviewee quotes, and refers similarly to human-induced global temperature increase and the associated weather effects (i.e. it is not the technical definition whereby global warming is associated solely with temperature). Climate change terminology is important, because it provides a key concept that frames the development and use of weather derivatives.

1.3. BROAD RESEARCH OUTLINE

Climate change has become one of the most powerful discourses in the modern world (Ashford, 2002; Boehmer-Christiansen, 2003; Demeritt, 2001a; Paterson, 1996). The rapid rise in temperatures ascribed to rising levels of carbon dioxide (hereafter CO_2) will potentially lead to a diversified portfolio of ill effects, from climatological to economic, social, political and biological (Houghton, *et.al.*, 2001; see Figure 1.1.).

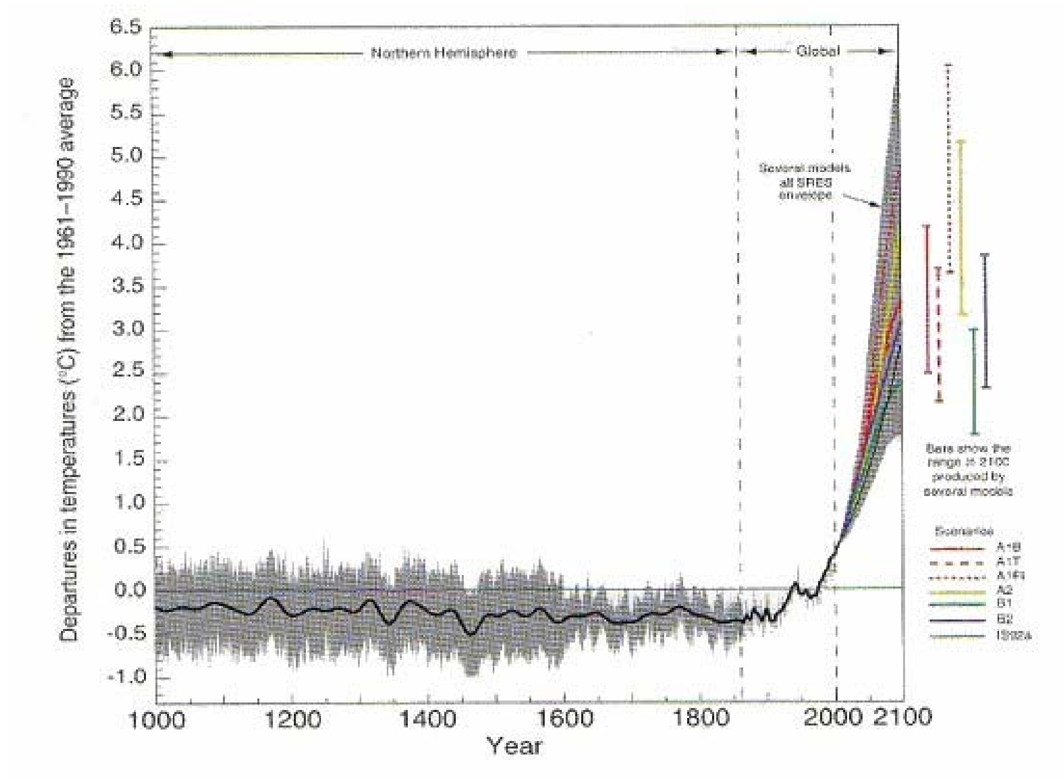

Figure 1.1: Variations of near surface air temperatures 1000 – 2000, including to 2100 using a range of IPCC predictions. The shaded sections display scientific uncertainty, more pronounced after the present day and before the start of instrumental records in 1861 (Houghton, 2005).

These claims are re-enforced, for example, by environmentalists presiding over the impending funeral of iconic species (Cole, 1997). By 2000, business magazines such as 'The Economist' (2000: 23) suggested that "[t]he time has come to accept that global warming is a credible enough threat to require a public-policy response".

Since the initial report (in 1992) the IPCC have included much wider discussion of the changing climate with likely future costs being presented to businesses (Dlugolecki, 1996; Nutter, 1996). This greater openness has coincided with an increased confidence in human-induced global climate change, whether this is as represented in models or the data-recorded actualities of a changing climate. With it a political will has been generated to do something about it. As Oreskes (2004: 1686) argues, despite the impression of confusion that politicians, economists and journalists may portray "[t]here is a scientific consensus on the reality of anthropogenic climate change". As Edwards and Schneider (2001) point out, no other science in history has achieved as much consensus through a strict peer-review process as the IPCC has with climate change.

> The scientific consensus might, of course, be wrong ... but our grandchildren will surely blame us if they find that we understood the reality of anthropogenic climate change and failed to do anything about it.
>
> (Oreskes, 2004: 1686)

Clearly when the lens is focused much closer there are uncertainties within the climate models including questions of parameterization and feedback mechanisms (Edwards and Schneider, 2001; Lahsen, 2005), but the purpose of this thesis is not to critically analyze these literatures. Rather it is to suggest how the predominant 'consensus' discourse(s) inspire a market response to both fears of a changing climate and aspects of climate change policy.

Concerns about the future impacts of climate change are engaging business attention with the climate and leading to a re-evaluation of firms' weather sensitivities (and hence climate change sensitivities). Firms are being forced to re-consider the ways they are conducting business, because of changes in the climate and the policies implemented to prevent anthropogenic climate change. Those working in financial markets have also been aware of the implications of this on trading, not to mention the proposals that financial markets should take on a role in spreading the costs of climate change. Insurers too have been subject to regulation and speculation about their role in mitigating the exposure to the costs of a changing climate (Dlugolecki, 1996).

The weather derivatives market developed in response to concerns about the effects of weather on businesses in the US energy sector and the then inability to manage these risks through any available products. With fears that weather patterns were changing, a new financial market based upon weather indexes provided an ideal mechanism for both transferring risk and for creating a new, potentially profitable business. Thus empirical questions for this thesis centre on the historical development and contemporary nature, size and scope of the weather derivatives market, particularly in the UK. The research, for the first time, aims to understand the practices of the weather market and the implications of this on a range of meteorological and financial factors. It suggests that the creation of financial products must have a profit component and are not just about managing particular environmental issues. Indeed for some, this indicates that the markets displace environmental risks and through commodification have a wide variety of implications for the science and environment at stake (Castree, 2003a; Harvey, 1999; McAfee, 1999; Swyngedouw, 2005). Though the new financial market on weather was created in the US, it swiftly expanded into Europe (and beyond), and this thesis focuses more specifically on the UK weather derivatives market, in particular, the energy sector. With energy being the creator and most voracious consumer of weather derivatives it is important to focus on how and why these companies are turning to weather derivatives as strategies for managing weather risk. Through advertising and institutions like credit rating agencies[1] and regulatory authorities the weather is turning from a classic business excuse for poor earnings to a domain that must be actively controlled.

Finally as the European energy sector encounters new challenges with renewable energy and emissions trading, as a result of climate change policy, it is important to analyze the implications that weather derivatives may have on these new and emerging areas. Weather derivatives are not just interesting phenomena; they have real discursive and material implications, not just on meteorology or finance, but also on climate change policies. They have implications for both business management and climatologists or government policymakers concerned with implementing policies to prevent further dangerous climate change. They are shaping market responses to climate change policy.

Key research questions focus on the size and scope of the current weather derivatives market and how it got to where it is today. How do companies with weather exposure find out about and use weather derivatives? This use relies upon a series of foundational issues being resolved including meteorological data and forecasts. How these are used in the weather derivatives market is clearly an important issue. It is also imperative to understand who are the individuals or institutions mobilizing the weather derivatives market and how they have actually shaped the direction of the market. Finally what implications do these products have for environmental governance? These key questions structure the research conducted for this thesis and these are particularly vital now as derivatives constitute a growing business, and financial markets are used as a mechanism for environmental management. Before going further, however, a brief

[1] Credit rating agencies are institutions that give companies a rating dependent upon a variety of factors including their financial stability. A company's credit rating affects not just the amount of debt they can acquire and the rates they have to pay on their debts, but also their potential trading partners in the financial markets, where for over-the-counter products credit ratings determine potential trading partners. The importance of credit rating agencies will be seen in chapter 6.

background history of derivatives markets and what they actually do will be provided, as this underpins the analysis of weather derivatives.

1.4. INTRODUCING DERIVATIVES

The rise of paper money and derivatives contracts has highlighted the increasing virtuality of money and the various meanings that it acquires (Davies, 1996). The virtuality of the financial system has been enhanced by the rise of derivatives markets, particularly with the rise of index trading (Pryke and Allen, 2000). Derivatives have existed in a similar form to today since the 16th century when they were made famous in the Dutch tulip market crises. The word derivative can be defined as

> … contracts specifying rights and obligations which are based upon, and thus derive their value from, the performance of some underlying instrument, investment, currency, commodity or service, index, right or rate.
>
> (Cornford, 1995: 10, adapted from another definition)

In 1848 the creation of the Chicago Board of Trade (hereafter CBOT) opened up futures markets on grain in Chicago with standardized contracts available around 1860 and a full clearing house in 1925 (Davies, 1996). This can be traced as the source of the modern form of derivatives that are seen today. Hedging in agricultural products established future prices for crops that were not yet grown. The mitigation of farmers' risks was also coupled with a speculative secondary market (Cronon, 1991; Zaloom, 2004). In 1874, the predecessor of the Chicago Mercantile Exchange (hereafter CME) was formed, called the Chicago Produce Exchange (it changed its name in 1919) (Chance, 1995). The story of farmer Henchard from the opening of this chapter highlights a number of points about this development, though there was not a formalized futures market for grain in Hardy's story. First it illustrates the role the weather played in future grain production and hence the value of weather information to speculators. Second the grain Henchard purchased had not been seen by him or moved, showing that when grain becomes commodity, then it is no longer necessary to have physical contact with grain (Cronon, 1991), though the physical grain did exist in Hardy's account (Hardy, 1994: 216). Derivatives thus increase the virtuality of finance. Finally Henchard's gamble did not work, demonstrating the potential risks in trading, which risks prompted a number of regulatory responses at various times. Derivatives were frequently banned in some countries for the space of a few years, though these bans were not always enforced (Cronon, 1991). In 1936, for example, options were banned in the US, but probably the most symbolic event was the prohibition on onion futures (Tickell, 2000). Indeed to this day onions are technically the only product on which futures cannot be traded (Tickell, 2000). This regulatory battle characterizes the unease with which derivatives are often portrayed, being both risk-mitigating products, but potentially risk-creating products.

The history of derivatives needs to be counterposed from 1944 onwards with a more general understanding of the changes in finance that were taking place. Most important was the Bretton Woods agreement, which ensured post-war international monetary stability with fixed exchange rates to, in theory, allow free trade (Leyshon and Tickell, 1994). Two important international institutions were also established at this time, namely the International Monetary Fund and the International Bank for Reconstruction and Development (later the World Bank). This system of stability depended upon currencies being fixed to the US dollar, but was more flexible than the gold standard, because it allowed countries the right to revise currency values. Hence the regime is often known as the adjustable peg regime (Davies, 1996). This financial ordering established an aura of stability and the discourses of stability, buttressed by the regulatory system, created stability, even where the edges displayed significant cracks (see Leyshon and Tickell, 1994). The 1950s also opened up new legal support for derivatives, driven from a US case, which argued that derivatives should be treated as ordinary income. Although briefly challenged in the late 1980s (Chance, 1995), this allowed derivatives contracts to be put together (or netted) for tax purposes i.e. the losses on one contract could offset the profit on another.

Until 1958 the international, financial regime under Bretton Woods achieved relative stability, but after this point European currencies returned to a form of convertibility. So began a growing problem in which European countries and Japan began to resist the control of US monetary policy and requested that their accumulated dollars be converted into gold (in effect a run on the bank US). The system of tying currencies to the US dollar broadly lasted until the early 1970s, despite the changes in 1958, but a series of events conspired to bring down the Bretton Woods stability, including the requests for dollar conversions to gold, the declining profit rates on US capital in Latin America and the cost of the war in Vietnam (Davies, 1996; Kindleberger, 1989; Strange, 1994). By 1965 a system in Eurodollars had also emerged whereby US dollars could be deposited and circulated in overseas banks in Europe. This promoted a rise in the financial services industry in Europe as Eurodollars were effectively an unregulated part of business. Eurodollars circuited domestic monetary policy and, as international money, fostered a global market for capital (Strange, 1994).

For Kindleberger (1989), the financial markets, taking the 'real' economy with them, have staggered from crisis to crisis since the fall of Bretton Woods. Derivatives markets, themselves, expanded rapidly after 1971 as regulations were being relaxed, the levels of financial risk, particularly foreign exchange risk, were escalating and the innovations in these markets opened up some very profitable business deals (Strange, 1998). In 1972 the CME created the International Monetary Market which allowed trading on the now floating currencies. 1973 saw the founding of the Chicago Board Options Exchange (hereafter CBOE) and marked the rise of the Black-Scholes formula for calculating options prices, which essentially provided a framework for valuing derivatives that mathematicized and normalized the risk (MacKenzie and Millo, 2003). The first interest rate futures soon followed on CBOT in 1975, but these were of limited commercial success until 1982 when the CME created Eurodollar contracts. Not only were US dollars based in Europe, but it would now be possible to buy futures contracts on those dollars. This also marked another key point, namely the emergence of cash-settled delivery. Prior to this derivatives could always be physically settled (at least in theory, see Cronon, 1991), but Eurodollar futures allowed a whole new form of derivatives products to emerge, including index based trading, because there was no requirement to physically deliver the product. This allowed the emergence of new levels of speculative trading and sets of financial indexes based on other financial products.

With growing speculation in the market it became clear, as MacKenzie (2001) notes, that one incident could set off a whole set of unexpected and potentially uncontrollable processes. This has been aided by the increasing internationalization of finance, the increasing computerization and the ability for 24-hour trading. One computer could trigger a crisis that would swiftly spread globally. For Boden (2000: 188) this is

"…action at a distance taken to a considerable extreme". Derivatives can therefore serve to increase risk, because speculative trading can be highly profitable. These serve less regard for financial stability (the hedging role of derivatives) and rather arguably increase the overall risk in the system (Green, 2000; Tickell, 2000)[1].

The 1980s saw the rise of sets of new forms of financial contracts including swaps and over-the-counter derivatives, and most large corporations were soon hedging and speculating on interest rates, exchange rates and commodities (Chance, 1995). The CBOE, for example, created an index of 100 stocks in 1983 (this became the Standard and Poors 100) that marked the expansion of index trading. Mathematicians and physicists were encouraged to become financial traders, offering these scientists levels of income that had been unheard of previously (Wilmott, 2000). A proliferation of financial products had taken place, including not just derivatives on a particular risk, but derivatives on those derivatives, creating a whole new economy founded on managing risk, but actually increasing the potential for a catastrophic event (Tickell, 2000). For Pryke and Allen (2000: 282) derivatives markets "… symbolise fully the dynamic character of a world of informationalized, monetized space-speed". Derivatives dissolve traditional categories of space and time by attempting to control for future events now.

Today, derivatives markets are the world's biggest business. Annual world gross domestic product in 2000 was approximately $147 trillion, whilst the combined annual turnover of over-the-counter (hereafter OTC) and exchange-traded derivatives was estimated to be $675 trillion in 1997 (Arnoldi, 2004). Since that time derivatives markets have continued to grow rapidly as part of a growing internationalization of finance. This growth in derivatives has also spawned complex combinations of products and markets,

[1] This is often cited in contrast to the stabilizing effects of insurance, but one need only look at Lloyd's losses in the 1980s to appreciate that insurance can equally create as well as spread risk (Raphael, 1998).

as well as a rise in the number of assets that can be hedged against. Most derivatives during the 1970s were in traditional commodity or financial products for example foreign exchange. Enron, however, was a primary component in the development of new derivatives during the 1990s as it attempted to 'commoditize everything' (de Goede, 2004), including bankruptcy, broadband, weather and water. It is in this context that weather derivatives were created (as chapter 4 will show). How do derivatives work in practice?

Coffee can be used as an example. Theoretically, coffee prices are affected by the supply in countries such as Brazil and demand. Coffee supply is dependent on a range of factors from the weather and soil conditions through to transportation and local economic factors within coffee-producing regions. For a coffee shop in London these prices will affect their profitability on the sales of coffee. To guarantee the price of the coffee, they can buy a coffee derivative (or future). This will say that at the appointed future date, x amount of coffee will be sold to them at y price. The coffee shop would probably not want to mitigate (or hedge) all their coffee price risk as it costs money to set up a derivative transaction (hedging cost) and coffee prices might decline so meaning they pay more than the market value. Should the coffee price increase, however, they will not suffer from that increase, because they have agreed to buy a certain amount of coffee at an agreed lower price. Thus it is an obligation in the future that derives its value from the underlying commodity coffee. In reality, the coffee shop would probably wish to buy an option too. Options allow the coffee shop, up to a certain date or on a certain date, to decide whether or not they wish to continue with the original futures contract. The contract premium will be higher with the option clause, but it will be worthwhile, because if the market prices go down, the coffee shop does not have to buy that coffee at a higher price.

Thus the term ‘derivatives’ includes a wide range of contracts, which can broadly be divided into three groups: the swap, put or call. All of these can be fitted with collars to place limits on when contracts pay out or what the maximum payout can be. Swaps are agreements between two companies whereby one company’s upside will pay for another company’s downside (see Figure 1.2.). So if one company benefits from lower coffee prices and the other loses, when coffee prices are lower the benefiting company will compensate the losing company (and vice-versa) [1]. Puts and calls are one-sided contracts, which mean that they cover only one side of the risk. This means that they would only cover either the effect of warming or the effect of cooling and hence function more like insurance contracts. So if a company benefits from lower coffee prices they will buy a put, so that if coffee prices are higher than the specified price (strike[2]) they will be compensated[3]. Calls are the reverse and would be useful for companies losing from lower coffee prices[4]. These contracts necessarily have higher premium costs, because somebody has to take on that risk, whereas with swaps both companies theoretically take equal share (Rutterford, 1993). How does this apply to weather derivatives?

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[1] In the weather context, a swap contract is an agreement between two parties A and B that at a specified future date, whichever party will have had the favourable weather for their profits will compensate the other. So if A’s profits increase in warmer than average weather and B’s increase in colder than average weather, should the weather be warmer then A will compensate B. In effect a swap is A selling a call to B and B selling a put to A. See figure 1.2.

[2] The strike is the value at which the contract starts paying out.

[3] In the weather context, puts are are one-sided contracts between two parties i.e. A buys a put from B for a premium that will compensate it should the weather be below the weather index, or in this case colder than average weather. B would compensate A.

[4] In the weather context calls are one-sided contracts between two parties i.e. B buys a call from A for a premium that will compensate it should the weather be greater than the weather index, in this case warmer than average.

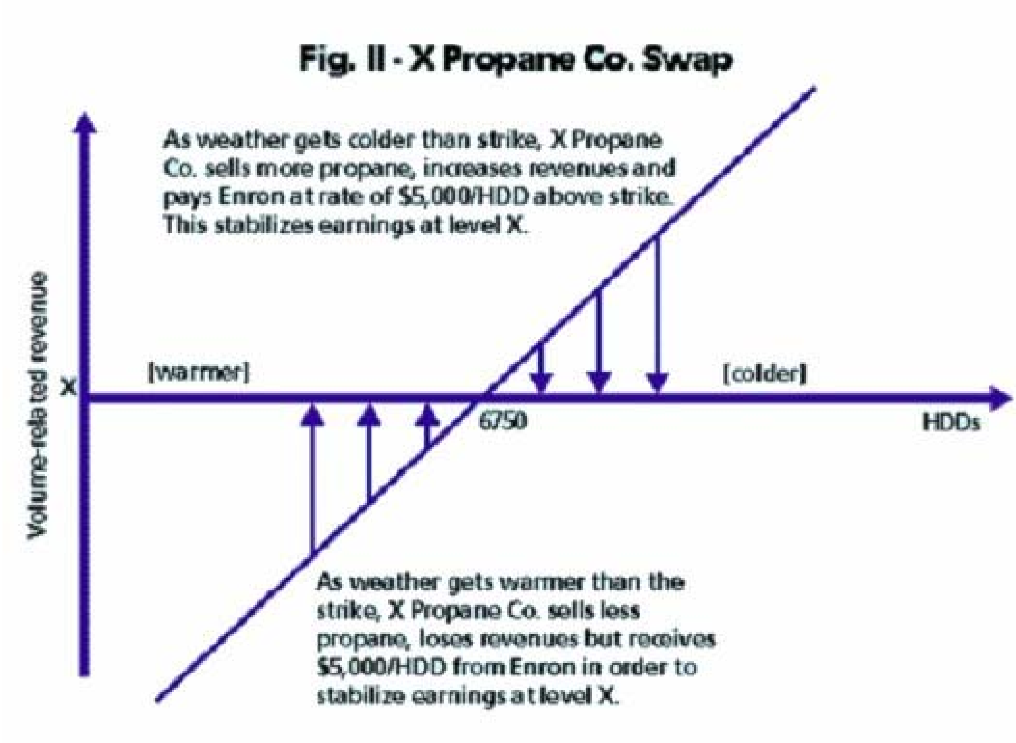

Figure 1.2: A standard swap contract (from EnronWeather's former website)

In their simplest form, weather derivatives are contracts that a company will buy to mitigate the cost of the weather on their business. These will be bought for a premium and will pay out compensation if the weather parameter is reached. Zeng (2000) describes the generic contract as having certain parameters; the contract type (swap, call, put), contract period, an official weather station to provide data for the weather index (W)[1], the strike rate (S), the tick (*k*)[2] and the premium. This provides simple equations for the cost or payment (P) for buying a weather derivatives contract.

[1] The weather index may be defined in terms of, for example, temperature, precipitation, snowfall or wind.
[2] The tick is the value of each unit upon which payment will be based, so for example, £100 per 1°C below 18°C.

$P_{put} = k\max(S - W, 0)$

$P_{call} = k\max(W - S, 0)$

(Zeng, 2000: 2076)

Swap contracts will have lower premiums, because less risk is being transferred i.e. as long as two companies' upsides (profit in 'good' weather) and downsides (losses in 'bad' weather) are similarly matched, then neither is bearing any more risk by taking out the contract (Clemmons and Radulski, 2002). The weather derivatives market has a mixture of swaps and calls or puts.

Weather derivatives are designed primarily to hedge volume risk not price risk. For energy companies, changes in gas prices are managed by the gas market whilst the changes in the volume of sales of gas can be managed in the weather market. This focus on volume risk is somewhat unusual within commodity derivatives where the focus is more often on managing price risk. Weather derivatives can currently be purchased on precipitation, wind and snowfall, but the majority of the market is based around temperature, particularly, the Heating Degree Days (hereafter HDD; figure 1.3)[1], Cooling Degree Days (hereafter CDD)[2] and cumulative temperature indexes. This reflects the history of the market within the energy sector (see chapter 4) and establishes 18°C as they major strike point. As Valor *et.al.* (2001) show, however, electricity demand, in particular, is not linearly correlated with temperature around 18°C and degree days may not be the best measure of demand. The choice of 18°C, created by heating engineers in

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[1] Heating degree-days are simply 18 degrees Celsius minus the average temperature. Or more technically Daily HDDs = max (0,(18-(Tmax + Tmin)/2). Tmax is the maximum temperature recorded that day and Tmin the minimum. So the colder the temperature the more heating degree-days are produced. These are calculated on a daily basis, but in the weather derivatives market it is common to use monthly or seasonal heating degree-day totals (Corbally and Dang, 2002).

[2] Daily CDDs = max (0,((Tmax + Tmin)/2) – 18). Whilst 18 is the common figure used for both HDDs and CDDs, degree-days can also be written in terms of other numbers (simply replace 18 with K). This might be useful in some areas where demand fluctuates around different temperatures (see Corbally and Dang, 2002).

the early 20th century, reflects the historical enterprise of scientifically heating the home to 21°C. 18°C is considered the outside temperature by which most houses internally should be at 21°C (Valor, *et.al.*, 2001). Regardless of debates about how to establish the predominant strike points in data indexes, these indexes form the basis of trading. Weather derivatives do not have 'physical underlyings', the financial term for derivatives on products such as coffee where at the end of the contract coffee can actually be exchanged (Rutterford, 1993). With weather derivatives it is not possible to provide a sunny day or a cold winter so they must be settled in cash (or other forms of financial payment).

Station Name	Data Type	Year	Total
New York LaGuardia Airport	Seasonal HDD	1994	4284.0
New York LaGuardia Airport	Seasonal HDD	1995	3492.5
New York LaGuardia Airport	Seasonal HDD	1996	4214.0
New York LaGuardia Airport	Seasonal HDD	1997	3753.5
New York LaGuardia Airport	Seasonal HDD	1998	3473.0
New York LaGuardia Airport	Seasonal HDD	1999	3556.5
New York LaGuardia Airport	Seasonal HDD	2000	3535.0
New York LaGuardia Airport	Seasonal HDD	2001	4132.0
New York LaGuardia Airport	Seasonal HDD	2002	3063.0
New York LaGuardia Airport	Seasonal HDD	2003	4254.0

Figure 1.3: Historical seasonal (November through March) HDD totals for New York's La Guardia airport (www.cme.com)

Data are generally received from national meteorological agencies or EarthSat[1] and converted into these standardized indexes for trading in the weather derivatives market.

The weather derivatives market contains two types of activities, a primary and a secondary market[2]. The primary market is driven predominantly by banks, but also insurers and energy companies, selling contracts to end-users, those that wish to hedge their weather risk. These sellers take on risk in this procedure and often then mitigate that risk by buying and selling contracts in the secondary market. Thus the two markets work similarly to insurance and re-insurance, except with the freedom of derivatives regulation rather than insurance (see chapter 6). The primary market is the important indicator of the overall reach of the weather derivatives market in mitigating the costs of the weather, whilst the secondary market provides trading opportunities for speculation and liquidity[3].

Contracts can be undertaken on exchanges such as the CME or in OTC trading. In the former, buyers can purchase contracts anonymously by using the exchange's online clearing system. These contracts will be standardized, set by what the CME is currently offering, and will be of small size (multiple purchases are possible). OTC trades are private contracts between two companies that may be of a non-standardized form and are therefore written in a unique manner to mitigate different types of risk[4]. The contracts are

[1] Earthsat are providers of weather data and services, primarily based on satellite observations, remote sensing and GIS, and who since 1990 provided weather products to the energy industry (Earthsat were re-named MDA in October 2005).
[2] Note that where the term market is used during this thesis it is referring to the overall market and not specifically to either primary or secondary trading.
[3] Liquidity is the number of buyers and sellers trading contracts on a particular location. A liquid trading site is one where there are always people wanting to buy and sell contracts; there is a constant availability of prices.
[4] In the early years of the weather derivatives market all standardized contracts were also done OTC, but since the arrival of the CME most of this trading is transferring across to the exchange, because in general it is cheaper and quicker to use, as well as having available prices on all contracts.

protected by different sets of rules about credit risk[1] and other financial issues, but the primary difference is normally in the uniqueness of the tailoring of the contract.

Thus weather derivatives are highly flexible tools that can manage many different types of risks. The majority of contracts in the UK are driven by the energy industry seeking protection against warm winters, but other types of deals are also becoming more popular, as chapter 4 will point out. The weather has gone from the realm of providence into the sphere of finance and this thesis outlines the ways in which the weather derivatives market has engaged in this process.

1.5. OUTLINE OF THE THESIS

In the following chapters, the thesis proceeds to provide an empirical analysis of the past and current weather derivatives market in the UK and the challenges that may be presented in the future.

Chapter 2 provides a theoretical basis for understanding the research questions, drawing upon current critical literatures within geography and beyond on 'nature-society'. After briefly outlining the contested notions of weather, climate and risk, the chapter proceeds to analyze three broad groups of literature. These draw respectively upon pragmatic philosophy of science, sociology of science and political economies. The confluences between these literatures suggest a plurality in both knowledge and reality and an appreciation of the instrumental nature of knowledge in specific contexts. The diversity between the literatures, however, point to a range of issues of power, politics and normativity, that can be but briefly touched upon, but which will be held in tension

[1] Credit risk is the risk that the company who is selling the contract will go bankrupt and be unable to meet its obligation. The exchange takes on this risk, unlike in OTC trading where the risk is with the counterparty, because companies must be members of the exchange to trade contracts.

through the thesis. That is, the thesis does not seek to make a theoretical resolution; rather it pragmatically ascertains the useful elements of various approaches that apply to a concrete analysis of weather derivatives.

This theoretical backdrop is followed in chapter 3 with a methodological framework of the thesis. This chapter outlines in more detail the main research questions of this thesis and suggests that a qualitative approach is best equipped to answer these questions. In-depth interviews are highlighted as the predominant research tool in this project, although the importance of the Internet cannot be underestimated. A sketch of the interviews undertaken is then presented in which it is argued that the material from these interviews can be justified in pragmatic terms based upon consistency, probability and trust. Though the interviews took many forms, and indeed the use of e-mails as an interview method has particularly needed justification, it will be argued that the research material presents a solid base for the conclusions based upon it.

Chapter 4 is the first of the empirical chapters and, though a context chapter, has had to be based upon empirical material due to the paucity of accounts of the history of weather derivatives. Weather derivatives emerged in 1997 in the US energy sector and the ways in which the initial actors established and attempted to grow the market will be examined. This analysis includes an understanding of both the human and non-human actors involved in creating the weather derivatives market, and illustrates that the weather product being developed at Enron and other companies could have been very different but for specific needs and issues at that time. This historical context provides some valuable understandings of the current weather derivatives market which, supplemented with graphs from the Weather Risk Management Association's (hereafter WRMA) industry survey, show that the market has grown relatively quickly both in terms of volume and in terms of geographical spread, albeit that this growth has somewhat stagnated at various points. The chapter finally provides an overview of the current weather derivatives market in Europe illustrating the types of companies that are involved in the market. This establishes a broad array of contextual material that will be important in appreciating the later chapters.

Chapter 5 takes as its theme the meteorological networks underpinning the weather derivatives market. Examining the role of meteorological data and forecasts, the chapter assesses the use, modification and creation of data, forecasts and expertise within the weather derivatives community. The weather derivatives market is shown to be a site for the production of meteorological knowledge and, with the new economic values attached to meteorological expertise, meteorologists' work is become re-valued, commodified and privatized. Though the commodification of meteorology here may be somewhat limited compared to the biomedical industry, nevertheless this chapter will show that it has the potential to alter the types of knowledges being produced as well as the availability of this expertise. Privatization may have many implications, not least on the retention of young atmospheric scientists within the public sector. The chapter also shows that debates on data, forecasts and models, which may have been assumed to be resolved (at least partially), are being re-opened. Quality of data and seasonal forecasts are two issues where there are clear divergences between the opinions of weather derivatives traders and public sector meteorologists, and even between traders themselves.

The marketing of weather derivatives forms the core of chapter 6. Changing corporate attitudes to the weather is a key component of the future viability of the weather derivatives market and this chapter will address the ways in which the weather derivatives community attempt to market their products and some of the challenges they face. The chapter shows the importance of marketing weather derivatives through both overt methods like adverts and more calculating methods such as the campaign to bring financiers and credit rating agencies into the new world of weather derivatives. This highlights that a key point for the weather derivatives industry is to turn weather from a site of providence, to a site of active management. Another challenge is regulatory, attempting to concretize the position of weather derivatives within commodity derivatives to prevent issues with both insurance and gambling regulations. Should this fail, there will be clear issues regarding the future of weather derivatives and the ability to sell and trade these contracts. These financial challenges provide a framework for the concrete analysis of the energy sector in the UK that will follow in chapter 7.

The energy sector is not only one of the most important economic sectors in the UK (and elsewhere), but it is also the largest user of weather derivatives. Taking material from interviews with most of the major energy companies in the UK, chapter 7 analyzes the ways in which energy companies are currently using and in the future plan to use weather derivatives. This provides a case study that explores the entanglement of financial and meteorological knowledges that results in particular forms of engagement within the weather derivatives industry, as well as tying this with the developments within and external to the energy industry that is changing the way it has to do business. This case study also examines the future role of weather derivatives as energy companies, under government pressure, increasingly turn to renewable energy and have to deal with emissions trading. These two examples also highlight the ways in which government legislation on the environment is actually being adopted within a specific sector and the ways in which companies are actively searching for the most profitable answer in dealing with these issues, potentially to the detriment of the environmental issue at stake. These important aspects of this relationship between weather derivatives and climate change have important discursive and material implications not just on financial issues, but also critical environmental issues.

The final concluding chapter, chapter 8, presents the key points from the thesis and presents a range of evidence, from the history of the market through to the current nature of the market, that suggest that weather derivatives could become an important financial market in the future and also that this market will have a range of different implications for finance, meteorology and climate change policy.

CHAPTER 2: THEORETICAL FRAMEWORK

2.1. INTRODUCTION

Talking about the weather is perceived to be a relatively risk-free subject for the British populace (Golinski, 2003; Harley, 2003), yet as the weather is arguably getting more risky with the threat of a changing climate (Houghton, *et.al.* 2001), weather-talk takes on new political, economic and social significance. The creation of a financial market based on the weather opens up questions about not just the significance of weather-talk, but also the processes of creating meteorological and financial knowledges that can predict or model the weather better.

If climate change discourses provide at least some of the incentive for awakening business leaders' understandings of weather sensitivity, then generating knowledge about the future directions of climate change, at a short timeframe at least, becomes a critical financial issue. The implications of this for climate change policies are not necessarily insignificant and an important aspect of the research here is to understand the creation of knowledges with a sense of what knowledge is being created for and for whom it is being created.

These questions have been variously analyzed within the context of nature, society and science. This chapter first outlines some perspectives on weather and climate, drawing upon broad literatures on nature and risk. Then it moves on to analyze three main groups of literatures that represent important ways for understanding the weather derivatives market and its associated knowledges. The first of these literatures is drawn from philosophy of science, to argue that there is a wide diversity of knowledges being created about the world, because the world is not a unitary thing. The approach is pluralist and pragmatic. The second literatures are drawn from sociology of science, in particular actor-network theory, to suggest that sociological approaches to understanding science are widely applicable in the subject of a new financial product like weather derivatives. These provide a core component of techniques for analyzing the empirical research contained in the later chapters. The third literatures are drawn from Marxist writings on nature-society, which provide explanations of power and politics, as well as a key theoretical understanding of how and why commodification of nature takes place.

2.2. NATURE, WEATHER, CLIMATE

Nature, as many authors attest, is a contested term (Castree, 2003a; Latour, 1993; Soper, 1995; Whatmore, 2002). Its history is long and variegated, being associated with an object of study for many sciences, biological difference and determinism, and non-human forms of life. "Nature", as Soper (1995: 2) writes,

> also carries an immensely complex and contradictory symbolic load ... [and] in recent times, it has come to occupy a central place on the political agenda.

The varying discourses of nature reflect upon the ways in which humans have imagined their place within the world and the (un)ease with which the natural world is viewed as (dis)similar, (un)predictable and (un)familiar.

Debates in geography today centre on this contested nature of nature and there is no need here to sketch a historical analysis of nature and, its twin dualistic other, society (see Castree, 2002; Demeritt, 2002; Whatmore, 2002). Rather this chapter teases out three main streams of literature that make contributions to the understanding of nature and society (whatever that might mean). Within this they also provide a framework for understanding weather derivatives. Whilst semantic debates on nature may continue, the purpose of this thesis is to explore the specific example of weather derivatives, a phenomenon that links natural scientific and social scientific knowledges.

Many studies of nature take too little account of sea and skies (but for the sea see Steinberg, 2001). For Serres (cited in Reed, 1983) this is because academics pay relatively less attention to the types of people most affected by the weather (farmers, fisherpersons, sailors). Recent attention has, however, focused upon the 'co-production' of weather and society (Rayner, 2003; Janković, 2004) to examine the multitude of ways that people think and feel about the weather (Janković, 2000; Strauss and Orlove, 2003). Though anthropologists, amongst others, are beginning to examine these issues, the questions of weather and climate have perplexed many writers through the years (see Boia, 2005). The atmosphere, containing the terms of both weather and climate, is the site for a brand of atmospheric physics, which is at the root of chaos theory and inspires the work of many other scientists (Boia, 2005; Massey, 1999). Weather and climate, however, are touchingly difficult words to define, escaping ordering, in perpetual motion and change. Climate is often assumed to be 'average weather', a statistical concept (Moran and Morgan, 1997; Serres, 1995; Zwiers and von Storch, 2004); it has been justified as a means of racism and determinism (Boia, 2005; Endfield and Nash, 2002; Livingstone, 2002); it is the angle of inclination to the sun enabling broad bands to be drawn across the globe (Boia, 2005; Serres, 1995); and connected with the word change has become one of the most powerful scientific, discursive and political ideas in history (Boia, 2005;

Demeritt, 2001a; Paterson, 1996). For the French philosopher Michel Serres the atmosphere illustrates that underneath everything there is chaos.

> We must praise any language that associates meteoric clusters, hail, hurricane, turbulence, squall, with the Greek word *climate*, which means: inclination. Yes, the climate depends upon the place, the place is defined by an angle that has reference to the equator. But I am tempted to see in this climate the inclination from which the time of order is born, making its appearance, a circumstance, amidst the clamoring disorder. In any case, climate is an aggregate concept, statistical and multiple.
>
> (Serres, 1995: 102)

For Serres climate is an aggregate phenomenon, yet Demeritt (1996: 94) has recently written, citing Friedman, that climate rather than being an aggregate

> ... can now be said to be the socially constructed product of three-dimensional mathematical models, run on multi-million dollar supercomputers.

No definition exceeds the possibilities of climate; it always implies more than the definition. It is multiple. The concept is suitably chaotic.

Similarly too with the term weather, which takes on a variety of meanings. Weather can mean the local sunshine, rain (etc) at a specific time or a general term for the British climate (Bone, 1946); it can also become a providential being endowed with power (weather permitting) or an analogy for the 'storms' of life (weathering the storm, weather the financial crisis). In Hardy's (1994) *The Mayor of Casterbridge*, mentioned at the opening of chapter 1, the weather prophet is treated with contempt, though many consulted him for forecasts, whilst each watched their own bodies and the weather-cocks to feel what the local atmosphere was and would be like at harvest (see also Golinski, 1999). “The weather was too public, too overwhelming, and too complex to be grasped within a single discourse” (Janković, 2000: 5). Weather also provides a core subject for conversation and belief (Golinski, 2003; Harley, 2003). Yet as Latour (1987: 181, emphasis in original) notes, “[o]nly a few thousand people are able to define *what* the weather *is*”, “… the billions of other utterances about it count for nothing”. Thus there is a divorce between weather as a popular concept embodied in lore and proverb, and the people (scientists) empowered to act as representatives of the weather who know this weather (or make more credible claims about it).

Weather and climate, thus, are difficult to define and bound. Where they begin and end, how long or short they are, is unclear (chapter 1). As Steinberg (2001) notes, the sea is frequently portrayed as an open space empty of social relations, yet is actually a site of production, representation and regulation. So too the sky. Weather and climate seem so external, yet in body climates and local biometeorology, to name but two examples, they are internalized in a variety of spaces. The politicizations of the atmosphere are concretized in their becoming the sites of fears about modernity. As Serres (cited in Golinski, 2003: 17) notes

> [t]oday our expertise and our worries turn towards the weather, because our industrious know-how is acting, perhaps catastrophically, on global nature.

The weather is deeply inscribed with meanings, cultural and political, that are shaped by a fear that a modernity-induced changing climate is radically altering it.

Increasing interest in nature is often coupled with concerns that nature is being changed or damaged or destroyed. Beck’s (1992) risk society thesis took root in concerns over Chernobyl and the growing environmental dangers that (post-)modern society seemed to present (Beck, 1987). Yet at the same time, as Bernstein (1998) suggests, it is not progress or love of technology that characterizes the modern world, but the notion that risk is controllable rather than in the whims of gods. The weather, however, has generally been considered a special case, an environmental risk that is essentially unmanageable. The relative failure of cloud seeding (Bruintjes, 1999) presents an example of the capriciousness of the weather that so eludes control. As Golinski (2003: 32) notes "[t]hinking about the weather obliges us to acknowledge the incompleteness of modernity." Risks are emotive; they are at once something unseen and uncontrollable, but on the other hand something that must be controlled. At the core of environmental risks is the question of knowledge.

Though modern risks in Beck's (1992) terms are something uncertain and unpredictable, they must to a certain extent be knowable to know that there is a risk. This interplay of risk and knowledge in environmental studies is important for understanding the development of a weather derivatives market. Weather becomes more risky through the discursive power of climate change, yet unless that risk is knowable and normalized it would be difficult to sell as a financial product (de Goede, 2004). Risk can therefore be ontological (the thing itself) or epistemological (for example ways of quantifying uncertainty) or in-between[1]. It depends on how it is mobilized as a concept by groups of actors. It is probably most correctly a co-constitution of 'nature' and 'society'. It has a social and institutional life and becomes a centre of practice (Zaloom, 2004). Risk is

[1] For the purpose of this thesis, ontology refers to what exists *and* how it exists (i.e. the relations of its existence) and epistemology to the nature and scope of knowledge about that reality. A caveat must be raised. Ontology as a term has many different meanings and is variously used to mean what exists (or could exist) and/or how it exists. Following Kaufman (2002) one could argue that metaphysics and ontology have been confused terms. He suggests that ontology should be restricted to the nature or relations of existence (not what exists). The distinction allows a relational ontology with a realist metaphysics (see also Longino, 2002). The term metaphysics throughout refers specifically to what exists.

practiced in different ways in different places at different times and the ways in which actors mobilize the concept, thus in part constituting the risk that is in question, is an important interplay in understanding the notion of weather risk used within the weather derivatives market. The environmental risk becomes a financial risk; it is repackaged in a different form. Weather risk has been transferred from the realms of providence to an active financial management; nature has been translated into financial interests.

How though is it possible to understand and analyze the creation of weather derivatives? Thinking about the complexities of nature-society, weather/climate and risk, highlights a range of theoretical debates in the social sciences (and beyond). The following sections argue that there are confluences and divergences between different theoretical positions that can usefully be engineered for understanding empirical practices. Three groups of authors will be called upon to attest to the vibrancy of a pluralist approach, namely pragmatic philosophy of science, sociology of science and political economies.

2.3. PRAGMATIC PHILOSOPHY OF SCIENCE

The first group of writers that can be called upon provide a philosophical underpinning to notions of knowledge pluralism and pragmatism. There is not space here to delve into the wide-ranging context of philosophy of science, rather the purpose is to pull out some key themes from one particular school of pragmatic realist philosophy of science (*contra* scientific realism) that are useful in articulating a theoretical apparatus for understanding the weather derivatives market.

Bhaskar's (1997) critical realism purports a hierarchical understanding of reality in which there is an immanent order both to the structures of the world and the disciplinary approaches dedicated to revealing those structures. He suggests that the social is underpinned, but not reducible to the biological, which is similarly underpinned, but not reducible to the physical (see figure 2.1). This hierarchy tends towards 'physics envy', the idea that physics is the foundational discipline for others to follow (Massey, 1999). The approach is also characterized by a scientific realism, in an admittedly mediated form, by which the role (and indeed process) of science is to make better ('truer') or more adequate representations of reality (Bhaskar, 1997; Sayer, 2000). Knowledge thus purports to be the representation of reality, which can be judged for conformation. Yet a metaphysical realism should not be conflated with a scientific realism (Longino, 2002). The physics envy derives from positivistic assumptions that the different pictures of the world can be built up to create one understanding or image of the world (Cartwright, *et.al.*, 1996) i.e. there is a fundamental unity of knowledge. That there is some form of real world 'out there' does not mean that the success of science or indeed knowledge more generally is dependent upon conformation to that singular reality. Rather pragmatic realists, in particular the Stanford School of philosophy of science (Nancy Cartwright, Jordi Cat, Hasok Chang, John Dupré, amongst others), argue that reality is not a neat singular thing and hence any form of knowledge is one particular ordering of reality (how that ordering comes about is a question for sociology in the next section).

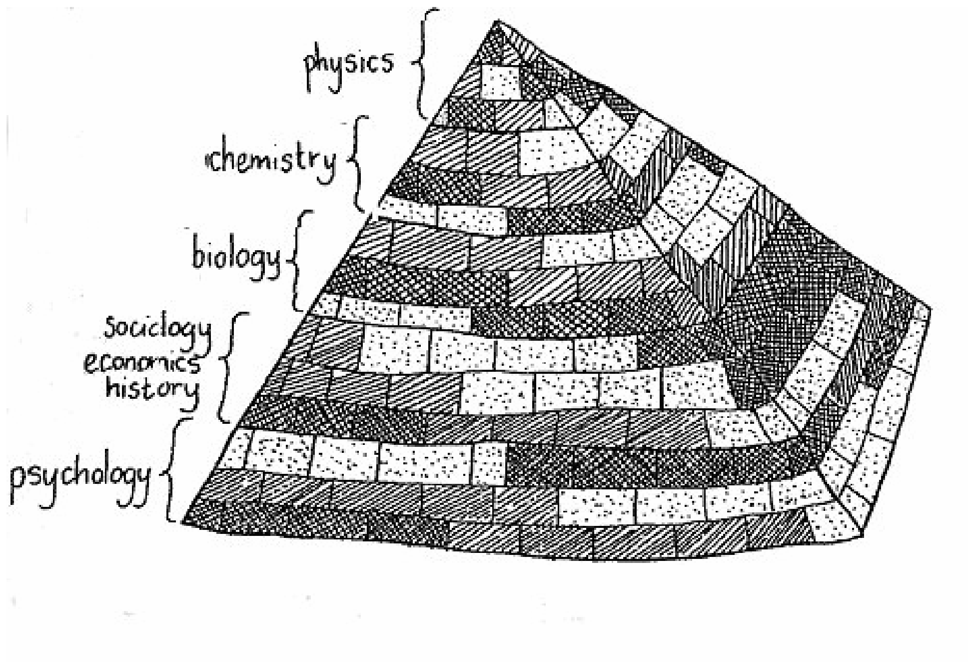


Figure 2.1. The traditional hierarchy of disciplines sometimes referred to as the depth model in critical realist parlance (Hacking, cited in Cartwright, 1999: 7).

This approach is similarly opposed to antirealists that suggest that accounts of processes can be made compatible with any empirical basis and none actually corresponds (in any way) to a real (Longino, 2002). Van Frassen (cited in Cartwright, 1999: 5), for example, claims that the primary question of philosophy of science is: "How can the world be the way science says or represents it to be?" Cartwright (*ibid*: 5), however, takes a different tack arguing for a normative question: "How can the world be changed by science to make it the way it should be?" This draws upon the work of Otto Neurath, a founding member of the Vienna circle and socialist social engineer. He was concerned to remove a foundational view of knowledge and instead proposed an associational view of knowledge that there are many sciences each displaying important things about different aspects of the world (Figure 2.2) (Cartwright, *et.al.,* 1996). These cannot be unified into a single theory, but instead become adept at explaining phenomena within their (not pre-defined) boundaries. Cartwright (1999) describes this as 'the dappled world.' Her book with this title opens with the claim

> … we live in a dappled world, a world rich in different things, with different natures, behaving in different ways. The laws that describe the world are a patchwork, not a pyramid
>
> (*ibid*: 1)

The world is not neatly ordered, ready to be discovered, but rather "… regimented behaviour results from good engineering" (*ibid*: 1). Thus sciences place order onto disorder; the world is messier than a single theory might suggest (see also Porter, 1995; Whatmore, 2002). Thus Cartwright's normative commitment is that if sciences place orders onto the world that then have a whole series of implications, if those sciences placed different orders a 'better' world may result.

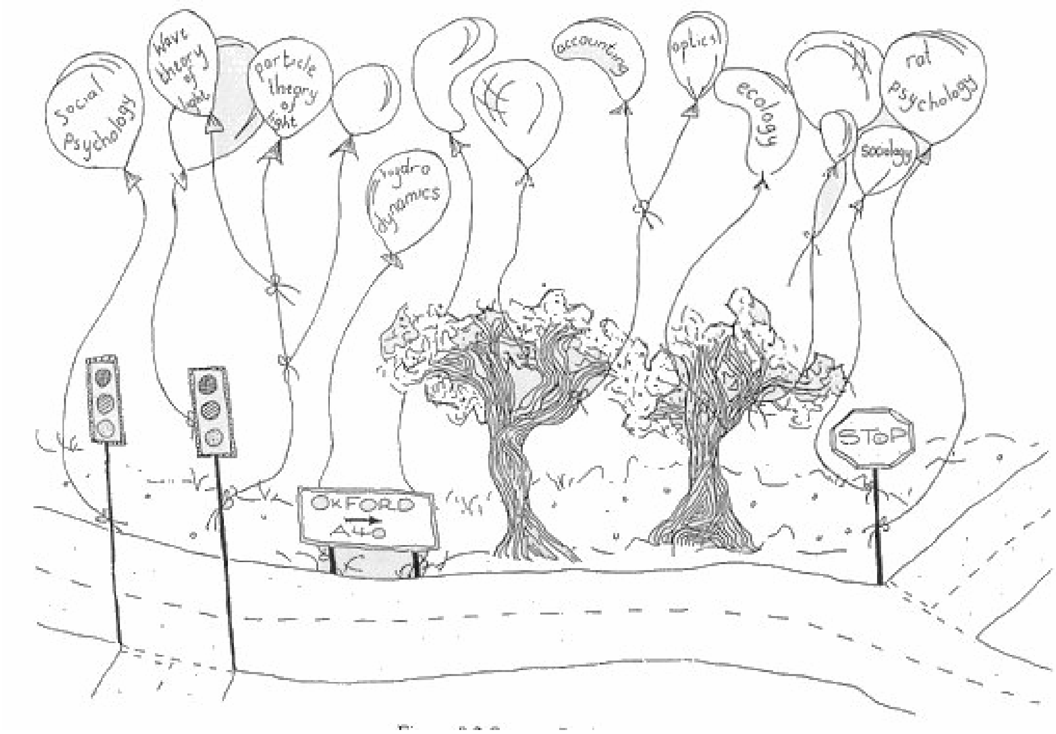


Figure 2.2. Different disciplines in a non-hierarchical relationship (Hacking, cited in Cartwright, 1999: 8).

Realism is vital, but must be promiscuous, and science, because of this underlying ontological complexity, cannot be a single, unified project (Dupré, 1993). It is rather held together by a sociological unity (Dupré, 1993). This difference, it is argued, is rooted not as is conventionally believed by some scientists because there is not enough knowledge of those universal laws (a meta-science) that underlies all the other sciences, but rather because the world is dappled and complex (Dupré, 1993; Cartwright, 1999).

Different sciences and other disciplines thus purport a unity that is undermined by the mottled nature of reality. Whilst there may be some very useful disciplinary angles on the world, it is highly restrictive on problems, such as arguably weather derivatives, that cross disciplinary boundaries. As Neurath points out (cited in Dupré, 1993: 8-9)

> [p]articular practical problems may require input from different parts of science for their solution, and all the parts of science should therefore be jointly applicable to the same question.

Interdisciplinarity here is vital, because reality requires it. Disciplinary imperialism does not allow the resolution of practical problems like these. As Sayer (1999: n.p.) argues these postdisciplinary studies, as he terms it,

> … emerge when scholars forget about disciplines and whether ideas can be identified with any particular one; they identify with learning rather than with disciplines. They follow ideas and connections wherever they lead instead of following them only as far as the border of their discipline. It doesn't mean dilettantism or eclecticism, ending up doing a lot of things badly. It differs from those things precisely because it requires us to follow connections.

In tracing connections across disciplinary boundaries, the requirement to reduce everything to a disciplinary perspective is removed. Though there are undoubtedly impediments to interdisciplinarity (Schoenberger, 2001), disciplines discipline the participant into ways of thinking, knowing and acting in the world. They can act to exclude. More critically, one can argue that disciplines, in this case the sciences, act within institutional affiliations to exclude 'pseudo-science'.

> … '[S]cientific' has become an epistemic honorific quite independent of any general consensus about what makes scientific claims any more deserving of

> credit than beliefs from any other source. The entitlement to this honorific derives, rather, solely from the institutional status of the persons from whom the claims originate.[1]
>
> (Dupré, 1993: 222)

The social networks within which the person is placed rather than the specific research in question rationalize what gets labelled science (Murphy, 2006).

These philosophers (and others) suggest that scientists do not search for truth *per se*, rather, scientists engage in questions of interest to particular people or communities, whether that is a group of scientists or a commercial funding body (Longino, 2002)[2]. This clearly does not mean science is no use, but rather suggests that science is not a monolithic thing (Science), but a series of diverse projects and ways of understanding[3]. This is important for understanding the generation of knowledges about things (whether that be finance or climate), in that there are many types of science being conducted within different communities with varying ideals of standards that are used to authorize what counts as knowledge. As Longino (2002: 188) puts it

> [t]he kind of knowledge a community seeks, the purposes for which it seeks it – that is, the uses to which knowledge will be put – guide the development of the community's standards

[1] Dupré's use of the word 'solely' in this quote is contentious, indeed arguably goes too far, but there is little doubt that sharp demarcations are drawn between those of 'science' and those outside 'science'. See chapter 5 for some differences between corporate and academic meteorology, and Latour (1987).

[2] There is a certain irony, or in Mirowski's (2004) view a type of performativity and justification, in some of the philosophical claims that science is goal-centred or instrumental in that it plays perfectly into the commercialization of academic research (see section 2.4).

[3] The approach here takes a middle ground between those that feel outsiders should "... sing only happy songs around the scientist's campsites" (Kitcher, 1998: 49) and the sociologists that too often conceive of scientists as "… brain-dead from the moment they enter the laboratory to the moment at which they leave" (*ibid:* 37-8). Scientists have many goals, some are explicitly social, political, economic, but others include advancing a field, leading new scientific explorations etc.

Evans and Shackley (1997) suggest that models produced in corporate rather than academic environments tend to be simpler and more instrumental, whilst the latter are more complex and the assessment of expertise is contested through peer review (on the role of peer review see Edwards and Schneider, 2001). Judging between approaches or models can only be understood in terms of current practices in the epistemic communities (Longino, 2002). Understanding how those knowledges produce particular realities is a more important question than rationally justifying the (in)commensurability between approaches i.e. the critical issue is how different scientific understandings are materialized (Murphy, 2006). It is therefore inexplicable to say that corporate models are not as good; rather they meet different requirements, for different goals, and create knowledges within those boundaries.

The next section outlines the ways in which this philosophy is translated and has continuities for understandings of knowledge in science, arguably the main area for sociological studies (though some sociologists promote a rather broader philosophical argument that has led them into conflicts with philosophers).

2.4. SOCIAL STUDIES OF SCIENCE: ACTOR-NETWORK THEORY

The second literatures outline a sociological account of knowledge and are vital for understanding how weather derivatives are a co-production of nature, science and society. Though there are many brands of social studies of science and technology (hereafter STS), the tack taken here specifically focuses upon one approach, namely actor-network theory (hereafter ANT[1]), but placing this within the context of other pathways.

[1] Though there are many variants of ANT, the singular ANT will be used throughout to describe the work in particular of Bruno Latour (1987; 1993; 1996; 1999a; 1999b; 1999c) and Michel Callon (1986; 1994; 1998).

STS writers are not one coherent group of theoretical, methodological or philosophical approaches to the study of science. Though STS approaches are not new *per se*, the current approaches can be placed within the emergence of a series of sub-disciplinary fields of science studies since the 1960s. This was in response to internalist histories of science that argued that science was developing progressively by virtue of rational process, that the past could be re-interpreted in light of present knowledge, and where the histories often acted merely to glorify the scientists in the debate (see the empirical critiques of this in Waller, 2002). Rationality provided the right scientific answers and the social only influenced science in cases of bias or bad science (Longino, 2002).

Mertonian studies during the 1960s did not critique the progressive nature of science, but rather suggested that scientists were institutionally socialized, that is they held particular values that enabled the creation of disciplinary regimes which enforced forms of conservatism (Barnes, 2001a). During the 1970s this institutional approach was challenged by authors within a peripheral revolutionary group (in Mertonian terms, see Barnes, 2001a), that became a widely adopted approach to science studies within which scientific knowledge was held as a social product and was neither impartial nor necessarily progressive (Barnes, 2001a). This associated the generation of scientific knowledge with social (and other) factors, values and interests. It was also a response to the perceived disregard philosophers of science gave to the role of the social, compared to the cognitive (rational) in science. They argued against the internalist histories that rationalized scientific activity and suggested that true or false beliefs should be judged symmetrically (Longino, 2002). Nature could not be used to explain the former nor irrationality the latter. In effect this revolution split into several groups, of which two became particularly important. The first group is often labelled 'the Edinburgh school' or 'the Strong Program' and became associated with strong social constructivism, whilst the second group followed the work of Latour (1987) and Callon (1986) with, what the devotees of the first group associated as, a return to realism (Sismondo, 1993)[1]. Indeed a debate in 1999 between Bloor (1999a; 1999b) and Latour (1999a) can be cited as an example of the divergence of positions held by the two groups. The Strong Program argued that social factors were the key to understanding the creation and settlement of scientific issues (Bloor, 1999a). Nature, via science, is constructed as a consequence of the negotiation of a range of social actors and interests.

> Nature will always have to be filtered, simplified, selectively sampled, and cleverly interpreted to bring it within our grasp … How we simplify … is not dictated by (non-social) nature. These processes, which are collective achievements, must ultimately be referred to properties of the knowing subject.
>
> (Bloor, 1999a: 90)

Latour (1993) critiqued the Strong Program for overcoming one asymmetry (the rational philosophical) and replacing it with another (the sociological). He argues that the Strong Program created a new problem by suggesting that nature was constructed by society, but leaving transparent social factors with the entire causal efficacy in debates (Longino, 2002). Bloor's position almost inverts figure 2.1. It fails to acknowledge the role of reality, in however a multiple or hybridized form, in scientists' constructions of categories

[1] The phrase 'Strong Program' as Bloor (1999a) notes was to distinguish this field of study from the 'Weak Program' of Mertonian studies. The 'Strong Program' was to analyze all systems of belief equally (symmetrically). Social constructionism means many different things depending on the context within which it is used and the (sub-) disciplinary group mobilizing the term (see Demeritt, 2002). Within the context here of the 'Strong Program' it can mean "… the material construction of the objects of scientific thought and representation" (Woolgar, cited in Demeritt, 2002: 773), although Bloor (1999a), for example, circumvents the strong, if not weak, idealism explicit in this (Kemp, 2005).

to understand nature(s). It engages in a dualistic structure that privileges society over nature. Thus Latour (1993) proposed a different symmetry that nature and society were outcomes of processes not pre-given points that decided debates in themselves. This removes the impediment of adding on the social or natural to the study, to consider equally the control of human and non-human resources (Latour, 1987). Latour (1987) also proposes a different set of social processes to the Strong Program. It is not enough, he suggests, placing the scientific activity as a result of social interactions, these processes are always in flux, being continually re-networked as industries and scientists re-negotiate their interests through each other (see also Callon, 1986).

This work from the 1970s and 1980s has been supplemented by a variety of other STS approaches. Barnes (2001a: 529) labels a third group 'cultural studies of science', which looks more closely at 'class, race, gender and colonialism' within the work of scientists. Haraway (1997), for example, has suggested that knowledge is always situated, both within wider socio-political contexts and also in places, machines or bodies. Though her work is arguably influenced by ANT, this approach to knowledge can be seen as *contra* Latour's view from nowhere (Amsterdamska, 1990), where the analyst simply follows a debate from an elevated position. Rather, Haraway (1997) suggests, all knowledge is partial, subjective and situated, because of the hybridized nature of the world and the position of being-in-the-world. There is not space here to delve into all the details in and between these positions in science studies, merely to attach a flag to one approach, namely ANT, which will provide some grounding for the research in question in this thesis.

ANT, as its name suggests, relies on the concept of the network, a concept, which is derived from a background in physical sciences through the notion of electricity

(Barnes, 2001b). Networks are unstable and can change quite rapidly[1]. They are held together by a series of associations some of which are weaker or stronger than others. Should these networks undergo tests of strength (trials), the network may be re-configured, collapse or emerge stronger with new sets of allies connected. These allies, or actors, are thus in continual re-negotiation within the network and their power is thus related to the length and extent of the network, rather than their individual power. Power is an outcome of the network and is not embodied within any particular actor (Latour, 1987). These actors can be human or non-human and made up of anything stretching from scientific data to experimental equipment to a particular individual scientist.

Whilst these researchers deny *an* ANT (Latour, 1999b; Law, 1999), they broadly follow post-structuralist concerns with the removal of essentialisms and address the ways in which boundaries are drawn around concepts such as nature-society[2]. Boundaries are drawn to achieve particular scientific or political objectives (Dupré, 1993; Latour, 1993; 1999c), because in close focus everything is hybridized. Hybridity can be described as the notion that nothing belongs to any specific category or strata, that everything is always already constituted as a hybrid (Haraway, 1997; Whatmore, 2002). This is an anti-essentialist argument whereby the categories of nature and society are thoroughly compromised, because they are both always already co-constituted in the other[3]. All modernist dualisms are therefore removed in search of the pre-modern (Latour, 1993),

[1] Albeit that Latour's distinction between ready-made science and science in the making suggests that centres of networks become relatively unchangeable (they become locked-in).
[2] Essentialism, for the purpose of this thesis, is the argument that objects have essential properties that make them a particular kind of thing (Sayer, 1997: 456). There are many types of essentialism from strong varieties that believe in the eternal existence of essential properties that make one thing natural and another not, through to what might be termed relational essentialists that " … attribute immutable capabilities to specific relata" (Castree, 2003b: 9).
[3] There are technically at least two types of arguments about hybridity, one which suggests that each object is a combination of natural and social things, and those that explicitly attack the ontological framing of nature and society such that everything must always already be hybridized (see Haraway, 1997; Whatmore, 2002).

particularly ‘non-debates’ such as ontology-epistemology (Latour, 1999c) and nature-society (Whatmore, 2002), which were products of Western enlightenment thought. With regard to the former Latour (1999c: 15, emphasis in original) notes that

> When we say there is no outside world, this does not mean that we deny its existence but, on the contrary, that we refuse to grant it the ahistorical, isolated, inhuman, cold, objective existence that it was given *only* to combat the crowd

Latour here can be read as supporting realist metaphysics and a relational ontology. That nature and society are products can be accepted without denying the agency of things that are in the world; metaphysical realism does not have to hold to pre-inscribed categories of existence. Rather if the importance of pluralism is taken from Cartwright (1999), Dupré (1993), Longino (2002) and others, a more nuanced view of ANT can be sought that engages in empirical enquiries of how debates are settled with the input of a variety of actors, without denying the efficacy of these things in the world. This distinction is important as it is the obscure plays-on-language that Latour (1999c) engages in that arguably frustrate people trying to use his work in practical situations and also philosophers.

ANT is arguably a non-representational theory as it is built upon the co-performance of epistemology and ontology that combine only in representational moments. Indeed as Hinchliffe *et.al.* (2005) note, simply suggesting that there are a variety of different knowledges that could be improved with better representations of the nature in question, loses sight of the ontological politics (Mol, 1999) imbricated in the co-production of people and things. Latour (1993) terms these modern ontological divisions ‘purifications’ that attempt to remove the messiness of life (or the dappled world, Cartwright, 1999). Latour suggests that Nature and Society are the result rather than the cause; they are products of a given understanding of the relations of reality, not the cause for settling debates. At a more concrete level, Whatmore (2002) has written at length about the networks of associations and practices that have continually ‘freighted’ the *a priori* nature-society dualism, whether this is elephants or genetically modified foods. A frequently cited example is the scallops of Saint Brieuc Bay (Callon, 1986). The arguments of the scallops, fishermen and scientists were interwoven in a complex account of nature, science and society that highlights the various interests of different actors. To proceed with the project of protecting scallops, the concept of nature became differently rendered and valued within each group. The scallops also came back to act within and beyond these groups, illustrating the importance of non-humans as actors within scientific, or other, projects. Nature and the sciences of nature here have no clear, unified image; rather nature, society and science are co-produced, and boundaries between nature and society are orders rather than pre-existing definitions (Cartwright, 1999; Latour, 1993; 1999c; Whatmore, 2002).

These case studies illuminate the failings of the modernist dichotomy, the ontological purification of nature and society that Macnaghten and Urry (1998) associate with years of environmental degradation and estrangement from ‘nature’. These approaches thus re-fashion the connections between human and non-humans to arguably engage in a normative project of environmental politics, to “… make a modest difference to the ferment of urban wild things” (Hinchliffe *et.al.,* 2005: 656). ANT writers are therefore engaged in showing how science transforms the world. Creating new scientific knowledges literally translates the world as we know it. This has an interesting parallel back to Cartwright’s (1999) pragmatic philosophy of science where she suggested that the task of philosophy of science is to suggest how science can change the world to make it the way 'we' want it to be.

In addition to these concerns about dualism, ANT writers stress multiplicity, the process of becoming and the de-centredness of actors. Multiplicity suggests that there are multiple worlds, which no singular perspective can adequately describe. Everything is always multiple (Serres, 1995) and here ANT shares some common ground with the promiscuous realists (Dupré, 1993) and the nonmonists (Longino, 2002). The process of becoming destabilizes notions of a settlement of an issue. Things are forever in the process of change; reality is a process, because the networks holding actors together are being subjected to trials that will lead to translations of interests, which leave no network unchanged (Callon, 1986). This notion is also linked to the argument about performance. The world is continually in a mode of becoming, because it is being continually performed. This supports ideas that climate models perform the climate or that mathematical equations perform the economy (Demeritt, 1996; MacKenzie, 2003). Within this network of becoming, actors are de-centred because they have no power in and of themselves. Power is a network function and actors are constituted by the networks within which they are placed (Latour, 1987). The de-centring of actors also allows non-human as well as human actors to be involved in the construction of networks of nature-society. Networks are built by actors in many different ways involving many different types of actors and hence cross many disciplinary boundaries. The disciplinary order prevents the connecting of various things that traverse continents and scientific practices (Latour, 1993; Elam, 1999), again paralleling both Sayer (1999) and Dupré (1993).

ANT, more concretely, provides two key concepts that are vital for understanding the development of weather derivatives. These concepts are namely, translation and the enrolment of actors, and centres of calculation.

The process of translation and the enrolment of actors are vital processes in marketing a new product. Latour (1987: 108) describes translation as "... the interpretation given by the fact-builders of their interests and that of the people they enrol". For weather derivatives to grow and be accepted as a core part of business culture required the successful marketing of this new product originally to a board at one company and later to other companies, regulatory agencies, exchanges, brokers, meteorologists, model-creators and so on (chapter 4). This enrolment is informed by the interests and activities of those other actors. The fact-builder, in this case the original actors investing time and effort in creating a new weather product to mitigate everyday weather risk, needed to support their claim or their product by enrolling, or strengthening their network, with additional actors. This may be more complex than a simple presentation along the lines of 'we want to create weather derivatives and grow our business so we want you to do this for us'. The immediate question is why anyone would want to do this if it holds no benefits for them, particularly in the financial sector where people's jobs are dependent on the creation of wealth. Thus to enrol these actors into the weather derivatives market requires a translation of interests, a marketing in a particular direction, to enable the weather derivatives community to set up their market. Translation can proceed in a number of ways and Latour (1987) describes four. These are namely the 'I want what you want' strategy, 'I want it why don't you?' argument, 'if you just make a short detour' reasoning and the reshuffling of goals and interests. Whilst Latour (1987) is specifically speaking about the interests of individual or groups of scientists, the general schema can be adapted towards the marketing of a new product. To establish weather derivatives required the enrolment of a range of actors from meteorological data providers, institutions to sell the product, financial regulatory authorities and individual weather events. Each present a different challenge, each require different levels of diversion from the main aim of setting up a weather derivative, but these translations have to be accomplished to market the new product. The process of enrolment does not define society by pre-existing roles or entities, but rather shows the series of negotiations and associations through which society is built up (Callon, 1986). These issues will be explored in more detail in later chapters, but the issue of enrolment is also tied to a second issue, which relates to power in the network.

Centres of calculation can be described as the central ordering office where information from the network is collected and used both to tie the enrolled actors closer to the network and to proceed with calculations, models, from the accumulated information (Latour, 1987). One example can be seen in the development of meteorology in the 19th century. Meteorological data reports were telegraphed back to the central meteorological office for the compilation of general weather forecasts. Those meteorological stations engaged in data recording had to meet set standards as specified by the meteorological office and this centre needed standardized data to produce overall images of weather in a region and aid in the production of forecasts. The centre of calculation, the meteorological office, had the power not just to control the networks by checking instruments and observers, but also to produce forecasts for those stations that sent in data (Figure 2.3.)[1]. The centre of calculation thus acts as an ordering body, that is, it orders not just the networks but also orders the world it is trying to measure, examine and perform. The

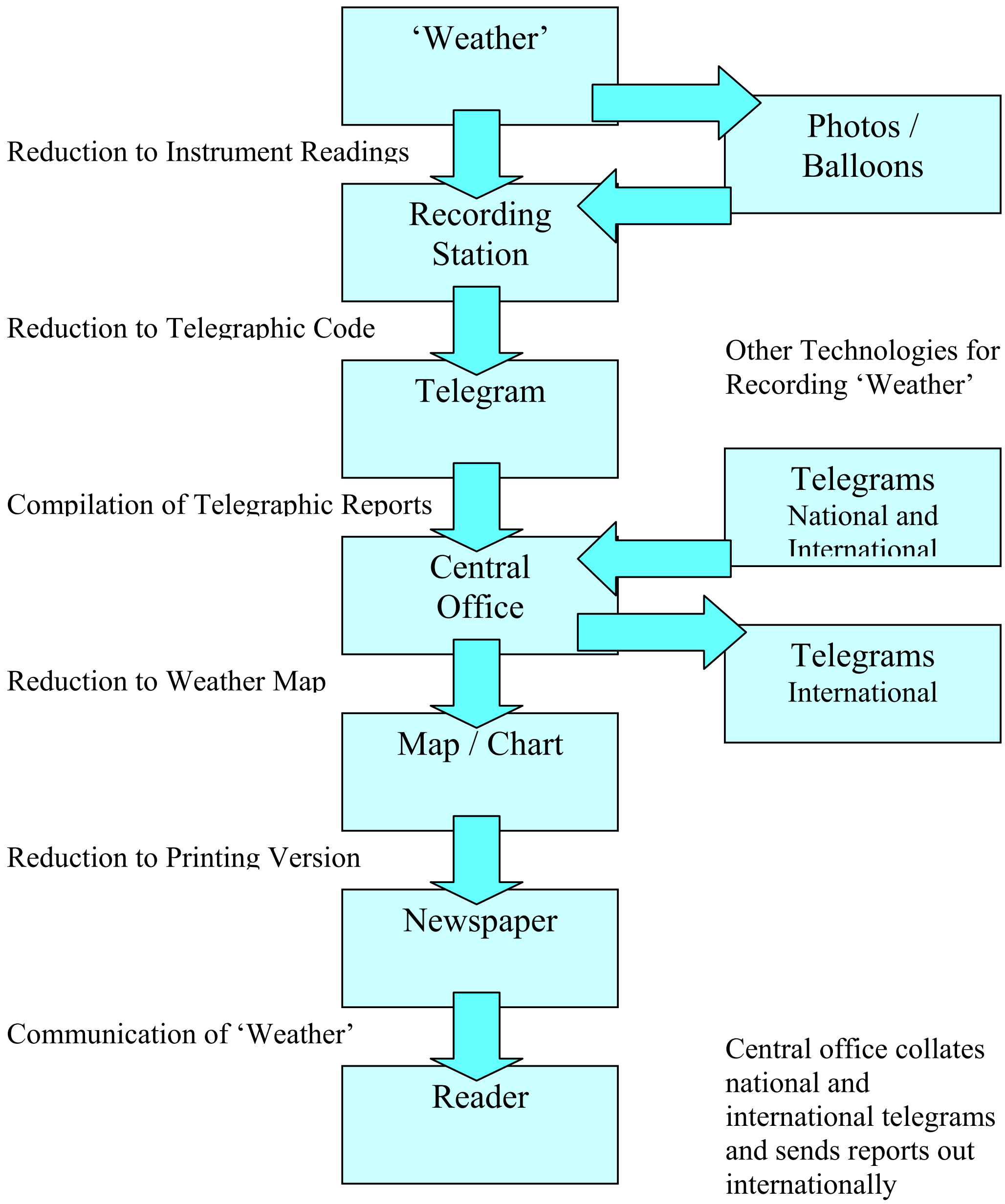
[1] This is an interesting example where some actors in a network appear more powerful than others. Though the power of the actors is doubtless dependent on the rest of the network, the centre of the network here is persistently stronger or more powerful than others. This may be a reconciliation place between political economies literatures and ANT (Castree, 2002).

power of the centre of calculation is a network outcome and without the network that centre would have no power in and of its own accord. Without the data providers, it could not act.

These two concepts provide tools of analysis that enable an understanding of the weather derivatives market. How does a new product come about and how are knowledges mobilized and transformed about a range of things to create this product? These are sociological questions as Longino (2002: 79) notes.

> The sociologist is interested in all the causal [sic] processes and interactions involved in the formulation of a model or in the discovery or construction of a hitherto unknown substance or process and in the processes and interactions involved in its acceptance-rejection in a community. Thus the empirical investigator is interested in the processes by which cognitive authority or the status of legitimacy is claimed and constructed.

This provides a neat encapsulation of many of the aims of this thesis. How is this product accepted or rejected, and what strategies lead to this? How is legitimacy for weather derivatives claimed? Quite clearly STS is relevant for a whole series of questions and to underline this, two areas of research will be briefly examined that have some bearing on the later chapters. These are namely STS-inspired approaches to finance and climate (change).



Producing weather

Figure 2.3. The translations (or reductions) undergone by weather parameters as measured by instruments to a product in a newspaper weather map. At each stage weather is transformed into something increasingly removed from its initial state. This chart neglects the reverse relationships, for example how readers might pressurize a newspaper for certain types of presentations of 'weather'. (Randalls, 2002: 36)

Finance has recently become a subject for the application of the tools and techniques of STS. Network approaches have inspired network accounts of 'the economy', many of which come under the broad label of the 'new economic sociology' (Granovetter, 1992). Understanding 'the economy' is not about accepting the economic models of it, but rather exploring the ways in which economic practices are constituted, the networks of associations of finance (etc) that produce economic effects. To understand finance the black box must be opened up (Pollard, 2003) such that the performative and associational effects of finance can be described.

For these writers there is no such thing as a separate economy, which organizes, structures and controls. The notion of 'the economy' is a creation, or a performance, of economics (see Callon, 1998; Gibson-Graham, 2000). As Callon (1998: 28) notes

> Without mediators like accounting tools and marketing management it would be impossible to distinguish between economics and an economy, just as it would be impossible to explain their interdependency.

MacKenzie (2001) argues that in financial markets language becomes cyclical and reinforces itself. Finance, companies and economies are all performative. "If an activity has been branded as uneconomic, its right to existence is not merely questioned but energetically denied" (Schumacher, 1973: 37). Similarly within the terms of a financial market it is the mathematical equations, the technologies and the social networks that construct and perform the market (MacKenzie, 2003; 2004; MacKenzie and Millo, 2003; Wilmott, 2000; Zaloom, 2003; 2004). What is financial, what is a marketable product, and so on, is not a pre-determined distinction, but rather one that is performative. Weather derivatives, thus, become derivatives because they perform being a derivative rather than that they are pre-inscribed as one (see chapter 6). These definitions are constantly in a process of (re)negotiation and (re)configuration. As MacKenzie (2003: 860) puts it, in the concluding paragraph in a paper that sketches the performativity of mathematical equations,

> ... the financial markets will remain ... an only partially configured world. The struggles to configure that world, and the forces opposing and undermining that configuring, are, and will remain, at the heart of the history of our times.

Weather derivatives are part of this continual re-configuring of financial markets and the challenges this presents to companies having to adapt to this ever-changing set of practices, rules and procedures.

O'Neill and Gibson-Graham (1999) have argued that concepts like the company should similarly be destabilized as firms are not singular beings with a unified logic of reproduction. They are instead (at times) disorganized, incoherent and contradictory. This thesis will use the word company or firm or business as a shorthand at various times to describe particular actions taken visibly as a company, yet clearly these actions are generated by particular networks of things within the flexible boundaries of that company. Similarly other financial notions used in this thesis are subject to similar proposals.

Credit ratings are a socially constructed system of managing the financial resources of companies by using forms of quantitative techniques for differentiation such that networks of finance can be enabled or disabled. The credit rating system is not static, it is continually being re-made, but it does have important implications for the ways companies can perform their business and of course perform in front of the people deciding the credit ratings. Finally an important point must be made about profit. Work in critical accountancy as well as STS have highlighted the constructed notions of things like profit, or balance sheets, or corporate reports, whereby particular rules and regulations come to define and perform the economy (Callon, 1998; Crowther, *et.al.* 2006; Hatherley, *et.al.* 2005; Porter, 1995). Profit, as used in this thesis, is a contingent outcome of a series of negotiations about how profit should be calculated, driven by actors supporting various forms of harmonized accounting regimes (Porter, 1995). Thus it can be said that profit is a key motive, for example, and that this has a wide range of effects, but that this notion is not stable, it is continually being re-made. Profit is contextual and the way the profit discourses structure business activity, or accounting of that activity, is critical for appreciating how weather derivatives could develop. "... [T]he rules become genuinely constraining, even if some room always remains for creative manipulation" (Porter, 1995: 98). Profit discourses create a set of economic practices that perform a particular economy. Changing those discourses could thus lead to a different way of thinking and performing 'the economy' (Gibson-Graham, 2000). This is not to suggest that the concept of profit has no power, or has no material or discursive implications; "definitions of financial value … are very *real* in their effects" (de Goede, 2001: 152, emphasis in original). Rather it points to the fact that profit is constructed, contextual and impermanent. Finance has become a topic for science studies inspired approaches, but the broad applicability of STS can be clearly seen in the switch from finance to climate (change).

Climate change, as one of the most expansive discourses today, has also come under scrutiny from sociology of science techniques. Demeritt (1996; 2001a) is particularly concerned about the already-made scientific accounts that are presented about the rising climatic problems due to increased CO_2. Borrowing from Friedman, Demeritt (1996:494) argues that climate is no longer a statistical phenomena, but rather "the socially constructed product of … mathematical models". It might not sound very promising for many scientists to hear the words social construction applied to climate. Indeed his accounts of climate science and climate change have come under criticism for being too socially constructionist (Schneider, 2001). Nevertheless Demeritt (1996; 2001a) is targeting the ways in which data, models and forecasts produce expectations of climates and potential future climates. This becomes particularly important when policy decisions are based on modelled climates rather than any empirical actualities that indicate a changing climate.

Global warming is the product of a set of general circulation models (hereafter GCMs), which are physically reductionist and normalize sets of social relations, particularly as they relate to the increased levels of greenhouse gases (Demeritt, 2001a; Rayner, 2003; Taylor, 1997). Understanding the assumptions, both empirical and theoretical, and the procedures adopted within the climate modeling community, which are arguably not as stringent as in many other modeling communities (cf. Edwards and Schneider, 2001) though they have achieved more consensus, aids the unraveling of a series of claims about climate change (Demeritt, 2001a). It provides a reflexive understanding of climate science, one that seeks to trace the networks of things that have been involved in the heterogeneous construction of global warming (Demeritt, 2001a).

Climate science has remained in the reserve of experts located in specific institutions, an important point within Dupré's (1993) understanding of the scientific honorific. Indeed Demeritt (2001a: 327) goes as far as to say that

> … the international epistemic community of scientists … coalesce[s] around the world picture produced by GCMs … [T]here has been little public discussion of the commitments embedded within and advanced through its technical practices. This closure has occurred in part because of the enormous complexity of climate change and of the highly specialized multi- and interdisciplinary bodies of expert scientific knowledge through which it has been understood. Open and reflexive debate has been stifled because of the way this knowledge has been organized and communicated[1].

This has resulted in an undue reliance on experts' understanding, perhaps following Latour (1987) as part of a strategy of reducing the number of competitors in advancing a particular scientific claim, which has also been reinforced by the emphasis on scientific uncertainty. Indeed non-experts have understood global warming in so many different ways that it may have 'lost' credibility as a concept, not least scientifically (Somerville, 2006). This is an example of a 'fact' taking on a variety of different meanings within different networks and being mobilized to support a wide range of concerns and normative implications (Latour, 1987). Technically, then, one cannot speak of climate change doing anything, as it is a constructed notion. Yet the discourses and knowledges about a changing climate do have discursive and material implications. If climate change, as a notion, is a construct of science (not denying the reality of an atmosphere that may have persistent changes), then analyzing the construction of it becomes a pre-eminent concern. As Demeritt (2001a) argues, his sociology of science approach should not be interpreted as a critique of climate change debates *per se*, but rather it highlights the ways in which climate change science has developed, which has allowed particularly vociferous

[1] Cf. Edwards and Schneider (2001), who argue that the IPCC through its very nature of debate actually embraces a scientific approach that is more open than in most other scientific communities.

opposition to discredit the scientific intentions (see also Shackley and Wynne, 1996). He concludes his paper by saying that

> Science does not offer the final word … [I]nstead scientific knowledge should be presented more conditionally as the best that we can do for the moment. Though perhaps less authoritative, such a reflexive understanding of science in the making provides an answer to the climate skeptics and their attempts to refute global warming as merely a social construction.
>
> (Demeritt, 2001a: 329)

Or as Cartwright (1999: 10) suggests in a discussion of the laws of physics and economics, models

> … tell us what can happen, not what will happen, and the step from possibility to actuality is a hypothesis to be tested or a bet to be hedged, not a conclusion to be credited because of its scientific lineage.

The pursuit of sociology of science is not to undermine the science completely, but to reflect upon the social processes that produce it and to illustrate to the public how climate change knowledge has been produced, not just to give the public technical details relating to future climate change (Demeritt, 2001a; Shackley and Wynne, 1996). Sociology of science, and specifically ANT, is enrolled as a tool to support the argument for a greater openness in climate science, to understand the (micro) social, economic and political processes, as well as the scientific decisions, that are continually being (re)made and to arguably create better understandings of the environmental science in question.

In this way ANT can become practical and even normative, despite the assertions of its critics that it is just about marketing (Amsterdamska, 1990; Elam, 1999). Millstone (1978: 121) complained in 1978 that

> [t]he sociology of knowledge should be pursued in relation to some broader social objectives, such as liberation and the elimination of oppression, or else it is just an irrelevant intellectual game

Callon (1994) suggests that sociology of science can become normative by completing the process of reflexivity. This, he argues, "... involves exhibiting not only one's results but also the interest of these results: the social space they designate and construct" (*ibid*: 418). For Winner (1993: 375) though, STS still fail to "... question the basic commitments and projects of modern technological society." The value of ANT has come under criticism on this point from two groups. For Marxists, this lack of a normative politics (Boehmer-Christiansen, 2005; Soper, 1995; see also Castree 2002), presents a fundamental stumbling-block in their desire to connect the practices of science with more macro understandings of capital, class and so on. For scientists and philosophers too, this account of science suggests that there is no rational basis for accepting scientific claims and it leaves ANT as not just an irrelevant project, but a superstitiously disabling one (Kitcher, 1998; Sokal, 2001). Yet in the two ANT-inspired literatures just described, ANT can surely be seen as a useful way of approaching issues and that it does highlight practical implications. Hence it is not difficult to see that these approaches can also inspire an interesting story of weather derivatives that shows how this product is in a process of becoming a hybrid form of financial product and meteorological expertise, with wider implications. This may be described as commodifying science/nature and the following section takes up this approach within the broader context of Marxian writings on nature-society.

2.5. POLITICAL ECONOMIES

The final group of writers have also been working towards more pragmatic resolutions of the question of nature, but with a more politicized lens that tackles power, commerce and politics more concretely. There has been increasing attention to the commercialization and commodification of nature and science, both in relation to political economy inspired sociology of science and a growing Marxist literature on nature-society. Before proceeding to discuss the political economies approaches it is important to outline some debates on commodifying nature as these are vital for appreciating one way of characterizing weather derivatives and the implications they have.

Commodification has been a critical issue in the notions of public versus private science and the role of corporations in scientific research (Morss and Hooke, 2005). Mirowski (2004) has re-engaged attention to the political economies of science and suggests that philosophy of science is complicit with this. He suggests that the consequences of commodifying science within the corporate world have yet to be digested. For Callon (1994: 418)

> … without this source of diversity [of interests and projects in public science], the market – with its natural propensity to transform science into a commodity – would be ever more doomed to convergence and irreversibility.

That is, the commodification of science or nature is done for instrumental purposes whereby certain sciences are locked in and there is therefore a convergence in science. Commodification, for Callon (1994), leads away from pluralism and diversity in science. Yet commodification is not a singular process and neither is there a turn from 'neutral' public science to industrial science. As Mirowski (2004) suggests, more correctly there is a change from government secrecy to corporate patenting, from science to entrepreneurship, and from government-university partnerships to corporate sponsorship. The assemblages of scientific activity are not stable; they are continually being re-negotiated (see also Demeritt, 2000).

The variety of commodifications is seemingly endless; from the commodification of emotion (Hochschild, 1983) to the sale of biodiversity (Castree, 2003c; McAfee, 1999); from the profit to be extracted from water (Bakker, 2005; Swyngedouw, 1997; 2005) to the (com)-modification of human biology (Dickens, 2001) and organs (Scheper-Hughes, 2004); and from the sale of oxygen (Elsom, 1996; Thornes and McGregor, 2003) to the rise of biotechnology (Bowring, 2003; Hughes, 2001). Everything in/of nature is becoming a commodity. Yet this commodification does not take place the same way each time and neither is it an even process. Castree (2003a), in an overview of the subject, argues that commodities are not pre-existing entities, but things which take on certain properties in order to become a commodity. Most commodities are 'natural' in one form or another, but the term commodification of nature has become specifically used for those 'obviously natural' commodities[1]. The commodification process is literally the creation of a commodity out of something that was previously not a commodity (Jackson, 1999). It has a value assigned to it, in particular, an exchange value, which is the *raison d'être* for

[1] Castree (2003a) notes the problems of this word natural here, but uses it as a handy reference term.

its production (Castree, 2003a). Castree (2003a) outlines six different ways nature is being commodified. First, is the notion of 'nature as external', for example the environmental externalities that result as a part of the input and output of the production process. An example would be the costs of air pollution from transport emissions. Secondly, there is direct commodification of nature as external where parts of the environment become privatized and commodified. Nature becomes "... an accumulation strategy for capital" (Katz, 1998: 46). Thirdly, there is a proxy commodification of nature as external such as is used in cost-benefit analysis using hedonic pricing of environmental goods and bads. Fourthly, there is a commodification of nature as internal, that is, unlike external, technological innovation has overridden material nature to create a pure commodity such as in genetically modified seeds. Fifthly, there is the commodification of the human body. Dickens (2001; 2004) analyzes the sale of human genes and the potential that nature will be commodified 'all the way down' (Katz, 1998). By playing with nature people are also transforming themselves, he argues, in a nod to Marx's concerns with emergence and alienation from nature. He draws attention to both the commodification of biology and also the gene, an information representation of the body. This commodification of nature as information is the final category Castree (2003a) draws out and cites additionally things like air pollution markets. Each of these forms of commodification will have different effects and different contexts.

How do weather derivatives fit within Castree's (2003a) schema? They can most clearly be seen as the commodification of 'nature as information', that is the commodification of weather data and knowledges. Weather data act as proxies or spokespersons for 'weather', so that weather itself (whatever that might be) is not directly being commodified. Nonetheless weather derivatives are not a proxy commodification in the way that placing values on ecosystems are, because the weather data are not artificially valued i.e. the value is meaningful in relationship to the companies involved. Weather derivatives as a commodification of information also makes sense in relation to the ways in which meteorologists have used weather data to construct models i.e. they are models of information not of weather *per se*.

How is commodification characterized? Is capital chasing around the world after opportunities in nature (O'Connor, 1996)? Or are there rather networks of science, finance and corporations enrolled within an individual capitalization project? Or are there just networks of things continually being re-made with no over-arching rationale for what occurs? Marxist nature-society literature can be divided into a number of groups (following Castree, 2002). Traditional eco-Marxists (Foster, 2002; O'Connor, 1996) fundamentally separate nature and society, highlighting the ways in which capital searches out nature for profit, but how nature will be the end of capitalism (the second contradiction for O'Connor, 1996). Dickens (2001; 2004) and Soper (1995) suggest that there is a distinction between 'nature' and 'Nature', the constructed representations justifying particular forms of politics and the environment that will unerringly strike back. Benton (1993) extended this to argue that nature and society are continually being 'articulated'. He wishes to avoid being sucked into a conservative natural limits position, but also avoid the alternative position that capitalism can treat nature as a *tabula rasa* (see Castree, 2002). These approaches are based within the critical realist depth model (figure 2.1.), which arguably retains the hierarchical approaches that tend towards this nature-society divide.

Poststructural political ecology and relational Marxism (Escobar, 1999; Robbins, 1998; 2006; Smith and O'Keefe, 1989; Swyngedouw, 1997; 2005) have attempted to move beyond the dualistic explanation to analyze the ways in which nature has been (co)produced. Escobar (1999: 2), for example, appeals to an anti-essentialist political ecology

> … that goes beyond the truism that nature is constructed to theorize the manifold forms in which it is culturally constructed and socially produced, while fully acknowledging the biophysical basis of its constitution.

Robbins (1998: 72) similarly asks how nature "… is produced through action and through narrative". This approach highlights the role of discourse in affecting material circumstances (see chapter 6; Rikoon, 2006) and combines both the representational approach with knowledge of biophysical processes. Weather is thus co-produced (Rayner, 2003). These perspectives take 'nature' and interests as contingent and problematic in contrast to earlier theorizing, which posited the unproblematic material base combined with actors with clear interests[1]. For relational Marxists there are networks of things internally related and produced, a production of natures plural, that capital seizes upon with an accumulation by dispossession (Harvey, 1999). The word production suggests that there is not an *a priori* nature waiting to be capitalized, but that nature is progressively produced within a variety of different contexts in different ways. Whilst this sounds highly constructionist it actually denies but also refuses to elide capitalism and nature (Castree, 2000). The co-constitution (or co-production) of nature and capital in practice alter their prior forms, which, of course, were not separate anyway. Agency and causality is thus relative and related to both the human and the non-human actors. As with

[1] Nevertheless as Milton (1999) points out, Escobar's acknowledgement of biophysicality has a hint of essentialism in that it suggests some form of nature with which there is a less-than-contingent knowledge terrain; it is actually out there and we know it.

the sociologists co-production is a key term here and hybridity a key ontological point. Poststructuralist political ecology and relational Marxists thus chart a territory that acknowledges the non-human agency and hybridity acknowledged within ANT, whilst maintaining an interest in power and politics within these networks.

This work has produced a more contextualized, diversified appreciation of the commodification of nature literatures. Though Marxists suggest that the fundamental motives for these productions of natures is profit, Castree writes that

> [t]he capitalist production of natures – which, strictly, we need to talk of in the plural - therefore means that in *particular* times and places in relation to *particular* environments capitalism is ecologically harmful whereas in others nature is produced in ways that have positive social and ecological effects
>
> (Castree, 2000: 30, emphasis in original)

Commodification is not new and the effects of commodification ('harmful', 'positive') are more important than a macro critique (Castree, 2000). These political economies must and are taking the micro-scale more seriously and understanding that the production of natures (or anything), although clearly motivated by profit, is much more context specific and malleable than has been suggested (Castree, 2002; Sayer, 2000). How the networks make weather derivatives is not inconsistent with the durability of motivations to create profit. Nevertheless as poststructuralists and sociologists of finance point out, profit and capital are not inherent structures that have pre-established boundaries in a timeless, spaceless universe (Gibson-Graham, 2000). It is not an external structure, part of capitalism; rather the concept has become stabilized through the acceptance of previous rules and thus has become a black-box. This means it is continually re-negotiated, but it is also a powerful concept in performing a particular economy. Yet Marxists at times lend themselves to a monism whereby the plurality of natures is in contrast to the singularity of capitalism.

> … ANT advocates might argue that Smith[1] gives us an explanatory monism, which, far from *resolving* the problems of dualism, gives capitalism all the power in the society-nature relation and therefore *erases* nature altogether in the guise of making nondualistic theoretical space for it
>
> (Castree, 2002: 131, emphasis in original)

Here Marxists, somewhat ironically, fall into the trap, as Latour (1993) would see it, of the social constructionists placing all agency and explanation on social factors. The problem appears to be a question of how to talk about non-human agency without engaging in a representational moment of it or in other words how to give agency to things without reference to nature or society (Hinchliffe, *et.al.* 2005). What does it mean to say that "the world kicks back" (Barad, cited in Whatmore, 2002: 5)? What does it kick back against? What effects does this kicking have on other things? No resolution of these issues can be presented here, but clearly the Marxist literatures have important points for understanding weather derivatives.

2.6. CONCLUSIONS

Weather and climate have been important symbolic resources for society throughout history (Boia, 2005). Pinning down definitions of what weather or climate is, however, are fraught with difficulty, not least because there does not appear to be an over-

[1] With reference to Neil Smith

arching framework. Weather and climate are both part of the atmosphere, but where any of their boundaries begin and end, and what any of their time-scales may be, are open to debate. These concepts are suitably chaotic. Clearly then the world does not appear to be unified or singular; rather it is dappled (Cartwright, 1999). Although accepting this without extensive empirical justification may be technically fallacious (Longino, 2002), an appreciation of metaphysical realism with an ontological multiplicity, opens up some important understandings of the role of science and knowledge. Even if academics struggle to understand interdisciplinarity, others in the weather derivatives market are practically engaging in combining scientific and social scientific knowledges (Pollard, *et.al.*, forthcoming).

Science and knowledge are not singular, indeed, cannot be, because of the promiscuous nature of reality (Dupré, 1993). This is vital for adopting a nonmonist position, which argues against the hierarchical approaches which tend towards a unity of knowledge that can be built up to create a singular understanding of the world. Whilst philosophers hypothesize about knowledge and science construction, however, sociologists of science have spent much more time tackling empirical accounts of this. They have shown in great detail that science, nature and society are co-produced through the associations between a range of human and non-human actors that combine to produce stabilizations in particular debates. This work is illuminative for tackling a subject such as weather derivatives, a product in a process of becoming, a still contested new thing that has to be marketed to a range of allies that can support its development. Whilst strong social constructionists arguably fail to circumvent the asymmetry in their explanations that place all causal efficacy on social factors, ANT writers and, to a lesser extent, relational Marxists have struggled with how to conjoin human and non-human without engaging in dualism. The relational ontologies of ANT and relational Marxism share hybridity and co-production. ANT writers have, however, more concretely avoided representation in their accounts, albeit that it is unclear that this is either successful or possible. Each theoretical approach co-constitutes its reality (one cannot argue that economics and climate science do, but ANT does not).

Escobar (1999) adopts one strategy in his discussion of three regimes of articulation namely capitalist nature, organic nature and technonature. Each of these he suggests requires different tools of analysis, but each of these is not exclusive or bounded from the other, rather they provide valuable insights that interplay with each other. Though his three regimes can be criticized for a tautological tendency to a "… circular self-confirmation of proposition, methodology and conclusion" (Hodgson, 1999: 20), his analysis highlights the hybridized contents of each regime that also suggests a need for a holistic approach, a search for confluence as well as difference. It is in the political combinations of these regimes that confluence is to be found. Theories thus understand particular 'noun' chunks of reality, but not other 'noun' chunks (Castree, 2002). This framework is thus political, normative and committed (see Cartwright, 1999; Escobar, 1999), but it fails to draw distinctions between disciplines and fails to provide the theoretical hierarchy that so many analyses draw upon. When applied, this should result in a closely contextualized empirical argument about weather derivatives, relating to disciplinary and theoretical themes, yet highlighting that the reality of weather derivatives is too mottled and complex to be explained in one meta-theory.

Advocates of any one of these approaches may criticize the theoretical disunity presented here and argue that muddling theory is tantamount to engaging in empiricism. Yet combining theories is not an uncommon approach in social science (see for example

Gouveia and Juska, 2002; Phillips, 2002). Whilst the thesis is girded by particular theoretical assumptions it resists adopting a singular, unificationist reading that is thoroughly non-pluralist. Indeed ANTs could be considered non-pluralist in that pluralism only exists during science-in-the-making, not after a dispute is settled (Longino, 2002). Yet pluralism still persists; aspects of weather derivatives could be read as capitalism seeking for profit or individual actors engaged in strengthening associations of allies for selling more weather derivatives, indeed these two are not necessarily incompatible. Key to this thesis, however, is that notions of data, forecasts, models, finance, and profit are not pre-settled, rather they are continuously contested and negotiated. The approach therefore focuses on the practices that constitute weather derivatives and the reach of these practices beyond the weather derivatives market. Though 'the weather market' will frequently be mentioned, in reality it is a highly diverse assemblage of human and non-human things (chapter 4). How would it be possible to acknowledge this diversity, if one viewpoint could assure that it was 'the view' of the world or if one theory could explain everything?

> Better, perhaps, different coats to clothe the children well than a single splendid tent in which they all shiver
>
> (Goffman, cited in Evans and Randalls, forthcoming: n.p.)

CHAPTER 3: METHDOLOGY AND METHODS

3.1. INTRODUCTION

Writing a methods chapter is always somewhat of a post-rationalization, a purification, making sense of what is usually a messy 'process' of research. The account presented here is therefore partial in that it reflects the already made rather than the research in the making (following Latour, 1987), which has the benefits, but also the purifications of hindsight. The typical genesis of research projects is a time of reviewing literature followed by a period of time 'in the field' and then a time of reflection. Whilst this neat categorization is never in principle neat, it nevertheless represents a particularly common experience in approaching research projects.

The research started before the project began and is still ongoing through formal and informal conversations with people working on or within the weather derivatives market (and beyond). The main period of research, however, was conducted between January 2003 and January 2005 and involved a number of different angles. First it involved desk-based research of the weather derivatives market using Internet sources, particularly important when there is little formally published literature on the subject. Second it included interviews with many of the key informants within the weather derivatives market. Third it became important to analyze business texts and materials and attend business conferences. Fourth it involved a critical analysis of those documents as well as adverts for weather derivatives products in industry journals. A thread through much of this research is the Internet and the concomitant use of e-mails as the primary mechanisms for making initial contacts with the informants.

This overview has suggested a number of issues that need to be addressed in this chapter. First in section 3.2. the overall research design in the project will be outlined alongside the research questions that guided the direction of the research. Then the chapter goes on (section 3.3.) to suggest why a qualitative methodology was implied by the research questions posed and how these methods may also be applicable more widely in applied physical geography. Section 3.4. discusses the role of the Internet and e-mails in the research process, outlining both the uses of these for desk-based research and the ways they facilitated the interviews. Section 3.5. highlights the analysis of business texts and adverts, and attendance at business conferences that provided more formalized appreciations of the weather derivatives market (the texts are already written). This formalized version is complemented with the co-production of materials in the interview process. Interviews, as section 3.6. will show provide an important method for trying to glimpse, however partially, the way weather derivatives work in practice and how people build up knowledges of this. There are clearly issues with the interview methods, not least related to confidentiality and access difficulties, but other authors in related fields have defended them. How to analyze the interviews forms the topic for section 3.7. and highlights the ways in which interview material is coded or interpreted to produce particular understandings of the things in question. Section 3.8. will briefly outline the approach to writing and the factors influencing what stories get written. This suggests that writing is always a partial ordering and that many other stories are always equally and coherently possible. Finally section 3.9. will outline more broadly some limitations of the research presented in this thesis, before the conclusions in section 3.10. tie the chapter together.

3.2. RESEACH DESIGN

It is traditional to acknowledge the funding bodies that sponsored a piece of research, but the results rarely make mention of the ways in which attracting that funding influenced the genesis of the research project. The research technically began before October 2002 in the creation of a funding proposal designed to attract money from interdisciplinary research funding made available by the Economic and Social Research Council and the Natural Environment Research Council in the UK. This was not just a case of putting forward a proposal to do some research on weather derivatives; rather it was about situating this within a range of contemporary issues and debates, including mitigating the costs of a changing climate and the increased attention focused on finance within economic geography. Complementary to this was the citation of key authors (including those that are always cited, but rarely read), presenting a proposal that appeared well thought through (i.e. which had definable outputs) with established (hence safe) methodologies and the relevant supervisors that were experienced enough in the 'right' areas to secure the funding. To attract research funding therefore the personal goals of researching weather-society and gaining a PhD had to be translated into a particular project that the research councils, or failing that, the department, would fund. The application being successful, a (potentially) luxurious three years stretched ahead to produce a small book and any other necessary requisites for future careers. This research, then, does not produce data, models, hypotheses, theories, for the purposes of truth *per se,* assuming this would be knowable. It attempts to answer questions of interest to somebody (Longino, 2002), or more precisely of interest to networks of things, namely the author, the supervisors, the funding councils, maybe, if lucky, the wider academic community or policymakers.

Over three years later it is easy to gloss over the historical genesis of the project and the ways in which it was positioned politically and academically. It was designed to look both at the development of weather derivatives in the UK and suggest how firms could use weather derivatives to mitigate some of the costs of a changing climate. Neither of the goals has been lost, but they have been translated, and the ways in which the research has been conducted and written up were not of course concretized in the initial proposal. Thus the thesis here is emergent from a network of things mobilized in the project, for example, interviewees, supervisors, social contacts, departmental seminars, a computer (or two), conferences and experiences. These cannot be reflected upon in detail here, but it is important to acknowledge that a PhD is not produced in a vacuum; it is a network result (disrupting the purpose of a PhD as an individual project) (Game and Metcalfe, 1996). How though did the research project proceed?

A number of issues emerged when implementing the exact ways in which this project would proceed. During the initial desk-based research on weather derivatives using the Internet (see section 3.5. for more details) it became increasingly clear that there were two key areas in framing the weather derivatives market, namely financial issues and meteorological issues. These two areas would provide analytical strands through which the development of weather derivatives could be traced. Another key factor was the lack of publications on the history of the weather derivatives market and with many of the primary actors in this history based in the US a research visit to the US would be a key component of the research. Not only would this provide contextual information, but it would also provide meetings with providers of risk capacity in the market. Though

European banks and offices provide many European contracts, many are still circuited through the US sellers, who are often more experienced and have greater risk capacity. Thus during March and April 2004, a month's visit to the US was undertaken, which in the process provided a third of the total number of interviews completed. This included interviewing some of the personnel involved in originally establishing the weather derivatives market and hence it provided some vital understandings of the historical development of weather derivatives.

The contextual material being in place, it is important to show how weather derivatives are actually being used in a specific industry and the potential implications this might have on present-day issues. The energy sector is a vital sector within the UK economy both of its own economic value and also the losses to other businesses which could derive from its failure to provide energy. Not only that, but the energy sector has been growing in political importance both within the context of the deregulation of a formerly nationalized industry and in terms of the relationship between energy and climate change policies. Energy companies also have the longest histories of participation within the weather derivatives market and to this day dominate the UK market. It is clear that if there was to be a case study the energy sector presented the most suitable opportunity. The energy sector also publicized some of their contracts thus making access and confidentiality easier issues to negotiate.

Clearly from this focus on energy, one of the most important implications of weather derivatives could be their relationship with climate change policy. Since climate change is such an emotive political and scientific issue, examining the ways in which private markets could influence government policies, or the effectiveness of those polices, becomes a critical issue in relation to environmental governance. These decisions in research design, thus, provide a context in which the research questions underpinning this thesis can be understood.

These broad research questions can be summarized into 6 groups.

- *What is the size and scope of the weather derivatives market?*
- *How has the weather derivatives market developed?*
- *How do companies with significant weather exposure find out about and use weather derivatives?*
- *What data are required for the construction of weather derivatives markets, how can the accuracy of data and forecasts be ascertained? And hence, how is the weather derivatives market regulated?*
- *Who are the key actors who construct and mobilize weather derivatives markets and knowledges for the UK?*
- *What are the implications of using financial instruments for the management of environmental risk?*

These questions provide a number of key areas, broadly following the strands outlined earlier. They centre around the development of the weather derivatives market, the use of weather derivatives in the energy sector, the generation of financial and meteorological knowledges about the weather and the implications the use of these contracts might have upon the management of climate change.

With weather derivatives presenting a relatively small sector of companies, especially if only those that actively market their use of these products are included, there clearly is not wide scope for a survey technique. The research was therefore designed to target the key informants within a relatively small industry. At the outset it is clear that the research questions just outlined required an approach that was sensitive to the practices of the weather derivatives market and that was able to describe the networks of things that constitute this market. This immediately suggests an in-depth qualitative approach and the following section outlines this methodological decision in more detail.

3.3. QUALITATIVE APPROACHES

The approach adopted engages with the actors' own terms and practices in generating an understanding of the weather market. These approaches are familiar to researchers in economic, and more generally human, geography and anthropology (Cook and Harrison, 2003; Hughes, 1999). In more detail, this must make use of extensive interviewing with market participants, including the brokers, sellers and buyers of contracts. It is only by understanding their experiences and creation of this market that an appreciation can be gained of the way the market has developed in certain ways and the pattern of weather derivatives use spatially, sectorally and historically. An interview approach, whilst a very standardized approach in much of human geography (Clark, 1998; Hughes, 1999; McDowell, 1992; Schoenberger, 1991; 1992), has not been widely used in aspects of applied physical geography. Yet qualitative data can be as valid and useful as quantitative methods in understanding aspects of society-environment relations, in this case, weather derivatives markets. Qualitative research provides a different angle on the issue, by positing different questions that provide what Bauer (1999) calls unknown alternatives. It is important that alternative methodologies are not rejected because they are unknown, but rather that they can be used to provide alternative understandings of these issues. That is, drawing from the pragmatic philosophy of science, it is important to adopt the right tools for the right jobs and to answer some questions in applied physical geography might go beyond the techniques normally considered by these practitioners. By teasing out areas of confluence and divergence between the results of quantitative and qualitative methods can also lead to some new questions and insights on the issue at stake. Thus the questions posed in this thesis that lend themselves to a qualitative approach might be countered in another project by different forms of questions and approaches that would illuminate aspects of this research.

The approach here rejects the notion of a solid bounded firm or weather derivatives market *per se* (though these terms will be used as convenient shorthand), to understand the networks of agents (both people and things like money or data) involved in these contracts, which illuminates the actual practices of these markets. In other words, the historical path of specific phenomena, say the use of weather derivatives by a particular company, can be re-traced. For Schoenberger (1991) this means that interviews are verifiable and valid in that they reconstruct how particular phenomena came about. Whilst this may be built upon positivistic conceptions (McDowell, 1992; Demeritt and Dyer, 2002), nonetheless it highlights the greater explanatory power of interviews in relation to certain aspects of or questions in applied physical geography[1]. An example could be the use of weather derivatives by an energy company. The decision to use these contracts is not just about the modelled weather-business output relationship, but about access to knowledge, financial support, and competition, to name just a few issues. To understand why this company uses weather derivatives the approach must therefore not rely solely on published information, but try to reflect upon the 'invisible' networks

[1] This is not to suggest with the methodological essentialists that interviews can answer all questions in physical geography.

supporting the project. This is equally important in applied physical geography where static views of society, or a failure to appreciate the ever-changing dynamics of society, can result not only in a simplistic understanding of the implications of environmental problems, but also in misleading policy recommendations. Not only this, but qualitative research is beneficial within physical geography research itself. As Harrison and Bender show (see Harrison *et.al.*, 2004), the landscape is made up of a combination of physical and social processes, presenting a case for putting archaeology, anthropology and physical geography in action together. To understand the land would not be possible without both an appreciation of physical process and historical studies of society in terms of land use. Within this methodological context, there are a wide variety of different methods and the following sections trace some of the specific methods used in this thesis.

3.4. INTERNET/E-MAILS AS A RESEARCH TOOL

The Internet is increasingly becoming an important research tool and has many advantages over traditional research methods, but also a series of disadvantages. Its advantages need few introductions, combining as it does a vast array of information, that can be quickly accessed and where news can be easily disseminated. For this research, it was vital to access both information about weather derivatives and to acquire the names of key informants. The news stories could provide a context of understanding about key weather derivative contracts and other publications gave rise to an array of perspectives on the pricing of weather derivatives. The Internet's advantages can be clearly seen in this research.

The most immediate disadvantage, however, is the speed of change in that many of the research materials this project depends upon are no longer in the memory of the fast-paced world of the Internet. They have been removed. This creates three parallel problems. First, there is no means of verifying the source at another date and there is often insufficient time to actually check the details of the reports. Reports have to be judged fairly quickly as to their reliability, which in the early stages of a research project is challenging, but becomes easier as the practices of the market become more familiar. That is, as the researcher is socialized into the research environment it becomes easier to judge what is most consistent or probable. The second problem is one of authenticity, but this can be somewhat disregarded for a couple of reasons. First, many news stories were also confirmed by interviewees and second, most other information came from the sites of weather derivatives practitioners and hence misunderstandings were much less likely than in the general media. A third disadvantage of the Internet is somewhat contradictory to the last two and is namely the store of out-of-date information. Whilst this can sometimes provide historical perspectives that can be usefully analyzed, these information stores can also mislead researchers. The empirical work outlined in this project at many points contradicts the information that is available on the Internet from general news sites[1]. Here there is a divergence between those sites with stories refereed by key actors in the weather market and those journalists that know little about weather derivatives and hence can

[1] In reading work from MBA students it is clear that some base their understandings on Internet sources, which are either out-of-date or written by inexperienced journalists. Whilst most ‘errors’ are rather limited, they nevertheless highlight a key concern in this thesis, in that they often contain hypothesized views of the weather market that have only limited grounds in the practice of the market.

make misleading assumptions[1]. Reliability may thus be achieved by confirming details with the relevant actors such that misunderstandings can be rapidly uncovered.

All interviewee participants (bar two met at conferences) were initially contacted through the use of e-mails. The WRMA website contains a list of member's e-mail addresses, albeit a somewhat outdated list, and through some additional Internet searching, e-mails were sent to the relevant weather market participants. On most occasions, there was at least one follow-up e-mail and/or telephone call to establish a date and time for a face-to-face interview. For a young market like weather, the Internet is often the primary means of communication and there were therefore few problems connecting with the relevant people through the use of e-mails. E-mails have an advantage in that they are generally sent to the correct person i.e. they are not forwarded through secretaries or lost as letters and even telephone calls can be. They also allow respondents to reply at their own convenience, though most interviewees answered within a couple of weeks. E-mails, however, are easy to delete and certainly easier to remove than people on the telephone, but in general there was a good response to initial e-mails and very few simply ignored them, though some replied that they were too busy[2]. E-mails thus were a successful mediator for creating initial relationships with experts and elites within the weather derivatives market. Though it is impossible to find out, it would be interesting to know how the use of e-mails in this research process set up particular relationships with

[1] By refereeing in general this does not mean that they restrict the flow of news about weather derivatives, particularly critical literature, but rather that they are involved in the news stories, often have been interviewed, and therefore the potential for misunderstanding is lower.

[2] Where the e-mail was sent to the correct person (i.e. the current weather trader in that company) the response rate was as high as 60-70% with those companies that are actively involved in weather derivatives, but falling to less than 10% with those companies less actively in the market. This of course radically alters the composition of interviews in this research project, but can be justified simply on the grounds that this project primarily analyzes the production of weather derivatives and the key informants are the people that sell and broker weather derivatives, most of whom announce it publicly.

the interviewees and what the implications may have been for access or the extent of conversations.

The use of e-mails for contacting interviewees was just one way in which e-mails were utilized within the research, the other being directly as a form of interviewing. Whilst communicating with e-mails may be commonplace they remain relatively underutilized as a method of conversation or interview. E-mail interviews are different from both the telephone, written questionnaires and face-to-face. They lack the personal connections made in face-to-face interviews and also the voice and tone recognitions in telephone interviews. Yet it would be too easy to describe them as a questionnaire form. Yes they are written rather than spoken, they do not establish the same level of personal connections, or dialogue, as face-to-face interviews and they have written questions (i.e. they are more structured). They are also different from questionnaires, however, in that there is more freedom of conversation, relatively quick responses and the ability in a short space of time to trade questions, answers and comments between the participants. E-mails are more flexible, allow interviewees to write on themes that interest them (albeit within initial structures placed by the interviewer) and allow an exchange or interchange of ideas in a less rushed manner than telephone or face-to-face as there is time to think about the response. Whilst this might lead to the protection of sensitive information which might be blurted out in a face-to-face interview, nevertheless it also means answers are often less rushed and wider issues can be addressed than in the short time-span of other interviews. The methods used to question and analyze are very similar to other forms of interviews, and indeed the questions used were the same as the ones for face-to-face interviews. Some participants more actively engaged in the e-mail process than others, with one infamous example (Interviewee 14) where the e-mail responses were neither addressed to anyone nor signed[1]. This of course presents a validity problem namely is the e-mail written by that person? In many ways this may not matter in the overall context of the research as for this project the content is as important as the person for many of the interviews with end-users. The only assumption that can be drawn is that as the e-mail came from their e-mail address the author was likely to be that of the e-mail address box name. E-mails thus can be a useful research tool, but they do pose issues concerning validity and the relatively structured nature of the conversation. Nevertheless, e-mails and the Internet played a key role not just in gaining contextual interviews, but also creating the opportunities for the interviews.

3.5. MATERIALS AND DISCOURSE

The analysis of business reports and attendance at business conferences also constituted an important part of this research. Two particularly useful events were attended, namely, a climate and environmental trading seminar at lawyers Clifford Chance in January 2004 and the WRMA European conference in November 2004. These provided important insights into the contemporary use of weather derivatives, particularly as they related to environmental trading in the energy industry and regulatory debates.

[1] Interestingly this contact may also have been somewhat resistant to the interview as they were asked to respond to me. At a weather and climate risk conference personal relations were established with another person in that company who invited me to e-mail her, which she could then forward on to the relevant person. On the 25th February 2004 an e-mail was dispatched to her at 12:46. At 13:59 it had been forwarded with the message "[Name withheld], met Samuel at the Emissions Trading day. Would we be able to help? Tks M." At 18:18 the same day this was forwarded again to the interviewee "I leave it up to you". Six days later the first response came "At present we don't use weather derivatives. But I suggest you contact...[name withheld]." It was only in a subsequent e-mail that the person finally agreed to an e-mail exchange. This shows the difficulties of access to a relatively new market like weather, but also may explain some of the reluctance this interviewee had to formalizing e-mails in a conventional style. One other facet of e-mails is exposed in this story; they leave a trail, which often cannot be seen when tracking down the right person when arranging interviews by telephone or regular mail.

The material generated from these events provided some valuable perspectives that built upon and extended some of the findings from the interviews.

The presentations from these events can be placed alongside the technical documents enclosed within conference packs and the material available in the industry journal *Environmental Finance*[1]. This provided valuable, if at times superficial, information about the current practice and future directions of the weather derivatives market. These documents generally only contain publicly available information, because the sensitivity of important business information would not be made available through these (or other) channels. Thus they represent the external image of the weather market, rather than actual practices, but nonetheless serve as important indicators of the latest developments.

These texts, together with adverts for weather derivatives, have also been critically analyzed for their associating images and discourses that construct particular notions about not just weather derivatives, but also climate change and business management. This 'armchair theory' (Aitken, 1997) has been especially useful in relation to understanding weather derivatives marketing practices. Adverts as images and texts designed to sell products, expertise etc can be analyzed in relation to a range of commonly occurring cultural metaphors. Thus, for example, the atmosphere has been considered a giant fan and therefore in specific ways a fan may be representative of the atmosphere. Or the placing of words in scare quotes can symbolize a set of ironies and uncertainties that play on and between typical conceptions or uses of those words. Therefore to write of normal people is different to 'normal' people. These discourses are clearly politicized, they are constructed for particular purposes and hence they are important actors in

[1] This journal covers weather derivatives, carbon trading and other environmental finance initiatives.

ordering ways of thinking about specific issues. An example may be the way quantitative language can be used as an arbiter to justify political decision-making (Porter, 1995). Analysis of discourses centre on the politicized nature of their construction, a deconstruction of the images and texts that are being displayed to probe additional depths of meaning associated with them and an appreciation of the ways in which these discourses are created (Aitken, 1997). This can be critical, for example, to understanding the ways in which organizations are performed and the ways in which corporate information is presented (Alvesson and Karreman, 2000; O'Neill and Gibson-Graham, 1999). Though this thesis makes relatively little use of formal discourse analysis, nevertheless it supports not just the analysis of texts, but also the understanding of interview material.

3.6. INTERVIEWS

Ethnographers often comment that the interview is not just about two people talking, but about appearances, tones, experiences and so forth (Cook and Harrison, 2003; Crang, 1994; Zaloom, 2003). In this section a fairly objectified style will be taken to highlight the ways interviews were conducted in this research, but this is not to deny the experiential powers within interviews. One example may suffice here. Entering an international futures exchange the two participants suggested that the interview should take place within the main coffee room[1]. Sipping a particularly strong cup of coffee the conversation turned to the ways weather derivatives were traded and that this was

[1] Tape-recording was not permitted in this interview. The exchange permit tape-recording only with the presence of an exchange official who can watch what employees say and make sure the corporate line is presented throughout. The participants, here, preferred to have a note-taken interview as this would allow them to express their opinions more widely and convey information that otherwise may have been restricted.

predominantly electronic. Indeed this exchange had recently adopted electronic trading for all its markets. “You know where you are sitting?” one of them asked. It looked like any other large clinical coffee room with lots of potted plants and a few statues and a smartly polished floor. “This used to be the trading floor” they continued “and behind these screens as you can see are the banks of computers that now do all the trading.” The bustle of the trading floor had been reduced to a coffee room with a gentle aroma of bleach, whilst behind the screens in clear view were the new traders, the new order, computing equations and buying and selling more rapidly than someone could wave their arms. This experience overthrew a conception of financial markets that has often been cherished, of the traders in their brightly coloured uniforms shouting and waving their hands around (see Zaloom, 2003; 2004). The aura of this visit was difficult to forget and it is perhaps interesting in the ways it shaped conceptions of the technological nature of financial markets and the computerized procedure of weather derivatives. As with grain (Cronon, 1991) weather is distanced from the purchaser in the financial markets and may be visualized through the computer screen rather than an office window.

These interviews thus involved observing some of the contexts and practices of weather trading. At times the role of the naïve observer seems particularly suitable to the positioning within the interview situations too. Knowing very little about financial pricing models meant a close listening to interviewees and a distinct lack of ability to judge their words. Of course at a later stage when familiarity was reached with some of the language then this inference gave way, but the naïve observer position also has some potentially useful implications as an outsider may not accept the basic assumptions implicit in what is being spoken about (Zaloom, 2003; 2004). Knowledge is only produced on the second visit to something, after it has been returned to the centre of calculation (Latour, 1987).

The centre of calculation, in this case, was the researcher, taking interview material, technical documents and so on back to the University to be dissected, thought about and ordered. This ordering thus meant that later visits would be different; indeed the early interviews were much more tentative than the later interviews, with the interviewer in the early ones frequently being lost by technical language or asking 'dumb' questions. Indeed the 'dumb' student image also works in other ways as it allowed the interviewee to be an uncontested expert and also allowed them to explain exactly what they knew or did.

Access to interviewees is often cited as a particular problem when interviewing experts or people in high positions or in the City (Cormode and Hughes, 1999; Desmond, 2004; Goffman, 1990; Sabot, 1999; Ward and Jones, 1999). The narrowing of the field, in this research project, to a few select actors that know far more than the researcher poses an interesting question about the power structures involved in the interviews. As Cormode and Hughes (1999: 299) argue,

> [t]he scholar is a supplicant, dependent on the co-operation of a relatively small number of people with a specialist knowledge.

Negotiating access and conducting interviews becomes more politicized, because each actor within the small network also has the power to block access to the rest of the network. Being 'dumb' then means that power may be with interviewees.

Whilst during this research most of the major actors in the market allowed some access, in however a mediated form, there were some who were not prepared to do this. Three reasons can be suggested. First, those that are simply too busy. One interviewee (24) who agreed to a brief interview at a conference worked 14-hour shifts and hence was reluctant to work even longer 'just' to speak to a graduate student. Second, those that cannot be bothered or are not interested in participating in the research project. There have been several rejections of this nature and indeed one interviewee (14) as noted earlier failed to sign or address e-mail correspondence. Third are those who would not speak, because they were concerned about confidentiality or wanted to keep their operations relatively secret. One institution, in particular, claimed to be 'too busy' to speak with me, yet employ more staff in weather derivatives than most other UK operations. Indeed one interviewee suggested that

> [i]f people don't want to speak to people in your position it can only mean they have something to hide
>
> (Interviewee 11)

Thus there were a variety of reasons potential interviewees refused to be interviewed.

Those that agreed often had other agendas, particularly that during this research project there would be wider advertisement for the weather derivatives market. The researcher became a marketing tool for them or for the market more generally. One interviewee suggested that

> [i]t will be interesting to see what kind of reactions [you get] amongst these people. I bet it will be very positive but whether at the end of the day they will do the analysis, figure out what kind of product is best for them. I'll be sceptical if they do.
>
> (Interviewee 6)

Though this interviewee regarded this research as a marketing tool for weather derivatives, they were somewhat sceptical that it would actually lead to more end-users coming into the weather derivatives market. Thus the researcher's goals become translated through the interests of the interviewee. Promoting the market, at a certain level, is clearly an unintentional effect of the research process of talking to people about weather derivatives, yet it was this that served as the mobilization for a number of interviews. The 'politics of *interessement*' (Callon, 1986) become seen in a methodological light.

Interviews took a variety of forms from tape-recorded and telephone to note-recorded and e-mail. A total of 26 people were interviewed for the project (one person was interviewed twice), which when placed in terms of the number of companies involved in the weather derivatives market serves to suggest that as many as 75% in the UK have been covered[1]. This presents an in-depth case study of the UK weather derivatives market, which case study is extended by speaking with 5 of the main 7 energy companies as part of this research, again providing high percentage coverage. The intention has been to speak to key informants within the market, rather than attempt a blanket questionnaire such as would be undertaken for larger survey projects, which the size of the market and sensitivity of corporate information in any case restricted.

The research proceeded in a loosely structured manner, with the initial contacts from Internet websites being interviewed, after which further contacts were either snowballed from these prior contacts or emerged from an increasing understanding of the key Internet directories containing contact information[2]. During the search for more

[1] Clearly the question of what percentage of the total number of participants in the weather market has been interviewed is irresolvable due to a lack of knowledge and difficulties surrounding confidentiality of these contracts. Hence this figure really relates to those that publicly admit use of weather derivatives.

[2] Snowballing, in research terms, is simply where the interviewer uses an interviewee's contact lists to establish new interviews. Its primary limitation is that interviews will only be conducted around a group of contacts or friends that are already networked and this presents the risk of only getting one side of the story. Within the weather derivatives market this criticism is somewhat redundant as the major actors know each other regardless and though there is rivalry and competition, the market is relatively small and most were open about those publicly-active companies within the weather derivatives market.

interviewees, the analysis of early interviews was undertaken. Thus they provided important information, things which were completely new at that time, which was able to inform the later interviews. In March 2004, a visit to key weather derivatives practitioners in the US added both to the number of interviews and provided a key context to the UK case study. These interviews were with some of the initial participants in the market as well as experts in the fields of meteorological and weather derivatives consultancy and purveying. A detailed list of the dates and types of interviews may suffice to show the general temporal progression of the research and this can be found in Table 1 (and replicated in Appendix 1 for ease of referencing throughout the remainder of the thesis). Anonymity and confidentiality are key concerns in undertaking research in the financial sector and though many interviewees (6, 10, 13, 19, 20) were relatively unconcerned with these issues, all interviewees have been anonymized in the final version here such that none can be readily identified. Thus each interviewee is represented by a number with only broad information provided about the nature of their employers. Whilst this does prevent the comparison of individual firms and their wider economic positions, the anonymity here still allows for the type of firm and the position of the worker (if directly available) to be clearly identified.

Number	Date	Type[1]	Nat[2]	Position/Company
1	24/04/03	N		Product Manager, Exchange A
2	15/05/03	TR		Weather Trader, Energy Company A
3	15/05/03	TR		Managing Director, Service Provider A
4	15/05/03	TR		Chief Executive, Service Provider B
5	28/05/03	TR		Director, Service Provider C
6	19/06/03	TR		Analyst, Energy Company B
7	19/06/03	TR		Trader, Energy Company B
8	24/06/03	N		Seller, Broker
9	02/07/03	BRF		Analyst, Energy Company C
10	12/11/03	TR		Vice President, Seller A
11	01/12/03	TR		Seller, Bank A
12	05/12/03	TR		Partner, Law Firm
13	20/02/04	N		Analyst, Energy Company D
14	Multiple	E		Analyst, Energy Company E
15	23/03/04	N	US	Project Manager, Exchange B
16	30/03/04	N	US	Executive Vice President, Seller B
17	31/03/04	N	US	Forensic Meteorologist, Consultancy
18	31/03/04	N	US	Managing Director, Seller C
19	02/04/04	N	US	Managing Director, Seller D
20	02/04/04	N	US	Meteorologist, Seller D
21	02/04/04	N	US	Independent Consultant
22	27/05/04	TEL	US	Consultant, International Institution
23	Multiple	E	US	Market-maker
24	05/11/04	BRF		Seller, Bank B
25	05/11/04	BRF		Business Manager, Energy Company F
26	02/12/04	N		Former Meteorologist, Seller E

Table 3.1. A list of interviews undertaken for this research with the date(s) and type of interview, as well as a broad description of their role (if known) and type of company where they were employed (this table is replicated in Appendix 1).

[1] TR – tape recorded face to face interview, N – note recorded face to face interview, E – e-mail interview, TEL – telephone, note recorded interview, BRF – brief (under 30 minutes) personal communications face to face often conducted at conferences

[2] Country that the interviewee was based in if not UK and hence where the interview took place (with the exception of interviewees 22 and 23, where the telephone or e-mails officiated over international exchange)

Interviewees' comments were also kept confidential when relating to specific issues and when talking to rival company employees. Information from several interviewees has been assumed to be public and in many cases has been publicized in industry publications. On no occasion did sensitive material from one interview transfer to other interviewees, though there is little doubt that more general material that was public knowledge in the market developed the questions as more information was accumulated and popular issues became known[1]. It should be pointed out, however, that interviewees were generally curious about who else had been involved in the project and a decision was taken early on that names of previous contacts would be provided if requested in a conversation as more often than not this generated other names, and often contact details, of people that were later interviewed for this research.

Some interviews were tape-recorded and others were not. Interviewees were asked if it was possible to tape-record the interviews and there is a distinct temporal pattern as early interviewees were tape-recorded and later ones not. The assumption would be that those who were happy to be interviewed, often the most public users of weather derivatives, were far more relaxed about being recorded than those who were more reluctant to give an interview. The US interviews obviously present a slightly different scenario due to the greater ability for litigation there and a decision was taken early on in the fieldwork to completely note-take these interviews. One important observation, however, is that much of the most interesting material was presented when the tape-recorder was switched off and thus for interviewees who were known to be critical of aspects of the weather derivatives market, the interviews were completely note-recorded.

[1] 'Public knowledge' can be defined as that which has been presented at industry conferences or was publicized in the media i.e. it was or should have been well-known within the weather derivatives market.

Regardless of the type of interview, a similar pattern of questions was taken to each interview, although in reality few interviews proceeded along the lines of the questions shown in Appendix 2. The interviews were far more conversational and were allowed to flow into areas that were of concern to the interviewees. These questions have altered as the project has proceeded with some areas becoming more important in relation to interviewees' understandings of the weather market and others less important. Questions about the ideal contracts for companies and the number of contracts have been reduced as this information is difficult to access due to confidentiality. The key questions have emerged, because of the way the research has proceeded and the topics of interest to informants within the market. This is not a 'clean' research slice about weather derivatives. It is partial as the questions have been negotiated and emergent from the participants. This has two important implications. First that it resists the interviewer placing too much control over the interview and allows the interviewee to express the issues that are of most concern to them. This reduces the problem that the questions might not suitably cover the areas of the weather derivatives market that are generating the most attention. Second, however, it then means that many questions were not asked and thus each interview becomes less comparable. That the issues of one interviewee are important cannot be denied, yet they may also have opinions on all the standard questions on the question list. There may simply not have been time to cover all the agendas on the question list. Though there were a core of issues that were important for the research, much of the way the project has proceeded and been ordered has been generated from the dynamics of the different stories told about weather derivatives. These are well-documented difficulties with interview approaches (see Hughes, 1999), but they can also be seen to create space to resist the power of the interviewer.

All interviews were conducted with an ethical stance in which interviewees were informed, not disregarded. At the beginning of each interview, the interviewee would be led through the general aims of the project, the potential use of their words, the executive report, then envisaged for each participant, and how the information they shared would be kept anonymous and confidential, as well as being encouraged to ask questions about the research. In general, most interviewees were relatively unconcerned by these issues, but it is important that they had the opportunity to become an informed participant.

The number of interviews needed to generate the materials for the research was not established at the beginning of the process. The research has relied on the 'saturation principle' (Schoenberger, 1991) that it is pointless interviewing endless numbers of people about a topic if the same material is continually being repeated. Thus the interviewing process was drawn to a conclusion when the same stories kept being repeated and little new information was being gleaned. This strategy allowed control of the volume of information that would have to be processed, whilst allowing as many different voices to be heard as was possible. In reality, saturation point was reached in terms of the number of weather derivative participants rather than a saturation of stories, with about 75% of participants from the market's main companies already interviewed. Nevertheless there was some saturation with stories too as many would refer to the landmark ABN Amro deal (see chapter 4) or refer to very similar aspects of the market.

At the early stages of the project an executive report was envisaged for each participant in the research process. This later had to be removed, because there was no practical way in which one single report could be sent to each weather derivative practitioner, because even with careful anonymity it would often be possible for an insider to work out the relevant identities. Not only that, but some interviewees were also cautious about giving information that would eventually be published to competitors and thus, though the inclusiveness of the research has been reduced, the publication of a report was too problematic. Indeed one interviewee (11) suggested that the practicalities of writing reports to circumvent confidentiality problems would mean individual reports for all and "... if you write everyone their own personal report, you could be there a while, couldn't you?" There is therefore less feedback from the research here into the weather derivatives community than might otherwise have been envisaged.

3.7. ANALYSIS

Analyzing interviews is also an important aspect of research. This involves searching through the material for coherent themes and constructing understandings of how and why interviewees thought and acted the way they did. Coding highlights both unity and disunity between interviewees. Coherent themes were picked out relating to a company's use of weather derivatives, meteorological data and forecast use, experience in financial markets, and so on. These were drawn from both the questions asked (i.e. that were directly suggested topics) and the themes that interviewees seemed to commonly discuss. Thus it is both responsive to contemporary debates in the weather derivatives market and also permits discussion of the research questions that enable this research project. This thematic linking provides a necessary approach to analyzing interview material as it allows both a systematic investigation of the material from different interviews and also a way of highlighting the (dis)agreements between accounts.

This material has not been used in a quantitative form to assess how many participants thought in a particular way as a method of generating results. Rather than being about how many people agreed on the subject, the purpose has been to unravel individual understandings of their weather derivatives trading and how this collectively comes to perform an overall market. Indeed often there have been only one or two experts available on a particular subject making quantitative justification an irrelevant question. Nevertheless where there is consistency between different accounts it would be easy to conclude that this is a reasonable approximation of events. One interesting problem that should be highlighted, and for which this thesis equally suffers, is that Enron, Aquila and Koch Trading all considered weather products around the same time, yet the latter two are almost always written out of or underplayed in accounts of the history of weather derivatives. Rindova *et.al.* (2006) suggest that celebrity firms like Enron portray business changes (the development of weather risk management would be one) as major events that demand attention, because that company is taking a leadership role in dealing with this change and can hence project a media image that develops this position. As Rindova *et.al.* (2006: 58) state

> [u]sing a firm as a protagonist in a dramatic narrative leads to overattributing industry-level change processes to the actions of the firm, thereby making the firm appear to be more important in causing the change, and the outcomes resulting from the change, than it actually was.

Enron liked to advertise its activities and was possibly more vocal than the other two companies, both in playing to media interests and through the inherent media interest surrounding the company[1].

[1] Another point is that the historical accounts of weather derivatives, in formal formats at least (e.g. Clemmons, 2002) are written by the people in the initial weather derivatives group at Enron.

Individuals disagreeing with each other, as in for example differences in opinion about models and forecasts, may be reflected in the interviews, yet this does not mean the interview material is at fault. Justification for these differing opinions is often contained in the interview itself and there is therefore no requirement to reject interview material because it is contradictory. The reality is that it may be impossible for an outsider to be able to judge what is probable or not, but during the research project closeness to the practices of the weather derivatives market mean that in most cases it is possible to make a judgement about the reliability of a particular account. Hence Collins and Evans' (2002) call for studies of expertise and experience become important methodologically too, as the qualitative material relies on these judgements. As Demeritt and Dyer (2002) note one pragmatic approach to dealing with qualitative material is to judge it based on trust and credibility. Those accounts that display consistency and probability are most likely to be credible knowledge claims, and since the informants are key actors within the weather derivatives market they are also likely to be trustworthy with regard to the material. That is not to say that everything they said must be trustworthy, maybe the interviewees were creating a false impression for the benefit of this research, but rather that because they are have specialist knowledge they become more believable. This is obviously a pragmatic position and follows Chang's (2004) suggestion that justification may well lead to coherentism[1]. Coherentism leads to pluralism and epistemic iteration, a search for consistent and probable (based upon current traditions) knowledges. This process of research should "… throw very imperfect ingredients together and manufacture something just a little less imperfect", an iteration which does not rely on "... the aid of an indubitable foundation" (Chang, 2004: 226).

[1] Coherentism is directly opposed to a correspondence theory of truth i.e. for coherentists there is no obvious way in which a system relates to anything existing outside of it. It is thus often associated with inevitable (relativist) pluralism for a failure to distinguish (or judge) between different sets of beliefs.

The bright colourings on the interview transcripts, however, attest to some of the commonalities of themes that were present in the interviews. Rather than dwell on inconsistencies in technique, it is important to recognize the themes and inconsistencies running through individual interviewee's accounts. It is these facets, indeed, that allow themes of meteorological data, forecasts, models, financial agents, advertisements, climate mitigation and so on to be drawn out of the analysis. The themes of the later chapters are drawn out from some of the primary issues and concerns within the weather derivatives market. The interview material can be coalesced into sections upon which different actors have often different conceptions and opinions, and in this process of aggregation the viability and vitality of different actor's views can be seen as credible and hence the interview material as probable. These analyses then provide the themes for writing the overall thesis.

3.8. WRITING

The final stage in the neat characterization of the research process is writing, yet clearly the writing is ongoing from the creation of the proposal, through early drafts of chapters, right until the present construction of a small book. Writing is an ordering of ideas, an ordering of stories. It is ironic, as Game and Metcalfe (1996) note, that academics disparage and are allowed to be disorganized about 'simple tasks' (admin etc), yet at the same time the concepts produced, the institutions in which these concepts are produced are rigorously ordered and organized. Writing is a process by which order is placed onto disorder; messiness is clarified through the strict parameters of diagrams, tables or text.

The writing here should not be considered the representation of truth in narrative form. Rather the chapters highlight particular orderings, particular stories that could be told, that are neither all-encompassing of other stories nor stories that if summed up could provide a whole. They are partial.

> Even if writing begins with an intuition, it isn't the presentation or unfolding of a pre-existing piece of truth, for the 'piece' is patch-work and the showing of it a piece of theatre.
>
> (Game and Metcalfe, 1996: 6)

There are many other ways in which different stories could be told; there are many other stories to tell; and these other stories could be equally coherent, plausible and consistent. Why then choose to write the stories presented in the later chapters?

Figure 3.1. presents some reasons for writing particular stories. There are pedagogical issues about disciplinary heritage, theoretical allies and individual interest. These shape the ways in which stories are written to meet particular interests. Stories can only be written about things that are available and thus accessibility becomes a key criterion. Finally some judgements are taken about what stories might be deemed coherent, what stories might be of interest to a wider academic community (or beyond) and how many stories can be told in 80,000 words. The process of writing is thus constrained. Other stories are possible.

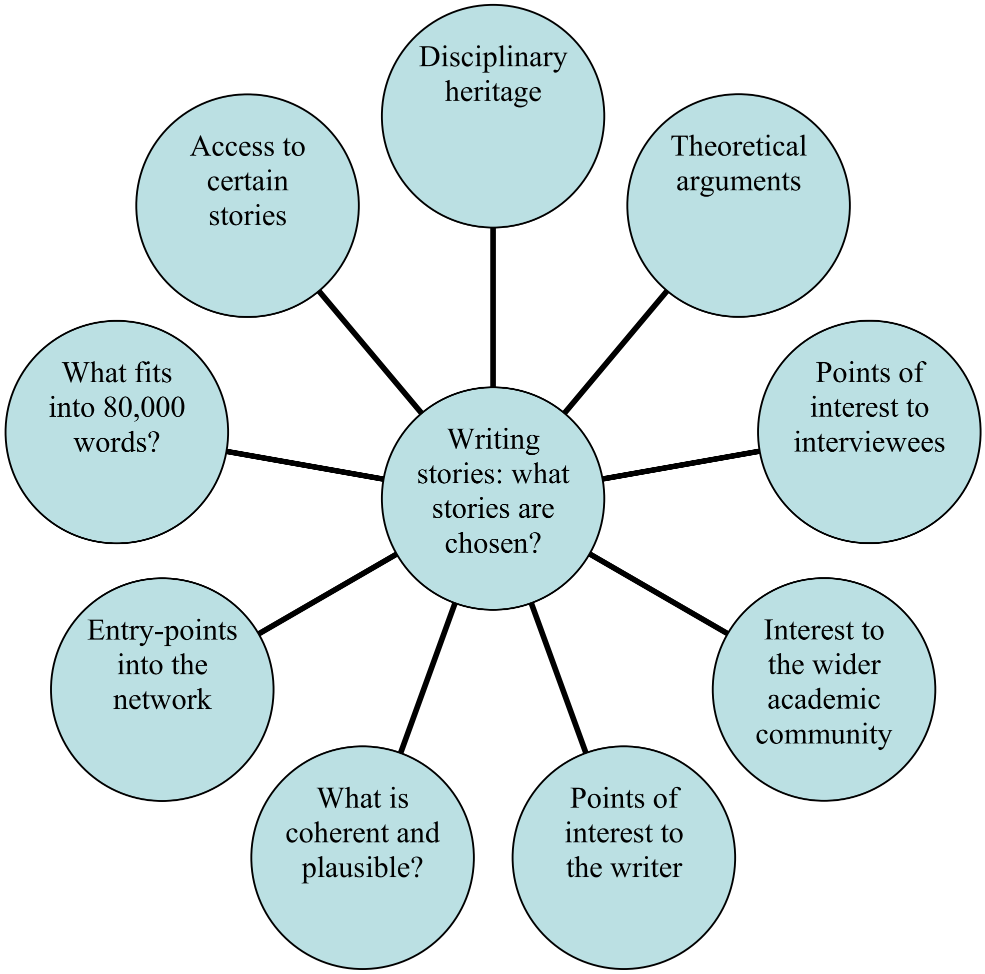


Figure 3.1. Writing stories: why are particular stories/orderings chosen and others not? A diagram illustrating the questions of which stories to write.

Constructing this thesis has taken many iterations, a long process of change, revision and reconstruction. This is not necessarily for the goal of better, clearer understandings, whatever they might be, but for the goal of producing defendable, 'tighter' work that will meet sets of criteria embodied either officially or unofficially within University departments or journal requirements. Writing, like science, is not a pursuit of a perfect account; it is goal-oriented. Similarly it is conducted, like science, within a network of other actors and within particular ‘laboratories’. Who will finish first this year? Will there be computers available? What happens if the computer breaks down (as it did)? Why do teaching, administrative work, conferences, get in the way (even though of course this is patently misleading as these very things often clarify or aid writing)? Why are there just four years? Why are there no jobs available? Writing produces orders out of this messiness, yet it cannot be (completely) detached from its context of production. To deny this, would be to be asymmetrical about science and STS. The thesis therefore is a product of a particular network that if re-configured could have produced very different stories. These orderings in later chapters should thus be considered partial and contextual, not as being the only way to understand weather derivatives.

3.9. LIMITATIONS OF RESEARCH

As with all research projects there are some limitations to the methods adopted in this study. One question relates to the lack of participant observation or why a more active engaged ethnography was not performed if the intention was to undertake an analysis of the practice of the weather market. This question can only be resolved pragmatically (not theoretically). Access to the relevant participants was particularly difficult in some cases and not only that, but in several interview occasions a caution was given by the interviewee that ‘this must not go any further’. Access to pricing software, for example, could only be granted on assurance that rivals would not be informed and no company spokesperson was willing to give out material on individual contracts, trading volumes or financial data[1]. To work within these institutions would, if it could even have been arranged, place the researcher into the difficult position of having to sign confidentiality agreements that would prevent any information being used for publications. Bradshaw (2001) highlights the dangers of signing contracts with participants in the research and no contracts were signed with any participants, though some verbal assurances had to be made. To work in those buildings, however, would have meant a weather derivative actor reviewing anything written for publication and this would have substantially reduced the critical edge to the analysis. Thus, though sustained ethnographic research in the field may have extended the understandings of the weather derivatives market in practice, it was pragmatically very difficult to achieve and therefore was not undertaken.

Another criticism that may be levelled at the research project relates to the relative lack of tape-recorded interviews, particularly those undertaken in the US and the later participants. There is an interesting temporal scale to the tape-recording with early participants being generally comfortable with being tape-recorded and later ones less convivial. Perhaps this stems from the fact that those interviews that had to be worked hardest at, where the people were less keen to speak to a young student, were also the ones most uncomfortable with being tape-recorded. Apart from providing a technological verification that what was said was said, tape-recording doubtless has advantages in relation to the ability to quote interviewees accurately and reduce the level of misunderstanding[2]. Note-taken interviews, however, are often equally as good at recording the most important elements of an interview and allow people the freedom to speak without fear of being directly quoted and named. Interviewees who gave

[1] An interesting position considering that the author had very little expertise in derivatives pricing and was hardly likely to take in, understand and then spread around all of what the person was saying or showing. Nevertheless this type of caution is very important in establishing the grounds on which research can be conducted and the extent to which contracts should be signed with participants (Bradshaw, 2001).
[2] Of course this in itself is problematic, as sociologists would point out (Goodwin, 2002).

particularly interesting, but also potentially controversial information, were encouraged by the lack of tape-recording[1]. Thus levels of material on tape-recorded interviews may actually be more sanitized than in note-taken interviews and, bar the technological adjudicator and the ability to find succinct quotes, the note-taken interview may be considered of no less value.

There is also a question about how much can be drawn out from interviewee comments, business texts and conference reports about an emerging area of interest in the weather market. For example, in analyzing the implications of weather derivatives for climate change mitigation policies (see chapter 7) much of the material underpinning that analysis draws upon limited (un)published material as well as some of the interviews. How much credence can be paid to this material? Again assessments can be made in terms of consistency and probability and a pragmatic judgement can be reached. Probably one of the biggest defendants of this material, like conference reports, is that it is fashioned at the coal-face by weather traders directly dealing with these issues on a day-to-day basis. The material, though likely to be filtered through corporate channels to prevent breaches of confidentiality, is likely to be a reasonable estimation of that individual's, mediated by the company, opinion on a particular topic.

Re-doing this research project in a few years time may result in quite different conclusions. An increased temporal understanding of the changes in weather derivatives may be achieved through further attendance at industry seminars and the reading of the industry journal *Environmental Finance*. Another key point is that due to an increased socialization into the practices of the weather derivatives market, a new project would be inherently different, because in the first few interviews undertaken for this thesis, there

[1] Though even here, one interviewee told me to write it down in my notebook in my own words so that (s)he could not be quoted. Further to this, note-taken interviews are often the only way to operate where secrecy, confidentiality or legal issues are concerns.

was very little already written on weather derivatives. Much of the material was ‘unusual’. This is why, for Latour (1987), the first visit is very different to subsequent ones, because knowledge is only created when it is recorded back home, at the centre of calculation, and hence becomes mobilized in the second visit. Weather derivatives were mainly unknown, but now any research process begins at a rather different point, with already inscribed sets of knowledges and practice. What difference this will make is an open question.

3.10. CONCLUSIONS

In this chapter the main methodologies and methods underpinning the research have been discussed. Starting with the wider research design, the chapter justified the use and choice of the case study sector and the overall framework of the research, including some of the primary questions. These questions, it was argued, are concerned with the actual practice of the weather market and this has particular repercussions on a choice of methodology. The general rationale for qualitative methods was outlined in section 3.3. alongside a discussion of the relevance of qualitative techniques for applied physical geography as well as for the social sciences. There are a wide variety of qualitative methods available, however, and the chapter then focused on the actual methods adopted namely the use of desk-based Internet search methods and interviews.

The Internet is a valuable source for information but suffers from three somewhat contradictory problems namely that some pages are out-of-date, material is removed so it cannot be checked for verification and problems of authenticity. It was argued, however, that as a deeper engagement within the weather derivatives community is achieved, it becomes relatively easy to work out those stories that are most probable or trustworthy. E-mails were also shown to be a useful research tool for obtaining interview contacts and their use as a method for conducting an interview was also discussed. Though relatively unexplored, e-mails as an interview method offer different challenges to face-to-face and telephone interviews, combining more structured questions, with a greater conversational ability over time to develop areas of interest.

The majority of interviews conducted for this research, however, were face-to-face with a variety of note-taken or tape-recorded interviews. These often came down to interviewees' wishes, which in a sensitive subject like weather derivatives had to be protected to ensure the viability of the interview. The interviews conducted embraced as many as 75% of the companies actively marketing themselves as using or selling weather derivatives in the UK.

The analysis of the interviews brought out a wide range of themes that can be clearly seen in the following chapters. Access to weather derivatives practitioners may have been difficult and the material generated occasionally somewhat difficult to justify in a rigorous manner, yet the research process has arguably widened understandings of weather derivatives and provided the first, clear, empirical research on the weather derivatives market.

CHAPTER 4: A HISTORY OF WEATHER DERIVATIVES

4.1. INTRODUCTION

Unlike many studies where the historical development of the topic in question has been widely analyzed an understanding of weather derivatives has had to be built up through interviewees' memories (but see Clemmons, 2002). Notwithstanding the problems with this that were mentioned in the previous chapter, relating to the minimizing of Koch Industries and Aquila in the history of weather derivatives, the histories provide a more involved perspective on the development of weather derivatives. There is, of course, the danger that they post-rationalize and relate the history of the market to the current market. This chapter, however, attempts to draw together the various interviewees' histories and, whilst admitting that the view is partial, illustrates the ways in which human and non-human actors were enrolled onto the network-building of weather derivatives sellers. It thus provides, for the first time, an in-depth history of weather derivatives.

First this chapter takes as its topic the history of the commodification of the atmosphere, briefly tracing some of the prior commodifications of weather and climate that form a context in which weather derivatives can be understood (section 4.2.). This places weather derivatives within an historical framework and highlights that, for a Marxist at least, they are but one example of a long practice of commodification. After this short historical sketch, the chapter proceeds to detail the actual processes whereby weather became a derivative (section 4.3.). Here it goes further than a simple macro Marxist analysis by attempting to weave together stories of a set of actors that through a range of associations created a network around weather products that has changed over time. By outlining in as much detail as is possible looking back on an event (i.e. the settlement already of what constitutes a weather derivative) the analysis nevertheless provides an example of how new products are created and marketed, two of which segments, namely meteorological and financial networks, will be examined in more detail in the following chapters.

The history of weather derivatives can be related to a wide range of actors including meteorological data, data authorities, energy companies going through regulatory changes, innovative corporate environments at Enron and other companies, insurance capacity and particular weather events. The story highlights that should any of these actors involved in the network had stronger or weaker effects weather derivatives may have ended up very differently to the way they have. Weather derivatives were products of their locations of construction during the mid-1990s. Indeed they became derivatives by virtue of fitting into regulatory categories and by being placed there because of the regulatory and financial repercussions of doing so (a topic returned to in chapter 6). The weather protection product being created in Enron and other energy companies became a weather derivative due to specific needs at that time and the experiences that these companies already had in other markets.

This early shaping of the weather market by the energy companies provides the core of the market to this day. Section 4.4 shows how weather derivatives have subsequently spread from being a US energy product to being accessible to both non-energy companies and to companies outside the US. The weather derivatives market has grown from being a few companies marketing a new product to a $45.2 billion p.a. market in 2006 (Figures 4.1, 4.2, and 4.3)[1]. As these figures show, the winter market has been

[1] Note that there has been a rapid growth between 2005 and 2006, where the market quadrupled in size. The interview material reflects the earlier much smaller market and though the latest figures are included here

particularly important for the industry, because of the needs of the energy companies in mitigating the costs of warm winters. In the US there is a more active summer market associated with air-conditioning load, but in Europe the summer market is much less active. The European market saw some of the highest growth rates, particularly after the bankruptcy of two of the early participants, Enron and Aquila, in 2001/2002 (Figure 4.4), though the most recent data shows a decline in the European OTC market. This can be related to energy companies diverting personnel and resources from weather to emissions trading as they are often traded from the same desk (O'Hearne, 2005)[1]. The weather market in Europe is driven by banks as well as energy companies and insurers, showing that weather derivatives are becoming part of the financial core as an accepted risk management product. Whilst relatively small in the overall scale of other derivatives markets, $45.2 billion in weather as opposed to over $600 trillion for all derivatives (Arnoldi, 2004), the weather derivatives market is nonetheless important due to its potential to become one of the largest derivatives markets and its wide implications for understandings of both finance and meteorological science.

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for reference, the market at time of research was markedly smaller, so throughout the 2003-4 and 2004-5 surveys should be considered the benchmark.

[1] Direct data for the UK market is not available so European data has to be used as a proxy for the relative growth of the UK market. Considering many sellers base their operations in London and since London is also the most traded location in Europe this correlation should not overestimate, and may even underestimate, the growth of the UK market (Interviewee 3).

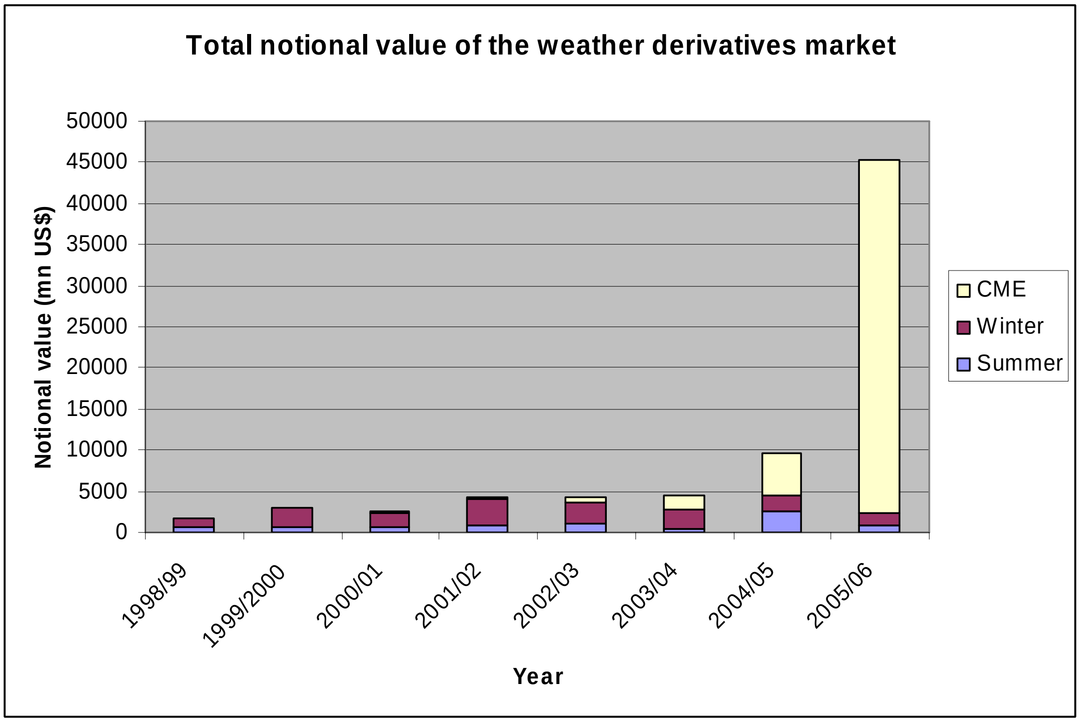

Figure 4.1. Total nominal, notional value (mn US$) of weather derivatives contracts by year. The figure shows the OTC contracts by season (summer/winter) as well as the year-round CME contracts. A more in-depth view of 1998-2005 is presented in figure 4.2. for additional visual clarity. Adapted from PriceWaterhouseCoopers (2002; 2004; 2006).

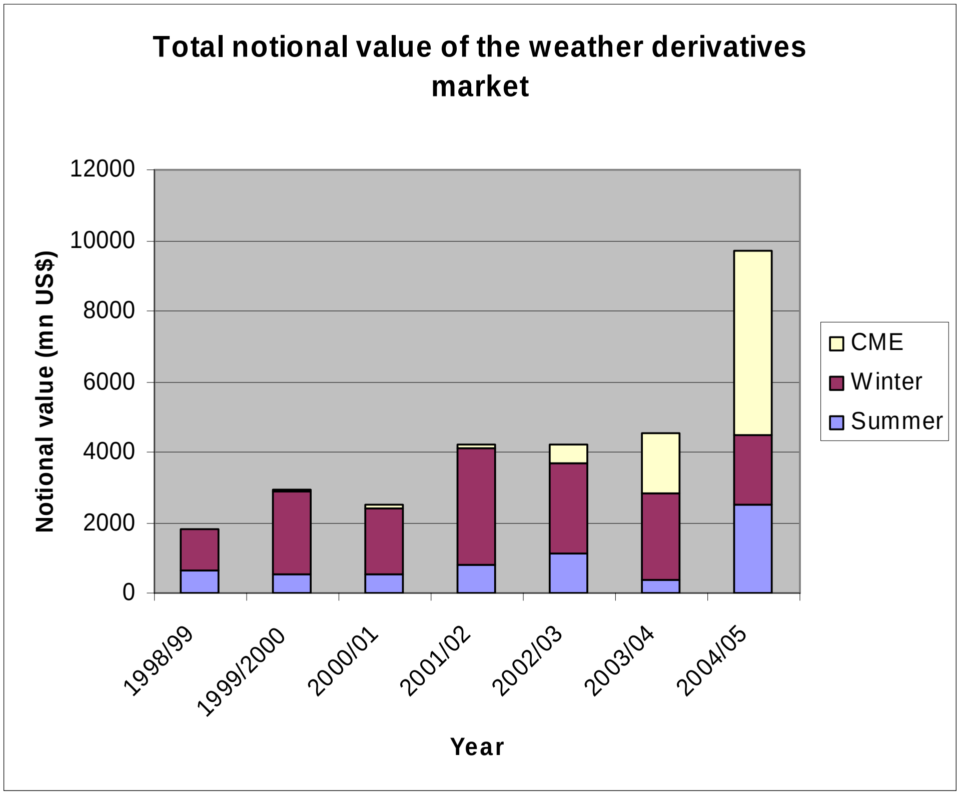

Figure 4.2: Total nominal, notional value (mn US$) of weather derivatives contracts by year. The figure shows the OTC contracts by season (summer/winter) as well as the year-round CME contracts. This highlights the dominance of the winter sector and the increasing importance of the CME. Adapted from PriceWaterhouseCoopers (2002; 2004; 2006).

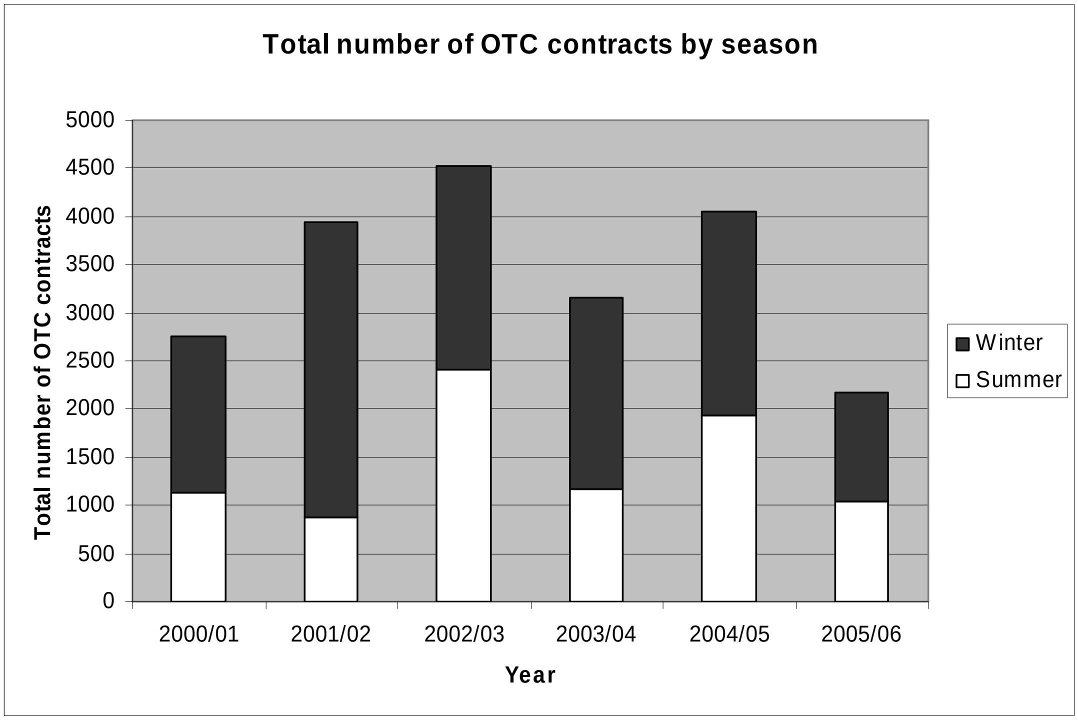

Figure 4.3: Total number of OTC contracts of weather derivatives by year. The figure shows the relative lack of growth in the numbers of contracts traded in the OTC market (albeit that the notional value of each contract may have increased) (adapted from PriceWaterhouseCoopers, 2006).

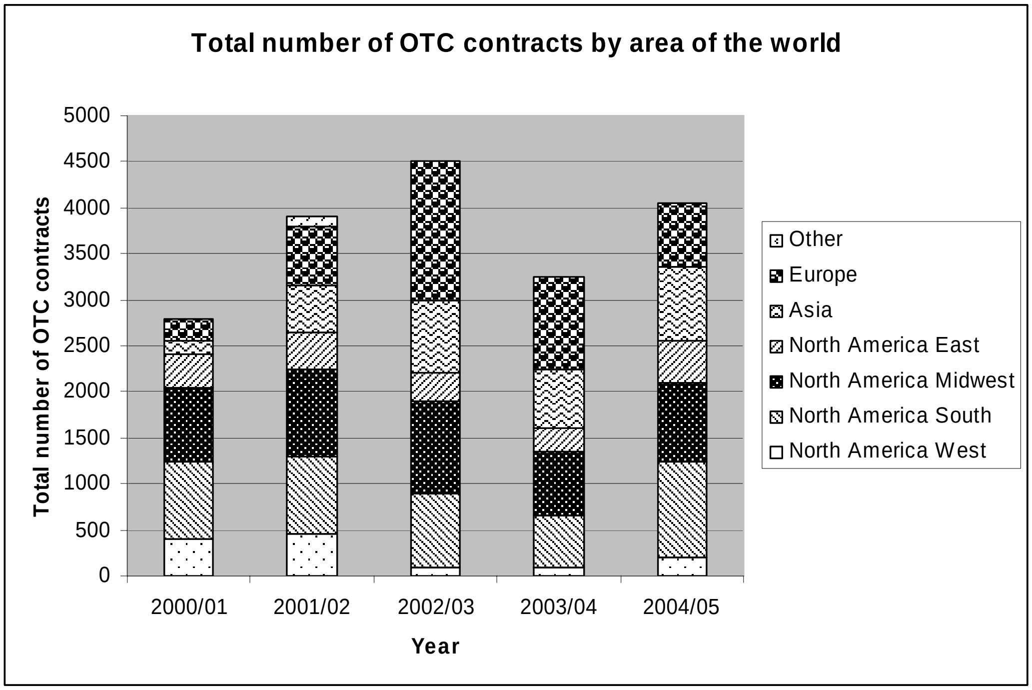

Figure 4.4: Total number of OTC contracts per area of the world and which shows the increasing diversity of locations for weather derivatives particularly after 2000/1 (adapted from PriceWaterhouseCoopers, 2005).

4.2. COMMODIFYING THE ATMOSPHERE

There is a long and varied history of commodifying the atmosphere from direct commodification to proxy commodification. In the 16th century, for example, the witches at Boscastle sold wind to the sailors for a safe and speedy passage (Pollard *et.al.*, forthcoming). During the 19th century the rise of institutionalized meteorological science formalized and bounded weather thus mobilizing commodification (in different fields see Bowring, 2003; Katz, 1998). It was not until the 20th century, however, that meteorology became heavily commodified when the rise of militarized air power required greater expertise in forecasting (Crewe, 2000a; 2000b). Indeed forecasting arguably became the pre-eminent aim of meteorology. The heritage of the military is aptly illustrated by the ownership of the UK Met Office by the Ministry of Defence[1].

Controlling the weather was also a vibrant theme. During the 1960s and 1970s a direct commodification of the weather started to become a reality through cloud seeding programs (Bruintjes, 1999). Cloud seeding, however, was considered less successful than many had hoped with resultant rain being unreliable and often falling in the wrong places (see Bruintjes, 1999; List, *et.al.,* 1999). Weather was no longer something that should be left to providence, but rather it should be actively controlled and managed. Weather is valuable and therefore information about weather (a proxy commodification) or a direct control over weather (direct commodification of nature) is not only viable but also vital for modern society (see Castree, 2003a). This highlights Bernstein's (1998) point that modern society is characterized by a belief in the controllability of risk.

The value of the atmosphere became a discussion topic during the 1980s and Ausubel and Biswas (1980) suggested that there should be an atmospheric sector within the economy. More recently Thornes and McGregor (2003) have suggested that the atmosphere may be worth as much as $80 trillion. Concerns about climate change have spurred economic measurements of the atmosphere through the costing of the effects of a changing climate. The atmosphere here is becoming part of the economic system.

During the 1980s proposals to fully privatize the meteorological services were put forward. Ellig (1989) argued that not only should forecasting and other value-added

[1] The Met Office adopted its present title (prior to that it was the Meteorological Department) in 1867 within the Board of Trade and in 1920 it became part of the Air Ministry. From 1964 it has been part of the Ministry of Defence though since 1996 it has acted as a private trading fund (see Burton, 1983; 1984). In many ways the situation in the US was almost the reverse. The National Weather Service, which was entitled the Weather Bureau until 1970, was set up as part of the War Department in 1870, then from 1891 became part of Agriculture and was transferred in 1940 to the Department of Commerce, where it now resides as part of NOAA (NOAA, 2004).

products be open to private competition, but so should data collection. After all, he argues, the Met Office can inflate the prices of data to prevent private enterprises creating new value-added services, and, regardless, data collection does not constitute a public good, but rather a private good. This privatization, he reasons, would not necessarily lead to poorer services, because to create a profitable service data would have to be of good quality, shared and exchanged (Ellig, 1989). Weather data takes on an increasingly valuable role and chapter 5 will show how weather derivatives have furthered this process. Yet weather derivatives are not the first financial market to take advantage of the opportunities for profit and potential for environmental management available in the atmosphere.

During the 1990s financial markets were increasingly used to hedge environmental risks particularly those associated with air pollution. Voluntary air pollution markets in the US encouraged a market-based approach to dealing with environmental issues and companies that could adapt quickly would find it most profitable (Elsom, 1996; Tietenberg, 1990). Through the mid-1990s energy companies in the US were becoming familiar with trading atmospheric contracts on pollutants including Nitrous and Sulphur Oxides. Subsequent to this there has also been the development of a market for renewable energy (Renewable Obligation Certificates, hereafter ROCs) in Europe that again attempts to promote economic growth with environmentally friendly sourcing of energy requirements. Finally, in 2005 the EU implemented a compulsory emissions market to trade carbon credits with the explicit aim of finding a market solution to concerns about the impact of greenhouse gases on the enhancement of processes of climate change (Bachram, 2004; see chapter 7). These air pollution markets can be seen as the forerunners and contemporaries with the weather derivatives market in that they broke with previous notions that the atmosphere could not be traded. Trading air pollution arguably provided a framework within which weather derivatives could be seen as acceptable, albeit that air pollution markets are government controlled whilst the weather market is privately transacted.

By 2002, the US government was investing $2.7 billion p.a. into meteorological operations and research, of which $745 million supported the National Weather Service (hereafter NWS) that generates the data (National Research Council, 2003). Weather has become big business, yet this figure of US investment is dwarfed by the size of the, admittedly international, weather derivatives market ($45.2 billion). From this it is clear that weather is moving to another financial level. Morss and Hooke (2005) suggest that meteorology is becoming more commercialized and that there is a growing potential for meteorologists to adopt the industrial practices of biomedicine. They caution that meteorologists need to think carefully about whether to pursue the commercial path, but neglect the ways in which it has already underpinned and continues to underpin meteorology. They also neglect the fact that meteorology is not emerging from a pre-commodified state; rather the sciences have been tied to other purposes, predominantly military and government (Mirowski, 2004). There are therefore a wide variety of different commodifications of the atmosphere, weather and meteorological science. From weather forecasts to air pollutants to rainfall, each has been commodified in various ways. What is the specific context of weather derivatives?

4.3. A HISTORY OF WEATHER DERIVATIVES

In this section the analysis focuses on the way in which the weather derivatives market has developed. From the early years when weather derivatives were struggling to acquire the relevant networks and access to become an acceptable part of business culture, this section proceeds to show the ways in which weather derivatives have changed since this initial development and have been extended through a wide variety of interpersonal connections. It provides a history of weather derivatives that is inevitably partial, but which highlights some key themes relating to the construction of new financial products.

4.3.1. THE EARLY YEARS

During the early 1990s some climate scientists such as Harvey Stern suggested that the financial markets should seek a solution to the costs of a changing climate (Stern, 1992; also Dlugolecki, 1996; Nutter, 1996). Or to place it in Marxian terms to find a financial fix to displace the new environmental problem. With climate change becoming an important political agenda, formalized at Rio and Kyoto, it is little surprise that corporations started to analyze their exposure to not just climate risks but also government or international policies relating to climate change. By 1995 the draft of the second report of the IPCC was being circulated to businesses, in particular, to insurance companies (Dlugolecki, 1996). Unlike previous IPCC reports, the 1996 edition contained far more information relating to the future economic, social and political costs of a changing climate. For the first time, businesses were presented with a rigorous costing of potential future climate changes on not just the overall economy, but individual economic sectors too. It is unclear how well the IPCC documents were received within those companies that would later provide the institutional frameworks for the generation of weather derivatives, but nevertheless there was a growing power in climate change discourses, enhanced by increasing media attention (Henderson-Sellars, 1998), that was undoubtedly increasing business awareness of the perceived threats of a changing climate.

The perceived costs of a changing climate promoted some companies to hire personnel that would undertake an examination of the company exposure to those risks (Interviewee 16). This was not just about extreme risk, but the potentially adverse economic effects of gradual changes in the day-to-day weather patterns. In a warming world an energy company will lose earnings during the winter heating season (and conversely gain money in the summer cooling season). Though weather derivatives have but a limited connection with mitigating the effects of a changing climate (chapter 7), the mobilization of climate change discourses provides a background to the ways in which a product mitigating weather risk could be created and sold. The perceived changes in the climate thus provided the need for the product, whilst the climate change discourses provided the marketing tools.

How did weather become a derivative around 1997? Many companies established or expanded environmental (trading) desks for examining business-environment relations and as preparation for the arrival of environmental markets. In 1996, the head of the environmental trading desk at Enron was Lynda Clemmons. During that year Michael Corbally joined Enron to work on a project examining gas pipeline risk. This is literally the amount of gas that is flowing through the pipelines and since Enron had 40,000 miles of high-pressure natural gas pipeline this was a potentially costly risk. He found that there was a distinct weather risk related to gas pipelines. During warm winters much less gas was being pumped through and therefore profits were lower (Randalls, 2005). Enron had established within its corporate image a notion of risk control (Cruver, 2003; Interviewee 16). All risks must be managed. Here though was a risk for which no contemporary product was available. Not only that, but, argues Boehmer-Christiansen (2005), Enron was also expecting greater volumes of business in its gas pipelines as it was lobbying the US government to adopt 'cleaner' fuels like gas rather than coal[1]. Thus Clemmons, Corbally and others on the environmental desk at Enron, including Jeff Bortniker and Phuoc Dang, approached insurance companies for protection against these risks, but were quoted, in their eyes, exorbitant premiums. As Clemmons (2002: 6) notes

> [t]he insurance industry ... was not then receptive to requests to provide non-catastrophic protection. Accordingly, the energy market was left to fend for itself. Energy companies, realizing that the market was changing, took control of their weather risk and created a new business around it.

The group at Enron was forced to either leave the weather risk unmanaged or create a new product that could manage this risk at an acceptable cost.

Before proceeding to show how this was achieved it may be important to briefly turn to the innovative capacity of Enron. Enron as a corporation was not just designed to be an energy company. It was going to become 'the world's most innovative company' (Cruver, 2003). Enron promoted innovation through a stringent framework for budding young professionals. If you had an idea for a new product you could take it to the board

[1] Cleanliness is an interesting term within the climate change literature. It often refers to carbon output with, in descending order, coal, oil and gas, followed by the 'carbon free' fuels like nuclear and renewables. This hierarchical ordering is clearly a transient, politicized moment, because new technologies ('clean coal') threaten to override it and because of what is included or not (the carbon output of processing uranium for nuclear power for instance). This cleanliness is an important strategy that may be used to support certain types of energy uses. In the next chapter, cleaning is used in a different sense, to talk about removing inconsistencies from datasets, but what is clean data may still be politicized.

and if accepted you would have an office and a year to prove that it could work. Many did so, but as many as 90% failed to meet financial targets and finished with a career that had failed dramatically within a year (Cruver, 2003). In 1996, the environmental trading group received permission to work on a new financial product relating to the weather. It was important that they met financial targets within the first year and to do this they needed to settle on a product and manage to convince other companies of its worth quickly. Here is an important point. At the core of weather derivatives had to be profit for Enron, within its system of accountancy and timescales, and without this there is little doubt that these products would have disappeared.

The Enron name and culture would doubtless have helped them. Enron was perceived to be one of the trustworthiest of organizations (Cruver, 2003) and certainly promoted image even to the extent that this would have less obvious returns on the profit account. Whilst the chronicle of the rise and fall of Enron is well known (as documented for example by Brennan, 2003; Cruver, 2003), during 1996 Enron was still in a time of rapid expansion in new financial markets and was nearly five years away from its later financial difficulties. Weather derivatives were just one in a line of new products that emerged during this period with other products including bankruptcy and broadband risk protection. How though was it possible to turn weather into a financial product and convince other people that they should seek protection rather than leaving it in the hands of fate?

The group at Enron created a product based on an index that would be familiar to every energy company, the HDD. This was an already-settled index that had been used in the past to calculate energy demands and hence gas and power trading requirements. There is a critical point here, which is that they used something that was already known to create a product that was still unknown. If they had used new datasets there would have been so little knowledge about the data and product that it is unlikely they would have had much success; it would have been perceived too risky (not known or quantifiable enough). The HDD would also have been familiar to the corporate board and other traders' training as well as to other companies in the energy sector. The question is not about whether degree-days were the best indexes for a new product, but rather how important already-articulated knowledge is within the creation and marketing of a new product. Not only was a changing climate, the risk leading to the day-to-day weather risks that were being mitigated, becoming knowable through the increasing consensus displayed by the IPCC, but the tools to mitigate this risk would also be drawn from something knowable, the HDD.

Other reasons for using the HDD indexes included a differentiation from insurance products, which would be vital in overcoming regulatory hurdles, and the ease of marketing this product to the energy sector, an important economic sector. Later users would often complain that weather derivatives were essentially an energy product (Interviewees 1, 4, 6, 11). Once the index had been established all that was needed for a trading market were different opinions on which way that index was going to go in the future. There are probably few other topics which divide people's opinions as much as the weather and, combined with the unreliability of forecasting beyond the short-term, this makes trading around a weather index look easily obtainable.

Trading would also be more straightforward in derivative markets than in insurance markets primarily because there are less regulatory restraints and products can be traded as private contracts between two companies (see chapter 6). Energy companies were also becoming increasingly involved in other derivatives markets, particularly gas and power, markets that expanded following deregulation policies. Energy companies therefore had the required financial expertise housed within them to mobilize derivatives contracts in a wide variety of contexts and the decision to turn Enron's weather product into a derivative would have been relatively straightforward within the energy sector. This is, however, another example of the ways in which the early weather market was shaped to suit the needs of energy companies, because many other companies who also had weather risk would have relatively fewer financial skills and knowledges to successfully trade within derivatives markets. The energy companies at this time also had good credit ratings meaning that they were able to trade quite freely with each other and attract financial credit. This focus on energy resulted primarily from the familiarity with energy products, the relevant personal networks across the sector and the need to make a quick profit, which is easier utilizing personal networks rather than having to cold-call. The construction of the weather derivatives market thus connected already established social networks within the energy sector with a new set of meteorological allies.

The nascent weather market had to overcome a number of hurdles with these meteorological allies, however, including the supply and use of meteorological data that fed into HDDs. Depending on the ownership of the meteorological data they generally cannot be re-used and adapted without explicit permission of the owner. In the US, weather data are considered an environmental good and hence are a public good. This means that data are effectively free of charge (excluding costs of transport and interpretation) and can be obtained equally for both the overall weather market and any individual participants in the market. Yet for whatever reasons the US energy companies did not establish particularly good terms with the NWS from the start. As one interviewee

(4) suggests, being markedly cautious in the language (s)he uses, and comparing the early years in the US with the later developments in Europe, that

> [a] lot of the reasons that Europe is growing steadily has to do with very pro-active working with the Met services rather than working in spite of them, which the, how can I say this without getting quoted and sued [pauses and laughs]. The derivative market in North America [pauses]. They take information, but then they make their own decisions about it and they never really had a very active discussion with the met services.

What (s)he seems to be suggesting is that Enron and others expected the NWS to provide the data that the weather market would need in the form that they needed it. Since in the US any re-use of data is not the role of the NWS, but of private weather organizations, and since they had no financial imperative, being government funded, to do exactly as the weather market demanded the relationship was rather cool. Also the quote implies that the weather market was using data in ways that would not necessarily have been conventional or acceptable within the eyes of meteorologists. This stems from the realization that the group at Enron needed to establish the product within a year and did not necessarily have the time to worry about data as much as they could or should have (see chapter 5).

They also settled upon using airport data. This was due to easy data access, the good historical records that many of these stations had, their proximity to major cities, and their perceived neutrality and security. It is vital to note here that weather derivatives became settled on cities instead of regions, which aided the attraction of larger numbers of buyers and sellers to the same site hence creating a liquid market. Most of the trading to this day is based upon cities such that even if a risk is located elsewhere a company would find it easier to trade based on the correlation to the city weather conditions (barring buying bespoke OTC contracts). It is also worth pointing out that energy companies' predominant risk is located in the city, because that is where the greatest concentration of domestic energy consumption can be found. Energy companies therefore also had a self-serving reason for utilizing airport stations. Unlike other stations, airport stations would arguably be more difficult to manipulate than stations located in unsecured regions of the countryside. This becomes a critical component in both regulatory issues (see chapter 6) and the more recent uses of weather protection policies by the World Bank in India.

With the new energy product being created internally, not only could Enron now seek risk protection, but they were endowed with particularly good knowledge of this product and could act in a risk-capacity role, certainly until the market had developed enough to encourage other entrants. With this in mind, Enron would not only be protected from weather risk, but could also make profit from deals where it took on additional risks. The one thing needed was liquidity in the market so that pricing could become 'tighter'[1] and companies would always be able to negotiate trades.

The energy sector provided a viable market following the deregulation policies during the mid-1990s and had a specific product requirement too. In the US this deregulation meant a shift from local monopolies to competitive regional wholesale markets (Clemmons, 2002). Companies now had to reduce costs to be able to increase profits or lower prices to the consumers. The energy markets (gas, power) experienced rapid growth in the number of trades and the rise of regional markets brought about increased electricity trading and an understanding of the effect of the weather on both short-term demand and long-term supply (Clemmons, 2002). With increasing competition

[1] Pricing tightness refers to the bid-ask spread. That is the price at which one person is willing to sell and another willing to buy. As markets become efficient the difference between these two should decrease (lower bid-ask spread) as they will have similar information and hence pricing strategies. Tight or low bid-ask spreads make it easier to state fair prices for particular contracts.

within the energy sector, companies were actively looking at ways to manage costs and increase revenues. Companies had to invest money in meteorological expertise to appreciate the weather effects on the power and gas markets. Whilst the gas market protected companies against the risk of fluctuations in prices, including those caused by the weather, there was no product that could adequately protect against changing demand. Since the weather is the most important sustained demand component for gas (Interviewee 9) a product was needed that could manage the costs of the weather on the demand side of the equation. The weather derivative was thus created to mitigate the volume risks rather than the price risks. Here again the weather derivative was created to resolve an issue that was of particular concern to the energy sector.

At this stage the data supply and the product had been settled all that was needed was the energy market to become involved. Surely, with some direct marketing, Enron would be able to sell this product to other energy companies? It had a specific use, perceived neutrality of data, a lack of correlation with other risks and potentially could also be profitable as well as simply mitigating risk. Demand, however, was not as swift as many had expected. Enron struggled to market the product originally as many issues relating to the product were still unresolved including notions of how it would actually work in reality and how it would be priced. There was also a reluctance to use a new product to mitigate a risk that many people in the financial world treated as 'natural' and hence unmanageable. Later on as the market developed, sellers of weather derivatives began marketing campaigns more widely to change both the standard conceptions of the weather as unmanageable and to promote their case to credit rating agencies (see chapter 6). Whilst several pioneering trades were done in 1996, most were confidential and payouts were often in the form of discounts on future power purchases (Clemmons, 2002). One contract, for example, in 1997 was agreed between Enron and Florida Power Light to provide the latter with a guaranteed margin return so that they could build smaller power plants. Florida Power Light's main risk was daily temperature affecting the air conditioning load, but this CDDs contract was again not solely about weather (Clemmons, 2002). Two companies, however, had also been formulating ideas about creating weather protection policies, namely Aquila and Koch Industries, and with Enron they arranged what has come to be known as the first pure weather derivatives deal in 1997. Although in effect the three companies just swapped risk between themselves, it created enough publicity to seal many more deals. Since this transaction weather derivatives have been predominantly cash-settled. The first weather securitization deal, which became known as Kelvin, was completed later in 1998 by Entergy-Koch Trading (hereafter EKT) and was worth about $50 million. The broker involved in transacting this deal, Risk Management Solutions, was involved in a wide range of natural hazard management techniques and was well acquainted with dealing with the risks of extreme and day-to-day weather.

Enron also approached the insurance companies again as the market was going to need more risk-taking capacity if it was going to succeed in the long-term. This time insurers, such as Swiss Re, Transatlantic Re and American Re, did become involved in the weather derivatives market for two reasons. Firstly a systemic change was occurring during the 1990s, namely, the convergence of the capital and the insurance markets[1]. Until then insurance had largely been separate from the capital markets, but the two became increasingly intertwined as companies sought to insure themselves in the capital market and trade insurance-style products more freely (Considine, n.d.). This convergence was

[1] The capital markets and insurance markets refer to the worlds of finance and insurance respectively which operate within different regulatory structures, the latter being much more heavily regulated with greater codes of conduct required. Insurance style products can be difficult to trade whilst capital products being cheaper have been mooted as potentially inexpensive ways of insuring certain types of risks. Chapter 6 will look at the debates on weather derivatives and regulation in more detail.

most apparent in the rise of the alternative risk transfer marketplace (hereafter ART) and the use of catastrophe bonds and the trading of catastrophe options on CBOT. For Considine (n.d.) weather derivatives are the logical extension of this process. This process was driven by the expansion of risk providers into new areas and the demand for new protection areas from those seeking protection (Banks and Bortniker, 2002). Secondly, the insurance industry in 1997 was going through a cyclical phase of low premiums from the traditional underwriting industry, which meant that they were able to release a significant amount of risk capital into experimental areas like everyday weather risks (Considine, n.d.). Insurance companies at this time, however, employed less meteorological expertise than today with the result that this risk was often undervalued, meaning that companies were able to buy contracts with lower premiums than would now be expected. Indeed as two interviewees have noted (Interviewee 6, 11) companies, including Enron, with more meteorological expertise were able to exploit the insurance sector's low contract prices. This continued into the following year, but the insurance companies either rapidly changed the deals or, as many did, pulled out of the market. As one interviewee (6) put it

> We were the only ones out there that were actively looking, the market was young and we did some really good deals. There's no way we're going to get such good deals now you know. They've all wised up to it.

The weather derivatives market thus began life as particularly profitable for the few energy companies involved at the outset, at the expense of a number of other companies, in particular, insurance companies. This has created a lasting discursive problem for the market in that many today still associate the market with Enron's (and other energy companies') strategy of profit making. Regardless of this image, the group at Enron met their internal profit targets and hence ensured that weather derivatives would not join the list of products that had failed. It is too simplistic to blame the Enron desk for this strategy. Each actor is working under particular targets and conditions, which have to be met, or have to be passed through, in order to build the network that will allow the further production and marketing of that product. Careers are continually on the line in the financial world.

The weather market was also aided at this time by a strong El Niño associated event (1997-1998) that affected the US. With the lower than normal sea surface temperatures (hereafter SSTs) in the Western Pacific and the higher than normal SSTs in the Eastern Pacific, the planetary-scale circulation changes and, during the winter, shifts the polar jet front northwards. There is anomalously warm weather in the northern US and, often, wet weather in the South. With many energy companies dependent on the city populations in the North, this warm winter left these companies with reduced profits. The weather here played a vital role as an actor in establishing the weather derivatives market. A product to deal with weather risk had just been created and along came a weather event affecting those very companies for whom the product was designed. As Latour (1987; 1996), and others (Callon, 1986; Whatmore, 2002), have noted non-human actors can play critical roles in the networks underpinning particular things, objects or associations. Latour (1987) highlights some of the times in which the non-human has intervened to the disruption of scientific and technological projects. Here an El Niño associated event interceded to the discursive and material benefit of a group of human and non-human actors endeavouring to establish a new product. The energy market under increased economic pressure from the competition established by the deregulation policies of the mid-1990s was now under even further pressure due to the poor gas sales of winter 1997-1998. Weather permitting, the weather derivatives market would prosper.

Weather derivatives had been established as a viable product, a network creation with a wide set of connections from gas pipelines to El Niño and from inspirational individuals to meteorological data stations. The stage had been set, it only remained for these allies to be tested over the coming years to strengthen or weaken various ties that would potentially alter the nature and scope of weather derivatives.

4.3.2. POST-1997 EXPANSION

From 1997 the market grew rapidly in the US for the next couple of years aided by strong growth in sales from Enron and Aquila (figures 4.1, 4.2, 4.3 and 4.4). Due to derivatives accountancy rules in the US, weather derivative value would be marked-to-market and hence remain off the balance sheet[1]. Enron was thus marking its weather contracts against expected market values in a market that it had largely created and in which it was one of the major participants. The weather desk showed continual profitability, but two interviewees (4, 21) have doubted the real profitability of many of their deals. This highlights two points. The first is the performative nature of finance that is clearly seen here, where particular accountancy methods inform the workings of a market that re-enforces that method of accountancy. The second point is that the notion of profit is in itself a creation, being the result of a set of negotiations about accountancy and business practice. Though profit may be a key part of the market, it is therefore not important to forget the way in which it is actually constructed.

[1] Marking to market is an accountancy mechanism that aligns the value of particular derivative transactions in line with the expected future value of the market.

In 1998, Enron also transacted the first European deal with Scottish Hydropower and opened a European weather desk in London headed by Nick Mooney. The desk in London set out to work in a different manner to the US. Though the product may be perceived as universal, geographical distance and regulatory differences constrained or allowed a European market to develop rather differently. The comments here will be specific to the UK, because London may be considered the predominant driver of the European weather market. In the UK, the new weather derivatives desks opted to work with the Met Office. Partly this was due to fundamental regulatory differences to the US in that the Met Office in the UK charges for data if the use is commercial. It owns data on a commercial basis and due to its part public, part private funding, only gives out for free what is in the 'general public interest'. The weather market here was compelled to work with the Met Office, not least to campaign for reduced charges for data. In 2001 a company called weatherXchange was formed to provide a concrete relationship between the Met Office and weather derivatives actors. It was 51% owned by the Met Office and 49% owned by Umbrella Brokers. Its main role was to provide data to the weather market, but also broker deals (see chapter 5). WeatherXchange was headed by Cindy Dawes, formerly a broker at Spectron, the largest gas brokerage in both Europe and North America[1]. They were one of several brokers interested in the nascent weather market from about 1998 onwards. Today, Spectron still broker weather deals, but as with its general focus on energy, to predominantly energy clients. The aim of weatherXchange was for the weather derivatives market to work with the Met Office to specify and obtain the data needed. The cost of data has, however, been highlighted as one of the major problems that

[1] At the end of 2005 weatherXchange went into administration with the data and forecast services expected to be sold off to an interested party whilst the brokerage side of the business would be closed (Anon, 2005a). In May 2006, Met Office staff had to account to a Commons select committee for the £4.5 million loss that weatherXchange had suffered since its inception in 2001 (BBC News, 2006).

hindered the development of the European weather derivatives market in the early stages (Interviewee 5).

The European market actors tried to work differently to the US model in two ways. First they did not want weather derivatives to be a predominantly energy product, though they arguably did not escape this (Interviewee 16, 21), and second they wanted to avoid the dominance of options, rather than swaps, in trading. As one interviewee (3) put it

> There was some crucial fundamental aspects of the North American market, which I just thought were crazy.

It only

> … suited the 3 big utility companies in the market[1] … We were what two years behind. We had the benefit of seeing what they had done which wasn't good. I think one of the first fundamental things that when we sat down at the first weather derivative meeting in London was this market has to be bigger than the utilities.
>
> (Interviewee 4)

Whilst energy companies were working with some insurers for business in the US, in Europe banks infiltrated the market as well. These provided a number of benefits including good reputations, more trust, client networks and a reasonable amount of risk capacity. It is arguable that the weather derivatives market may not have grown so rapidly in Europe but for the involvement of the banks, because they secured the reputation and

[1] Enron, Aquila and EKT.

aided the promotion of the market. Here the growth of weather derivatives is strengthened by adding the associations of the mainstream financial institutions, that would provide a number of other networks, including further clients and additional, more empowered, actors in regulatory debates.

Many of the early actors in the UK market were already active or had some interest in the US market and the development of weather derivatives within banks was often achieved through personal networks. A good example is that of Societie Generale (referred to as Soc Gen in this quote) who,

> … were one of the first people we contacted in the bank and insurance markets on that first round [in 1998]. Soc Gen's what they call their insurance derivatives group is headed by a man called Diego Wauters. He used to be head of insurance derivatives for AIG and AIG was one of Enron's big insurance companies for globally managing what we call business interruption insurance, burst pipelines and things around the world. So he was someone we knew and they were doing insurance derivatives and we said 'well what about the weather?' [pause] there were people like the Wellington group and a lot of the Lloyd's people, but it was really Diego who had made that leap from insurance into that converging area who became quite a big power in the first year or so.
>
> (Interviewee 4)

The early enrolment of Societie Generale into the weather derivatives market was achieved through the personal networks that had been established at Enron. Diego Wauters "made that leap" because he was easier to attract to the weather derivatives community through his prior personal relationships with people on the Enron weather desk. Enrolment of actors is often about the already-established networks and in chapter 6 the banks will also be shown to be adept at this by utilizing their current client networks to sell weather derivatives.

In 1999, the weather derivatives community established an industry association, WRMA. As a network of weather derivatives actors it is endowed with greater power and has been busy lobbying a wide variety of other actors about weather derivatives, including credit rating agencies and lawmakers (see chapter 6). One interviewee (21), however, has two concerns about WRMA. First is that they are arguably an in-house community that protects current participants rather than opening the market to new participants. Second is that they do not seem to encourage meteorologists into the community (Interviewee 21). This would serve the first point that they are more about keeping the profit internally within the current group rather than taking on advice. The criticism of WRMA appears harsh, but nevertheless these elements in the organization could undoubtedly be improved. WRMA are one of the most visible bodies for the weather derivatives market and their marketing and campaigning have been of numerous benefits to the market.

As importantly, also in 1999, the CME started listing weather contracts for 12 US cities. The person charged with the responsibility of setting up a CME weather market was Felix Caballero, formerly an energy trader on the New York Mercantile Exchange (hereafter NYMEX), which has a significant focus on energy trading. The CME had little experience in energy markets, but saw that weather had the potential to be much broader than an energy market. Caballero was able to generate interest in the weather desk through his network of former colleagues who were all energy traders at NYMEX (Interviewee 15). As energy was the biggest market at this time, it was important that the CME attracted the energy actors into their market. Although the number of contracts sold was relatively limited at first, as the weather market has grown they have played an increasingly important role (as figures 4.1 and 4.2 testify). This is not least due to the attraction of a lead market-maker, Wolverine, in 2001 that means there are constant prices available on all contracts and hence necessary liquidity. Since that time their market share has grown rapidly due to increased price transparency in the market and the constant availability of prices on contracts[1]. The CME is also 'anonymous' so no one else in the market needs to know what is being traded. There is also less credit risk within the CME. Credit risk is an important factor as it can restrict OTC trading. Many companies have regulations that only permit OTC trading with companies of the same credit ratings and this has been particularly problematic in the US with the fall in credit ratings of many energy companies. There are issues relating to the default of payments and, indeed, many companies, particularly in the US, have introduced margining on contracts[2]. The CME thus provides an ideal platform.

The London International Financial Futures and Options Exchange (hereafter LIFFE) also seized upon the possibilities of an exchange-traded weather derivatives market and set up their weather indexes in 2001. After seeing only a few trades, however, their market swiftly died, in part due to changes they had made to their indexes. Instead of using standard HDD indexes, they added 100 to this. This was designed to provide different products to the OTC market, but in reality ended up being quite confusing (Interviewees 1, 2, 4). Not only this, but it was not easily compatible and hence already knowable. Earlier it was suggested that the HDD indexes were chosen because they were

[1] One interviewee (15), however, suggests that the CME was already beginning to grow its market share and Wolverine's main role may not have been in directly putting prices into the marketplace, but actually providing, for the first time, an information page on weather trading that allowed other companies to see both data about stations and prices.

[2] Margining is when a company sets aside into a bank account a certain proportion of the contract it is involved in, in case of that contract paying out. As the payout date gets closer the company which looks to be paying out has to put a greater percentage of that money into the account ready for the payout. This is to reduce credit risk i.e. the risk that the company will default on its payments. Margining is often the only way that companies with poor credit ratings are enabled to trade at full capacity within the derivatives markets.

already known and LIFFE provides an interesting example of a company that chose to create something new and ended up without a market. There is resistance to change, because many traders simply do not have the time to invest in understanding unusual products. With many individuals either having to rapidly acquire knowledge about either the financial or the meteorological aspects of weather derivatives anyway, further complications like LIFFE's indexes served only to distance users from them. Whilst there is some debate about the level of market consultation between LIFFE and weather derivatives users (Interviewee 1, 2, 4), the CME adopted the position of creating products that consumers requested.

A year later, therefore, the CME established European weather contracts and London Heathrow is an important liquid location in the world[1]. In 2004 the CME expanded into Asia for the first time in support of the Japanese weather derivatives market. Since the turn of the century, Japan has been an increasingly important national market for weather derivatives and WRMA hold committee meetings in Japan (as well as in Europe and the US) every year. Though little will be said about the Japanese market in this thesis, it has grown along different lines to both the European and US market. With a greater business trust and confidence in Japan, swap deals have become more prevalent and the mitigation element of the market is much stronger.

Whilst the CME has been expanding, others have been losing market share and the competitiveness of the market has come to the forefront. With the weather market having a relatively low number of actual end-users, the market has become very competitive. The addition of hedge funds since 2004 has also encouraged increased levels of speculative

[1] In 2000, Chicago and New York were the only two liquid locations. Since then London has become one of the most traded locations, but other locations are equally and more liquid at certain times of the year (Interviewee 15). The recent market expansion has greatly diversified the list of liquid locations.

trading. The competitive nature can be seen from the quote of one European banker (Interviewee 11) who bemoaned the actions of US energy companies.

> [Y]ou'll find a lot of the big American companies, they've got such a tight portfolio, they can just swallow us up and can almost always beat you on price just out of spite. It might not even be the best deal they want to do, but they'll just undercut, because they've got so much going on.

With competition for end-user orders quite intense, much of the market has been driven by speculative trading (Interviewee 26). There may be little doubt that speculative trading increases liquidity in a market, vital in a market like weather where liquidity was such an issue in the early years, but for several interviewees (2, 11, 21, 26; others disagree, for example, interviewees 15, 16) it also damages the general perceptions of the market. Yet speculative trading is equally a feature of other financial markets, for example CBOT, and it can often be hard to differentiate hedging from speculative activities (de Goede, 2001; Zaloom, 2004). The legitimacy of speculation is not an easily resolvable question and indeed what becomes speculative (or not) may be a post-rationalization as management of any risk is in a sense speculative about a future unknown thing. An interesting point is that the process of short-selling (exchange of shares without a physical possession of the commodity) was termed in the Amsterdam market *windhandel*, or "… the seller, so to speak, sells nothing but the wind and the buyer receives only the wind" (quotation in Barbour, cited in de Goede, 2001: 153). *Windhandel* in the context of the weather derivatives market seems a particularly apt term.

One point that has been neglected in this analysis so far is the role that individuals based within Enron and Aquila have played just before and after their companies respective collapses. In 2000, many of the Enron group, namely Lynda Clemmons, erstwhile president of WRMA, Jeff Bortniker, Phuoc Dang, Michael Corbally and Martin Malinow, left under a haze of uncertainty (Interviewee 21). They re-surfaced at a new company called Element Re running a weather derivatives operation out of Bermuda, though the people were physically located in New York. This company, later taken over by XL Reinsurance and re-titled XL Weather and Energy, became a new driver within the weather market providing insurance capacity to the weather market. The reasons for their departure from Enron are unclear, but the move at least changed the dominance in the market bringing in the insurance sector once again. At the same time in London, Nick Mooney left to set up a weather derivatives information portal (I-Wex), whilst the rest of the weather desk were visited by Andy Fastow who had a 'great place to store bad deals'[1].

Meanwhile at Aquila, other high profile weather actors were beginning to leave including Brian O'Hearne, the WRMA president 2004-2006, who established, with a group of ex-Aquila workers, GuaranteedWeather, based in Bermuda. Again this added different risk capacity to that provided by energy companies and perhaps signalled that weather derivatives were becoming more mature by being re-located to more traditional financial or insurance services channels. Personnel in these two companies, GuaranteedWeather and XL Weather and Energy, would become, and continue to be, key actors within WRMA, albeit that many of XL's personnel are now located elsewhere. Koch Industries, later EKT, retained many of their initial staff until 2000, when Jeff Porter and two others left to establish a weather desk at Hess. Nevertheless EKT has remained a much more stable participant in the weather derivatives market than Aquila or

[1] No London deals, however, were 'bad enough' to be transferred to LJM1 or 2, Fastow's special vehicles for moving debts off Enron's financial statements. (Personal communication, for reasons of confidentiality her/his name cannot be disclosed here, 27/01/04).

Enron and it now has become part of the financial mainstream with its transfer to Merrill Lynch in 2005[1].

After the initial phase of departures in 2000, Enron and Aquila entered financial problems leading to bankruptcy and the closure of their weather desks. Some Aquila employees moved to other companies, but others left the market. At Enron, one employee, who had worked in weather since 1997, headed the weather group into its final days at Enron. Indeed such was the profitability of the weather group, that it appears he was paid $300,000 to stay at Enron the first 90 days after bankruptcy, one of many people paid significant retention bonuses (Cruver, 2003). After this, he left to head another weather derivatives group. What should be clear is that though the institutional housings may change it is fundamentally one group of people that is continuing to replicate the weather market, particularly in the US. In the UK, however, because of the role of the banks and different employment strategies within the energy companies more new individuals have been attracted to the market. This has resulted in what appears to some interviewees as a greater diversity and input of different ideas within the European as opposed to the US market (Interviewees 4, 6).

Weather derivatives have gone from a still-to-be-settled energy product in 1996 to an international market today. Important to this was the enrolment of a variety of human and non-human actors including information about the weather, through the meteorological data produced and guarded by meteorological gate-keepers, the interest of the energy sector, itself undergoing regulatory transformation, and the availability of risk-taking capacity in the insurance market. The current weather derivatives market may have been very different if any of these actors had been weaker or stronger, more or less

[1] For the sake of clarity and historical continuity, however, the EKT name will be used throughout.

inclined to participate. Each factor is vital in contributing to the creation of weather derivatives. For example, if energy had not been deregulated it is unlikely these companies would have considered their volumetric risk in as much detail. If there had not been a warm winter just as the market was starting, there may have been less immediate interest in the product. There is also little doubt that the people at Enron were young, inspirational thinkers aided by a forward-thinking corporate environment, yet they were constrained initially by the insurance system.

Weather derivatives are a network creation, an unstable product in the mode of becoming an accepted part of business risk management and environmental governance. How does this initial stabilization of weather derivatives translate into the current weather derivatives market?

4.4. THE CURRENT WEATHER DERIVATIVES MARKET

Weather has arguably gone from something unmanaged, something in the hands of providence, to a commodity, something that can be bought and sold. Previously

> it was just accepted that oh it's in God's hands … it's only since 98 that we've had to sort of think about our weather risk[1]
>
> (Interviewee 6)

This commodification of weather risk has led to the growth of an active weather market worldwide by 2006. In the UK the energy sector is still the most important sector within

[1] The reference to 1998 is to the deregulation of the energy sector in the UK rather than the emergence of weather derivatives. Doubtless however the weather derivatives market was vital for some companies for the management of weather risks at this time (see chapter 7).

the weather derivatives market in terms of number and size of contracts traded (Nicholls, 2004; 2005). Indeed one interviewee (16) suggested that as much as 60-70% of weather hedging in the UK is performed by Centrica-Accord (certainly until 2004). Other companies also involved include RWE-Innogy, Powergen, Scottish Power, Scottish and Southern and EDF trading, owners of London Electricity (see chapter 7). Thus six out of seven of the large energy corporations within the UK are actively involved in the weather derivatives market, though their focuses are often different and their level of involvement varies considerably. Interviewee 16 also suggested that 99.9% of deals in the UK are based around temperature (see Figure 4.5 for the global dominance of temperature contracts) and it is perhaps not surprising that since 2002 London has been one of the most liquid locations for temperature deals globally. Indeed such is the power that London has generated as it became a settled leader in weather derivatives that other companies were forced to trade or back up contracts through the British capital. This matches other analyses of the concentrating power of the city of London (and others like New York and Tokyo) within the financial world (Clark, 2002; Faulconbridge, 2004; Sassen, 2000). The first European weather desk was established in London in 1998 and since then French banks Credit Lyonnais and Societie Generale, and Germany's Deutsche Bank have established their main weather desks in London, even if much of their weather business is not in the UK. The only exception to this pattern is Dutch bank ABN Amro, which has operated out of London and Amsterdam from the start. This concentration in London may well be because it became the first European centre of weather derivatives, but it can also be related to the developing social networks in London. Many interviewees are closely connected through either drinking networks or close business relationships[1].

[1] For example, there are drinking friends, people who watch sports together and those that attend each others' weddings (Interviewees 3, 4, 5, 6, 10). These are just some of the many examples of close personal

These act as vital conduits of knowledge within the weather market and have established London as the primary leader in European weather derivatives.

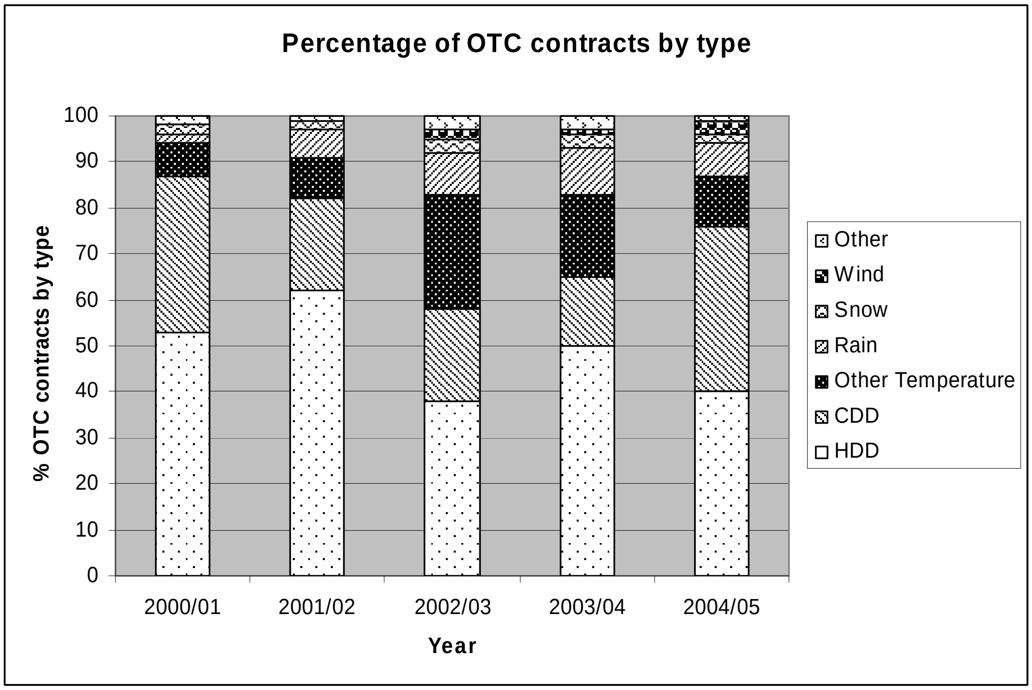

Figure 4.5 Percentage of OTC contracts by type (temperature, precipitation etc). What is clear from this is the dominance of temperature contracts, but the growing number of alternative contracts (adapted from PriceWaterhouseCoopers, 2005).

The European market is largely driven by the banks and less so the insurance and energy companies. Unlike in the US where energy companies and later the insurance companies became the leading providers of risk-taking capacity, in Europe the banks have taken on this role. The four banks mentioned earlier are the primary banks involved in weather derivatives, supplemented by occasional interest from banks like Barclays,

relationships within the relatively closely woven, small weather derivatives community in London.

Goldman Sachs and the Royal Bank of Scotland who will provide weather contracts if clients request them, but do not actively market them (Interviewee 5). Insurers have a less active role in Europe, but nonetheless XL Weather and Energy and Swiss Re are important actors. In general, European companies who wish to take out insurance policies will have to go to US insurance companies. It was not until 2004 that XL set up a weather desk in Europe, although interestingly with XL's changes and staff departures in 2004, the London office became the primary sales office for XL's weather derivatives operation[1]. Energy companies do play an active role in the European weather market, but EKT has been most extensive in selling contracts to other clients (Interviewees 2, 16). Other energy companies have also tried to sell contracts, but purchasing risk protection cover as end-users is more common. The European market has been taken over by more mature economic institutions that have already-established names and images as sites of financial acumen. This has provided a much-needed financial image of the weather derivatives markets that accepts that these are *bona fide* commercial contracts for the purpose of risk mitigation. Since 2005 however the European market has slightly declined possibly due to resources being allocated to emissions trading (Nicholls, 2005), whilst the aggressive expansion of the CME has brought a considerable rise in value of trading in the US.

The energy sector contributes a high proportion of trading in the weather derivatives market internationally. The main energy contracts in Europe are to protect against the costs of warm winters, but precipitation is also important for hydropower and wind energy is clearly weather-sensitive too. Chapter 7 will discuss these contracts in more detail. Energy, however, is not the only sector involved in the European weather derivatives market. Wine bar chain Corney and Barrow initiated a contract with Enron in

[1] Since 2004, Lynda Clemmons, Jeff Bortniker, Michael Corbally and Martin Malinow have all left XL or moved into non-weather positions.

1999 that protected them against Thursday and Friday summer evenings when it was too cold or wet for customers to take advantage of their large outdoor seating areas and took their drinking elsewhere. Worth a relatively small amount of £100,000 it nonetheless became a well-documented contract through the publicity it generated. Indeed many analysts have commented that they earned enough publicity to more than recuperate the premium they paid on the contract (Interviewees 2, 5). Refuting claims that this was a publicity stunt, in 2004 Corney and Barrow returned to the market with XL Weather and Energy, the ex-Enron employees, for another contract as they were concerned that summer 2004 would not be as warm as summer 2003 in the UK and their wine sales would decline again. Retailers Thorntons and Sketchers Footwear have also taken out weather derivatives contracts at various points, with Thorntons particularly concerned about the relationship between ice cream sales and temperature (Interviewee 4). Munich's Oktoberfest event is covered by a weather derivative in case it rains on the beer festival (Anon, 2004b). In 2002, the Gut Apeldor golf club in Hennstedt (about 100km north of Hamburg, Germany) bought a weather derivative from bankers Societie Generale that would protect the club against summers with more than 50 rainy days (Anon, 2002; 2004b)[1].

One of the largest contracts in the weather derivatives market involves ABN Amro and a Dutch construction company that has some link to the national government[2]. Worth about €100 million per year, this five-year deal initiated in 2000, was renewed again in 2004 for a further five years. The contract protects the construction company from frosty

[1] Many of these contracts would be considered the traditional terrain of pluvius insurance except that they are over longer timeframes. Pluvius insurance is typically used to protect outdoor events from, for example, the costs of being unable to open or hold events due to rain or wind. These insurance contracts have, however, been increasingly difficult to obtain.

[2] Many interviewees mention this deal (2, 5, 6, 10, 11), but nobody seems to know, or is willing to divulge, exactly who this company is or the nature of its relationship with the government.

mornings when workers have to be sent home from work under Dutch law and, indeed, they would struggle to make cement in these conditions anyway. Covering November through March, the contract will pay out x amount per day over 19 frost days (the average number of Amsterdam frost days during this period). The trading generated by this contract will be discussed at greater length in the next chapter, but suffice it to say that this deal has not only put a large amount of money into the primary hedging market, but also into the secondary (re-hedging) market. This one contract has inspired a great deal of trading within Europe and can be said to be particularly important to the growth of the European weather derivatives market.

In India, the World Bank is engaged with local microfinance institutions and groups such as Basix and ICICI Lombard to sell weather derivative contracts to protect small farmers against weather that would damage their crop output (Rhode, 2006). This is a partial, cheaper replacement for crop insurance and is focused solely upon the weather risk. The country with the most innovative deals, however, is Japan. In addition to protecting the cherry blossom season and ski resorts, there are also contracts that protect construction companies against years when there are a below-average number of typhoons and they have less rebuilding work to do. Even the 'divine wind' (Durschmied, 2000) has been commodified[1].

4.5. CONCLUSIONS

This chapter has provided a historical overview of the network-building that the initial actors undertook to create a viable market in weather indexes. This involved the

[1] The 'divine wind' is the translation of the Japanese word kamikaze, which was applied in the thirteenth century to a typhoon that destroyed a Mongolian invasion fleet (Durschmied, 2000).

enrolment of a range of allies and the translation of interests, from weather data series to the HDD index, from energy companies in a deregulating environment to the weather events of winter 1997-1998, and from the experimental risk capacity available from insurers to the discourses of climate change. Commodifying weather indexes was not just about capital searching for opportunities in nature; rather weather derivatives had to be made, negotiated, contested and translated. It would be too simplistic to suggest that the rationale of weather derivatives is the capitalist system commodifying nature in search of profit. Rather individual actors in specific companies responding to particular needs created a product that would generate the profit, as accounted for in that company, required to meet their targets. To do this they had to engage in many other forms of network-building that were not centred explicitly around profit. This is arguably a hybrid of the arguments of political economists and actor-network theorists. Latour (1987) suggests that larger motivations cannot simply be read off social actors to explain outcomes and there is much here that points to the way that non-human and human actors were enrolled into a network-building exercise that attempted to stabilize a thing called weather derivatives. To suggest though that therefore profit played no part would be to undermine both the evidence presented in this chapter and also the predominant models of business. The notion of profit may be constructed, but the notion has persistent recurrences.

Constructing weather derivatives required a range of allies, in particular, the fears over future changes in the climate. These fears became enhanced through the power of the 1997-1998 El Niño events, the increasing governmental attention paid to climate change and the IPCC reports. Weather derivatives can be seen as a partial response to these fears, yet as much of the history suggests, they are not purely derived from climate change. A host of institutional, sectoral, contextual factors shaped the attraction of different meteorological and financial allies, which transformed the product. Weather derivatives were not the rational, financial response to climate change (policy). The products developed to meet specific needs and as later chapters will show have a variety of implications for future climate change (policy). This is a recurrent theme through the following chapters.

From being a small energy product the market has grown sectorally and internationally to become a $45.2 billion market in 2006. Continuity of personnel has been a theme of the weather market and until larger numbers of end-users are attracted to these products, the market may not grow as rapidly as some would like (Nicholls, 2004; 2005). The weather market has grown thus far by extending its networks to enrol a wide variety of different actors. This assemblage is necessarily temporary as it is continually being re-negotiated and changed. For convenience, however, the term weather derivatives market will be used without qualification through the remainder of this thesis to designate this assemblage. Thus when the weather market does something it is this assemblage of actors that do things, not an ‘out there’ weather market, correctly delineated, suitably separated, to permit clinical examination. The market is altogether messier than that.

This historical background forms the basis for appreciating two groups of allies that were enrolled to support the weather derivatives projects. The next chapter examines in more detail the meteorological actors involved in the weather derivatives market, focusing particularly on the creation of data, forecasts and expertise. Chapter 6 then examines the financial actors and the ways in which weather traders are marketing these products to future consumers, as well as important industry organizations like credit rating agencies or regulatory authorities. These two themes are then pulled together in chapter 7 with a case-study of the energy sector and the implications of using weather derivatives both in supporting particular industry practices and also in its role in climate change mitigation policies.

CHAPTER 5: METEOROLOGICAL NETWORKS

5.1. INTRODUCTION

Morss and Hooke (2005), in a paper in 2005, suggest that meteorological research should resist the temptation to follow the field of biotechnology into the path of increased corporate sponsorship, where scientific research plays a secondary role to the creation of profitable businesses or products. They glimpse the early stages in the growing value of meteorological services of a potential issue of conflict between funding agencies and meteorological research that may adversely, they believe, lead to patenting, privatization and issues regarding data sharing. Though they state that there are few examples of this yet, they espy the rising value of meteorology as a time for reflection about which way the science should go in the future. They conclude their paper

> [m]eteorologists are … most likely to find continuing opportunities to conduct research, develop user applications, and help humankind by remembering that the partnership among academic researchers, government, and the private sector exists primarily to serve society, and by acting accordingly.
>
> (Morss and Hooke, 2005: 932)

This chapter draws upon Morss and Hooke's (2005) observations to present a case study of commodification of meteorology in action and argues that rather than primarily serving society, commodification may rather be more instrumental than that and in particular it may be more concretely connected with the generation of profits. Atmospheric sciences are clearly important within a financial market that trades upon weather. Whilst the previous chapter showed the importance of negotiation with data and data-generators, this chapter extends the analysis of the meteorological networks underpinning the contemporary weather derivatives market. This is important as it outlines one particular group of allies that the weather market needed to enrol to ensure that the project could be materialized and highlights the pragmatic relationship with meteorology that was developed. In other words the creation and use of particular knowledges was goal-oriented. To achieve a profitable market these meteorological allies had to be associated and tied as strongly as necessary.

The chapter addresses the ways in which the weather derivatives community has interacted with meteorology, whether in data, forecasts or expertise, and shows that to make a profitable product a number of pragmatic decisions have to be made about the types and quality of data and models used. Weather derivatives practitioners consume large amounts of data and forecasts. This is re-shaping the value that meteorological offices place on certain data and the different types of forecasts. Section 5.2 will examine these data inputs into the market and what companies are trying to do with them. It will suggest that data are not an uncontested notion within the market and the weather derivatives community are engaging in a dialogue with data providers about issues of quality and types of data. The re-valuing of data will also be discussed as it links to the development of weather derivatives and the differing systems for meteorological services in the UK as opposed to the US. Nevertheless for many actors data are accepted pragmatically as it performs a secondary role to the actual trading of weather risks. In section 5.3. the focus is on the forecasts being used within the weather derivatives market and the types of knowledges being produced about those forecasts. Not only are weather derivatives traders voracious consumers of weather forecasts, but they are also creating their own models to generate forecasts, particularly on a seasonal basis. Thus weather derivatives traders are increasingly employing atmospheric physicists to build models to allow trading on not just the weather, but also other financial markets like gas or power. Finally as section 5.4. suggests there is a growing privatization of meteorology as some of the most qualified scientists are employed by energy companies seeking trading advantages. Not only has the value of data changed, but the exchange value of meteorologists has also increased as companies fight for a competitive advantage in their climate and hence pricing models. This further commodification of nature as information, a feature that Cronon (1991) highlights as a feature of other futures markets, is having potentially important ramifications on the production of meteorological knowledge. If, as Morss and Hooke (2005) suggest, most future meteorological expertise is within the private sector what is the potential effect on publicly funded meteorology as well as debates such as climate change? Whilst weather derivatives are only one influence on meteorological employment and expertise, they are nevertheless of high economic potential in the future. The weather market, thus, is not just a response to fears about climate change it is actively developing the sciences which underpin some of those fears. The chapter will conclude by summarizing the meteorological networks involved in the weather derivatives market.

5.2. DATA

5.2.1. CREATING DATA

Key to the weather derivatives market is the provision of timely and accurate data. The traded indexes for weather derivatives are based upon underlying meteorological indexes, which are derived from one or more meteorological data series with or without modifications. For example, HDDs are dependent on having the computed average daily temperature and taking that from 18˚C (or 65˚F)[1]. The weather derivatives market has also promoted a re-engagement with issues relating to the availability, cost and reliability of meteorological data. In this section the meteorological data requirements are first examined within a historical context and it is shown that some weather derivatives practitioners believe that data are of poor quality, but that meteorologists do not worry as the cracks can be papered over in forecasting models. Other traders disagree, however, and trade on data regardless of whether it is right, as long as it is correlated with their risk needs and everyone else is having the same problems. Questions of data become problematized within economic and political issues. The value of data becomes the subsequent topic for discussion in that many European meteorological offices, espying a rising value for data driven by the weather derivatives market, are raising the prices for that data. This has been particularly unhelpful for US-based weather traders, engrained within the US model that treats data as free, who have attempted to turn weather data into a trade issue to prevent the practices of the European meteorological offices. Commodifying data has wide-ranging implications beyond simply the cost to weather

[1] The weather derivatives market therefore requires two streams of data, minimum and maximum temperature per day to compute the average temperature.

derivatives traders including, for example, regulatory and contractual issues, or the costs for companies who do not use weather derivatives. The nature and changing value of data are significant issues for the weather derivatives market and beyond.

Weather information, as seen by the public during the later 19th century, had gone through many transitions or reductions. This begins with aspects of weather recorded (translated) through the data-producing instruments, which data travels by telephone or internet to a centralized ordering body from where they can be collated, checked and disseminated into publication formats (see Figure 2.1.). This central body thus acts-at-a-distance from the network of observatories (Latour, 1987). Observation equipment must meet the standard requirement, which during the 19th century was set by the Kew thermometer (Randalls, 2002). The situation is little changed today with only changes in communication technologies differing (from the telegram to the Internet). Whilst weather derivative actors are interested in the instrument records they must negotiate passage through the central organizing bodies that can charge for this rite of passage. In the UK this would be the Met Office or companies such as EarthSat. As value is created along the chain and as demand increases the exchange value of this, then the central organizing body can charge ever-increasing amounts for this data access.

How did data interact with the early human players in creating a weather derivatives market? In the US, where Enron was based, data becomes free by virtue of being labeled a public environmental good. Under current US regulation any data considered in this way must be made freely available to public and private sectors. Meteorological data could be easily enrolled as a series of numbers. There were, however, issues about the length and quality of data recordings, which fed into debates about what the future price of a contract should be. Weather derivative traders perceive that these data have trends within them, towards warmer winters in particular (Interviewee 5, 11). The average temperature when analyzed historically, however, will vary dependent on the length of data included within the average. Juggling their own corporate attitudes to risk a ten-year average has become established across the weather derivatives market in both Europe and the US, not as being most correct, but being most acceptable to risk averse managers (the future is likely to be similar to the recent past). Interviewee 21 believes that this average is much too short and that there is not enough strength in the consensus climate change argument to reject the thirty-year average when pricing contracts. This results in opportunities for arbitrage[1]. Indeed the weather data has resisted the ten-year average in New York during the winters of 2002, 2003 and 2004 (Interviewee 17)[2]. Thus utilizing the ten-year average for those winters would have overestimated the effect of global warming and traders using a thirty-year average would have been able to take advantage of this pricing 'anomaly'. Regardless of this possibility, in reality once a certain average has become established it is difficult to trade upon anything else; pricing mechanisms, forecasting, risk management software all become enrolled into the orbit of the ten-year average. This echoes Latour's (1987) point that fact-making is a collective process and that facts become facts as they are adopted and utilized by others.

It is not just data, but the interpretation of data that can be variable, particularly when, as in climate change debates, it relates to political-economic issues. The introduction of barometers in Britain in the 18th century, for example, was not

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[1] Arbitrage is the process of taking advantage of 'mis-pricings' within financial markets, whereby one can buy the same asset at a different price on one market than on another. Hence the difference between the two is the potential for arbitrage. Arbitrage can be a profitable business, however, Long Term Capital Management's collapse has been blamed on its arbitrage strategies (see de Goede, 2001).

[2] Though weather data providing resistance may seem a strange concept, nonetheless it is important to understand that non-human actors have forms of agency that directly influence human actions. When Latour (1987) talks about experiments, for example, he argues that certain chemicals etc resist being classified into certain categories. That is, they do not fit with what the scientists wants them to do. The scientist wants one thing, the chemical resists that action. This is the sense of resistance meant here.

straightforward, with scientists looking to the public both for consensus about how to use the instruments and being exasperated when users placed too much trust in them (Golinski, 1999). Connected to discourses of health and prosperity, as exemplified for example by farmers like Henchard whose bodies at harvest time "... became a sort of flesh-barometer, with feelers always directed to the sky" (Hardy, 1994: 211), barometers provided both quantitative accuracy with qualitative interpretation and judgement (Golinski, 1999). Similarly with early storm warnings, though the Americans and the Cubans used the same data, their interpretations were very different as "[w]here the American saw numbers, the Cubans saw poetry" (Larson, 2000: 120). To phrase it differently, the Americans were rational, the Cubans romantic. These divisions of approaches in understanding data continue to this day and it is clearly too simplistic to divide rational and social interpretations. Data do not answer questions in and of themselves neither is the process of settling upon datasets, deciding upon what counts as data, a value-free process. It is thoroughly social (Longino, 2002). In meteorology, data feed into models that are used to produce forecasts. These models have become progressively more mathematicized, progressively less easy for non-specialists to understand (Demeritt, 2001a). Yet whilst formal academic meteorology develops models, farmers and fisherman still relate to the weather with the traditional weather lore that has been passed down through the generations. The rational and the romantic, to replicate the traditional dualism, here come side to side. Farmers use both their local, experiential knowledge as well as the forecasts produced by models and communicated through the media (see for examples Strauss and Orlove, 2003).

What constitutes a 'good' quality of data? This is a long-running debate within meteorology, because measuring temperature may be considered a circular process

(Chang, 2004). Quality of data arguments centre around how usefully reliable an observation seems to be in relation to other current nearby observations and the past history of data produced at that place. The recent debates on the maximum temperature recorded during the UK heatwave in 2003 illustrate this well, an example that will be returned to later in the chapter. Airport stations have become normalized within the weather derivatives markets as the sites for the data inputs into their contracts. These stations are considered more reliable, because security at airports should be strong and they take observations on a very regular basis. For weather derivative actors, there are two key points about the quality of data. First is the use of data in pricing contracts, where continuity becomes important. Second is the use of data in contract settlement, where instrument anomalies are immediately represented in financial loss.

For pricing contracts then it is vital that data displays continuity. The moving of a thermometer with little notice given to the concerned parties can result in sudden shifts in temperatures measured. This occurred with a minimum thermometer at Houston airport that, after a short move, registered about one degree higher minimum temperatures (Interviewee 5) [1]. In case this is assumed to be isolated to the US, in Europe there have equally been divisions about the moving or closure of the meteorological equipment at Manchester (Interviewee 5). One trader that is aware of this change in meteorological instruments can trade with another trader who is unaware of this change and make profit out of doing so. Interviewee 5 blamed this effect on the meteorologists who, citing the Houston example,

[1] It is difficult to judge whether Celsius or Fahrenheit is meant here, but in the context of the interview it is probable that Fahrenheit is meant.

> ... make such a hash of making the measurements. They've got a thermometer and they just move it and the meteorologist actually made an announcement that 'this will not affect the measured temperatures' ... but when you look at the measured temperatures there's a huge effect, but the meteorologists are just really naïve about this and partly because they think that the change of 1 or 2 degrees is a small effect, whereas for weather derivatives that's a huge effect[1].

There are two issues raised in this quote. First, that blame for the profiteering of certain energy companies is laid at the door of the meteorologist. It is not the fault of the trader making money out of their knowledge advantage, but rather the poor nature of the meteorological observation network. Secondly, in the quote the meteorologists' assumed position (moving the thermometer will have no effect) is counter-posed to the empirical reality demanded by the weather derivatives market (the thermometer measured one or two degrees different). Both are acceptable statements. The fact of the move of the thermometer becomes differently valued by weather forecasters and weather derivative actors. For the former the move has arguably little effect really. One or two degrees are not seen as a large change and they can soon be managed within forecasting models that anyway are becoming ever more reliant on synthetic data. For the latter, however, this change was influencing whether weather derivative contracts would pay out and what the 'fair' price for a contract would be. As one interviewee (10) notes with regard to different valuations of datasets

> [t]he observations are probably at a level which is adequate for inputting into a weather forecasting model … whereas for a weather derivative … the impact of that weather station is very high. So there's opposing needs.

[1] See the previous footnote

Another interviewee continues

> … the Met services … weren't set up to provide data for the financial market and because they had other priorities there had to be some kind of pro-active approach to actually get things set up for the financial market. It's very, very difficult…
>
> (Interviewee 3)

In the previous chapter it was noted that in many respects the European weather market tried to work with rather than against meteorological agencies (Interviewees 3, 4). This can be seen in the establishment of weatherXchange, the joint venture between the Met Office and a brokerage, which aimed to cross the divide between meteorological services currently offered and the needs of the burgeoning weather derivatives industry. Weather derivatives, again, re-engage debates about the purpose of making data, the constructions of this data and the uses to which data are put. The data here are perceived to be of different value to different people and there is an inherent assumption that weather derivative traders want better standards than public or academic meteorologists, though why the latter should not want this depends on the use of data and the scientific culture within which they are based. Empirical meteorologists might have different views to modellers, particularly as the former group equally perceive too little money going into observations (Brettle, 2006; Lahsen, 2005). Thus different types of data are generated for different ends and the interesting point is that the private sector here takes a position in the debate on the types and nature of science that should be funded. This raises important questions about the funding of science and potentially highlights that commercial interests may preserve particular forms of science that otherwise might become less regarded within publicly funded research groups.

The second use of data for settling contracts means that data must be reliably produced without sudden deviations or changes. Contracts do have back-up stations if no data are recorded, but if the data are ‘wrong’ there is no time in the fast-paced settlement of weather derivative contracts to correct those observations. Though meteorologists may not be too concerned about this, preferring to concentrate on continuity, they miss a salient point. Weather derivatives may be agreed over a five-year period and moving instruments halfway through a contract might not be acceptable, particularly if no warning is given. Upsetting the data stream during the period of a contract can have potentially large economic consequences, and there are questions about whether, if negligence could be proved, it would be possible to sue the service providers (Interviewees 26). The question about law will be returned to in section 5.3. Thus weather derivatives are having an effect on the current ways in which meteorological science is being undertaken by promoting a more sustained engagement with the quality of data.

For other weather derivative actors, however, data quality is not even an issue as long as there are none of the trading (dis)advantages of the Houston thermometer example. As Porter (1995: 28) suggests, accuracy is not as important as an “… adequate quantification”, that “… everyone is measuring and reporting… the same way” and “… it is possible to combine and manipulate data.” Interviewee 2, for example, a trained meteorologist, states that

> you know as long as we are where the market is once you know we’ve got the same averages and standard deviations as the rest of the market has we’re OK.

The data are not a fact pre-formed here, but they become fact by virtue of being enrolled by the prominent actors within the weather derivatives community. This again accords with the notion that the settlement of what data is accepted or counts is decided by social interactions, not by a purely rational process (Longino, 2002). Yet not anyone's opinion would count. As long as data are accepted by the data gate-keepers every actor can use them. These gate-keepers include both the risk pricing software companies and companies such as weatherXchange, which deal specifically with providing data to the weather derivatives market. These gate-keepers will have more experience of dealing with data and hence should be able to make better informed judgements about the reliability of that data. This does not of course mean that each of the gate-keepers would come to the same judgement, as other interests may intervene. WeatherXchange was an interesting example as it was a joint venture between the Met Office and Umbrella Brokers. The Met Office was providing data to weatherXchange to sell to the market, but at the same time the brokers may have wanted to write contracts on that data. Surprisingly no interviewee raised concerns about the threat to the perceived neutrality of meteorological data. Again, as long as every trader is the same (the elusive appealing concept of the level playing field) there is less concern for scientific accuracy. Or to put it in other language, as long as the measurement scheme is accepted by more people (in preference to other schemes) then it becomes objective by virtue as much of consensus as reliability (Cronon, 199l; Porter, 1995: 96).

It is important, therefore, not to overplay the role of meteorology within the weather derivatives market. Doubtless it is a component of the market, but today

> ... it's rare, even now, in the market to find a meteorologist who works alongside on an equal basis with the financial people and they're working together
>
> (Interviewee 4)

The trading of weather derivatives, though utilizing increasing amounts of meteorological expertise, often takes place independent of the meteorologist. With the exception of some companies (Interviewee 2), meteorologists have often had few opportunities to take up trading roles despite the fact that they would have the expertise to appreciate price discrepancies. The financial market is left to those who have expertise in other financial markets[1]. Thus weather derivatives as a fulfilment, for the Marxist, of the need to commodify and displace weather risks, make pragmatic use of meteorology. As long as the risk can be displaced the data becomes of secondary importance, indeed in many cases trading may be undertaken not fully understanding or knowing what the index or thing is that is being traded upon (the Houston example showed this). Displacing risks may actually be deepening the levels of risks exposed to, from the risk of weather to the risk of not knowing the traded index.

The debate on data has also become prominent within the World Bank's efforts to establish weather derivative contracts in developing countries, particularly for farmers. There is always a 'moral hazard' (Interviewee 22) that farmers will tip rain out of the rain gauge so they rely on local actors to support the policies. Implied within this is that no Western insurance company would offer contracts on stations that may have little security protection, but a local insurer who has close social and economic networks may be willing to take on that risk. If this risk can then be aggregated it can be sold on to the wider market where Western companies would be willing to get involved. Individual data points become less risky when aggregated. The World Bank takes no risk itself and merely acts as a conduit between the local policies and the international weather derivatives (or insurance) markets.

[1] Several weather derivatives traders have experience in other exotic options markets (Interviewees 3, 10, 19).

5.2.2. RE-VALUING DATA

Data are becoming re-valued in a variety of ways. Principally, there is now a greater commercial value attached to data because businesses are using it to make financial decisions. In the past, with weather forecasts the hegemonic weather service for businesses, the data were relatively unimportant compared to the accuracy of the forecasts. This suited militarized meteorological science, which had become largely dominated by weather prediction and control. Arguably there has been a shift to a corporatization of meteorology. So far this has been of a very limited nature (the weather derivatives market is still relatively small), but the connections between two seemingly disparate spheres are becoming more closely entangled. With it comes a greater economic value placed upon meteorological science and a re-valuation of aspects of meteorological expertise.

Since the 19th century meteorologists have devoted a lot of time to collecting data. Even the Met Office collects vast reams of data that are never used. The important point is that for some stations the data and the data record are now crucial, because of the increased value placed upon them by the weather derivatives community. Commodifying meteorology has further implications for the re-valuing of meteorological data. Though it is important not to over-stress the importance of the weather derivatives market for the provision and valuing of good quality data, with the airline industry being an equally important liquidity provider for the meteorological stations, it is placing the value as much on the data itself as the products from that data. The Met Office, having realized this, has chosen to keep or increase charges rather than promote a fledgling industry

(Interviewee 5) [1]. Without data there could be no weather derivatives market and this re-valuation has encouraged a concurrent debate about the collection and value of data.

Ecomet was established to provide data to any company in Europe for a fee, but in reality it was impractical due to the continual increases in prices and the lack of people who wanted to pay to access it (Interviewee 4). In the US model, the NWS provides free data as weather data are regulated as a public good, but forecasts and services are private activities. There is a sense in which this data appears more 'neutral' than that in Europe where data collectors can also sell services based on their own data. The cheaper costs of data make it easier for value-added meteorological service markets to grow as Table 5.1. testifies. This practice of charging for data in Europe has come under scrutiny within the weather derivatives community.

[1] Data charges are often in the region of €0.5 and 10 per data point depending on the amount of processing involved (Pollard, *et.al.,* forthcoming). WeatherXchange charge £350 per dataset for core sites for daily updates of weather for one year (non-core sites prices are individually negotiated). Historical datasets are charged at £400 for up to 40 years data (data previously available from www.weatherxchange.com, last accessed 06/04/06).

Commercial Meteorology in the US and Europe		
	US	Europe
Gross receipts (US$)	400-700 million	30-50 million
Number of firms	400	30
Number of employees	4000	300

Table 5.1. The value of private meteorological services in the US and Europe in 2002, showing that the US system of data leads to greater value of commercial meteorology (Weiss, 2002). Note that this is separate from the $2.7 billion spent by the US government (National Research Council, 2003). It also highlights how the value of weather derivatives contracts can dwarf the overall value of meteorological services.

Lynda Clemmons, then President of WRMA, writes to the Honourable Deputy Samuel W. Bodman at the US Department of Commerce in 2002 to thank him for the National Oceanic and Atmospheric Administration's (hereafter NOAA) attempts to help and promote the weather risk management industry (see also Dutton, 2002). She writes

> Data issues are critical to sustain our industry, not only in the US, but globally as well. Other governments are not as enlightened as our own, and see data as a way to take taxpayer funded information and effectively auction it off. We believe the access to global weather data is in fact a trade issue, and we hope through your efforts, you can assist in raising awareness of this important anti-competitive stance.

Here the association promoting the weather risk management industry are trying to enrol the US Department of Commerce to take a position about weather data value that will have implications for international trading. By appealing to the concept of free trade on a level playing field Clemmons strengthens her arguments. It becomes less disputable, because it is an issue of *laissez-faire* economics. The politics of the US weather actors can also be seen here as they are the biggest losers from the data charges of European meteorological offices. For European-based actors the data *has* to be bought to engage in primary trading. For the US operators however, who may want to engage primarily in speculative or secondary trading in the European markets, the data costs restrict this involvement. WRMA have subsequently been lobbying the European Parliament in Strasbourg about liberalizing the freedom of data and rules regarding the re-use of data (Interviewee 12). The re-use of data is a real difficulty when trying to encourage end-users into the market. Contracts are settled on weather data, but end-users as well as sellers must buy that data to check those contract settlements as Interviewee 12 explains.

> [Y]ou want to make sure that the information you need … to verify the contract you can get access to in a cost-effective way because otherwise you end up with them saying the contract's worth x and you say 'well how do I know', he says 'go to the Met Offices and buy data', and you say 'well you've got the data', 'sorry can't give it to you the license doesn't allow me to do it'

That weather data are licensed is unsurprising really considering the value attached to it, yet there is little wonder that US traders in particular get frustrated with this system when they are used to environmental data being a free public good. In the US, the market has been able to grow organically as no one has expensive purchase costs with regard to getting data. Within Europe, data costs and access have been blamed for the initially relatively slow development of the market (Interviewees 3, 4, 5; Weiss, 2002). The US should not, however, be held up as the nirvana of weather data. As Interviewee 3 explained, although the data are free in the US they are often in difficult-to-read formats or require editing. For companies with limited meteorological expertise, the acquisition of the necessary knowledges to reliably use this data may be equally as expensive. In the UK for example data comes cleaned and packaged, but at a cost.

The subject of cleaning data is also particularly interesting as there are questions implied relating to what is clean or dirty. These terms carry wide connotations. The cleaning of data is ostensibly to remove inconsistencies with nearby stations and obvious errors. There are, however, problems that were highlighted in the case of the maximum temperature recorded in the heatwave of 2003. Burt (2003; Burt and Eden, 2003) provided the initial overview on the subject and suggested that the maximum temperature at some stations, some run by the Met Office and some by other organizations, may have been unreliable due to nearby hedges and other problems with the equipment. The Met Office (2004) responded with a denial of the criticism levelled at sites they controlled and a re-affirmation of Faversham, a Met Office station, as the maximum temperature recorded. This debate, however, was far from settled and rumbled on for several months in the pages of *Weather* magazine (Burt, 2005; Hill, 2005; Prichard, 2005; Shanklin and Colwell, 2005). The point here is merely to record this debate, not make a judgement on it. Data quality is not a settled issue and adjusting data for surrounding conditions, checking for consistency, and so on is all a part of the final presentation of 'correct data', whatever that might mean, to the data records. Here the timescale point raised by the weather derivatives community becomes important; cleaning data takes time, a time that contract settlement does not allow.

Despite the Met Office's claims with regard to Faversham, in other ways they accept that quality is not always good. The Met Office argument to the weather derivatives industry is that if they want greater data quality and wider data coverage, they should pay for this privilege as it is not part of the public service that they provide (personal communication, for reasons of confidentiality her/his name is not disclosed here, 10/12/04). Poor data, this implies, is acceptable for the public service, which primarily consists of forecasting and is publicly funded, but not for other commercial uses where more profit is available to fine-tune the products. An example is the moving of instruments or closure of meteorological stations and in particular the recent moving of the thermometer at Manchester Airport. The Met Office left the old thermometer in place for six months to provide a correlation with the new instrument, which was located at a different site (Interviewee 5). For the weather derivatives market, however, this was completely unacceptable, because there was not even a year's correlated data. Even a year may be insufficient if it happens to deviate significantly from the average. For forecasting this was of little importance, because many models cross-feed data from nearby stations. For weather derivatives, this is crucial as the contract is settled on that station, not the ensemble of observations from nearby[1]. Who, though, was going to pay for the maintenance of this old thermometer? If it was moved, for example by virtue of demolition of the former station, more practical reasons become important. If the weather derivatives community could not enrol enough support, particularly financially, that thermometer was going to be moved. Data generation is not about a search for truth; rather it is a socially interactive process whereby social judgements rationalize particular decisions on the type and nature of data to be generated.

[1] Though some wind contracts are exceptions as they may be regionally-averaged.

Rising costs of data may also restrict the use of meteorological data by companies that practice their own forms of weather risk management, independent of the weather derivatives community. The changing value of data may affect other companies' weather risk strategies as it becomes too costly for them to purchase. This might prevent them engaging in mitigating actions or force them into using weather derivative contracts as many of the costs will have been borne anyway[1]. Thus the rising value could also encourage other participants into the weather market. Data are re-valued by virtue of their essential role in the network of weather derivatives. Earlier it was noted, however, that litigation may be possible if the Met Office failed to provide an adequate services and by increasing the charges for its data it must clearly be seen to provide a better service.

5.3. FORECASTS

5.3.1. CREATING FORECASTS

Moving from data to forecasts, how are the weather derivatives actors creating, changing and developing forecasting? Data are undoubtedly important, but there is probably far more economic value to be extracted from an investment in or improvement of forecasts. Short-term forecasts are widely used for speculative trading or secondary market (re-insurance style) trades and these are fed into prices within the weather derivatives market. There is little unusual about this except that the value of these forecasts has risen and increasing meteorological expertise will be purchased to ensure the best value from the forecasts. Seasonal forecasting is, however, a less well-practised art

[1] In reality though, many traders (possibly those concerned with hedging more than speculating) would purchase forecasts and services, rather than buy data and attempt their own analyses on it.

within the atmospheric sciences. Chaos theorists might suggest that it is problematic, yet energy companies in particular are investing in attracting the brightest young atmospheric physicists to work on creating worthwhile seasonal forecasts (Interviewees 19, 20, 26). An emerging knowledge sector is being created within the corporate world and some company spokespersons are bold enough to assert that their models are better than the public sector's models. Forecasting is thus a valuable art and the weather derivatives market is again promoting different types of engagement with meteorological science and arguably changing the boundaries of what is valuable, possible and predictable.

Evans and Shackley (1997) note that there are some common differences between models produced by public scientists and those used within the private sector. The public models are, they argue, much more open to public scrutiny and hence also much more complex, whereas the commercial models are much more instrumental.

> ... [T]he persuasiveness of specific numerical outcomes to very specific users and customers is what matters here. Such business users are not overly concerned about 'research' per se, and their own modellers are much less part of, or constrained by, the peer community than in publicly-funded research domains. Hence, their identity as the 'expert' goes relatively uncontested.[1]
>
> (Evans and Shackley, 1997: 2)

Yet as they go on to point out, the increasing complexity of academic models actually makes policymaking more difficult and these models less useful. Simplistic though

[1] This does neatly miss the point however that, throughout history, scientists have been employed in the private sector or at least have had private means to maintain their science, more than in the public sector. Indeed public funding of science emerged in the UK during the 19th century and was concretized within military funding in the 20th century. Public funding could certainly not be said to be interest-free and whilst peer-review may be the best available method there is little doubt it is not the only method. More research needs to be conducted into exactly how funding, public and private, influences science, particularly with privatization being an important issue at present (Demeritt, 2000; Mirowski, 2004; Morss and Hooke, 2005).

business models may be, they are at least readily useable within a commercial or broader context. Later in this chapter these themes will be more concretely addressed in relation to the models produced by the weather derivatives community.

Commercially available forecasts, from both the Met Office and private companies, are used by the weather derivatives market in two main ways. The first is for season-ahead trading/pricing and the second for short-term trading. Season-ahead trading involves buying a contract often several months before the start of the contract coverage period to mitigate risk over a five-month time scale (i.e. winter trading in the Northern Hemisphere is November through March). Detailed forecasts are not available and the concern here is with the trend or likely directionality of the coming season i.e. will it be warmer or colder than average however average is defined. These forecasts are used by the people pricing contracts to estimate the fair price for the seasonal contracts and by the people buying contracts for the same reason plus a decision on whether to take the contract or not. This is not as simple as buying into the discursive power of global warming. Interviewee 17 claimed that their company had been successful at predicting the cool winters in New York in 2002-4 by sidelining the climate change arguments and looking at other indicators such as the North Atlantic Oscillation. Long-range forecasting, however, is particularly difficult, but one energy company (Interviewee 20) claimed that their models are far more sophisticated than anything in the public or academic sectors. As Evans and Shackley (1997) suggest these models are kept private, but this is not necessarily because they are inferior or only do a particular job, but rather because they are a source of financial competitiveness[1]. Indeed this can be illustrated by the fact that these companies primarily employ people who have completed a PhD. These models are

[1] Another example would be the software used to price weather derivatives. An outsider can get little access to these models to critically analyze them for fear of corporate loss from the leak of information (Interviewee 5)

not made by those with no expertise and hence highlight the importance of acknowledging expertise outside of the public scientific community (Collins and Evans, 2002). For Interviewees 20 and 21 these employees ideally should have training in physics rather than the specific science of meteorology as they see the future of these models as being related to expertise in physics rather than any detailed atmospheric training. This draws a distinction, or rather lines on a continuum, between two types of meteorological knowledges within the weather derivatives market. The first is physics-based and is founded in predictive-chaos or the theory of fractals. These see the world as ultimately unpredictable, but somewhat directional so that nothing that happens is completely random. The models are based on more physical understandings of the atmosphere and are processual in form (Interviewees 6, 20). The second is statistics-based and can be found both in the pricing-software companies and some buyers/sellers (Interviewees 2, 5, 21). The world here can be understood in numbers (Zwiers and von Storch, 2004) and many of the producers of these knowledges have backgrounds in mathematics or finance. For statistical knowledges it is about finding the best fits, for physical knowledges it is about creating better models. Often these knowledges have been associated with climatology and meteorology respectively. Both, however, can function within the spaces of the weather derivatives market and, of course, they create a trading environment by their different opinions.

Short-term forecasting is much more important for backing-up contracts or for speculative contracts. As a trader, short-term forecasts have a number of implications. Firstly, to buy or sell a contract one would like an accurate forecast i.e. what the forecast says will happen, does happen. One example of this can be seen near the close of the coverage period of the biggest current contract in the weather derivatives market. This contract is between ABN Amro and a Dutch construction company that is worth about €100 million risk every year and covers the latter for frosty mornings when the workers have to be sent home under Dutch law. The coverage period for this contract is November through March and it is a highly valued contract within the weather derivatives market as it is the opposite side to most energy company contracts, which want protection from warm winters. In March 2003, as Interviewee 5 explains, there was a lot of activity around this contract as

> [i]t actually got to 19 frost days which is the 0, which is the dividing line. If there was one more frost day then it would pay out and everyone was biting their fingernails, there was two weeks to go and a lot of trading was going on at that point on London Heathrow temperatures which are highly correlated with temperatures in Amsterdam, because people wanted to suddenly neutralize their positions, because they were terrified that they were going to have to payout and that created a lot of trading activity and in the end it didn't pay-out.

To neutralize the risk position that people were holding with this contract they needed to trade it out. Effectively they needed to buy a contract that would cover their payout if the weather was cold. Amsterdam was not a liquid traded market, so without a sufficient volume of buyers and sellers, companies had to turn to London Heathrow[1]. The trading could only be done based on the correlation between London and Amsterdam temperatures[2]. Trading on correlations may seem dangerous, but in reality all weather derivative contracts are based on correlations. Most UK energy companies buy weather derivative protection based on London Heathrow, despite the fact that they are hedging

[1] In September 2005, however, the CME started listing frost days contracts on Amsterdam Schiphol airport to facilitate the trading associated with this contract. Thus on the exchange at least it is probable that much of this correlation London trading will transfer to Amsterdam.

[2] It is unclear what defines a good or a bad correlation for individual weather derivatives traders and what kind of significance level is used.

national demand. In the UK, national energy consumption is very well correlated with Heathrow (i.e. as Heathrow cools, Manchester cools at an equal rate) and this is cited as a reason for the growth of the UK market (Interviewee 2). Again this emphasizes the point that actual data/actual weather losses are not necessarily the core components of the weather market for all types of trading. There is a wide variety of opinion on the wisdom of trading based on correlations. One energy company, as Interviewee 2 explains, is quite happy to trade on correlations.

> [O]ne of the things we do obviously is look at the correlations between those locations because if you're trying to fit a hedge in you might find that you can get a better price in Paris than you can in London… and it varies according to which month you pick; some months are much better correlated than others.

For other companies, however, as Interviewee 6 explains using the example of this ABN Amro dealing in March 2003, this is a dangerous strategy.

> Last winter the correlation nearly went against them ... they were going to lose money here and they were going to lose money there so that shows you the dangers of correlations and you know dirty hedging … it's a very brave person that trades correlations.

Yet at the same time this company must trade on UK correlations to mitigate their national energy exposure. Most of the debate on correlations is about drawing the line at some boundary, but it is difficult to pinpoint the reasons for differences between these companies. Both Interviewees 2 and 6 have a postgraduate training in meteorology, so there is no one scientific answer to this. The issue, however, is not just about trading on present correlations, but also about trading on correlations lasting in the future. This is where it is vital to have good forecasts for both locations so that the likelihood of the persistence of this correlation into the future can be assessed. Short-term forecasts here are economically very valuable and buyers/sellers will pay significant sums of money investing in this expertise. Most companies will buy in a minimum of ten forecasts from different companies as well as produce their own in-house forecasts and this has resulted in a raft of investment opportunities within the private forecasting and meteorological consultancy layer.

Short-term forecasts also have a second implication in relation to the pricing of weather derivatives contracts. Forecasts are an important source of information in the weather derivatives market and each new piece of information will affect the trading in the market. In receipt of certain forecasts, prices will either be raised or lowered. Why do forecasts make the market prices change? The market-makers for the CME, for example, buy in forecasts from a variety of sources. For these and other companies the forecasts are ensembled into one forecast that will illustrate the most likely probabilities of the weather pattern for the next day. This can be used to change the price. Why does the forecast change the price? If the market-maker on the CME are trading an HDD contract at 430 for the month of December and the forecast illustrates that the second half of the month will be cold, then the market-maker would naturally want to raise the estimated HDD level to 450[1]. If they do not act another company may buy the contracts at 430 knowing that with cold weather likely the HDD count is going to be vastly more and they will be paid. Indeed Aquila UK's first deal in the weather derivatives market was exploiting a

[1] This means the contract is trading based on the prediction that there will be 430 HDDs in December.

perceived slip by Innogy (Interviewee 26). Interviewee 23 explains the fair value for a monthly temperature contract as:

> FV (Fair Value) = Month to date amount + forecasted amount (for the next 12 days) + 10 year average (for remaining days of the month).

These fair values are generally calculated from proprietary forecasts or from widely used paid services such as EarthSat. EarthSat, as noted earlier, are important data and meteorological service providers for the weather derivatives community with the pricing software developers using their services. Notice here that, as with data, it is not whether a forecast is accurate (Interviewee 23 admits to doing no forecast verification), but whether the forecast has become fortified by being the 'reasonable' voice within the market. The CME, therefore, becomes a site for investigating the declared fair value of contracts, such that individuals would not always need to calculate them themselves.

For the seller and for the buyer it is vital to get a competitive advantage on forecasts, because with these a company can engage in speculative trading based on those forecasts. With maybe as much as 80% of the market based on speculative trading (Interviewee 26; though this figure is not unusually high compared with other markets for example those on CBOT, Zaloom, 2004), it is clear why forecasts are so economically important and why some companies are investing money in meteorological expertise to produce their own in-house forecasts. These forecasts must outperform publicly available forecasts for the investment to be worthwhile and thus these meteorological knowledges are primarily instrumental in nature, but nevertheless may push areas of forecasting beyond what the public sector currently offers. This highlights the way in which the motive for profit generates a desire for knowledge where, as with the medical biological industry, improved knowledges create trading advantages or products that will be financially successful.

A forecast can also be a vital tool in informing the market. A 'bad' forecast can be beneficial if the market prices are changing in line with that forecast, but one knows that it is a bad forecast. The knowledgeable trader can take advantage of this. As with data negligent practices could have financial repercussions and potentially legal action. In reality though, the expertise flowing into the market should ensure that the most probable forecasts are accepted and this poses a fascinating question about whether the weather derivatives prices can become a good predictor of future weather conditions i.e. can they perform weather.

The weather market acts as a grand ensemble of both public and private forecasts. In an interesting post on the Wilmott Message Boards[1] one 'Paul (senior member)' writes

> People are so fond of 'calibrating to the market' that I imagine I can tell if it is raining outside by looking at the prices of weather derivatives. (That was meant to be sarcastic!). P.

This leads back into debates that people price based on where the market is trading and judge the future weather situation on where the market is trading. One argument is that the weather derivatives market, with the inclusion of a variety of different forecasts, the product of computer simulations and meteorological expertise, will become a better weather forecaster than publicly available forecasts, particularly at the seasonal scale. There is little doubt that this would be the probable result of the expertise flowing into the weather market prices *ceteris paribus* (it works like an information market). It may be

[1] These message boards operated for a short time at www.wilmott.com, an early actor in the weather derivatives market, but became silent very quickly.

easy for meteorologists to deride the weather derivatives actors' statements that their models are better at seasonal predictions, an area which the Met Office thinks of as experimental[1], though there is growing interest in it, nonetheless the amount of expertise now flowing within the corporate sphere and the willingness of these people to use their models for trading suggests that there might be some substance to their statements[2]. These models or forecasts may be predominantly instrumental (Evans and Shackley, 1997), and might predict the weather derivatives market's version of weather, but ignoring their claims may be a politicized strategy to protect previously bounded knowledge terrains from alternative approaches. This is arguably the problem Piers Corbyn faces in justifying his 11-month ahead predictions that rely on statistics and sunspots (Standage, 2003; Wheeler, 2001). Indeed those closest to the models, of whatever type, may often become emotionally or scientifically invested in that model to the extent that it can be difficult to accept criticism or perceive alternatives (Lahsen, 2005). Different lines on the physics-statistics continuum produce different models with different utilities. They each accomplish different objectives, and should be equally considered knowledge production, because there may be no singular way to model the world.

There is also a growing move from deterministic styles of forecasting to probabilistic ones, both in weather and also climate prediction[3]. How, though, do

[1] The caveats it used to place on its four week forecasts were indicative as are the claims that its seasonal forecasts are just indications or suggestions (www.metoffice.gov.uk). At the end of 2005, the Met Office, however, decided to remove its four week forecasts in place of a two week forecast. Anyone requiring the month-ahead forecast would now have to pay for the Met Office's Monthly Outlook product (Met Office, 2005).

[2] Nevertheless if one company was predicting the weather better than everyone else it is likely people would watch their trading and prices would move in accordance with that company's trading. This accords with the reasons some traders give for the importance of pit trading rather than screen-based trading, as body language and trading patterns can be followed much more closely (Zaloom, 2003). There are, however, a number of strategies to create noise in the market to disguise this pattern, one being the purchasing of contracts in the opposite direction to encourage pricing in that direction.

[3] Note, though, that Dupré (1993) asserts that probabilism is still a form of determinism (determinism in another form).

individual companies use ensemble forecasts and in particular probabilistic ones? The weather traders are frequently interested in probabilistic forecasts as well as deterministic ones, but there are difficulties integrating them into the economic pricing models.

> Probabilistic forecasting is a more advanced way of forecasting for sure. It relies on people that are using that forecast a) believing that other people are using it and b) being able to price a bimodal distribution of the two-week forecast into their pricing models
>
> (Interviewee 10)

There are two interesting points here. The first is that people might use probabilistic forecasts if other people did, that is to a certain extent the weather derivatives market becomes a shadow of the performance of a meta-forecast or dataset that everyone believes whether it is right or wrong. Here again the argument is not about whether probabilistic forecasting is better, but whether it is the accepted means of procedure. One clear reason is the difficulties in trying to agree on the prices of hedging contracts if one trader used deterministic forecasts and the other probabilistic and the two produced radically different results. The second point is the difficulty of integrating probabilistic forecasts into the current pricing models. This seems somewhat strange as financial pricing models for weather derivatives arguably require Monte Carlo simulations rather than Black-Scholes (Dischel, n.d.), which broadly means that they are priced probabilistically[1]. Here, it could be assumed, probabilistic weather forecasts should be

[1] Note that Black-Scholes relies on a table of probability distributions, but its calculations are more deterministic than in Monte Carlo simulations. 'Monte Carlo techniques' is a phrase that encompasses any statistical sampling employed to approximate the solutions to quantitative problems. In derivatives terms, the expected price of a contract is calculated approximately using a form of probabilistic analysis. Due to the complexity of these equations, the mathematical formalization will not be presented here, but descriptions can be found in MacKenzie (2003) and Rutterford (1993).

relatively easy to integrate into pricing models. A minor diversion into pricing models is required here to sketch this more concretely in terms of the outcomes of these different approaches.

The Black-Scholes equation for calculating the value of options contracts mathematicized and rationalized the pricing of options based on assessments of the future price and volatility of the underlying asset (Arnoldi, 2004). This mathematicization normalized and sanitized the risks of derivatives (MacKenzie and Millo, 2003; Wilmott, 2000) and it has had a "... world-changing, performative aspect" (MacKenzie, 2003: 852). Dischel (n.d) suggests Black-Scholes will not do for the pricing of weather derivatives, because the price of weather contracts is not derived from weather, but from weather indexes that have different statistical parameters to financial indexes[1]. For him, Monte Carlo simulation pricing models have the most utility. Ironically then, although weather derivatives 'require' probabilistic economic modelling, it has been difficult to integrate probabilistic weather forecasts into those models. It is interesting that the economic and meteorological models share a similar theme, yet the inertia within the financial system of pricing, prevents the inputting of anything other than a determined figure into the equation. Pragmatically, deterministic forecasts may be 'good enough' as the second set of probabilistic models, the economic ones, will provide another layer or black box that will produce a distributive effect. These differences in models and forecasts also have performative outcomes in that different traders using different pricing systems will create and take advantage of arbitrage opportunities. Indeed as Interviewee 11 notes, whilst using Black-Scholes may be technically wrong it still produces right results much of the

[1] Technically weather derivatives can be priced in two different ways: market based and actuarial. Actuarial pricing is predominantly used in insurance (style) contracts. Also note that other traders give different interpretations to Dischel. Interviewee 6, for example, suggests that the lack of a physical underlying is the reason for not using Black-Scholes, not the nature of the index, though they are undoubtedly linked.

time and banks often do not have the time, expertise or risk-taking capacity to experiment with other, less familiar forms of economic models.

Pricing models are a vital component of any weather trading desk. To calculate the expected payouts and values of contracts quickly enough to enable trading that both supports hedging contracts and speculative opportunities, requires a set of models to accurately price what the value of the contract should be, in line with the weather forecasts, on a rapid time basis. The result will be a spread of fair prices, upon which a trading decision can be taken, which should at least stack the odds in the right direction. More formally, this suggests that there is both a judgement about which mathematical techniques to apply to the pricing of a contract and a judgement about which of those spread of prices is preferred. The pricing software, however, is not cheap and for a company to engage in weather trading would cost them around £40,000 (Interviewee 5). Without these models, a company would be 'unable' to ascertain the fair price; the pricing software thus acts as a black-box that integrates weather forecasts and pricing models into a distribution of prices. The software developers thus become centres of calculation (Latour, 1987). Fundamentally each trader will make pragmatic decisions as to what types of pricing models and forecasts they are going to use. Thus, following Porter's (1995) analysis of accounting, the quantitative techniques in themselves do not solve this problem. Expertise enables particular judgements to be made about the relevance of those results. Utility is the key point and different sets of knowledges lay side-by-side in understanding the world. None of them is 'fully right', whatever that might mean. Weather traders, certainly at an aggregate market level, are epistemological pluralists.

In another way, however, weather derivatives somewhat remove the need for forecasts if the trading is purely about hedging risk (Interviewees 4, 5, 18). If a contract can be purchased at an acceptable price it is no longer important what the weather does or what the weather forecasts are. Weather forecasts, in any case, only contain information out to ten days. Most businesses make plans on much longer time-scales, several months ahead, when there is very little concrete information, in modeled formats, about the future weather. Thus for Interviewee 5, for example, weather derivatives partially spell the end for the dominance of weather forecasts in business planning with relation to the weather.

> Weather forecasts are from a business point-of-view extremely limited. Most companies can't really make changes to the way they run their business on very short time-scales ... weather forecasts aren't really useful in many cases because they're just so poor and so short into the future, whereas weather derivatives are ideal. You've got any kind of weather risk at any point in the future, 6 months, 12 months in advance, which is the kind of time-scales that people make business plans and so on then weather derivatives can deal with that.

In other words weather forecasts are deemed less useful than weather derivatives for mitigating risk in part because for these actors weather derivatives (or advice on weather derivatives) are their source of profit, not the production of weather forecasts. The argument in this quote is also potentially persuasive in a marketing situation as it suggests (with reference to Latour, 1987) not a 'I want it why don't you' line of argument, but rather a 'you want to manage the weather, but forecasts are not that good, so you just need to make this diversion and become a weather derivatives consumer.' 'Why take this diversion rather than use the already available forecasts?' they might respond. 'The answer is clear; weather derivatives will compensate that risk.' The reduction of forecasts can also operate as a way by which the weather derivatives industry further strengthens its own arguments about the products available to mitigate weather risk, regardless of how weather derivative traders are, ironically, voracious consumers of weather forecasts[1]. Packaging up weather knowledge and mitigation into one package, weather derivatives traders thus espy a way of building value on top of meteorological services and hence generating further profits.

Weather forecasts, however, still have one advantage over weather derivatives and that is that they are much cheaper, but in reality they cannot mitigate risk to the same extent as weather derivatives contracts. Weather forecasts aid planning and that might be useful for certain types of business risk, for example short-term supplies of particular foods on the supermarket shelves, but for most businesses forecasts do not provide enough mitigation. Thus weather derivatives have a complex relationship with forecasts, utilizing them heavily, but also arguably going beyond them to leave them with a certain level of redundancy. Nevertheless what would happen if there were perfect forecasts? The risk would be taken out and the weather derivatives market would either collapse, as the need for it will have been dissipated, or it would become perfectly priced and more like an insurance market, with no opportunities for arbitrage. Somewhat ironically then, though actors in the weather market utilize and develop weather forecasts, the aim of gaining a trading advantage would not be helped by certainty. Certainty would preclude action.

5.3.2. RE-VALUING FORECASTS

In the terms of the US model of meteorological services, the value added services are increasingly being adapted within the weather derivatives community. The re-valuing of meteorological forecasts is creating new forms of these services that specifically deal

[1] Albeit that at the seasonal scales that this interviewee is talking about the forecasts are created and used within the weather derivatives industry, more than in public spheres.

with the needs of the weather derivatives market. Weather forecasting has been the erstwhile value-added-service for meteorological science since the early 20th century (Katz and Murphy, 1997). Today, forecasting is an exceptionally valuable business. For example, one large UK supermarket hire in a weather consultancy company, Weather Commerce, to provide forecasts so that they can manage their product lines more efficiently[1]. So if the weather forecast is for a warm week in summer they can increase stocks of, for example, ice-cream and lettuce. This expertise is highly valuable, because if the forecast is wrong a large quantity of stock will be disposed of at considerable expense. This supermarket, however, take the logic one step further. People do not buy solely based on today's weather, particularly with Internet shopping. Therefore on their website one can find the same forecast that they are using to stock their shelves[2]. As long as enough Internet shoppers buy based on that forecast the supermarket still sell their goods regardless of what the weather does. This is another form of weather risk management strategy that companies can adopt. The forecasts here are economically valuable for both business planning and as a risk mitigation strategy. For weather derivatives, the latter reason becomes even more commercially valuable.

Forecasts become part of not only a pricing mechanism, as discussed earlier, but also a trading decision. Many companies will buy in at least ten forecasts from different companies, which has created a rise in demand for forecasts of, particularly, temperature and precipitation at the most liquid sites like London Heathrow. Note also that this requirement is site-specific, an important point as weather forecasts have traditionally not been as good at this. Competition for forecast provision services can be great with many companies such as supermarkets giving out three-year contracts. The forecast is enrolled

[1] Personal communication, Dai Roberts (15/09/04). The name of the supermarket has been removed for confidentiality reasons.
[2] Personal communication, Dai Roberts (15/09/04).

within the trader's box of tools to assess the viability of a particular trade and whether a particular price is worth trading at. It is vital for a company to know which forecasts to use and how to judge their accuracy. Innogy were the first UK company to employ a meteorologist in a trading position in April 2001 (Interviewee 2, 4) and Centrica followed soon after (Interviewee 4, 6). This need for in-house meteorology will be discussed at further length in section 5.4. In reality weather forecasts may be as if not more reliable than in other financial markets, certainly in the short-term. Interviewee 3, for example, states that the weather forecasts are much better than "Greenspan on the interest rate markets". So forecasts are financially valuable within the market. The diversity of knowledges being created about data and forecasts, however, attest to the plurality of ways of conceptualizing the world. Private science does not necessarily lead to convergence, though there are undoubtedly broad convergences (cf. Callon, 1994).

Within the weather derivatives market, there is an arena for services such as these to grow and make a profit. This highlights that an initial commodification can spawn many further commodifications. Forecasts are being consumed and also developed within the weather derivatives community. Whilst academic meteorologists may deride the expertise of business meteorology, weather trading is clearly opening up new forms of meteorological knowledges and aspects of prediction that some meteorologists would decry. Forecasts are economically valuable and thus companies are keen to invest money into them to attempt to improve the profits that can be made from them. The ways that companies attempt to hire people to do this and to privatize that knowledge to prevent the loss of their competitive advantage provides the themes for the next section.

5.4. PRIVATIZATION AND THE INSTITUTIONS OF METEOROLOGY

The commodification of meteorology within the weather derivatives market has also spawned a process of privatization. Commodifying nature has material and discursive effects upon the future production of nature and science (Castree, 2003a). Knowledges, which were previously of little value, now become commercially tradable, thus requiring sufficient protection (or in Marxist language, dispossession). Not only this, but young scientists are also being attracted to the corporate world of meteorology with a lure of better working conditions and substantially better wages. This re-location of meteorology (indeed one of many re-locations, as meteorology only became publicly institutionalized in the 19th century), whilst only a relatively minor process compared with the numbers still employed within the Met Office (2,000 employees) and academic environments, does bear some important implications for the future conduct of meteorology. The privatization is partly connected to debates about the relationships between meteorology and law. Meteorology is becoming closely entangled within the legal realm in two ways, which will be described here. First is the possibility for legal action against meteorological service providers for 'bad' data or forecasts. Second is the privatization of meteorological knowledges through systems of patenting.

Klein and Pielke (2002a; 2002b) suggest that weather forecast lawsuits are unlikely to succeed as liability would only be activated at times of misrepresentation (not using reasonable care) or fraudulent forecasting. The possibility of litigation over data is a relatively different development to forecasting, but although in theory there is nothing preventing litigation, proof of negligence might be difficult. Meteorological data providers would probably escape litigation, because they are perceived as performing these duties with a degree of care (Klein and Pielke, 2002a; 2002b). It is, however, not clear whether in the case of private data collection (or perhaps where the Met Office makes weather derivatives actors pay for better data), liability would become a greater issue. Law is not a pre-established body. It is created, negotiated and translated in response to changing circumstances. It is certainly not inconceivable to imagine that data providers could be sued, particularly where a service contract is agreed between two institutions i.e. if a weather derivatives actor did pay the Met Office to improve a particular series of data.

The weather derivatives actors also work in a different way with law, namely the protection of knowledges through both patenting and a less formal privatization process. The most infamous of the patenting cases within the weather derivatives market, was the patenting of wind power indexes (hereafter WPI) by EKT in 2003. This would provide "a method and system of generating wind index values for a facility"[1]. For wind derivatives there is a discernible problem in that wind can vary so much between the location of the meteorological station and the location of the wind farm. EKT's product therefore compiled regional wind indexes that were applicable to all individual sites within that area. During this process, an index of wind power curves would be established, cementing the relationship between the invention and the wind energy industry. This is a significant development from the standard weather derivatives that rely on the data at one particular point. For interviewee 21 for example this is a good thing, as areal averaging would decrease the risk premiums that companies would have to pay as it would package the risks much more effectively for the seller[2]. Wind power, however, was and is gaining

[1] UK Patent Application: GB 2 389 930 A

[2] This is the classic argument about collateralizing risk. For collateralized debt obligations, for example, there is less risk for the company to hold one parcel of a thousand contracts than a thousand individual

political and economic currency (see chapter 7). EKT were not the only ones spying a profit in the government drive for renewable energy use by 2010. Peter Brewer, then at Credit Lyonnais, contested this patent as he wanted to use wind derivatives in relation to wind farm financing, but he did not want to use EKT's indexes. There was a vociferous argument at a risk management conference in Autumn 2003 regarding this filing (Interviewee 21). Nonetheless the patent was successfully filed and should EKT receive a critical mass of interest in using their indexes for wind derivatives they will have a key financial passage point within the market. Like all inventions, however, there is the danger that others will find different routes around the problem to avoid the costs or deficiencies of EKT's indexes. At the present time, it is unknown how financially successful these indexes will be, but needless to say they may have implications for wind trading and hence renewable energy. This example also demonstrates how the Met Office's privatization of data by charging for it has also encouraged privatizations of the re-use of data. EKT are not the only company to have filed a patent relating to weather derivatives. As of early 2005 there are 2 patents in the US and 3 in Japan relating to weather data indexes and pricing software in the weather market.

With the weather metaphorically becoming re-privatized within the weather derivatives market[1], some of the sciences underpinning this market have also been progressively protected and valued. This has advanced the employment of meteorologists in the commercial world and is adding to the sites of production of meteorological knowledges (see also Table 5.1.). For much of recent (post-19th Century) history, meteorological science has been concentrated within the academic, public and military

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contracts. The chance they will all pay out at once is very slim. So too with weather derivatives. If you have 10 contracts in North East USA it is unlikely they will all pay out at once.

[1] More accurately the weather is multiply constituted by different groups of people at the same time. Weather is neither public nor private, it is made so by the actions of particular scientific (and other) communities.

spheres. Although there has always been interest in some industries such as energy and retail it is only recently that one could argue that they are producing rather than replicating meteorological science. These new producers of scientific knowledge have been created by the increased profit margins within meteorological expertise and the weather derivatives market has certainly strengthened this.

Interviewee 20, for example, highlights that employing meteorological expertise within the company is a profitable exercise, both for weather derivatives and also for increasing the trading performance of other parts of the business. In this energy company the employment of meteorological expertise helps the gas-trading desk, as most gas price spikes during the winter will be linked to a prediction of or actual cold weather. For this task, only the most accomplished scientists will do. For energy companies this must normally be people with a PhD in physics, because the climate models being built are dependent on processes within physics rather than anything specifically atmospheric (Interviewee 20). It may be interesting to note that several people within the weather derivatives markets, in particular the analysts and pricing experts, have PhDs (Interviewee's 5, 6, 17, 20, 21, 22). This ties in with the observation that many of the actors within the market are relatively young (under the age of 35)[1]. These climate experts are producing models and forecasts which they claim are better than anything the public or academic spheres can provide (Interviewee 20). The normative issue for meteorology and climatology, as publicly-funded sciences, is the potential brain-drain to the private sphere, and in particular energy companies, of most of the young scientists. Put simply,

[1] A number of reasons can be posited for this. The Enron desk were mainly 'bright, young things' and it is this group that has driven the market both in its inception and subsequently in the companies they have chosen to work for. Many companies also use young employees to investigate new products and anything which has too much uncertainty to be considered a sound investment for using older, more expensive staff (Interviewee 14). Also weather as a product has not been fully accepted by some of the older generations that rely on the strategies that they have been using in the past (Interviewee 14).

pay and working conditions are better (Interviewee 6, 20)[1]. There is however a concern about whether energy companies are likely to be the most reliable creators of climate models. Would debates on climate change be radically shifted if many climate scientists were employed within energy companies? This question clearly cannot be answered here, but it speaks to the heart of Morss and Hooke's (2005) concern that meteorology could follow biomedicine into a corporate era. It also speaks to a key point for further research, namely more precise understandings of how the finance of science affects the conduct of science. It is not clear that a publicly funded science adopting a commercial approach of budgets, assessment exercises and concentrations of power (whether in the award of grants or publishing papers)(Demeritt, 2000) produces qualitatively better science than a 19th century gentleman operating from private funds or a meteorologist working within a corporate environment. Yet the examples presented here clearly highlight some concerns relating to instrumentality and profit. What is the purpose of science becomes a key question?

5.5. CONCLUSIONS

It goes without saying that meteorology forms a key component of the weather derivatives market. This chapter has attempted to unravel some of the ways in which meteorology and meteorological networks are being used and re-shaped by the weather derivatives community. That is, in translating the needs of the weather derivatives community within the meteorological data and services industries, the products, data and services are also being changed. In the opening section the subject of meteorological data

[1] The UK Met Office starting salary for a minimum-graduate trained meteorologist is £17,837 with an average of £23,674 (Met Office, 2005b). As an example, one meteorological expert working within the weather derivatives sector started on a salary of £38,000 (Interviewee 5).

was analyzed and it was shown that the weather derivatives market is promoting a re-engagement with debates about the quality of data. Different actors valued data differently and, they suggest, for many forecast models data quality was less of an issue than for weather derivatives that are settled on one station.

Others denied any concern with the quality of data choosing rather to focus on *laissez-faire* arguments. As long as everyone is using the same data with all the faults in it then it is not an important issue. Here meteorological data is seen as less important to the weather derivatives market, which begs the question, of course, of what the weather derivatives market is actually trying to achieve. As long as profit can be made from the sale of weather indexes, scientific accuracy (etc) is far less a concern. Similarly with forecasts many weather traders have promoted increasing levels of in-house meteorology to improve their own models that they assess (admittedly uncontested) will be better than anything the public sector can provide. This is particularly the case with seasonal forecasts, which the Met Office believes are experimental, but weather traders are using to make multi-million pound decisions. These models may be instrumental in nature and less concerned with modelling weather *per se* than adequately predicting the future prices and direction in the weather market. This can be seen in the debate over the value of probabilistic forecasts where *laissez-faire* rises to the surface again as traders assert that as long as no-one else is using them, there is little point investing the time and money in them. It is not what is 'good' that is enrolled, but what is good enough to suit a particular purpose.

During these debates and struggles, the weather derivatives community has attempted to enrol a wide variety of actors to support their claims. Some enrol weather data to support their views that the weather market is using the wrong average. Others attempt to enrol the trade organizations to protest that the Europeans charging for data is an unequal act that should be made a subject of free trade laws. A few seek the enrolment of the legal system to protect their models and indexes in a privatization of meteorological knowledge that could potentially have implications for the future performance of meteorological science. Still others campaign the UK government and the Hadley Centre to stop 'wasting' time on mid-range climate forecasts which are of no use to any business and invest instead on what the businesses want, which is the provision of timely and accurate data. Meanwhile, other firms invest large amounts of money into creating expertise in climate forecasts for pricing contracts into the future; forecasts do become useful for businesses.

There is no singular thread to the weather derivatives community's engagement with meteorology. There are differing opinions, divisions about the future direction of the market and questions about the validity of types of data or forecasts. Meteorology here is enrolled in different ways, yet some broad trends can be identified. First, that weather derivatives are re-engaging debates about the quality of data, whilst also producing their own forms of datasets, the construction of data in reality. Second, that forecasts and data are becoming more valuable, but that some types of forecast may be replaced by the mitigating element of weather derivatives, whilst others will increasingly be produced in private environments for the benefits of corporate trading. Third, that this privatization process could have ramifications for meteorological science, particularly if the weather derivatives community expands in the future. Fourth, that meteorological expertise is engineered towards the financial market, that is, it is not purely a pursuit of 'science', but science for a purpose, or perhaps more correctly, science for a profit.

Thus for the weather derivatives actors to respond to fears of climate change and create a product that could manage the risks of changes in everyday weather patterns, a number of meteorological allies needed to be enrolled. These allies shaped the way in which the market was constructed and still shape the trading within the market. The meteorological allies, however, are not left unchanged by their involvement within weather derivatives; in particular, their value (economically) is altered. Weather derivatives are not just corporate responses to fears about climate change, they also have influences on the nature and conduct of scientific observation and forecasting that underpin debates on climate change.

In the following chapter the financial networks within the weather derivatives market will be analyzed and in chapter 7 a case study of the UK energy sector will show how this meteorological and financial knowledge is put to practice in the mitigation of weather risks within that sector. Finally this chapter has hinted that the weather derivatives community has the potential to influence the future performance of science and chapter 7 shows how the weather derivatives market may actually affect the future climate, through its varying relationships to climate change mitigation policies.

CHAPTER 6: MARKETING WEATHER DERIVATIVES

6.1. INTRODUCTION

Weather derivatives are a contextual historical development that answered particular needs in specific companies during the late 1990s and the previous chapter highlighted how this development required the co-operation or co-option of a range of meteorological allies, from data to forecasts. These meteorological allies also had to be counterposed with a number of financial allies that could provide means of selling these contracts to other companies. As much as natural science has been interrogated in the previous section, it would be ironic to then take the financial actors for granted, and hence I have applied a symmetrical discussion (Latour, 1993; 1999a).

This marketing and these financial allies take four main forms. First are the credit rating agencies who by virtue of calculating and controlling access to finance can become critical allies to the weather derivatives industry by creating a financial need to use weather contracts. Second are the banks who have large networks of clients that they can engage within the weather derivatives industry, particularly where other financial parameters are involved. Third is the direct advertising of weather contracts by companies that trade weather derivatives, to effect a change in business behaviour. Managing weather risk is not about growing a profitable business *per se*, rather it is imperative for economic stability to manage weather risks in these days of climate change. Fourth are the regulatory authorities re-making the legal frameworks of insurance, derivatives and gambling. Enrolling these actors is critical to making sure that weather derivatives become a *bona fide* derivative, not a speculative energy business.

To support the nascent product responding to financial concerns about changing weather patterns, required a series of financial allies to support both the capacity of the weather market, but also to serve as ways of marketing the products. These strategies have a variety of implications for who has access to the contracts, the ways that firms' will have to conduct their finances in the future and also on climate change fears. Weather derivatives, as this chapter will highlight, have material and discursive effects on both financial practice and (individuals in) corporate understandings of climate change.

The chapter can thus be said to centre around the marketing of weather derivatives. Marketing does not necessarily mean a direct form of explicit advertising, though this will be discussed. Rather marketing is about attracting stronger allies to support the growth of the weather derivatives industry and in parallel to the previous chapter which analyzed the enrolment of meteorological allies, this examines financial allies. In section 6.2. the credit rating agencies and banks are discussed, as these are centres of financial expertise that shape the ways in which other firms conduct their business. Then in section 6.3. the role of direct advertising is treated with a particular focus on a long-running advert by Swiss Re's weather desk. Finally in section 6.4. the focus is turned to regulatory authorities, the actors endowed with deciding what will be insurance or derivatives, what is gambling or not, what is good practice. The importance of enrolling these actors as strong allies will be highlighted in the concluding section.

6.2. CREDIT RATING AGENCIES AND CLIENT NETWORKS

The weather traditionally makes a good business excuse for poor profits. Challenging this reasoning is one of the biggest difficulties that the weather derivatives community has faced. Weather is institutionalized financially as an uncontrollable influence on the bottom line, but traders in the weather derivatives market want to make the management of this risk as generic and 'essential' as reducing foreign exchange exposure or mitigating the costs in commodities. As de Goede (2004: 199) puts it

> … the successful marketing of risk management products requires cultural parameters that see it as morally and economically compulsory to be insured against the risk in question.

If the risk is still acceptable to be left in the hands of providence, there is no compulsion to purchase risk mitigation products. Larson (2000: 121-2) cites Piddington's 'Sailor's Horn-Book' to show how resistant in general society is to change using the example of the rise of weather forecasts of hurricanes and storms for the shipping industry in the 19th century.

> [W]e must expect to find many 'of the old school' who do not like 'new-fangled notions;' many who 'do not like to be put of their way;' many who 'think the old plan is good enough;' and that 'hit or miss, for luck's all,' is quite good enough with a stout ship and a good crew.

Thus many ship captains rejected the use of storm forecasts (risk mitigation) and chose to take the old 'riskier' path. Nowadays it would be almost inconceivable for a ship to ignore storm forecasts. For the weather derivatives market it is important to change traditional conceptions about the weather risk. It must no longer be seen as acceptable to blame the weather for financial losses.

One energy trader notes that weather risk management has

> ... got to be something that is intuitive to people, you know like people manage their foreign exchange rates and if they don't and they lose money then questions are asked as to why they didn't manage it. I think the same thing has got to happen to weather. You can't carry on using it as an excuse, you know, profits are down because we didn't sell our coats, because it was a milder start to the winter. Well you can now hedge that risk, so no excuse
>
> (Interviewee 2)

Changes in the prevailing attitude are vital if the weather derivatives market is to succeed. Weather has to change in the business imagination from something uncontrollable, in the hands of providence, to something that should be actively managed, weather as finance. At the heart of this is the job that weather derivatives are arguably meant to do i.e. mitigate weather risk. One energy trader notes that "[t]he idea is that we smooth our p & l due to weather fluctuations" (Interviewee 6)[1]. Whilst some companies take this pro-active line in order to impress the city (Interviewee 6), most boards are harder to convince as it requires wholesale changes in the ways in which companies have managed the costs of the weather (Pollard, *et.al.*, forthcoming). Though there may be someone employed within a company to analyze weather risks and work out ways of reducing them, actually getting permission to undertake weather derivatives can be quite a complex process. One interviewee (13) highlighted the struggles of marketing weather derivatives to boards that have traditionally seen the weather as one of the uncontrollable effects on earnings volatility. Indeed this interviewee suggested that one of the problems with weather derivatives is a persistent image in many quarters that this is just speculating on the weather and in presenting a case to the board it was important to show how the planned

[1] This is corporate shorthand for the profit and loss account.

use of weather derivatives is purely about mitigating risk. These issues of selling the market will be concretized in relation to the energy sector in chapter 7.

Thus companies for a long time have been allowed to blame losses on the weather. The weather derivatives community is endeavouring to enrol the credit rating agencies to ensure that the weather cannot be blamed in the future. Whilst current client networks will prove a potential source of customers for banks (and others) unless there is a need to manage the weather risk they are likely to have limited long-term growth. In other words, for weather sellers to make a profitable product, the heart of developing weather derivatives, they need to be able to persuade others that they must manage the weather risk.

Credit rating agencies rate companies by standardized criteria (AAA to junk bond[1]) based on the financial results of a company, particularly taking into account the perceived economic stability of the company. The assignment of numbers, or more correctly letters, to a company mobilizes a series of financial networks determining for example how much a company can borrow and what kinds of repayment have to be made on already active loans. A downgrading to junk bond status can have significant economic repercussions on the future viability of a company and its ability to attract future finance. Credit ratings are also important in a second way and that is the ability to trade in OTC derivatives markets. Many firms' regulations prevent or restrict the trading of financial contracts with companies with a lower credit rating. The ratings are trusted as symbols of economic security; the categorization leads to faster decision-making. Credit ratings are perceived to be changing more rapidly too with companies being downgraded much more quickly than in the past (Interviewee 19). The cycles of accumulation and profit are

[1] Anything under Ba rating, by Moody's, or BB, by Standard and Poors, is considered to be somewhat speculative in nature and hence is assigned the name junk bond.

speeding up, especially as finance becomes ever more fluid; the concept of the celebrity firm (Rindova *et.al.*, 2006) is a good analogy, as image and popularity wax and wane. This has caused a number of problems in the weather derivatives market since 2000 as many energy companies in the US have seen their credit ratings fall towards junk bond status. One result of this has been more margining in weather (and other) contracts (Interviewee 19). This highlights the ways in which finance is mobilized through a series of regulatory actors that become centres of calculation from which they determine other companies' future financial stability. Finance, thus, is not immediately accessible to all, and examining inside the black box shows that firms have to create particular images to secure access to that money (Pollard, 2003).

Notwithstanding the problems that credit rating agencies have created within the energy-dominated weather derivatives market, the weather community has actively lobbied credit rating agencies to accept weather derivatives as a *bona fide* commercial product; this is a key development for the market as it will force other companies to use weather derivatives. Weather derivatives would also be firmly established as a proper financial product and their use would become as normalized as foreign exchange products. Credit rating agencies, however, have been slower to introduce weather contracts as a core part of risk management guidelines with which to judge companies' performance. Perhaps this is partly the result of stymied growth in the weather market over the past few years and the still continuous concerns about the availability of access to the market, which can at times be seen as secretive. To date no company has been downgraded because of uncontrolled weather risk, although two companies in Germany have been praised for their weather risk management. Only Standard and Poor's have also marketed the fact that they now consider weather as a risk that can be managed (Brown, 2004). If credit rating agencies could be more actively enrolled by the weather derivatives community it is likely that there would be a rapid growth in the use of weather derivatives contracts. As one banker puts it

> The company likes to have an excuse to have bad results and the classic up to now has been 'the weather didn't go our way'. But more and more as these people have started to hear about weather derivatives, they're not some sort of crazy backward product, they do get mentioned in the papers that sort of thing, the equity analysts are realizing well this isn't a valid excuse.[1]
>
> (Interviewee 11)

Credit rating agencies here figure as important actors in the potential expansion of the weather derivatives markets and companies with extensive client networks would be particularly keen to see these agencies take a more active role. It would help with the marketing to the clients. 'If you do weather risk management, your credit rating will improve'. This is particularly the case when companies have been affected by the weather in a particular year. This happened with water companies in the UK as storage is a problem in the industry and if two dry years occur sequentially the costs can be large.

> The same water companies I spoke to at the start of the year said 'no not interested', they're now saying 'oh', because they realize they have got a risk and they find they need to do something about it. 'Cos most water companies can survive one summer with no rain, not a problem, they can even survive two summers with no rain as long as they get the rain in the winter and top it up. If they don't get that then they start paying out huge amounts of compensation to

[1] There is no space in this thesis to look at the role of the media in the weather derivatives market, but this interviewee clearly points out the potential symbolic and discursive role it plays.

> their customers ... so I think there has to be a need. If people get stung one year people start to think about it
>
> (Interviewee 11)

Thus one marketing method is to trawl business news reports and target those sectors and companies that are currently underperforming due to the weather. The volatility of the water sector here may have led to credit rating drops, particularly if the agencies perceived that there was a viable precipitation market. Regardless of this, it would be much easier to market products to companies that had recently suffered from weather losses particularly if those losses were present on the balance sheets presented to the banks with weather derivative expertise. How do these companies use their client networks to directly sell weather products?

Banks in particular have extensive client networks built up not just with those that actually bank with them, but those that buy other financial products from them. Access to corporate accounts is relatively straightforward, they are centres of calculation, and weather derivatives can be marketed either directly to potential clients or by bundling them up with other financial contracts in an overall risk protection strategy. Bankers thus work in two ways, by selling via the telephone or by sending weather derivatives information to the advisor within the bank who specifically works with that client where the interpersonal relations will be much stronger.

> ... it could be that London Electricity is a client of ABNAmro, that London Electricity does all its banking with ABNAmro, gets loans from ABNAmro, buys interest-rate derivatives from ABNAmro. So the account manager who works for ABNAmro, who is the account manager for London Electricity, will be trained now to understand what weather derivatives are and the next time he sits down

> with the CFO of London Electricity and they're having lunch, he's going to say, 'well we've got this new product which is weather derivatives are you interested in that' and London Electricity may or may not be interested.
>
> (Interviewee 5)

The weather derivatives end-user market thus grows by the power of the bank in controlling its clients' economic needs and information. It acts as a centre of calculation (Latour, 1987) that assesses quantitatively other companies' financial performance. For a soft drinks company, for example, the bank receives the financial report and

> … as soon as you see the sales figures through the summer that's just gone, we'll run it against the weather. You can see, it's right in front of you, if it's a cold summer or pissing with rain then people aren't buying as many soft drinks, beers, what have you. So once you can get a slight bit of interest you can then sort of prove it with numbers and then you've got them, and then it's just a case of haggling about how much they want to spend on it.
>
> (Interviewee 11)

The numbers here are not simply a representation of a company's financial performance; they become mobilized as proofs that weather derivatives are necessary. It is implied that without numbers there would be insufficient proof and hence quantification becomes a politicized strategy to persuade and justify (Porter, 1995). The power of money and institutions like banks to enforce trading was also illustrated in the opening of the thesis when Mr Henchard was forced to sell off grain at lower prices than he paid for it, because further losses were feared and, by implication, one could not simply hope the weather would change (Hardy, 1994).

If this is the way in which client networks are utilized, the rationale for using these client networks is that many bankers, or the sales team selling weather contracts, also work under strict sales targets.

> [I]t's all driven by the fact that these banks have set up very small teams and these teams have been told 'make money or we'll sack you' and that's the way these banks work {laughs}. They are completely ruthless. They're given 12 months … [and] if they don't make money they get sacked … it's very high risk, high reward for these people to go and do this for these banks and if they sell 15 million pounds worth of weather derivatives they themselves will make a million pounds. So they can potentially earn a lot of money.
>
> (Interviewee 5)

Individuals therefore are working under targets to retain their jobs. It is too simplistic to argue that individual traders are engaged in imperfect practices and should change this when their role is circumscribed by the institutional agendas set for them. To understand weather trading it is important to understand the institutional cultures and the power of the profit and loss account in structuring trading activity. Using client networks is clearly a much stronger sales strategy than cold calling and with most of the people operating on short time-scales, which for weather risk is problematic, because it takes seasons and years to gain averages (the climate does not work on the short time-scale of the financial markets), then securing the 'easier' deals is paramount. This becomes an important issue when related to climate change policies. Thompson (1996), for example, suggests the need for banks and the investment community to work with longer timescales to support climate change mitigation policies. Investments such as renewable energy often offer longer rather than shorter time-scales of benefits, whereas most investment activity is geared towards short-term returns (see chapter 7). 'If you want a loan' these bankers might say 'you need to stabilize your weather risk'. Again, following Latour (1987), this is a strategy on the lines of 'this will be of benefit to both of us, so let's take the small diversion and look at weather risk management as this will stabilize the company accounts and allow the attraction of further loan finance'. Thus the connections between banks and clients are potentially vital to the development of weather derivatives.

The same also applies to insurance companies and energy companies. For example, two energy companies have examined the possibilities of not just using weather derivatives to manage their own risk, but also using this expertise to sell weather derivatives to their own clients who buy energy from them (Interviewees 2, 14). Insurers can similarly tie in weather contracts to other forms of insurance products that they sell to clients. Nevertheless banks have an immediate advantage in this market. As Interviewee (5) states

> when I was at ... a company that was buying equity derivatives from the bank [recently] I said to the guys in this company 'Why don't you go to the various ... exchanges and buy them there?' and the guys at the company said ' well cos that would be so much trouble. We'd have to join the exchange, we'd have to figure out how to trade on this exchange, we'd have to employ somebody to do that. Right now we can just phone up our bank and buy what we want immediately and well maybe we pay a little bit more for it, but...'
> So a lot of people say that in the long run it's going to be the banks that are going to dominate, because you just sort of assume that banks are the people that should be doing these sorts of things

Banks have the perceived expertise, economic stability and credibility that people want when purchasing financial contracts. This becomes exacerbated within a market like weather derivatives, which had an initial reputation for being a product of 'crooked' Enron. One banker (Interviewee 11), for example, loses little sleep over the competition from energy companies and insurers

> That's why I think being a bank comes in, because if you've got a relationship with them you know they're not trying to rip you off

The bank is not going to rip a client off, because it is perceived to be acting in the long-term interests of the client and selling contracts would *obviously* not just be profit-driven. There is also less risk of a default with a bank with a strong credit rating than with an energy company with a fluctuating credit rating. Though energy companies are still important actors in the weather derivatives market, in part because the predominant numbers of buyers are still energy-based, in the long term it seems likely that the major commercial banks and the exchanges, as with most other financial products, will take over the leading role.

6.3. SELLING THE MARKET

There are a variety of ways in which actors have attempted to visibly market these weather contracts to potential purchasers. In this section some of the adverts of weather derivatives sellers will be examined using, at greater length, the example of a long-running advert by Swiss Re. Selling weather derivatives has also utilized fears about a changing climate as weather becomes a major, rather than a secondary risk.

One of the primary discursive strategies for turning weather into a manageable economic risk is through the use of adverts. Predominantly these are in the pages of the near-monthly industry magazine *Environmental Finance*, but others are also in wider risk magazines and other publications that are likely to reach a wide financial audience[1]. Indeed in April 2005, ABN Amro had a weather risk map enclosed with the journal *Reactions*[2]. This map highlights the effects of the weather on different sectors in Europe and North America. In the UK for example the map shows that the weather has particularly noticeable effects on the transport, construction, food and beverages, wholesale and retail trade, healthcare and gas industries. Under the map, which is A1 size to be attached as a wall poster, ABN Amro claim that "[w]hen dealing with the unpredictable, you need a financial partner you can rely on". Further they say that "[t]hanks to our partnership approach, you can be sure of our support and commitment, come rain or shine". This map in each copy of *Reactions* not only went to the subscribers of *Reactions*, a much wider body of financial actors than for *Environmental Finance*, but was also dispatched as a complimentary copy to the attendees of the WRMA European conference in November 2004. This served both as a reminder to the weather market that ABN Amro "… boasts proven experience from the largest ever weather derivatives transactions", but also to a different audience that would be reminded or informed that weather is a risk, a large risk, that needs to be managed. This is just one advertising strategy, one that is particularly different from the mainstay of page or half-page adverts in *Environmental Finance*.

Several institutions that sell weather derivatives have established formal advertising campaigns in industry journals. One of these adverts in *Environmental Finance*, which has run, albeit not in a continuous form, from autumn 2004 to autumn

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[1] 10 issues a year. July-August is one issue and December-January is another single issue.
[2] Volume 25, Issue 4 (available from: http://www.corporates.abnamro.com/corporates/resources/includes/attachments/WeatherMap.pdf, last accessed 01/02/06).

2005 is displayed in Figure 6.1. and shows one of Swiss Re's adverts for their weather risk desk. It shows a giant fan on the top of a building in Manhattan with other skyscrapers in the background and the then head of weather derivatives at Swiss Re, Mark Tawney, looking up towards the sky[1]. Or more correctly to where the sky should be as the sky is actually absent from this advert. Indeed all that can be seen are rays of sunshine glinting off Manhattan glass and highlighting Tawney. He is in the light of the sun, because he is able to manage the costs of the weather. He also by seeing the sun can direct other businesses towards the light. The sun here plays a traditional dualistic role with darkness, that whilst many companies may be unaware of the ways of managing weather risks, those that see the sun have experienced something better. The traditions of sunlight and darkness have a long history. Those suffering from illnesses were advised to seek out the light, spend time outdoors in the sunshine, whilst reducing air pollution was coupled with 'letting in the light' (Mosley, 2001). For industrialists though the smoky sky was traditionally seen as a sign of industrial prosperity; here in weather derivatives the image is inverted. Those that let in the light of weather risk management can find financial prosperity.

Tawney in this advert is enlightened in two ways. He is enlightened by being part of a modernist project to control the effects of nature, that society can escape the vagaries of the weather. Secondly he is favoured because he can see the light and direct other business concerns. That is he has become an expert on weather management, he is enlightened by the knowledge of how to manage the costs of the weather. Weather here is ordered by the financial system. This order is represented in another way. Next to Tawney in this advert is a large industrial fan, larger than Tawney himself, but not too large that he

[1] Mark Tawney left Swiss Re in autumn 2005 to take charge of a hedge fund dealing in weather derivatives.

cannot see the sun. The atmosphere has often been considered a giant fan and it speaks of chaos, disorder, in a word, weather (Golinski, 2003; Serres, 1995). Indeed the fan is the only representative of the sky in this picture (excepting the sun glints). It is therefore symbolic of the atmosphere. For those that have seen the light however and implemented a weather risk solution, the fan is both stopped and encased. No longer is the atmosphere an external problem as it can be properly ordered and managed, and not just anywhere too. Here it is represented as small compared to the glittering skyscrapers of Manhattan. The weather is no longer external to business but it has become part of the financial world; it is within the boundaries of Manhattan, encased within corporate skyscrapers. No weather event can now exceed the abilities of Manhattan to manage it. The environmental risk, the weather, has been displaced. No longer is it an environmental risk, but rather it has become a financial risk, one that will, like all financial risks, ultimately be controlled by the safeguards surrounding the financial system (de Goede, 2004).

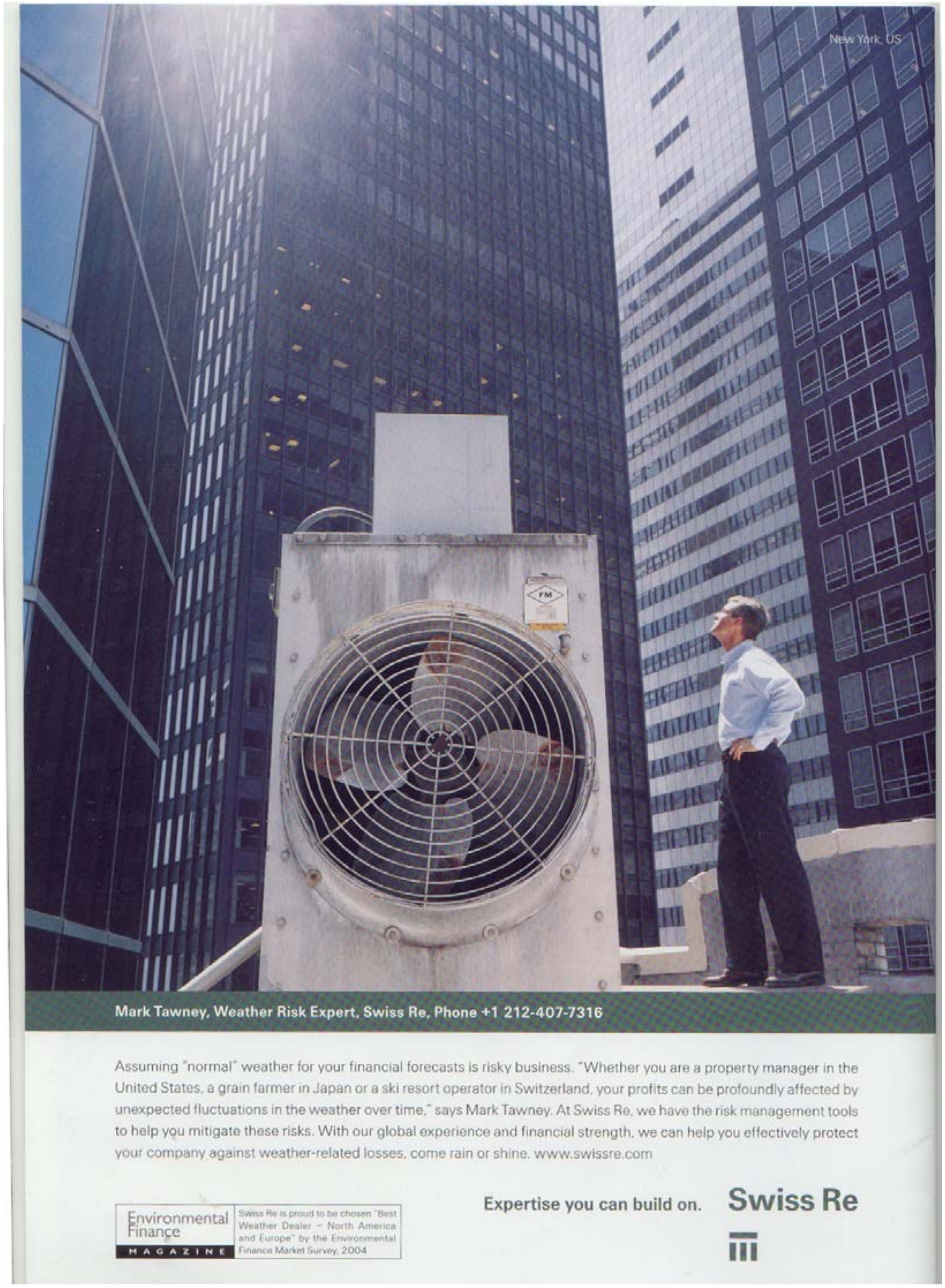

Figure 6.1. An advert for Swiss Re's weather desk from *Environmental Finance* magazine.

Finally, the text at the bottom of the picture is of some importance too as it starts by proclaiming that "assuming 'normal' weather for your financial forecasts is risky business." The word normal is placed in scare quotes. Climate change means that there is no longer such a thing as normal weather, whether climate change is treated ontologically or epistemologically in this context. Here in the advert is the reminder that weather derivatives may be useful at any time, but that they are essential now because the weather is no longer normal. With the weather now abnormal, it must therefore be made as normal as possible through the financial markets. This is a vital aspect of promotion as de Goede (2004) points out, because the marketing of new financial products comes down to a normalization of the risk. Weather must be financially normalized; if it is not considered imperative to normalize the risk there may be little incentive for companies to spend money purchasing weather derivatives contracts. The financial markets are now the answer to concerns about changing weather patterns. Discourses, as political ecologists (amongst others) have argued, have material implications (Rikoon, 2006).

The questions surrounding future climate, however, are as contested within the weather derivatives market as they are outside of it. Indeed some people use climate change as a selling strategy, despite their own scepticism to the idea of anthropogenic sources in a changing climate (Interviewees 5, 11). The volatility in the weather provides ample marketing opportunities for potential clients of the need to manage the seemingly increasing exposure to an unpredictable meteorological and climatological future. It is indeed a climate of fear.

> Where it [weather] used to be a secondary risk it's becoming a major risk
>
> (Interviewee 3)

Climate change, for many sellers of weather derivatives, is the issue or discourse that is bringing the management of weather onto the agendas of many corporations. Companies that in the past blamed their losses on the weather can no longer do so, because the climate is becoming more volatile, more unpredictable and non-stationary. It is trending in a particular direction and 'normal' weather, as Swiss Re suggest, is no longer present. Using the rhetoric of climate change has become a good selling strategy for weather derivatives actors, but for policymakers it does highlight that business awareness of claims about a changing climate should be growing. One interviewee states that

> If people don't believe in global warming then I don't even bother speaking to them
>
> (Interviewee 11)

There are two principal reasons for this. First is the difficulty of convincing someone that they need to manage the risks of the weather, if they fail to see any changes in the weather i.e. the compelling reason to manage weather now. Second are the disagreements that would result over the fair price, which is dependent on how each party expects the climate to change over the length of the contract. On a five year contract (or longer) the difference between using 10- or 30-year averages, for example, becomes pronounced in different fair prices. Many statistical analyses of the climate are undertaken to 'accurately' price weather derivative contracts (Jewson and Caballero, 2003), in itself a performative quantitative act, and each individual's view on future climate may result in quite different trading behaviour. Indeed the lack of consensus about the directions of future climate creates a trading environment as different people are prepared to take on different positions based on their understandings of future climate. This trading creates liquidity within the market.

There are obviously many other adverts, which there is not space to discuss in detail here so just three others from *Environmental Finance* will be outlined. Interestingly few adverts use the word derivative, preferring weather protection, a factor particularly important in places like Germany and India, where derivatives conjure up notions of risk (Interviewee 11, 22). First is HVB, a German bank, who advertise with the slogan “we care about the weather”. This makes a potential purchaser feel that HVB know the weather, that they are doing something about the weather, but also has the sense within it that ‘we care, so should you’. This may be considered a ‘I want it, why don’t you’ strategy (Latour, 1987). Here HVB are saying that they care about the weather, that they want to protect their clients from the costs of the weather so therefore the clients should also care about the weather. This exhibits a strong enrolment technique to encourage companies to purchase weather derivatives from HVB. Second is a series of adverts from the company GuaranteedWeather. Putting aside for one moment the name of the company, these adverts are often brightly coloured and the background show landmarks of nature that would be readily recognizable.

> [T]he implementation of a GuaranteedWeather solution, [means that] weather volatility no longer translates into fallen shareholder value

They provide “[w]eather risk management that endures”. These adverts reflect the name of the company in that they guarantee weather for the future, it is risk management that endures, and it is a permanent solution. Economic stability is thus ensured, because one of the factors of volatility has been controlled. The name also reflects a notion of a guarantee on their product that the weather from now on will be assured, taken care of, and secured. Third, WRMA, the industry organization, have realized the importance of advertising the market. Their adverts show a volatile temperature series, such as one might find on the notes next to a hospital bedside, overlaying pictures of weather events. Lightning and hail are accompanied by volatile downward trending lines, whilst sunshine is overlain with an upward trend. The slogan reads "[y]ou can't do anything about the weather … or can you? … Weather is no excuse for poor earnings". It is now no longer acceptable to blame the weather for poor financial performance as there are products that can manage the risk so the old approach is no longer good enough. Again the sun is used as a symbol for positive prosperity, whilst storms are overlain with downward lines[1].

These adverts are powerful discursive tools, yet their effectiveness is somewhat unknown. Many of these adverts have been placed within the pages of *Environmental Finance*, the industry journal, and their outreach is probably limited to participants already in the market rather than new participants. Nicholls (2004: 14) claims that in private many industry insiders suggest that "... too much of the industry is prepared to settle for a steady flow of existing business, rather than invest to build the market". Few end-users actively publicize the deal which leads him to suspect that there are not that many of them. The hope, however, is that banks really are growing their business and that eventually the market will become mature and companies themselves will market their use of weather derivatives, encouraging further consumers into the market. The CME is probably one of the most active marketers with its weekly *Wall Street Journal* slot and in listening to the needs of customers it has developed a market based not on advertising *per* se, but pre-empting the advertising by generating the products that consumers require.

[1] This connection of weather events and economic prosperity, with sun as positive, storms as negative, is actually intriguing when it may be considered that several weather derivatives contracts seek protection from too little rain or too little wind.

Nevertheless these adverts present an interesting perspective on both the ways the weather market advertises itself and also how it perceives itself. Weather products are not risky as many perceive, rather they smooth the economic volatility. This is a vital advert for regulatory authorities too as the weather derivatives community has been arguing that weather derivatives are *bona fide* commodity derivatives. The next section analyzes in more detail these regulatory challenges.

6.4. REGULATION ISSUES

Regulation is an important topic within the weather derivatives market and beyond, particularly as weather derivatives are translated in different parts of the world. As Pollard (2003) notes, despite the globalization of finance significant national differences still exist in both financial markets and forms of corporate governance and regulation. Markets and firm finances are thus geographically rooted. Weather derivatives challenge the existing national distinctions between financial, insurance and gambling contracts. There are differences between the UK and US legal environments and an example of this will be illustrated through the recent dispute in the US between the National Association of Insurance Commissioners (hereafter NAIC) and the International Swaps and Derivatives Association (hereafter ISDA). Then it is important to look at the current European regulatory challenges facing weather traders and highlight the ramifications that regulations have on the ways that firms perform their business.

First what are the main regulatory differences between insurance and derivatives? The comments here will be most specific to the UK in particular, but many of the themes are also important in the US. When a contract is written between two companies, it is not pre-determined which regulation it will fall under. It rather becomes a derivative or becomes insurance by meeting a certain set of criteria. This is important because even though both parties may be planning a derivative, if different sets of language are used the contract could easily turn into insurance without either side necessarily realizing. Should any problems occur, or should it go to the board, or should it go before regulators, it may be not just an unenforceable contract, but technically illegal too[1]. The different criteria are summarized in table 6.1. Insurance contracts have two principal components, proof of loss and an insurable interest. The company taking out protection must have something at stake, or something to lose, and be able to prove that the loss occurs because of that particular event. So a hotel in Florida may have hurricane insurance such that if a hurricane causes damage to the hotel they may be compensated. They would only be compensated, however, if the hurricane caused the damage. This is the primary difference between weather insurance and weather derivatives. Derivatives are regulated as financial products and should have neither proof of loss nor insurable interest. A company can thus literally gamble on the weather though there are some constraints as the discussion of the gambling-derivatives distinction later will show.

[1] It will certainly be seen by one of these groups, particularly if it is formally and legally registered and especially with insurance contracts.

Factor	Insurance	Derivatives
Proof of Loss	Yes	No
Insurable Interest	Yes	No
Premium	Yes	Yes or No
Maximum Payout	Coverage limit	Payout limit
Coverage Application	Policy period	Effective dates
Event Insured Against	Weather peril	Weather peril
Threshold for Loss	Trigger of claim	Strike amount
Neutral source of trigger of coverage	Weather station	Weather station
Uncertainty of outcome of contract	Yes	Yes

Table 6.1. Comparison of weather insurance and weather derivatives (derived from NAIC, 2003).

So why is it important to meet the regulations? One reason is that insurance is a more regulated market and therefore the government can relatively easily intervene within the market, as they have done in the US with flood and hurricane insurance (Dlugolecki, 1996). With insurance, the buyer of the contract must disclose all information relevant to the contract[1]. This is not the case in derivatives. Similarly the seller of an insurance contract has to pay insurance premium tax. "The tax follows the law" (Interviewee 12) and if the contract is deemed insurance then tax is liable. This adds an extra cost to insurance as most companies pass this tax on to consumers.

There are also institutional regulations. In the UK, for example, a company cannot be both a bank and an insurance company. To sell products from the other side is a breach

[1] Duty Of Disclosure. An example would be taking out travel or life insurance, knowing that pre-existing medical complaints might increase the probability that a claim is made on that policy. Derivatives do not require duty of disclosure as it is the buyer's responsibility to ask questions (Interviewee 12).

of contract. In the US, selling insurance requires an insurance license and to trade derivatives a trader must be registered with the National Association of Securities Dealers (hereafter NASD)[1]. That trader cannot trade insurance as well. So for example, the weather desk at Swiss Re operates by transacting derivatives through its New York office and insurance through its Zurich office. Other companies also pass business between each other when the contracts are likely to fall into the opposite regulatory frameworks (Interviewee 11, 12). The regulatory complications become exacerbated in countries like Germany and the UK, for example, where a banking license or a financial exam is required to trade derivatives (Interviewee 19). These can be costly and may prevent companies becoming involved in derivatives markets. Thus traders in derivatives markets require effective training that establishes credibility and logic to the trading activities; the educational process works to perform a particular market.

Returning for a moment to regulations such as the NASD registration, because weather is currently not a *bona fide* derivatives product in the US, traders in weather do not technically need an NASD registration. In Europe similarly, weather has only just become a commodity product and hence its regulatory status has been similarly questionable. Whilst most companies treat weather contracts in line with commodity derivatives or weather insurance, it is not certain if it would be illegal to work outside of the current regulatory boundaries (Interviewee 12; Bates, 2004). Indeed until weather becomes a listed derivative many companies may be less than comfortable trading it.

One other critical difference between insurance and derivatives is an accountancy issue that is particularly applicable in the US. Derivatives are marked-to-market whereas

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[1] Insurance regulations are particularly complex in the US. As Kramer (2004) points out, the penalties for breaking these regulations vary extensively state-to-state. For example, in California breach of license would be classified as a 'misdemeanor'. In Connecticut, fines and imprisonment can result. In Delaware, a company can lose its charter.

insurance is not. This means that the value of the contract is changed in line with the expected value of the market and it also goes through on the profit and loss account rather than staying on the balance sheet (Interviewee 12). If the value of a contract is increasing this has an immediate benefit for the amount of profit being generated. Enron were able to push through high volumes of contracts and mark them to market value in a market whose value largely derived from the impetus Enron was giving to it. In other words, Enron's predictions of the future value of the market became performative and the renewed value of the contracts formed a feedback circle that allowed it to put even more profit into the profit and loss account and allowed it to further inflate the value of the future market[1]. Insurance contracts on the other hand remain on the balance sheet and the valuation of these contracts in the future is thus much more stable. The profit and loss account actually takes on an active role in the weather market as it forces traders to work in particular ways to generate particular forms of accounts that may result in corporate and personal financial gain. Finally, insurance comes with a set of smaller issues. Insurance contracts are not normally sold through a third party, their markets are also more difficult to trade in and if a risk is taken it is a lot harder to re-insure it than it is within the derivatives market (Interviewee 19).

The difficulties and issues with the classification can be highlighted with the debate between the NAIC and ISDA in the US. On September 2nd 2003 the NAIC released a draft paper entitled 'Weather Financial Instruments (Temperature): Insurance or Capital Markets Products' (NAIC, 2003). The NAIC document sets out to establish whether weather derivatives "… have been misclassified as a capital markets product" (NAIC, 2003: 1). This misclassification, for them, is the result of the emergence of

[1] Some have argued that many of Enron's contracts were simply unprofitable (Interviewees 4, 21)

weather derivatives within the energy industry, which could not sell insurance products as it was not regulated to do so. Part of the issue with weather derivatives, they argue, is that they are not regulated as tightly as insurance and hence many buyers may be less protected than they could be[1]. This follows the case in 2002 of energy traders artificially inflating the indexes used to price natural gas for personal gain (NAIC, 2003). Classification as insurance would bring with it a host of buyer protection clauses and would ensure sellers maintained adequate capital reserves. States are also losing valuable premium tax revenue according to the NAIC (2003). With weather derivatives 'essentially' acting in the same way as insurance to transfer the risks associated with temperature, the contracts are in effect 'disguised insurance'. Are weather derivatives to be insurance or derivatives? At this stage, it is not clear.

Though the NAIC document points out many similarities between weather insurance and derivatives, it "… glosse[s] over the structural differences between derivatives and insurance, reaching the erroneous conclusion" (Kramer, 2004: 10) that they have. Thus, WRMA submitted a formal response to the NAIC on January 23rd 2004 (WRMA, 2004), which was swiftly followed by a formal response from ISDA on February 23rd 2004 (ISDA, 2004) [2]. Kramer argues, using New York law as the example, that as long as proof of loss is not inserted into the contract it falls into derivatives regulation as derivatives such as catastrophe options do[3]. WRMA (2004) likewise use

[1] Exchange-traded derivatives are subjected to the Commodity Futures Trading Commission's Commodity Exchange Act, whilst OTC derivatives are simply classified as private negotiations and hence are less regulated.

[2] WRMA actually sent two letters, the first dated January 6th, but it is the one dated January 23rd that contains the detailed response to the NAIC documentation.

[3] This is particularly important as catastrophe options deal with extreme weather, the traditional domain of insurance. The New York law however highlights the main difference being that derivatives transfer risk with no regard to actual loss whereas insurance only transfers risk in relation to a purchaser's actual loss (Kramer, 2004). Insurance contracts are "any agreement or other transaction whereby one party, the 'insurer', is obligated to confer benefit of pecuniary value upon another party, the 'insured' or 'beneficiary', dependent upon the happening of a fortuitous event in which the insured or beneficiary has, or is expected

New York law, possibly because it is considered the most important state in setting financial laws that are adopted by other states in the country (Kramer, 2004), to highlight this key difference and also bring up the notion of an insurable interest as another primary distinction. Weather derivatives cannot be insurance, they argue, as there is strictly speaking no insurable interest.

> … [T]he subject matter of a weather option is the specified weather component … and it is a conceptual impossibility for anyone to have an economic interest in the elements[1]
>
> (WRMA, 2004: 8)

As weather derivatives use the weather, not the economic effects of the weather, as the underlying resource, *contra* insurance, there is strictly speaking no insurable interest. WRMA, however, accept that this narrow view may be disputed, but argue that even where it might be conceived that there is an insurable interest, this is undermined by the fact that contracts pay out when the weather strike is met regardless of the existence of an insurable interest. In these two aspects, they argue, weather derivatives are clearly not insurance. They also argue that the NAIC is unjustifiably concerned with the regulation of weather products considering that there has been neither complaints on the part of buyers purchasing contracts nor would it even be possible to manipulate weather indexes (unlike natural gas). Secure meteorological stations at airports thus become critical allies in supporting the regulatory arguments. WRMA (2004) also point out that they encourage use of the ISDA documents in all weather derivative transactions. If ISDA, as the symbol

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to have at the time of such happening, a material interest which will be adversely affected by the happening of such event." (New York Insurance Law Section 1101(a), cited in ISDA, 2004: 3).

[1] This arguably may be contradicted by cloud seeding, where money is paid to generate particular weather elements.

of derivatives authority, provide the documentation, NAIC would have to find fault with not just WRMA but ISDA too. WRMA thus directly mobilized ISDA, both as an active spokesperson and symbol of regulatory authority, to construct their argument against the NAIC claims. Other factors like the airport meteorological stations and the welfare of contract purchasers also helped.

ISDA sent their formal reply to the NAIC a month after WRMA. They point out that in early 2000 the New York State Department of Insurance agreed that weather derivatives lacked the fundamental requirements of insurance (ISDA, 2004). Indeed it is quite clear, they argue, when looking at current insurance contracts that there is a clear distinction between insurance and derivatives, based upon the insurable interest and proof of loss criteria. Further they suggest that weather derivatives actually serve a complementary purpose to insurance, aiding the everyday weather market rather than the extreme weather market and also offering alternatives to the insurance model of dispersing risk across the base of participants. Derivatives, in theory at least, match parties with offsetting risks. ISDA claim that even the government should be interested in weather derivatives through the crop and flood markets.

> The very fact that government subsidization has been needed in the crop and flood insurance markets indicates the need for a complementary market offering additional, affordable and adjustable risk capacity
>
> (ISDA, 2004: 8)

Derivatives are not only important for the stability of the economic system, suggest ISDA, but they can also provide risk-taking capacity that will aid both the insurance companies and government. Therefore if insurers and government wish the market to serve this purpose with economic benefits for them, they must let weather derivatives remain regulated as a capital market, not an insurance product.

The weather market negotiates the interests of the insurers to ensure that they can remain as a relatively less regulated derivatives market. This was a diversion from the main task of making money out of selling weather derivatives, but had to be passed through to establish a regulatory basis. For government and the insurers this became an important point too, as risk protection had to be ensured, but neither of these parties wished to provide that cover. Here is a good example of an obligatory passage point in which each group had to pass to attempt to meet their targeted outcomes (Callon, 1986; Latour, 1987). The NAIC's draft paper was dropped. Weather derivatives would remain as derivatives, certainly in the short-term. In the US the main argument therefore has been about distinguishing weather derivatives from insurance. In Europe, on the other hand, the debates have been about securing weather derivatives away from both insurance and gambling contracts, at both a (inter)national regulatory scale and at a corporate level.

At the corporate scale it is vital when using derivatives to make sure that the company is allowed to trade them. Not only is this particularly important when engaging in swaps markets where credit ratings are very important (hence influencing the companies one can trade with), but also it is important to make certain that the contract is enforceable. The famous London borough case of Hammersmith and Fulham (Tickell, 1998), for example, highlights the problem of trading derivatives illegally. If a company is not permitted to trade derivatives the contract is annulled, no matter which way it should pay out. This may explain one of the difficulties of growing the weather derivatives market as some of the most weather-sensitive sectors are under forms of government control and therefore may be unable to trade derivatives contracts[1].

The EU Directive on Financial Instruments Markets (hereafter ISD2[2]) was being written up, debated and analyzed as this research project was proceeding. It was agreed in April 2004, after protracted negotiations, and member states had until April 2006 to bring their national laws in line with this directive. In 2004 during the research it seemed that weather derivatives would not be included under this Directive, but after an ongoing process of review they were included in the final documentation. To ensure weather derivatives presence in ISD2, the market actively campaigned for their inclusion and it is this campaigning, with the outcome then uncertain, that is the focus here.

WRMA, for example, have been lobbying the European Parliament about this issue, again with the enrolled support of ISDA, as the new Directive presents a range of generally attractive policies for traders. The most important of these is the new EU passport, which allows cross-border trade. Currently a company has to have a license in each EU country to be able to trade derivatives there[3]. The new Directive removes this layer of regulation allowing EU licensed banks and financial firms an EU-wide passport to trade derivatives. This is particularly appealing for the European banks involved within the weather derivatives market. There are some downsides to this for certain companies. One is that many participants in the weather derivatives market do not have a financial service license. This fear, however, is likely to be allayed with a couple of exemptions in

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[1] Local councils, highway agencies, aviation in many countries, water in some countries and so on are generally public bodies that cannot trade derivatives.

[2] Note that this is more recently referred to as the EU Directive on Markets in Financial Instruments (MiFID), but ISD2 will be used in this thesis as being the term of discussion in the weather derivatives market at the time of research.

[3] Failure to be part of ISD2 would mean contracts would fall under individual country's additional derivatives regulations thus what is acceptable in Germany might not be legal in Italy. This particularly affects issues such as the ability to net contracts. Netting is part of the hedge accounting rules that if one hedge loses money and the other hedge gains money the two can be netted and any tax liable on the hedges is annulled.

the Directive protecting those that only do derivatives trading ancillary to their main business or only trade for their own account (i.e. no third party transactions or acting as a market-maker). Should weather derivatives be caught under this new ISD2 they would be regulated as a *bona fide* financial instrument. If not, weather derivatives would not benefit from protective laws, including the guarantee of enforcing the closeout of netting agreements and protection from the risk of invalidity under gaming laws. Strengthening the associations of weather derivatives, thus, results in a whole set of network outcomes.

Whilst this EU regulation may hold many benefits to some companies within the weather derivatives market, in reality the overall regulation of derivatives will be relatively unchanged. A derivative will be regulated as such if it meets the standard requirements of a derivative contract, that of being for "… *bona fide* commercial purposes" (Interviewee 12) and having an acceptable contract certificate.

> … [T]he thing in the financial services market is that of a contract certificate, it's done by a definition. It's a contract whose purpose or intended purpose is to secure a profit or avoid loss by reference to fluctuations in an index or property … or any other factor and that covers all swaps essentially for fluctuations in value … if you didn't take those steps you would be moving outside into you hope contingent commercial contracts, but you could be on the slippery slope down to gambling.
>
> (Interviewee 12)

Contingent commercial risk is described by this interviewee as the grey area between derivatives and gambling, where it probably just escapes gambling regulation and hence holds onto derivatives regulation. It is not a conventional term, as they readily admit, but it does neatly encapsulate the complexities within derivatives regulation showing that the best way of thinking about these different forms of contracts may not be as separate entities but as a continuum. It is not insurance or derivative *per se*, it becomes more derivative or more insurance by sliding along this continuum (figure 6.2.).

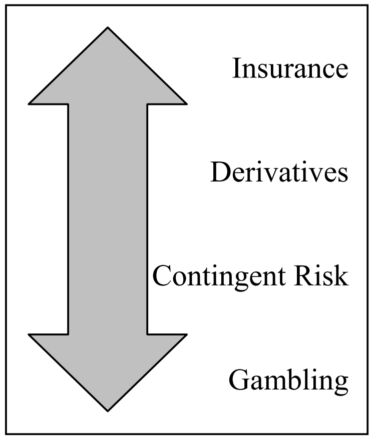

Figure 6.2. The continuum of regulation: insurance to gambling. Arguably the regulations are tightest at either end (derived from a diagram drawn by Interviewee 12).

Making sure a contract does not become gambling is important for two main reasons. First, gaming contracts are basically unenforceable. If the seller of a weather derivative contract fails to pay out on the contract they can be taken to court and forced to pay out. With gambling contracts, however, the courts generally will not have the time or desire to extract the money from the seller (Interviewee 12). Second, the sellers of gaming contracts are also more regulated than in the derivatives market. Sellers of gaming contracts must keep up to 90% of the total payout value in reserve in case that contract pays out. This is the regulation that bookmakers must abide by to ensure that they always have the money available to pay out. With derivatives contracts, however, a company need only reserve capital against that contract paying-out to the likely probability of a payout. If, for example, weather forecasts show that next month will be cold and the contract pays out if it is warm it makes little sense to reserve money against that contract. The capital can be better used. Thus derivatives allow companies more freedom to use their capital more efficiently (Interviewee 2). In reality, as one Interviewee (12) notes, these regulations have little effect on those companies looking to buy a weather protection policy that is a good hedge with their underlying risk (i.e. it meets classic derivatives requirements).

Issues over regulation therefore are complex but critical for the future development of the weather derivatives market. Whether weather products are predominantly insurance, derivatives or gambling has clear implications for the cost of the contracts, the enforceability of the contracts and the ability of different companies to buy and sell them. The battle for regulatory status and the enrolment of allies to support this is crucial, because of the ramifications of the regulations.

There is little doubt that weather derivatives becoming commodity derivatives under ISD2 has many advantages for the weather market. ISD2 protection gives weather derivatives a sense of belonging, a permanent identity. One reason, arguably, that WRMA have been so keen to put forward their campaign to the European Parliament is that it will have an immense marketing benefit, distancing weather derivatives from their roots in Enron, and giving them the credibility of a *bona fide* financial product. This is particularly important in southern Europe where there is seemingly less enthusiasm for trading weather (Interviewee 5, 12). Building the weather derivatives network thus requires the attraction of stronger allies (Latour, 1987).

Becoming a commodity derivative under ISD2 also helps with the enrolment of credit rating agencies who could become vital allies for the weather derivatives market.

There would then be no excuse for companies ignoring the costs of the weather as there are products for weather in the same way as every other risk. At the moment, the weather derivatives market is struggling to enrol credit rating agencies and one of the reasons for this may well be that it is not yet a conventionally accepted product. With weather derivatives included under ISD2, WRMA can present a stronger argument to credit rating agencies, because the EU has been enrolled. 'See,' they might say, 'it is not just us who are supporting this market, but *even* the EU have accepted the argument that weather derivatives are like other commodity derivatives'. Without having a strong ally in the credit rating agencies it will be difficult to force companies to use weather derivatives. Without strengthening the argument to credit rating agencies, however, they are unlikely to act too strongly on other companies as the weather derivatives market could be seen as not meeting the standards of other financial markets. Once the EU can be enrolled within the weather market, a whole set of other networks will be more rapidly mobilized, which would lead to the development and financial gain of the weather market. Campaigning to the EU and credit rating agencies may be seen as diversions from the main activity of making money in the weather market, but to reach that goal the weather market has had to go through many negotiations, many passage points (Callon, 1986; Latour, 1987). The weather market under ISD2 is a negotiated outcome and the new European regulations may produce new forms of market to that which it occupied beforehand. The processes of translation leave no party unchanged.

It is also important to note a potential danger to the US weather market that WRMA has been campaigning against, in the form of weather normalization clauses. This means that regulators would allow energy companies to pass on any weather effects on earnings to gas consumers. This has clear repercussions for the needs of the US energy sector to use weather derivatives and WRMA have thus campaigned the regulatory authorities to suggest that consumers should not be over-charged for the weather seeing as there is a weather product energy companies can use to protect their risks (Nicholls, 2004). Here WRMA need to enrol the regulatory authority to accept their arguments that weather costs are manageable and, the normative part, that the companies should manage the costs rather than being passed on to the consumer. Should this fail the US weather market would suffer a serious downturn in business. Making sure weather is a standard commodity derivative is thus vital to the market.

6.5. CONCLUSIONS

This chapter has highlighted some important questions for the growth of the weather derivatives market related in each case to marketing. First it considered the role of credit rating agencies and client networks in marketing the use of weather derivatives. Second it considered direct marketing strategies. Third it considered the marketing to regulatory authorities and the implications this might have on marketing the products more widely in the future. Firms are therefore being forced to change the ways in which weather risks are managed. For the weather market, however, it was imperative to enrol these actors to speak for them. Table 6.2. summarizes the consequences of enrolment of these actors for the industry.

Actors:	Actors enrolled	Actors not enrolled
European Union	"You see, even the European Union treat weather derivatives as commodity derivatives (like coffee or oil)"	"The European Union have not accepted the weather derivatives argument, why should we?"
Banks	"Our bank is telling us that we need to mitigate our weather volatility"	"Even our bank do not use or sell or recommend these products"
Credit rating agencies	"The credit rating agencies are advising us to use weather derivatives or we may be downgraded"	"Our credit ratings will not be affected by whether we use weather derivatives or not"
Climate change	"With the threat of climate change we must find ways to mitigate our weather exposure"	"Even if the climate is changing, there is nothing we can do to mitigate the effects"
Other companies	"If all our competitors are using weather derivatives, maybe we should too"	"Nobody else is using them, why should we? If it fails we will appear to be taking risks"

Table 6.2. The consequences of enrolment. The effects of enrolling key actors for someone's decision to use weather derivatives or not (with due acknowledgement Latour, 1987).

The fears about a changing climate are mobilized to support the weather derivatives industry's claim that not only is weather risk important anyway, it is especially important now because the weather is no longer normal. Rather it must be normalized through a financial market. This normalization however relies upon the necessity of weather derivatives being *bona fide* derivatives, that are supported by regulatory authorities, and that are mobilized by key actors in the financial world, in particular, credit rating agencies and banks. Building a network for weather derivatives is not just about attaining a whole series of things to support the industry. Rather the weather traders have to translate their goals to meet other people's interests and goals that then change the character of the products at stake. Weather derivatives are not derivatives by right, nor sold in particular forms because that is the only rational form they could take. They are thoroughly interactively and historically socialized through the sets of allies associated and enrolled within the goals of individual actors.

There are a number of centres of calculation that have to be passed through to attain the goals of setting up weather derivatives and generating profit by this. Banks, as centres of expertise, financial control and calculative economic information, become vital allies within the marketing of weather derivatives more broadly to clients of those banks. Credit rating agencies as centres of calculation, literally in the form of quantifying economic stability, become potential allies that would enhance the need for weather derivatives by removing the rationale for excusing ignorance. Regulatory authorities as centres of legal expertise also must be enrolled to make sure that weather is a real derivative so that further sales of contracts are enabled. Each of these centres have their own networks of interests and goals. Thus power may be conceived as decentred from the weather derivative industry itself, to being placed within the network. Yet this would miss the implications that power is also re-centred within those calculative centres. Banks, credit rating agencies, regulatory authorities do generate power by nature of their networks, but they are also endowed with the ability to wield powers as allies within other networks. With profitability a clear motive in many cases, it could be argued that there is therefore persistence of this notion across these networks. There is some form of shared goal.

The regulatory issues also point to another point about the movement of weather derivatives from their initial use within the US to Europe and beyond. In each region weather derivatives not only have to meet different regulatory challenges, they are also translated. Products are not simply stabilized and then transferred universally; they are translated in different settings, becoming qualitatively different things. In the UK, with banks taking on a leading role, the market regulation became more concerned with the status as *bona fide* derivatives contracts rather than the concerns about disguised insurance that influenced US debates. Similarly as the Dalian Commodity Exchange in China considers trading weather derivatives, issues there centre on gambling and cash settlement[1]. In the US and Europe, and as may happen to China in the future, it is not just the weather derivatives actors that are translating interests. The regulations in those countries are also brought into closer focus and may be changed during these regulatory disputes. Building networks into new geographical areas requires translation to meet pre-existing criteria and also translates those criteria. The geographies through which financial products move and are translated thus become critical to understanding the development of the weather market (and beyond) in different regions.

This network building goes to the heart of questions about who is using weather derivatives and the purposes of this use. At the same time it is clear from this chapter that the weather derivatives industry is engaging other actors, like regulatory authorities, and will likely have intended or unintended outcomes on the ways that others perform their business. Changing the old school that left weather unmanaged may open up a new era of weather risk management, but this will have consequences in a wide number of areas. The following chapter highlights some of these consequences by providing a case study of the use of weather derivatives in the energy sector in the UK. This suggests that energy companies are adapting and having to adapt to new business strategies and that this will potentially be extended in the future with consequences for government policies on climate change.

[1] Personal communication, Lucia Siu (05/07/06).

CHAPTER 7: ENERGY AND CLIMATE CHANGE

7.1. INTRODUCTION

Within the context of a growing consensus and fears about a changing climate, energy companies are at the forefront of debates, both in relation to the weather-sensitivity of demand for their services and their role in reducing carbon emissions and responding to government climate change policies. The energy sector is undergoing rapid transformations and since the 1980s has gone from a sector of engineers trained in producing power to being a sector dominated as much by energy services as delivering energy. Challenges of deregulation and policy have led to the period till 2010 being described as a critical time for energy (Jean-Baptiste and Ducroux, 2003).

In previous chapters, some of the meteorological and financial networks underpinning the weather derivatives market have been illustrated. These associations are important for understanding the historical development and continuing growth of the weather derivatives market, that is how other things shape weather derivatives, but they do not concretize how weather derivatives are shaping other economic sectors. This chapter focuses upon the energy sector's use of weather derivatives for three reasons. First it is the largest consumer of weather derivatives in the UK. Second it is the sector that has most engaged with constructing and extending weather derivative practices. Third it is also innovating weather products to serve specific requirements, particularly in response to government policies.

This chapter begins by outlining some basic statistics of the UK energy sector, before proceeding to provide a brief overview of the contemporary nature of the deregulated energy industry (section 7.2.). It then proceeds (section 7.3.) to outline some of the weather risks that challenge energy companies illustrating that weather risks are some of the most important factors in energy demand. Then in section 7.4. it identifies the ways in which weather derivatives are currently used to manage those risks. This suggests that the use of weather derivatives is not uniform in this sector as different institutional histories have provided different contextual environments and opportunities for trading. There are a large number of reasons why people become involved in weather derivatives and it is not just about mitigating warm winter risks. A changing climate has been cited as a reason for the development of weather derivatives and the importance of the energy industry in this market, but it may also be possible for weather derivatives to take on roles in mitigating the volatility associated with future climate.

Weather derivatives, however, may have more direct implications on climate policy through two newer areas that the energy sector is dealing with in response to government policies. One of the most important points in this thesis is that the network-building highlighted in previous chapters also has implications for contemporary issues in environmental governance. In section 7.5. the renewable energy industry is analyzed as it presents opportunities for tying weather derivatives into the financing of new industries and also it engages interactively with Renewable Obligation Certificates (hereafter ROCs). Financial markets do not just circulate money, they actively make a difference to the ways in which industries are financed and can conduct their business. This market interaction is addressed further in section 7.6. where the subject becomes the relationships between weather derivatives and the European emissions trading scheme (hereafter ETS)[1]. In both renewable energy and emissions trading, weather derivatives provide

[1] 'Emissions trading' refers specifically to the ETS that began in 2005.

practical solutions to dilemmas that energy traders are experiencing in responding to government responses to a changing climate. In the former case weather derivatives may serve to support the renewable energy industry, whilst in the latter case they may either buy time for companies to respond or circumvent the stated environmental objectives of the scheme. This chapter thus not only looks at the current use of weather derivatives in a particular industry, but also the wider implications of this on environmental governance.

7.2. OUTLINE OF UK ENERGY SECTOR

The energy sector is one of the largest economic sectors within the UK economy and is worth over £25,000 million a year (Littlechild, 2005). The energy sector consists of two main areas, gas and electricity. The two are interlinked, but are traded as separate products on energy markets and most companies separate the two operations internally. The total sales value within the UK energy sector is £27,826 million, of which £12,325 million is gas and £15,501 million is electricity (DTI, 2005). Gas consumption is increasing in the UK (DTI, 2005) and is made up of both large industrial consumers as well as domestic consumers. Most of the demand for gas is during the winter months for heating. Electricity consumption is also increasing and currently in the UK 29% of electricity is produced from coal, 39% from natural gas and 27% from nuclear power (IEA, cited in Rowlands, 2005). Renewable energy currently accounts for just 4% of total electricity production, compared to 1.7% in 1997, though the government has targeted an increase to 10% by 2010 (Rowlands, 2005). The energy sector is undergoing rapid changes at the moment as a result of government policies, first in deregulation and more recently in climate change policies that promote renewable energy and have also established an emissions trading scheme across Europe. Indeed this can be termed a critical five to ten years for energy (Christiansan and Wettestad, 2003; Jean-Baptiste and Ducroux, 2003; Markussen and Svendsen, 2005).

Prior to 1996 in the gas market there was only one gas company, namely British Gas (Table 7.1.). Though British Gas was privatized in 1986, only in 1996 was a competitive trial launched and in 1998 the full competitive market was launched (Interviewee 7). The system between 1986 and 1998 consisted of a series of companies that would supply energy to the national grid at a set price, whilst British Gas delivered this to the customers. These other companies sold their energy regardless of whether it was required or not and the system produced energy corporations that were primarily made up of engineers exploiting means of producing power more quickly and efficiently. To this day many of the executives on energy company boards are businesspersons trained in engineering rather than management (Interviewee 13). The electricity market prior to 1998 was predominantly composed of the twelve main regional electric companies, which, upon the privatization and deregulation of the market, were purchased by the energy companies whose names are familiar today.

These seven large energy companies comprise six that sell gas and electric to consumers and the National Grid/Transco, which is responsible for the large movements of energy across the country. They own all the large power transmission lines, whilst individual companies such as Aquila, who sell their energy pipelines/transmission lines to energy suppliers, operate smaller ones. The six main commercial providers of gas and electricity can be summarized in Table 7.1. These six companies are namely: RWE-Innogy, owners of npower; Centrica-Accord[1], owners of British Gas; Scottish Power, also

[1] Accord is the trading subsidiary of Centrica that engages in the trading side of the business. This separation of energy supplier and energy trader is prevalent in most energy companies, although similar

owners of Scottish Hydropower; Scottish and Southern, owners of Southern Electricity and Scottish Electricity; EDF energy, owners of London Electricity; and E.ON, owners of Powergen. These six are all to some extent involved in the weather derivatives market, a topic worthy of more discussion in section 7.3.

	Market	Shares	Electric %		Market	Shares	Gas %
Company	1998	Aug 01	Dec 04		1996	Aug 01	Dec 04
Centrica British Gas		18	22.5		100	65.5	56.5
Powergen		7.5	21.5			4.5	13
RWE-Innogy npower		18.5	14.5			9	9
EDF energy		10	13.5			2.5	5
Scottish & Southern	12.5	14	15			5	8.5
Scottish Power	7	10.5	12.5			4	8
TXU[1]		15.5				7.5	
Seeboard[2]	8	5.5				2	
Other RECs[3]	72.5						
Others		0.5	0.5			0.5	0.5

Table 7.1. The market share of the major UK energy companies in the domestic (i.e. not industrial) gas and electricity markets 1996/1998 to 2004 (Littlechild, 2005).

From the table it is clear that deregulation has had a major effect on the energy markets, allowing a group of six large companies to dominate the markets in both gas and electricity. Nevertheless there are some historical trajectories involved, as can most clearly be seen in the fact that Centrica still hold over 50% of the gas market. The

names for the two businesses are adopted, for example, EDF and EDF trading. The two are separated to aid accounting and credit ratings. In most cases interviewees, though employees of the trading company, will talk about the main company as a whole.

[1] Now defunct.

[2] Now defunct

[3] Most of the original 12 regional electric companies have been sold off to other energy companies in this table.

electricity market is far more decentralized. Both markets are susceptible to weather risks and in this deregulated environment, managing those costs becomes an important activity.

7.3. ENERGY AND WEATHER

How does everyday weather affect energy companies? This section can be split into three parts. The first is the direct effects of temperature upon sales of gas and electricity. Other types of weather events form the second, whilst the third is made up of the ways in which the weather influences prices in the gas and electricity markets. Of these three only the first two are protected by weather derivatives contracts, though weather-linked contracts may be used to cover the latter. These hybrid contracts have become somewhat popular with Deutsche Bank selling them to German energy companies (Anon, 2004a). These contracts protect against changes in both the price of gas and the volume of gas sold, whether those changes are from the weather or other events too.

One of the most important weather influences on the energy sector is the role of temperature in determining demand. 18°C has become normalized as the figure at which no heating or cooling is required and a 2°C change in temperature can shift revenues by as much as two-thirds of the total sales with costs running into the tens of millions of pounds (Interviewee 13)[1]. Changes in demands for energy can be modeled in a very straightforward manner as there is a near perfect correlation between temperature, in the form of HDDs, and gas demand, although the correlation is slightly weaker in the case of electricity (figures 7.1. and 7.2.). These clear quantitative measurements provide ample

[1] There are suggestions that though 18°C might be acceptable in the US, in the UK a figure nearer 20°C might be more appropriate (Interviewee 6).

evidence of the critical weather sensitivity of energy demand and, following the previous chapter, sufficient tools for marketing those products.

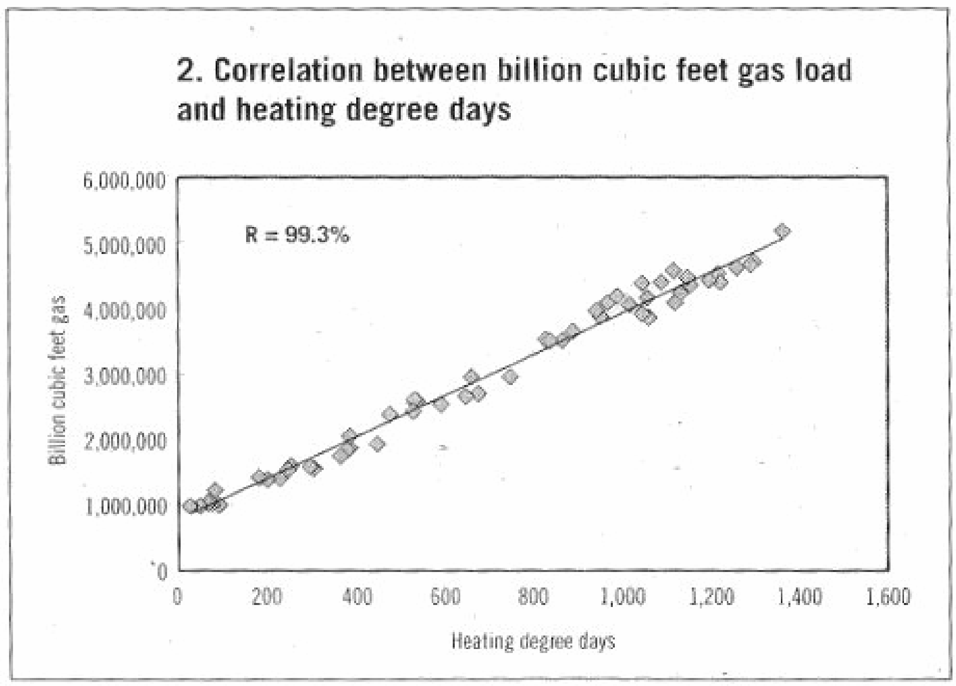

Figure 7.1: Correlation between gas load and HDDs in the US (Clemmons, Kaminski and Hrgovcic, 1999)

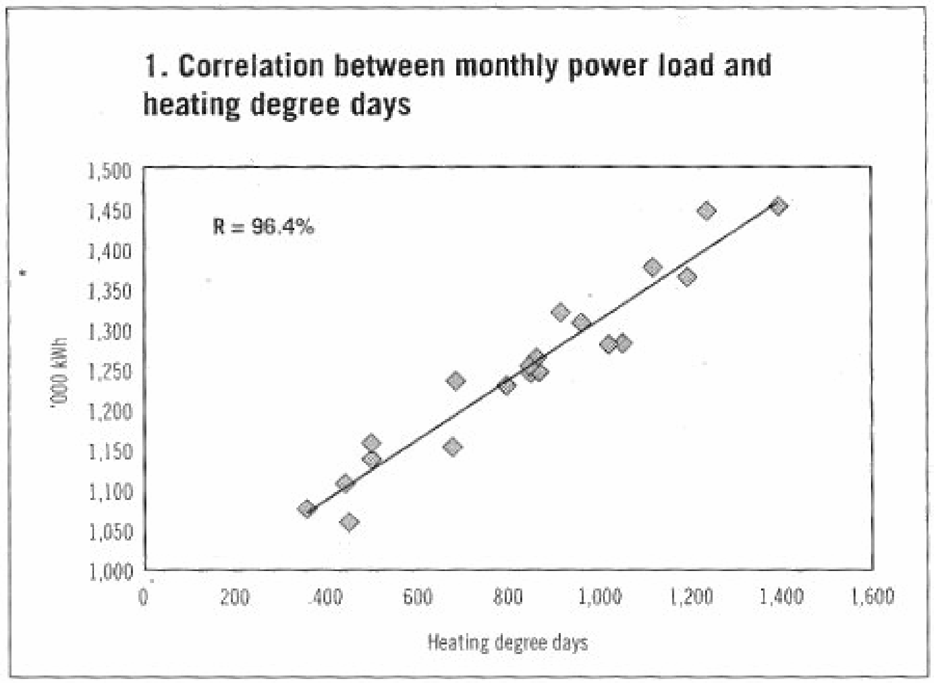

Figure 7.2: Correlation between power load and HDDs in the US (Clemmons, Kaminski and Hrgovcic, 1999)

The colder the winter the more heating is required and the higher the consumption of gas. In winters when the temperature is warmer than average, demand is clearly lower. This is a financial burden to most energy companies, particularly with fears over a global warming trend, as the winter is the key sales time of year, certainly in the UK. Indeed in winters 2002-2005 only two months have seen temperatures lower than the thirty-year average, namely February 2003 (-0.3% lower) and March 2004 (-0.7%) lower (Met Office cited by DTI, 2005). This trend of warmer winters arguably provided the rationale for creating weather derivatives in the first place. It should be noted, however, that if warmer weather does become more common during the summer then air-conditioning might become more readily available and this would create a more profitable summer market for the energy companies. In the UK the demand is lopsided at present as the relationship is much stronger for HDDs than it is for CDDs. During the summer, with the UK having much less air-conditioning than in the US, there is a far weaker effect of temperature. HDDs, as can be seen from this sketch, make intuitive sense to employees in most energy companies. The fact that the weather derivatives market has adopted them as their base indexes shows, as chapter 4 noted, the close historical relationship between the weather market and the energy sector.

Undoubtedly temperature is the primary component, but it is not the only influence upon the rises and falls of energy demand. Cloudiness is also an important component. A change from clear skies to cloudy skies increases demand as does a change from no precipitation to precipitation (Interviewee 9). An increase in wind speed or a change in wind direction can also rapidly increase demand (Interviewee 9; Rogers, 2003). There is little doubt however that the correlations between temperature and gas demand are by far the simplest and temperature is often more important than other events such as popular television soap operas like Coronation Street or the two minute silence on remembrance day November 11th (drop of 700MW) or an eclipse (drop in demand followed by 3000MW spike) (Rogers, 2003). The weather, however, does not only affect gas demand. It also influences the supply of wind power, for example, and the ability to generate renewable energy.

Despite the simplicity of temperature graphs (or other weather variables), in reality demand risk is not the only cost from changes in temperature and a very cold winter could be more expensive than a warm one due to increases in wholesale prices (Interviewee 13). Indeed the weather is a critical component in the price of energy supply. This is particularly the case in Scandinavia where much of the energy is generated from hydroelectric power and supply is highly correlated with precipitation. A sudden cold spell in winter will also lead to a spike in the gas prices, because suddenly demand will outstrip supply, particularly if the period of cold weather had not been adequately predicted. This price risk has largely been controlled through the gas market, hence the reason why many energy companies already employed some meteorological expertise prior to the development of weather derivatives. Energy companies however have also seen the acquisition of improved meteorological expertise through the weather market as having corollary benefits for the gas desk too i.e. the implications of weather derivatives stretch beyond the one market into the development of trading patterns in other markets. Though there are some linked contracts, most weather products for mitigation of risk are centred on the volume risk.

So the weather affects energy companies in a variety of ways and the next section will examine the strategies companies use to mitigate this risk. Temperature is the largest component of the weather derivatives trading, but the rise of renewable energy has made wind and precipitation key components of some contemporary contracts. This brief survey of the effects of weather on energy demand is critical in appreciating the rationale for using weather derivatives, but despite these clear correlations use of weather derivatives is uneven and not necessarily targeted at these correlations.

7.4. CURRENT USES OF WEATHER DERIVATIVES

With the energy sector a critical component of the UK economy, the potential ways in which weather derivatives influence future economic activity within the sector becomes a vital contemporary issue for government and society. It would be fair to say that prior to deregulation in 1998 UK energy companies took few steps to actively manage the costs of the weather upon their business, although they were still keenly aware of these effects as is evidenced in the fact that most companies employed meteorologists, albeit fewer and with less financial incentive than today. Since 1998, however, energy companies have employed people to attempt to understand and find creative solutions to the fluctuating costs that affect their business. At this stage it should be pointed out that the system of regulation means that consumer price rises are always somewhat restricted and therefore to increase profits, costs must be kept under greater control[1].

> It's only since 98 that we've had to sort of think about our risk … people can get their gas from ... anyone and we have to think about 'ok well we've got to give them better prices'
>
> (Interviewee 6)

Here an employee of one energy company provides a simple rationale. If the costs of the weather are kept under control better prices will be offered to consumers to encourage consumers to stay with this particular company. In a competitive market the assumption would be that most consumers will transfer to the cheapest operators, although this is often not the case (Littlechild, 2005), and hence keeping the costs under control is an important factor. Prior to the deregulation of the energy markets there was little incentive to reduce costs and reduce risks as the government bore the risk, not the company. The weather was, as Interviewee 6, states just accepted that "... it's in God's hands". The

[1] This may be why Pryke (2005) refers to the re-regulation rather than the deregulation of the energy industry. For consistency here, however, the term deregulation is preferred.

move to de-regulation has prompted a range of new cost mitigation measures and a series of strategies to increase profits, all of which must be achieved within the regulatory frameworks the government has established. Weather derivatives are one part of these responses and provide an illustrative example of the ways in which companies adapt to a changing regulatory environment.

Why does a UK energy company select to attempt to mitigate that risk and why choose weather derivatives? Some of the reasons can be explored through this extended quote.

> Since the market became deregulated obviously there's an incentive to hedge … to be clever and to just try and minimize our risks. At the end of the day our gas will be competitively priced or even cheaper than anyone else, because we use them [weather derivatives]. That's the whole idea. So since then we have always considered weather hedging. … It started with an internal decision … If you just look at how our demand varies with temperature you think there's no way we can live with this risk when there's a way of getting rid of it. It's just an easy decision to say 'let's try a hedge' ... I also believe now the City for example looking at [our energy company] and knowing that we weather hedge I'm sure they take that as a good sign that 'they're doing something to manage their risk' so I think it was always an internal decision
>
> (Interviewee 6)

For this weather trader, the decision to use weather derivatives was internal; it was not imposed. There was an energy product available, a weather derivative, that had been well-advertised within energy circles because of the marketing of companies like Enron, and energy companies had fewer challenges to overcome to use these contracts. Financial and meteorological expertise were being developed within most major energy companies, adapting to both gas and electricity trading as well as employing meteorologists to spot trends in one of the most critical external influences on their business, and it may seem straightforward that a company would use weather derivatives. Implicit in this quote, however, are two further points. The first relates to the image that this energy company will have within the City and hence to analysts or credit rating agencies. The management of a business risk also becomes a discursive strategy to obtain greater access to financial mechanisms and to promote an image of a risk-aware company. Although it may be an internal decision, it was also designed to engage the attention of other financial actors and influence their financial decisions based on this new information. Weather hedging is something to be proud of and to open up new opportunities for capital. The second point relates to the now competitive nature of the energy market post-deregulation and the need to attract consumers. Weather derivatives, the Interviewee reasons, will stabilize the earnings flow and hence cost savings will be passed on to the consumer in a bid to increase market share. It is profitable to weather hedge, not specifically for the trade itself, but because it has implications for the wider commercial success of a core business i.e. supplying energy to consumers. As far as can practically be judged, no energy company has yet informed consumers that they are using weather derivatives to bring lower prices to them. If something is profitable, it may not be advantageous to inform consumers as they might expect lower prices, whereas if something is costly, like the emissions market (see section 7.6. and Anon, 2005b), it is worth making public so that the cost can be passed on to the consumer. If the use of weather derivatives is beneficial for financial stability, corporate image and lower prices in a competitive market, all major energy companies should surely enthusiastically follow.

Yet even to this day some energy companies are far more reluctant users of weather derivatives than others. Rayner (2003) suggests that companies are sometimes reluctant to adopt new technologies or approaches because by using the old approaches even if a loss is incurred nobody will complain too much, whereas failing using innovative approach leads to immediate repercussions (Table 7.2.). This, he argues, lends conservatism to business practices. For some companies, therefore, the old approach to weather has been good enough, because any losses blamed on the weather will be accepted by shareholders. Yet this fear of innovation is not the only factor influencing a company's use of weather derivatives, there are also many historical and other institutional factors.

	Established Procedures	*Innovative Methods*
Desirable Outcome	Low visibility 'Business as usual'	Low visibility 'Why bother?'
Undesirable Outcome	Moderate visibility 'Soon forgotten'	High visibility 'Heads will roll'

Table 7.2. Payoff matrix for managers to adopt innovative methods, which leads many to stick to established procedures (Rayner, 2003: 285)

It was always going to be easier for some companies to use weather derivatives, argues Interviewee 13, because companies such as Powergen, Innogy and the former state monopoly that became Centrica built up huge cash reserves during the nationalized era. These companies were in a better position to take advantage of the new opportunities offered by the financial markets, because of their better credit ratings and previous experience in the City. Also those that became involved the earliest also took advantage of the most profitable deals, as the pricing and data issues had not fully been resolved at that time. Scottish Hydropower undertook the first UK deal in 1998, in a deal with Enron, and other companies such as Centrica swiftly followed. These two are still very active traders in the market, above newer entrants such as EDF trading and Powergen. As one trader suggests, there are fewer opportunities for profit now than there were in the early years. In an extension of a quote from chapter 4,

> ... the market was young, and we did some really good deals. ... They've all wised up to it. 'Oh yes' [laughs]! Our first deal was brilliant I mean it was just so perfectly hedged that there's no way we're going to do anything like that now.
>
> (Interviewee 6)

Interviewee 6, here, highlights that their first deal was "brilliant" and thus the 'positive' experience from this enabled the weather traders to pressure higher management to employ more weather risk management techniques as this clearly was a market in which money was there to be made. Hence profit again can be seen at the heart of the weather derivatives market and this reputation for profit can also provide a problem for new entrants into the market. There is a problem in selling weather derivatives as many want to "... win their first deal" (Interviewee 4). If the first deal does not result in a payout then that company will probably not take out another contract[1]. For the energy companies that were involved in the weather derivatives market at an early stage, they have subsequently developed their expertise to maintain a continual trading position within the market. It

[1] This is a real issue in the market today and one German golf club, after taking out a deal which did not pay out, failed to take out another stating that they would only use weather derivatives if they got hurt by the weather again (Anon, 2004b).

should be noted, however, that they are not able to perform as good a hedge again. They have to translate their interests to broker a deal, for the companies providing the risk capacity are not willing or able to trade on the previous basis. Here theorized notions of what weather derivatives should be break down into how deals are negotiated and what is ideal on paper is rarely what is actually achieved in practice.

For other companies it has been significantly more challenging to persuade the executives that weather trading should be commenced. Many managers and senior traders in the energy companies at this time were trained in engineering rather than business management. Their aim was to produce as much power as possible for the nationalized industry grid would purchase it all anyway, so this was clearly the most profitable strategy. Risk management, like the use of weather derivatives, is a relatively unfamiliar genre. Indeed one Interviewee (13) has had to engage in frequent dialogue with the board just to try and establish a contract that is purely about mitigating weather risk. Thus what is easily accepted in one company poses problems for many others. In part as noted earlier this comes down to cash reserves, but the level of financial knowledges must also take account of the individual, contextual environments of different companies.

The marketing to the German and Indian markets has been different to UK/US marketing with an explicit avoidance of terms like derivative, which have connotations of risk and danger. Interviewee 13 similarly suggests that when outlining weather derivatives to boards of engineers in energy companies in the UK suitable language has to be adopted with words like ‘hedge’ and not words like ‘derivative’, because the former is perceived as risk averse and the latter rather more risky. These discursive plays become a vital part of persuading people educated under a rather different system of business management to accept a new product with little public coverage. Interviewee 13, however, does note that the business culture can change within the space of a year. In the early years of the weather market in the UK, one energy company only employed a work-placement person to analyze weather risk and see what contracts might be done with little plan to actually implement them. One year later, however, the company line had changed to one of having to manage the risk and this time the weather derivative could be operationalized (Interviewee 13). Whether this decision came from internal reviews or from the increasing visibility of weather derivatives within actors like the credit rating agencies is impossible to assess from this research. Nevertheless it is possible to say that it can be related to the networks of associations that engage in performing a particular type of financial operation within this company, whether to do with credit agencies or reports, from within or from traders of weather derivatives, which associate lower profit margins with a growing environmental risk.

With the historical association between weather derivatives and energy, it is clear that it would be easier for energy companies to use these products. As weather derivatives distance themselves from the image of a US energy product under the control of the 'world's most innovative company' (Cruver, 2003) and become an important part of business culture, particularly within energy, there is no excuse now for energy companies not examining the management of weather risk, especially since most other major energy companies in the UK do it. The temperature market is the most developed within the overall weather market and the products are clearly available to manage an energy company's largest volumetric risk. This forms another reason energy companies have been more active in the weather market. The correlations between demand and weather are much better than in almost any other sector. As Interviewee 6 suggests

> To be honest temperature is the best for our gas exposure ... obviously coming up with a product with a composite weather variable just around the country isn't possible so we have to make the approximation of HDD. That's fine, we're happy to take that risk. Precipitation from a power point of view is probably more relevant [than wind]. There's such things as the MISERY index, people put on their heating if it's raining and if it's dark … I've looked at those areas but I've got a simple job. By far the best thing for us is temperature and the main thing we do hedge is our gas book.

Though it is admitted that the current temperature deals are not perfect, nevertheless the correlations are so good that a weather trader in an energy company has a straightforward job. Precipitation, wind, cloudiness may all be important factors, but they are happy to take that risk and just trade temperature as this is clearly the most important factor for them. Another trader (Interviewee 2), however, disagrees, arguing that it is not necessarily easy to pinpoint the exact weather risks that a company will face and their associated costs.

> You could take a utility liability where we have customers buying gas from us. If the agreement is that they will buy gas at a fixed price, then we have what we call volume risk and the risk is if it is cold we will sell more at a fixed price, if it's warm we'll sell less at the same price. Now if it's cold and we sell more we've also got to have that gas to give to them. So unless we have enough gas, we may have to go out to the marketplace and buy more gas at inflated prices. So there could be a cold weather risk there, because although we are selling more to our customers and there'll be a little margin in the price we sell it at ... we may be losing money because we have to buy more gas out in the marketplace where it's more expensive. If it's a warm winter and we don't sell as much gas, then we may actually have excess gas that we need to sell back into the marketplace and we

> won't get as much for it as we paid for it. So it's quite a complex risk … and I think you've got to try and break it down.

Here the trader is examining additionally the third type of risk that was identified earlier, namely the effect of the weather on the costs of wholesale gas and electricity. These decisions here become even more complex when placed in the context of emissions trading as will be seen in section 7.6. Interviewee 13 likewise asserts that though the weather derivatives market manages the volume risks relating to weather the most costly risk is undoubtedly a cold weather price risk. A sudden cold spell will push wholesale prices up and companies will be faced with buying energy at inflated prices and selling at lower fixed prices to customers. Indeed the cost of a cold period could be double that of a warm winter (Interviewee 13). This situation actually occurred in Scandinavia in 2003 (see section 7.5.) in relation to precipitation risk and renewable energy. Thus even working out the weather sensitivity of a company presents a number of complex issues and this may be cited as one reason many companies are unable to engage in weather trading. Formalizing the risk illustrates the nature of the sensitivity and Interviewee 2 is clearly integrating two forms of risk, price and volume, which was a critical separation in the early years of the weather market. Price risks can already be managed in the gas and power markets, and the key thing for the weather market to be successful (i.e. to grow), is for firms to be able to distinguish this price risk from the volume risks that can be hedged in the new market, though doubtless the interdepencies create opportunities.

The simple temperature deal is clearly at the core of the energy sector's use of weather derivatives. In 2004 for example Centrica took out their third contract with XL weather and energy, an insurer with most of its weather derivatives desk until recently based in Stamford, Connecticut (now the sales desk is in London). These contracts took the form of direct swaps (Anon, 2004c) though Centrica have also engaged in put contracts (Anon, 2005c). If the winter is warmer than average XL compensates Centrica x amount of pounds and if the winter is colder than average Centrica compensates XL x amount of pounds, with suitable collars placed on the maximum payout. It is not clear how large the deal is in terms of Centrica's energy risk, but as much as 80% of their weather risk on the demand side could be covered under this deal. Thus if the winter is warm and sales are down, the company will be compensated to roughly the amount of the lost sales. There are good reasons for doing this, not least because they have a steady income for the next few years regardless of what the weather does and they can make better business decisions. There is likely to be less volatility in their earnings, a smoothing of the profit and loss account, and hence more money available for new investments. The advantage of this deal for them is that it is a near zero-cost structure that is they are paying no premium (no sunk costs). What XL gains from this deal can only be guessed at, but they may be encouraging end-user deals which bring in new risk capital. They could well use this to engage in a lot of secondary market trading to pass the risk on to other companies or they may have some cold winter risk on their books and be engaging in a form of portfolio management. Regardless of the rationale for this particular deal, the motives are surely related to generating business for increasing profits.

More common are one-sided deals, which are sold for a premium. Indeed a recent article (Nicholls, 2005) has suggested that the growth in swap deals is particularly good for the market as there is a sense in which weather derivatives trading has become premium heavy. Interviewee (21) believed that weather derivatives had become a zero-sum game where companies after short-term profits were selling a call and a put rather than a swap primarily so they could charge two sets of premium instead of none. Many energy contracts like this are fairly straightforward calls which are taken out with a bank or insurer and will, for the upfront premium, pay out if the winter is warmer than average. For many companies these types of contracts are far more realistic than swap deals as credit ratings are less problematic (only one side's credit rating is important) and few have the time to search out a company that will take on the exact opposing risk.

> We try and push the put option, but the nice thing about swaps is that they are free. There's no up-front cost, but we have to say 'well are you big enough?'
>
> (Interviewee 11)

Though many companies would prefer swaps, issues like credit ratings prevent this and one-sided contracts have to be sold. These contracts, however, do have an immediate advantage in that though there is an up-front cost, there is no danger of losing a business upside, yet there is protection against the business downside[1]. In this way they feature more like standard insurance contracts and have become popular because of this (they are more familiar and less scary). There is a downside, however, which is that the up-front cost of one-sided contracts can turn some potential participants off the market. This is one more cost that has not been paid before and rather than seeing this as preventing future costs if the weather is poor, it is rather seen as something which has never been paid for before so why should it be now (Interviewees 4, 13). This opinion though may well be changed if credit rating agencies really start failing to accept weather as an excuse.

There are therefore two approaches to managing the costs of everyday weather through weather derivatives, the swap and the one-sided puts or calls. The different

[1] Upside and downside are terms for profit and loss, whereby in the case of an energy company, during a warm winter there would be a business downside, but a cold winter would produce a business upside. In a swap contract the business receives a set income, but cannot exploit the upsides it may otherwise have gained.

choices in structures can be down to credit ratings, individual corporate preference and also geography.

> The American utility companies prefer to enter put options on HDDs. They prefer to hedge their weather that way, to pay off the premium to have that exposure, but then they keep their upside if it's a very cold winter. They don't have to pay any money out. In Europe in particular the way that we favour entering structures is by entering two-way things. So they're free to enter ... but if it's cold we have to give up some of our upside and if it's warm we'll get compensated and we prefer to enter that because the whole idea of hedging is to smooth your p & l … we want to eliminate that weather risk from our portfolio.
>
> (Interviewee 6)

For this interviewee, hedging is more efficient with a swap contract. The two different contracts have a geographical feature here, which might be explained by the lower credit ratings of US as opposed to European energy companies and the higher levels of margining in the US. These two angles also present two discourses of risk, one, the swap, for those mitigating future risk to have a defined income, the other, the put or call, seeking an insurance against inclement weather for short-term gains. Although swap deals are still relatively rare in the market, except in Japan, it is noticeable that the energy company that most publicly advertises its deals, Centrica, has entered a mixture of put and swap contracts for its risk hedging strategy (Anon, 2004c; 2005c). Weather derivatives are clearly geographically diverse; they cannot simply be transplanted from the US to Europe to Asia. Contextualized knowledges are clearly important for adapting weather derivatives to suit the perceived differences in risk averseness and terminological fear in different cultures.

Energy companies also adopt different strategies to weather derivatives in terms of meteorological expertise. The employment of additional meteorological expertise within energy companies has advantages to many other parts of the business, not just to weather derivatives trading (Interviewee 19). It is only really in the energy sector that meteorologists have held trading roles. This expertise is valuable not only to weather derivatives for mitigating risk and speculative trading. The culmination of financial and meteorological knowledges can also be used as a product in and of itself. That is some energy companies are marketing themselves as new sellers of weather derivatives. As one Interviewee (6) explains

> People like Innogy for example have very big industrial customers that they can individually approach and say we're going to hedge your weather risk.

It is easier therefore for some energy companies to enter the market as sellers of weather derivatives, rather than or in addition to being consumers.

> We have our internal risk that needs to be managed, but now we've got experience in the weather market we can do like we do in the gas and power market where we have gas and power risk management expertise that we can take to other companies and offer them those kind of services and we can do the same now with weather. So it's profitable.
>
> (Interviewee 3)

Innogy and EDF trading, for example, do less risk mitigation themselves in preference of selling weather and financial expertise to their networks of corporate clients. Thus the investment in expertise for weather trading is not solely about mitigation, but also about profit. The implication here is that if this expertise could not be made profitable, there would be less incentive to actively engage in the weather derivatives market. Displacing environmental risks must be a profitable strategy for it to be followed. Others, particularly those with more domestic customers, including companies like Centrica and Powergen, are engaged more in mitigating their own risk rather than selling that expertise on to other people. Weather derivatives therefore are not just valuable as risk mitigation tools for energy companies; they can also be remunerative in the form of knowledge (as content) that can be sold on to other people. Not just this, but also knowledge that can be utilized for speculative trading and short-term gains. This multiple strategy highlights the various financial rationales for creating weather desks and that this must often be an individual decision, with no one factor, like the first trading date, seeming to explain this pattern. Individual firms are working out their own needs and uses for weather derivatives, making sure that profit can be generated in this process. With the energy industry a central sector in the UK economy the ramifications of weather derivatives upon that industry are critical for economic policy and beyond.

Finally is there any role for weather derivatives in mitigating the changes in climate that may adversely affect energy industries (and others)? This is certainly a possibility, although weather derivatives would only mitigate changes in volatility not the trend itself. This is not to suggest with Stern (1992; 2005), therefore, that a weather market could act to serve 100-year contracts to equalize the winners and losers of climate change, a possible, but not practicable type of trading, not least because why would anyone take on those risks. It is not clear that, barring moral arguments (Nutter, 1996), companies would take on unprecedented risks for the overall stability of the international economic system as Vellinga and Mills (2001) model for a financial market solution to climate change would propose[1]. The financial system as many interviewees (6, 10, 11) have suggested does not tolerate excessive risks, somewhat ironically perhaps (de Goede, 2004; Tickell, 2000), particularly in a market like weather that is relatively undeveloped. Weather derivatives cannot (at present at least) mitigate the overall trend, but they could be used to mitigate volatility around that trend.

> What we are seeing with climate change … is a greater volatility in weather … [V]olatility in the weather is what we aim to smooth
>
> (Interviewee 10)

The weather market is concerned with volatility in earnings in the relatively short-term, not over a long period of time, when uncertainties in forecasting are relatively large. Also to take on long term risks around global warming, for example, would also be to take up correlated risks i.e. the danger that they will all pay out at once. Bankruptcy could be a rapid result.

> Our aim is to smooth that line and if in 20, 50 years time the UK is a much warmer place then nobody's going to be protecting it against deviations from the averages we've seen in the past. They're going to be protecting it against deviations from the new average and as that average gets hotter or colder, wetter or drier then the market will change around that
>
> (Interviewee 10)

[1] Iain Hardie suggests that weather traders might negotiate long-term contracts, because for that individual trader as long as the contract does not lose too much money immediately they will probably have left for a different position before the problems can be felt (personal communication, Iain Hardie, 10/10/04). This would require an autonomous trader, however, as it is doubtful many corporate boards would permit such contracts.

Indeed this volatility in the weather is important for companies and is an important facet in mitigating the costs of a changing climate. In this sense, weather derivatives can act as a financial markets response to a changing climate. It is, however, a limited response. It is not climate change *per se* being mitigated (whatever that might mean), but the increased year-to-year volatility of future climate. Climate change policymakers cannot just invent markets to use for their own purpose and presume that the theoretical notion of market practice is constituted in market reality. Informed studies of market practice could be invaluable to environmental policymakers in the future. It also highlights that policies must translate business goals too if they are to be successful in achieving their own goals.

7.5. RENEWABLE ENERGY

With fears over the effects of CO_2 emissions on a globally changing climate, governments across the world have been formulating alternative energy plans. With coal-fired power stations being targeted a major source of CO_2 emissions, governments have been analyzing future energy plans that place less reliance on coal, but that combine a suitable energy production mix to ensure supply (Jean-Baptiste and Ducroux, 2003). Across the EU, €50 billion of capital investment is being made in renewable energy to the year 2010 (White, 2004). The UK government has pledged to produce 10% of UK energy from renewable sources by 2010 (Rowlands, 2005). Key to meeting this requirement will be hydropower and especially the wind industry.

Renewable energy is particularly weather sensitive and there is not just a volume demand risk, but a volume production risk. That is if the sun does not shine less solar power will be produced, low wind averages will result in decreased wind farm production, and dry years will undermine the hydropower industry. Expanding renewable energy is an important political objective and financing the industry has become a critical concern for meeting that objective. The analysis in this section thus illustrates the important role that weather derivatives could play within leading contemporary issues of environmental governance. It demonstrates that weather derivatives can have important effects on the likely successes or failures of particular policies.

Hydropower, for example, is clearly subject to precipitation risk and there is a strong correlation between precipitation and the amount of power generated. This becomes critical if changes in precipitation patterns are likely in the future, especially if there is increased volatility. If the precipitation comes down all at once there are serious difficulties in controlling water to manage any following dry spell.

> I think in terms of the world generally, I mean we say it's global warming, that trend seems to be wrapped up in it somehow, certainly noticeable … is that we get the same amount of rain each year pretty much, but we get long, long, long dry patches and then it thumps it down for a week or something like that which is no good
>
> (Interviewee 11)

If climate change is resulting in, or constituted by, more rain less frequently, the energy production may become less predictable[1]. Weather derivatives could effectively buy time

[1] The argument (leads to and constituted by) here is that changes in the climate may increase the incidence of unpredictable rain or winds, but that the changes in rain are indicative of a changing climate. It is a perfectly circular interpretation. There is not space here to delve into this interesting issue, but note that the IPCC steer clear from stating that climate change does something (see Houghton, *et.al.*, 2001). In other circles however there is some slippage as climate change is often said to be doing something to the weather conditions or society (examine the titles of papers, to begin with, in journals such as *Climate Research*). This highlights how climate change has taken on various ontological meanings in different communities.

for companies to adapt to the changing climate, by removing some of the volatility in earnings streams now, which hinders the level of capital available for new projects.

In Scandinavia, for example, a lack of precipitation can cause bankruptcy for energy companies as the price of energy goes up as firms increasingly turn to alternative power sources, particularly nuclear, yet they cannot pass on those costs to the consumer. For winter 2003, Interviewee 5 takes up the story.

> Last summer [2003] was extremely dry, the hydropower dams were all empty and then last winter … it was very cold and so everyone used a lot of electricity. So there was this combination of a lack of supply and increasing demand and so electricity prices went through the roof … As a result of that various companies went bankrupt … especially in Norway, where I guess, pretty much 100% of their electricity is hydropower … So a lot of companies are now trying to sell weather derivatives in Scandinavia saying 'well if only you had a weather derivative last year you'd have been OK, why don't you buy one this year', because it could well be a similar situation this year, because the dams are still empty and someone told me that unless they get three times their normal precipitation in the summer the dams won't fill up so there'll still be a shortage come next winter. If it's a cold winter, then the shortage of supply and increased demand, will drive the prices up again. So the obvious thing for people to do is buy a hedge against a cold winter.

Weather derivatives here become a vital part of the hydropower industry and the Scandinavian market has seen increased trading activity since 2003. Perhaps this relates to an earlier comment that companies often use weather derivatives only when they feel there is a need. Weather derivatives, to protect against these risks with hydropower, would not necessarily have to protect against the precipitation risk, contracts that can be more challenging due to the variability of precipitation from one location to another. As this quote emphasizes, the lack of precipitation may only become a problem if there is increased demand due to a cold winter. In any other situation, the risk may not be mobilized. In effect a hydropower company can buy a temperature contract, which will be more cost-efficient due to the greater maturity of the temperature market, rather than purchase a precipitation contract. This will protect against cold temperatures when the failure to produce hydropower would be most keenly felt. Hydropower presents quite a complex risk.

Wind is arguably becoming the most critical renewable energy source in the UK (Berry, 2005) and there are clear correlations with the weather. If the wind does not blow at the wind farm output is reduced and hence additional power has to be sourced from non-renewable sources at increasing expense. The lack of reliability of the wind blowing has led to many banks requiring some insurance against this volatility. The wind not blowing, however, is only half of the problem, because there are similar problems if the wind blows too strong as the wind farm has to be shut down temporarily. So the risk with wind is on both sides, too little and too much. There is little doubt, however, that the former is by far the most expensive and is the main source of earnings volatility for wind farms.

With the potential economic volatility of wind farms it has often been difficult for new wind-based companies to attract loans as their expected credit ratings are very low and they appear a poor, risky investment to outside investors. Some companies have become particularly pro-active about supporting the wind energy industry, for example energy traders EKT and several banks (Interviewees 11, 25). EKT invented a series of regional WPIs (discussed in chapter 5) specifically for use by the wind energy industry. These, they argue, are well correlated with a wind farm in any location in that region and hence can be successfully used within weather derivatives contracts.

Banks have also been encouraging wind energy companies to buy derivatives to reduce their economic vulnerability. Weather derivatives could become a key component of wind farm financing. The logic is simple. If Credit Lyonnais, to use an example, has been approached for funds by a new wind farm, that farm will not have credit ratings and there is currently little experience of wind energy investments. There is little likelihood that the bank would want to take on the risk of loaning the wind farm money without adding a large premium, or down-payment, or charging excessively high interest rates. In this situation the wind farm is likely to fail at the first hurdle, as financing will be too expensive. For the bank, however, wind energy is a growth industry as it is being driven by national and international policies. The wind farm will need financing for the first five to ten years at a minimum, but how can the bank ensure it gets its money returned with interest? To smooth the economic volatility of the wind farm, that farm could buy a weather contract that would compensate them for years when the wind does not blow enough. If the bank sell this derivative, they can keep some premium from that deal and know that the wind farm will earn x amount of money regardless of whether the wind blows. This means that their loan will be repaid with interest and thus the initial hurdle of volatility that prevented the wind farm obtaining an acceptable loan has been breached. The bank will make a profit on the deal regardless of what happens to the wind farm; their loan will be returned with interest and they might keep the premiums on the derivative contract. Wind derivatives are supporting the development of renewable energy, although the financial stability of these firms beyond the five to ten year period of the initial weather derivative is debatable especially if the weather derivative has proved costly to the bank.

Thus weather derivatives could become a vital component of wind farm financing. This is not just about managing the economic risk of the weather, but mobilizing weather derivatives to ensure that other financial channels, like loans, can be utilized. For the weather market this creates valuable liquidity in the market and it also sets a precedent for the future use of weather derivatives in the energy and other sectors. If banks start tying weather risks into their assessment of economic risks, in particular loans, more companies will be forced to use weather derivatives. This works in the same way as credit rating agencies using weather risk management as a criterion to judge economic performance and stability.

Here wind derivatives are arguably being used to support climate change mitigation policies. The derivatives are not part of a government-induced plan to 'push' forward the development of new wind farms. They are, rather, a market solution to a market problem and thus subject to market forces. If the government decides not to place money and emphasis on wind farms, especially with the option to return to nuclear power, this source of financial contract will clearly fade away. Another problem is time-scale. Whilst a wind derivative may secure funding for a wind farm and create economic stability for the first ten years it is less clear what will happen after this period. If the bank has paid out on that contract most of those years there is little doubt that they will either be unwilling to renew the contract or that they will wish to put a higher premium on it.

In a climate change scenario where the long-term maintenance of specified CO_2 levels is a priority, the failure of wind farms to be self-sustaining ten years into the future may be a worrying prospect. This would be particularly the case where wind farms are built in marginal sites with the knowledge of ten years financial security i.e. in areas where there is only just sufficient wind to justify the costs of building a wind farm.

Should the pattern of winds change or areas become less windy many of these marginal sites might become unprofitable. These farms are likely to close quite rapidly should the derivative protection disappear.

Weather derivatives are normally on short-term time-scales and traders can react very quickly to changes in the mean climate. As Dlugolecki (1996) and Nutter (1996) note in relation to insurance, because most contracts are renewed on an annual basis, insurance companies can respond very quickly to changing patterns or intensity of hazards. This quick response potential has been stopped in some parts of the world. In Florida, for example, local government stepped in to pass legislation preventing insurance companies reducing their business in an area by more than 5% a year (Dlugolecki, 1996). With insurance being a highly regulated business, this is more straightforward, but with weather derivatives, there may be little that governments can do to prevent banks and other sellers adding or removing cover as they see fit. Government policies may be thwarted, because of a less regulated industry that has (unintentionally) helped them in the past, but has ceased protection. As weather derivatives operate on short time-scales, sellers of these contracts will be quick to react to any climatic trends and move the strike point or increase the premium of the contract.

Many future climate change scenarios suggest that the weather will become stormier than in the past (Houghton, *et.al.*, 2001) and the increased wind speeds may be advantageous for wind farm operators. There is, however, a caveat. If winds should exceed safety requirements wind farms have to be shut down. Though changes in the climate may lead to and be constituted by windier conditions these may well be in the form of greater intensity of storms. Whilst an increase in average wind speed would help wind farms, increased volatility in wind speed would be less advantageous. In the future wind derivatives may need to take account of both sides of this risk, but also remain competitively priced. If wind farms lose financial stability, the loss of weather derivatives would further erode that stability and the perceived positive future of wind energy (Houghton, 2005) could rapidly turn to gloom. Climate, one of the factors arguably leading to the creation of the renewable energy industry, could act to economically destabilize that industry. Tied in to this network are a host of actors including the government, banks, the weather derivatives market, and as importantly the climate. Non-human actors can play vital roles in the ways in which the human world creates its business, conducts its networks and so on. Thus although wind derivatives can be seen as a supportive step in the encouragement of renewable energy in the UK, these effects may be ameliorated if these contracts are not renewed or if there are any external changes in the weather derivatives markets.

Weather derivatives can become a financial component of developing the renewable sector in the UK, which leads to some broader questions about the role of finance in these forms of projects. Financing firms is still a relatively neglected part of economic geography (Pollard, 2003) and here the role that the financial markets can play with the development of an industry is clearly illustrated. Finance is not something that falls into place when policymakers require particular decisions, rather it has to be enrolled to support (or not) particular projects. There is pressure from WRMA, credit rating agencies, banks, other companies and so on to use weather derivatives in particular contexts, which has implications for financing industries as well as the circuits of finance that ultimately reflect back on the sellers too.

Finally, what role will ROCs play in all of this? ROCs have become a key part of the government's encouragement of renewable energy. Each company has a number of

ROCs and if they cannot meet their criteria of renewable production must buy in additional certificates to cover this shortfall. Conversely if a company produces more renewable energy than its target it will generate excess ROCs and can sell these to other companies. The economic value of ROCs obviously varies depending on both the total number of ROCs in the market and the demand for them. Producing ROCs can be economically advantageous and several energy companies are exploiting the economic benefits of switching to renewable energy (Interviewee 13). One potential problem with the system is that the returns on ROCs become less as more companies become involved in renewable energy production, but so far this has not been an issue.

If an energy company has most of its renewable energy in wind, if the wind does not blow the company will not produce any ROCs. This will be of financial detriment to the company as it cannot cash in excess ROCs and may have to buy additional ROCs in the marketplace. A wind derivative could be purchased such that if the wind does not blow, the contract will compensate that company for the estimated cost of buying ROCs or the estimated potential loss from not being able to sell ROCs or the payout could be denominated in ROCs (Interviewee 10). The ROCs market thus could potentially drive the weather derivative market. No company has so far publicized any weather derivative deals on this basis, but several Interviewees (2, 6, 13) from energy companies mention the possibility of doing this kind of deal.

The market can also work in reverse. Effectively one could trade the wind risk through the ROCs market.

> If the wind doesn't blow, you won't produce as many ROCs so you maybe could hedge your wind risk by buying in ROCs, but we've yet to go down that road.
>
> (Interviewee 2)

If the wind blows, a large number of ROCs will be produced; if the wind does not blow there will be less ROCs in the market and the economic value of ROCs will increase. If the company has stocked up on ROCs at the start of the year they can sell these back into the marketplace for a profit at times when the wind is not blowing (hence hedging wind risk through ROCs). This provides extra financial protection for a wind farm as they can make money on the ROCs even if they cannot make money on the wind. So relationships between weather derivatives and other environmental markets can be complex, but energy companies are exploring these interrelationships for market opportunities. The government imposes restrictions on the number of ROCs available in the marketplace to encourage wind energy, but wind energy companies exploit this market at times when renewable energy cannot be produced, a risk mitigation strategy. Trading in ROCs or weather derivatives or their correlations provides not just mobilization of renewable energy projects, but also speculation and the ability to buy time in responding to government policies (Byers, 2004; Interviewee 13). These networks of government power and business finance within the energy sector are therefore complex (Boehmer-Christiansen, 2003). The competing agendas of different actors are worked out through passage points (Callon, 1986), but the interests are thoroughly translated in each case to the aims of that community[1].

The government is encouraging renewable energy under pressure from international bodies such as the EU and the Kyoto Protocol, each of which are themselves networked bodies of interests and agendas connecting politicians to climate science. The energy companies need to make a profit for themselves, because a failure would be seized

[1] There is not sufficient space here to discuss nuclear energy, but suffice to say that if the government returns to nuclear industry, people are considering the potential to sue the government for the costs of implementing renewable energy (Byers, 2004).

by shareholders and credit rating agencies alike, so are interested in renewable energy for the profit margins that it might be able to generate, particularly if the cost of fossil fuels increases. Wind farms however are expensive and therefore need to mobilize loan funding to establish these projects. Banks, however, also have to answer to their own economic concerns, hence the requirement for derivatives. The weather derivatives community is welcoming this extra activity, because it should encourage not only an intensification of weather derivative use by those already in the market, but also other companies to become involved in the market. Most of the energy companies are already active in this market so it is a familiar terrain, which they are growing in experience and confidence about. The government, however, has created new financial markets such as ROCs and emission, which are not market driven, but policy driven. These markets happen to be correlated with markets in which energy companies feel more confident and they can therefore exploit these links by backing up potential costs in the government markets using a private industry market.

The EKT patents on its WPI also highlight the issues of using private markets for climatologists and for government. For the former, it demonstrates how commercially valuable knowledges will be protected through the legal system especially where the economic factors are influenced by external policies. For the latter, it suggests that whichever way government policy leads, even if it is openly ethically or socially responsible, profit will be accrued on the way. For both, there must be a concern that in the future the commodification of these knowledges may alter the ways in which science and government are conducted. Weather derivatives arguably reduce reliance on coal-fired power stations and help develop clean energy. Renewable energy must be profitable to be sustained, whether that profit is derived from the energy created from it, or the finances underpinning it. One normative question that arises is merely is it better to make the environment part of capitalism in an effort to promote green issues or is this a form of selling nature out (McAfee, 1999)? Yet as the emissions market shows, environmental markets are increasingly the preferred mechanism for environmental governance. Here too weather derivatives are having implications.

7.6. EMISSIONS TRADING

The IPCC has produced global emission scenario reports (hereafter SRES) of the future changes in the amount and composition of carbon in the atmosphere. These SRES scenarios can be fed back into climate models to determine the future emissions cuts that need to be made to create a particular future climate (Arnell, *et.al.*, 2004). Skipping over debates on the efficacy of carbon cuts on future climates (Boehmer-Christiansen, 2003; Byers, 2004), political acceptance and consensus has grown to cut CO_2 emissions where possible to reduce the likelihood of accelerating global warming. Since the Kyoto agreement was first announced (prior to ratification), the EU has examined different ways to promote the reduction of emissions, down to the baseline 1990 level, within their border[1]. Tietenberg (1990), in a different context, and Fiddaman (2002) have examined different environmental approaches to businesses highlighting that there are two main approaches. First is the institution of laws, controls and procedures to force businesses to change. Second are market-based instruments that through financial incentives encourage businesses to change. For emissions trading, the EU elected the latter option, which was

[1] The 1990 baseline has become mobilized as the figure everyone makes plans around, yet it is not clear what level of CO_2 emissions are 'right' to produce the 'desired' climate nor how to engineer that future climate most effectively. There is not space here to discuss the ethics of climate control and geoengineering, but see Jim Fleming's forthcoming book on Fixing the Weather and Climate (due out 2007/8).

favoured more strongly by businesses, although possibly not by EU governments (Boehmer-Christiansen, 2003).

The UK emissions market began in January 2005 in line with the overall ETS. This was going to be implemented regardless of the ratification of the Kyoto Protocol. It is clearly important to government objectives and hence warrants the focus on it in this section. What is the ETS? The scheme will run in two stages up to 2012, 2005-2008 and 2008-2012. The industries involved in the ETS include energy, paper and steel amongst others, although there is no place for transport (the industries involved are estimated to make up about 46% of the EU's CO_2 emissions). Each country has a national allocation of emissions allowances, which are distributed amongst the firms in each company who are required to be part of this scheme. Each company will receive an ever-decreasing number of allowances over the years and if they exceed their allowance will have to pay a fine (€40 per tonne of CO_2 for 2005-8, €100 per tonne 2008-12) and buy in the relevant number of allowances from the market at market prices (Biello, 2004; Byers, 2004). Across Europe there are differences on how this mechanism will function. In the UK each company will be responsible for purchasing required emissions allowances, whereas in the Netherlands the government will buy the extra allowances as companies require them. In the long run the number of allowances available on the open marketplace should decline and therefore their economic value will increase. Currently the credits are valued at about €25 per tonne of CO_2, but this price may be being flattened by the cheap availability of allowances in Eastern Europe. This is due to allowances being set at 1990 levels of emissions and many countries in Eastern Europe have substantially reduced emission levels. Indeed in the UK allowances are far greater than current emissions output so there is little economic incentive yet to drive companies to reduce emissions levels further.

Emissions costs are potentially injurious for energy companies as passing these costs on to the consumer on an individual basis is tricky as the competitive nature of the energy market means that market share would probably decline. Nevertheless in July 2005, the rising cost of carbon credits was cited as one of the reasons for the rise in energy prices at Powergen (Anon, 2005b). Therefore energy companies have to seek out alternative strategies to managing the costs of these emissions policies. There has been an active forward trading market in EU allowances since February 2003, a clearly speculative activity although the ETS did look very probable at the time, and spot trading began at the start of the scheme in February 2005. The number of allowances being sold in the market will be heavily dependent on how much renewable energy each company has been able to produce; the more renewable energy produced, the less CO_2 polluting non-renewable sources used, and hence the more allowances that companies can sell into the marketplace. This is clearly a weather-related risk, on both the supply and the demand side.

On the supply side, Rowland (cited in Biello, 2004), writing in 2004 before the start of the scheme when estimates of carbon prices were expected to be €7-10 per tonne[1], claims that

[1] It is an interesting point that this estimate of up to €10 per tonne on average for the 2005-8 period was the figure quoted during 2004 by many presenters at business conferences, in *Environmental Finance*, and in journals like *Energy Policy* (see for example Berry, 2005), yet which underestimated the price of carbon, around €15 per tonne in spring 2006 (down from €25 per tonne earlier in the year). Whether this is due to systemic miscalculation or to do with certain policymakers or the energy industry creating a number that they perceived to be correct and which others then mobilized as correct, is unclear, but the rising values actually mean that the use of hedging mechanisms becomes more not less urgent for these companies. One caveat, however, is that the volatility in emissions prices suggest that the potential for external shocks are as high as those related to weather events, thus limiting the usefulness of weather derivatives. At the time of writing, however, this was not stopping plans for a weather-emissions index (discussed in more detail in the next paragraph).

> If we went into one wet year, we could see the price of carbon dropping to €5 per tonne … On the upside, a dry year would only raise the price to around €18 per tonne

This is due to the dependence upon hydropower for renewable energy in Scandinavia. During wet years the Scandinavian energy companies would have excess allowances to sell into the market thereby deflating prices. A UK energy company would therefore be affected by Scandinavian precipitation. The same applies to hot weather in France when nuclear reactors have to be shut down due to warm water problems and these patterns are replicated across Europe (Byers, 2004).

A weather index is currently being designed that will act as a proxy of the overall production of renewable energy across Europe and this could be traded to manage a company's emissions exposure. For example, if a UK company has to source more energy than expected from carbon-producing sources it will have to buy in the relevant number of allowances from the ETS marketplace. If Scandinavia has been dry, there will be fewer allowances available in the market making the cost of buying those allowances much more expensive than under wet years. This is an unexpected increase in costs for these companies, which may have relatively little to do with the weather conditions 'at home'. Thus to reduce that emissions cost a company could buy a precipitation derivative in Scandinavia such that if extra carbon allowances have to be purchased, if it is a dry year the company will receive compensation on the weather contract that will partly defray the additional costs from buying in the allowances. A weather index could also be created across Europe, an idea first put forward at the WRMA conference in London in 2004. This would mitigate wind, rain, temperature and so on across the relevant parts of Europe and provide a much more sophisticated hedging instrument than one that simply protects against one area of risk. All the leading energy companies could use a weather-emissions derivative to reduce their exposure to European weather events in the ETS. There would be an obvious advantage to this over traditional weather derivatives as it would cover the risk of renewable energy failing in more than one country under just one contract, which would be much cheaper than having to buy several contracts to cover the different risks in different parts of Europe. Thus there may be workable correlations between emissions allowance prices and the weather. Emissions costs here could be managed through the weather market[1].

An energy company in the UK will likely be dependent on wind energy as its major renewable source. If the wind does not blow, that company will be forced to use more carbon emitting energy sources with the resultant need to buy increased emissions allowances. To manage this risk, energy companies are actively looking at purchasing wind derivatives that will be valued at the expected cost of buying in the emissions allowances. So if the wind does not blow, the company will be compensated to the amount required to pay the emissions allowance and penalty. In this way, companies have less economic incentive to try to reduce their use of non-renewable energy sources. If a company can effectively manage their emissions cost, which of course is dependent upon a low hedging cost in the weather market, regardless of whether the wind blows, regardless of how much renewable energy is produced, the economic profitability of the company will not be affected. Obviously as the value of the emissions allowances increases, the value backed up in the weather market will have to increase and the WRMA conference in London in November 2004 was actively involved in encouraging this

[1] It should be pointed out that obligations can be carried forward till 2008, so there may be less requirements for weather derivatives until that time.

activity (speakers have talked about this subject at subsequent WRMA conferences too). This highlights that companies are adopting strategies to mitigate new regulatory environments, but that this is dependent upon other circuits of capital, namely the financial capacity to back-up these contracts. The networks of finance are interlinked.

On the demand side, if the weather is cold more power has to be generated and the quickest way of producing energy is coal power plants (Interviewee 4).

> Emissions credits will kick in when it's cold … if it's very cold and demand goes through the roof more and more old coal plants will come on … then you're also going to have to pay a lot of money for carbon credits to cover running that plant.
> (Interviewee 4)

This will cost the company money in emissions fines, but this risk is clearly weather sensitive. Many interviewees (2, 3, 4, 6, 11, 12) have speculated that there is a role for the weather market in hedging this risk. If the emission allowance and fines are dependent on cold weather a straightforward solution is to purchase a weather derivative contract that will compensate the company to the amount of the fine and allowances when the weather is cold. This could potentially be a good liquidity maker for the weather market, because most energy companies want compensation when the weather is warm and here is the type of opposite risk that will aid portfolio managers. Of course it could have the opposite effect as energy companies realize they have both sides of the risk and hedge internally with no need to purchase a weather derivative.

Some companies, however, drive this strategy one step further, as Interviewee 6 explains.

> What is interesting is the correlation between emissions and weather, because … let's think about an electricity producer, if it's using an installation which is capped but it's the cheapest way to produce that electricity if it gets cold, you have a question. Do you go for the penalty of producing too many emissions i.e. above the cap level and make a profit on the stuff you sell or do you not produce and then miss the profit or you could you hedge the emissions penalty you're going to pay by using weather derivatives? And it's not well understood at the moment, but there are clearly sort of correlations in that the amount you need to pollute is related to weather in a great many industries. So it may be weather has a role to hedge emissions.

Energy companies are seeking out strategies to balance a set of demands, from consumer requirements for energy, to the costs of emissions credits and the cost of weather events. Each company will work out different strategies to dealing with these new risks and opportunities. Could a company make a profit out of selling extra energy to the market in the cold weather, particularly if other companies are afraid to because of their lack of emissions allowances, and hedge the cost of that emission using a weather contract? The quote that "the amount you need to pollute is related to weather" tends towards a suspicion that energy companies will be exploiting the emissions market for profit opportunities (see also Bachram, 2004).

The financial justifications are clear for mitigating emissions costs, but questions must be raised about the partial circumventing of the 'purpose' of the ETS in the first place i.e. to reduce overall emissions. There are two assumptions in this argument about the role of emissions trading. Firstly there is an assumption that emissions markets are designed to reduce emissions. A sceptic could respond that they are merely a business show, supported (or not) by government, of making pretence to be doing something about the changing climate. Emissions markets do not necessarily have one purpose; they are a negotiated outcome, which is the product of the needs and desires of a whole range of actors, from carbon-emitting businesses, to politicians and to climate scientists. Secondly, the use of weather derivatives for this purpose would only be short-term, as they clearly cannot protect against long-term changes in emissions prices. That does not mean of course that weather derivatives are not circumventing regulation to a certain extent, but that the process may always be somewhat limited. The concern is that because energy companies may have taken out the instability and many of the financial costs associated with emissions trading, they may also take out the value of the climate change mitigation policies that implemented this trading system in the first place. This may reduce the financial incentive for companies to reduce emissions supporting a 'carry on as usual' scenario. Weather derivatives, Stern's (2005) financial answer to a changing climate, rather become a potential critic.

Yet the use of weather derivatives to stabilize energy companies financial flows within the emissions markets may not be completely negative for policies mitigating future changing climates. The smoothing of the revenue stream may allow these energy companies to invest additional money into renewable energy plants, which will help them to reduce their reliance on power plants that emit CO_2. In other words, the use of weather trading will buy time to work out the best ways to fix the newest (regulatory) problem. This use of weather derivatives would be much more supportive of climate change mitigation policies and is one that proponents of the use of weather derivatives in the emissions market like to express, certainly informally[1]. It is more likely, however, that energy companies look at mitigating the costs of emissions without an actual regard for

[1] When challenged at industry conferences, seminars etc informally, this is one argument that is presented (personal communications, Anon, 27/01/04).

how this will affect climate change mitigation policies[1]. It is not the responsibility of each individual energy company to concern themselves with the potential effects on climate change mitigation policies; that is the concern of policymakers, government and climate scientists. Here weather derivatives are just used to mitigate risk. Ironically perhaps they may achieve in this area that mitigation rather than speculation that has been desired in the overall market. Nevertheless there are doubtless opportunities for speculating as well on both the weather market and the emissions market.

Regardless of whether the weather derivatives market was designed to mitigate the costs of emissions trading and it clearly was not, it is a use that the market may be put to in the future. Again this highlights how, like many technologies, a financial market may be constructed for one purpose, but used for a variety of others and that this use may have far-reaching implications beyond its own boundaries. Many other industries will also be affected by emissions trading, but most of these may not use weather derivatives as they do not have the expertise in this market that the energy companies have obtained. The effects on the ETS may therefore be somewhat more limited, but it may be important for non-energy companies as the use of weather derivatives could raise or lower the price of emissions thus changing the strategies that these companies may have implemented. This could result in those companies being disproportionately more conservative about emissions and also investing more in emissions reductions. The use of weather derivatives thus may have other implications for the wider market on emissions and for other industries. Who bears the primary costs of emissions trading may come down to the industry least able to hedge those costs in other markets.

[1] This is the more usual response to questions about their planned use of weather derivatives to mitigate emissions costs (personal communications, Anon, 27/01/04).

Though there is still uncertainty about future climate changes at regional levels (Houghton *et.al.*, 2001), there will undoubtedly be an influence on emissions prices in the future too. Using the examples drawn upon earlier, if the average wind speed declines or if it becomes more variable there will be less companies using wind energy and hence more demand for additional emissions credits. Similarly, if precipitation in Scandinavia declines or becomes more unreliable, the demand for emissions credits is likely to increase. Changes in climate could therefore have implications on the production of energy and the costs of carbon emissions.

As noted earlier, weather derivatives only mitigate volatility around the trend and not the trend itself. There is the potential, as with wind energy, that weather derivatives become too expensive to use for the mitigation of emissions costs. In this scenario, as well, renewable energy would also be struggling financially and emissions prices would be very high. This would either make weather derivatives financially acceptable again or would lead to the collapse of the European energy industry. It is another dilemma that policymakers examining the issues of a changing climate face. If there is more volatile wind and precipitation, renewable energy becomes a far less successful strategy. If this occurs, will there be enough capacity within traditional energy resources to continue the current levels of energy production? If not, what will be the future answer to energy, nuclear power? Changes in the climate thus act upon the policies designed to target those changes; they take an active role in re-constituting policy.

Returning to Tietenberg's (1990) and Fiddaman's (2002) division between market or control approaches to dealing with environmental issues, the emissions market perhaps illustrates that using market approaches allows firms to invent new products or corroborate with existing markets to reduce their exposure to the environmental issue. On the other hand, the use of weather derivatives in the emissions market can testify to the success of environmental markets in that it allows businesses to slowly respond to environmental problems without suffering detrimental immediate economic or trade setbacks (within the EU). That is it allows a gradual adjustment, a temporary fix, to the greater environmental awareness that will be required in the future. Though attribution of future changes in climate is unresolved, it is clear that those very corporations at the heart of carbon emissions may also be the ones most able to find financial fixes to either the effects of a changing climate or to the policies designed to manage a changing climate. The trading of goods in Chicago, the financial fixes in one space, is not just about the financial markets there, but the connections they have to a host of economic and environmental repercussions elsewhere (Cronon, 1991). There may be some credibility to claims that fears of a changing climate merely act to extend the current political-economic system (Bachram, 2004; Boehmer-Christiansen, 2003; Paterson, 1996).

7.7. CONCLUSIONS

This chapter has provided a case study example of how weather derivatives operate in practice in one sector, the energy sector in the UK. This has demonstrated the role that weather derivatives now play in mitigating the weather risks in a specific industry and some of the implications of this trading. Following deregulation in the energy sector in 1998, weather derivatives have taken on an increasingly active role in the risk management products utilized in the sector. Weather is clearly correlated with energy demand, and with the experience gained in other financial markets, it is not difficult to see why the energy sector is the most important part of the weather market today.

The chapter has demonstrated how weather derivatives are changing the typical ways in which companies have responded to weather risks and the motivations for engaging in weather trading. These motivations are various from the creation of profitable activities to the fear that leaving the weather risk unmanaged is no longer possible in the days of climate change. As Interviewee 6 put it there's now "no way we can live with that risk". The weather risk has become normalized in a financial product, whereby it becomes necessary, or morally compulsory (de Goede, 2004), to protect against that risk. Yet many energy companies in the UK have been rather slower than anticipated to adopt weather risk management, perhaps due to a lack of formal recognition in financial channels such as the credit ratings system or share prices. There is not a singular knowledge about the effects of weather on the energy company's profit or loss, rather different communities housed in different companies have created different understandings both of that relationship and also the best ways of managing that risk.

Analyzing the current use of weather derivatives, however, has only been one part of this chapter's aims. The other has been to suggest some implications of this in the future on climate change policies. The renewable energy industry and the emissions markets, respectively, both become new profitable opportunities for weather traders. The former is particularly centred around banks' financing of renewable energy projects and the earnings volatility that many of them arguably suffer from. The latter is about managing the new government-induced markets on CO_2 which are weather sensitive and hence which volatility can be managed using weather protection contracts.

These practices clearly have implications for government policies to mitigate a changing climate. Whilst weather derivatives may, at least in the short-term, support renewable energy projects they act within the emissions market to buy time or circumvent emissions regulations. This would suggest that Fiddaman (2002) is perceptive in suggesting that tax-based schemes may generate more environmental action, as financial markets generate financial responses, not necessarily environmental ones. This could be positive, however, in terms of the stated policy if companies buy time to invest money in much more strategic emissions reductions, rather than the easiest ones that they might have to when acting on short time-scales.

Finally Stern (1992; 2005) has suggested that weather derivatives could be used to mitigate the effects of a changing climate. Whilst it was argued that volatility may be managed in this way, it is unlikely that a long-term climate index will be available with sufficient risk capacity to enable trading. It is also perhaps indicative that the solutions to a changing climate, insurance and financial markets, protect the very institutions that may have been responsible for the problem in the first place through their carbon emissions. Climate change thus, for Paterson (1996), furthers 'ecocolonialism'. Who would have access to these contracts is a moot point, not least due to the financial knowledges and levels of market access (credit ratings, capital availability) required. Thus the actors mobilizing data, forecasts, finance, marketing and so on, are just one part of the weather derivatives market. The other is a peculiarly tougher side that has implications not just on the ways in which firms conduct their business in the future, but also for environmental governance.

CHAPTER 8: CONCLUSIONS

8.1. INTRODUCTION

Concerns about the actualities of a changing climate have prompted a re-engagement of the relationships between firms and ‘the environment’. Firms have hired individuals to examine the corporate sensitivity to weather or climate effects, and from this people began to examine the possibility of using financial markets to manage particular types of these risks. Since 1997 there has been an expanding weather derivatives market that has encompassed a diversity of interested parties concerned about the impacts of everyday weather on their operations or sales. The creation of weather derivatives, however, relied on a whole host of allies, from meteorological to financial. To accomplish a project of weather derivatives required the enrolment of data, forecasts, banks, credit rating agencies, climate discourses and the creation of a discursive necessity to manage weather risks. This financial market also has a series of implications for those allies too, in that it not only is shaped by them, but it re-shapes their businesses too. The re-valuation of data, the creation of different types of forecasts, the necessity to manage weather risk, and so on, can all be cited as examples of this. Weather derivatives are also having important ramifications for climate change policies, particularly as they relate to the energy industry. Thus they are not only a response to climate change fears, but they are also shaping financial responses to those fears and to government policies derived from those fears. Weather derivatives thus matter for both issues of financial management and for environmental governance.

As the story of Farmer Henchard highlighted (chapter 1), trading based upon the anticipated effects of weather is not new within the financial markets, but the weather market is the first attempt to actually separate weather risks and trade upon them, rather than through approximations in the prices of other goods. The weather prophets may have been superseded by the multiplication of methods for scientifically forecasting, or calculating, future weather, but the pragmatic decisions made by weather traders are similar. Gaining a competitive advantage is a key issue and any forecast, information, must have utility. Weather trading, from being a black art, has become sanitized and normalized in the financial markets, with a whole series of repercussions, which are qualitatively different from prior forms of weather trading through commodity markets.

For the WRMA European conference in Toulouse in 2006, one company offered a weather derivative contract on temperature for a lucky participant, with the payout a 'grand prize'. The participant is chosen through a weather forecast contest on a weather derivatives index, which contest is initiated two weeks before the conference to allow for some forecasting effectiveness (WRMA, 2006). What is happening at a small scale here is being replicated in larger quantities internationally by companies seeking protection from and looking to make money with the weather.

This thesis has highlighted the importance of undertaking research on weather derivatives and in this final chapter summarizes three main groups of take-home messages. First it outlines some of the important empirical findings from the thesis (what one considers important is of course dependent upon the standpoint). Second it suggests some ways in which the research here prompts renewed theoretical engagements over nature, science and society, as well as the critical issue of knowledge. Finally it highlights the policy implications that flow from this research and shows that weather derivatives may have a series of consequences for implementing particular types of policies. This suggests that scientists and government need to engage in empirical attention to the practices of financial markets and corporate finances in relation to policies on environmental markets and business understandings of climate change.

8.2. KEY FINDINGS

8.2.1. EMPIRICAL CONTRIBUTIONS

The main empirical contributions can be broken down into five main areas. First is the historical genesis of the market within the US energy sector that has had a wide range of repercussions on the weather market to this day. Second is that the enrolment of meteorological allies was fraught with pragmatic decisions and contradictions, but this in fact created a trading market. Third is that marketing weather derivatives is a critical factor in establishing the market. Fourth is that the UK energy sector's use of weather derivatives is uneven for a variety of institutional reasons. Finally is the importance of combining knowledges within the weather market and the necessity for skills in both natural and social science.

First, the weather market emerged within the energy sector in the US as a response to concerns about changing weather patterns that would adversely affect their business, the insurers lack of expertise and willingness to write contracts on these risks and the deregulation of the energy sector at that time. Though part of a history of commodifying meteorology, weather derivatives have emerged through the stabilization of a particular network of actors at a specific time that allowed a somewhat standardized product to emerge around which people could trade. Weather derivatives could have become a different product, but for a series of contextual reasons including the experience of financial markets in the energy industry, the regulatory framework that prevented them using insurance and the indexes chosen for trading, which suited particular needs at that time. Though it has become a $45.2 billion market in 2006, the hoped-for growth when the research was conducted failed to materialize at that time and the weather market always appeared on the edge of the next big step (Nicholls, 2004). This can in part be associated to the persistent image of weather derivatives as an energy product and the ways in which they were designed to suit energy companies' needs. Few can doubt the potential of the market with 70% of UK firms being weather sensitive (Met Office, 2001), but so far the growth has been muted by the relative paucity of new end-user entrants into the market. Even with the recent rapid expansion the number of new end-users has not matched the involvement of hedge funds.

The current weather derivatives market embraces banks, insurers and energy companies, as well as brokers, meteorological service providers and a range of other companies. This includes the construction sector, the site of the largest ever weather derivatives transaction, the leisure industry, particularly golf clubs, the agricultural sector and the retail sector. Yet though this wide diversity of actors presents a broad range of companies, in reality there are a few key actors in the market. The banks, insurers and a few energy companies provide the main part of the market as they offer large amounts of risk capacity, and in the latter case, also purchase high-value contracts. Hedge funds are playing an increasing role, particularly as people like Mark Tawney establish new weather-led hedge funds. Though weather derivatives at this moment have been described in this thesis, they are still in a mode of becoming an accepted financial product, and there is undoubtedly scope for further research in this subject in the future (see section 9.3.).

A second key contribution has been the pragmatic and instrumental use of meteorological data and forecasts within the markets, whilst at the same time the level of investment in meteorological expertise has increased. Good quality data are vital to the weather market as the settlement of contracts relies on accurate measurement and the pricing of contracts depends upon consistency. For some traders, the nature of weather data is an important issue, but others dealt with it more pragmatically, arguing that as long as everyone was using the same data then it did not matter whether it was accurate or not. Similarly for forecasts where some traders consumed vast numbers of forecasts for using in trading decisions, whilst others generated their own in-house forecasts for competitive advantage and others, engaged mainly in hedging risks, argued that forecasts were not important as they could not mitigate risk. These meteorological allies have been enrolled in various ways by different actors and it is clear that there is no singular interpretation of future weather. Indeed if there was, then there would be no need for a trading market nor any trading as there would be a situation of perfect information. Yet most traders do use forecasts and some invest in meteorological expertise, which has led to a privatization of meteorology, albeit on a relatively small scale. Patents, lawsuits, data charges are all repercussions of this corporate system of managing the data measurement and collation processes. Weather derivatives therefore are prompting a renewed engagement with issues of meteorological data, forecasts and expertise, and this may have a series of implications for meteorology.

Third is the marketing of weather derivatives. An important contribution of this thesis thus has been to highlight the ways in which weather must be normalized as a financial product to permit trading, and the enrolment of financial allies. Weather is no longer an excuse, it must be actively managed, a message that WRMA hope credit rating agencies will begin to use more strongly. To develop a weather market requires a range of supports; from credit rating agencies to force companies to use weather derivatives or face downgrades and consequent loss of financial access; and from banks to utilize their client networks to persuade companies that they must use weather derivatives if they want to secure certain types of financial commitments; from regulatory authorities that weather derivatives are *bona fide* commodity derivatives and should be freely traded as such. These networks of allies are in negotiation and whether the weather market can tie them in strongly enough to support its projects is an unanswerable question at present. Marketing weather derivatives, however, requires not just that these financial networks are in place, but also a need to use these products and climate change or climate change policies are providing this sense of urgency. Fears about future climate are translated into the necessity to manage weather risk now. Weather is no longer uncontrollable, it must be actively managed.

A fourth empirical contribution is the case study of the UK energy sector that highlights that the rationale for using weather derivatives, even within one sector, can be quite various. The use of weather derivatives is uneven and can be related to the historical development of the market, the reserves of money individual energy companies have available, the types of expertise on the board (engineers may see derivatives as more risky than financial managers) and the different weather sensitivities of different companies. Energy companies have also varied between buying contracts to mitigate risks, engaging in speculative contracts and selling on meteorological and derivative expertise to other companies. Two new areas are also emerging that may promote the development of weather derivatives and both result from government policies on climate change mitigation. The difficulties of financing renewable energy have highlighted the need for risk management products that could enable these companies to gain better financial access. Tying in weather derivatives into bank loans could be beneficial for both the bank and the company. The energy sector has also been responding to the creation of a emissions trading scheme across Europe where the price of carbon credits may be weather sensitive and hence the variability in costs of credits could be readily managed. These two areas also have implications for government policy (section 8.2.3.).

Finally another key contribution is that there is a combination of knowledges used in trading weather derivatives. Traders combine both financial and meteorological expertise, to model both future changes in weather and how to price these into contracts. Yet weather derivatives have implications for both, requiring the development of new areas of seasonal forecasting that many in the public sector are unwilling to engage in concretely and the development of new ways of pricing derivatives as Black-Scholes may not be correct for weather contracts. The engagement with both sets of expertise, albeit that they arguably both have a fundamental mathematical base that aids unification and decision-making, points to the fact that though academics struggle to operationalize interdisciplinarity, it is already in practice, and a source of profit, in the business world (Pollard, *et.al.,* forthcoming). This reflects upon the nature of the world, that it is dappled (Cartwright, 1999) and that therefore there are a plurality of knowledges, each of which has something to say about certain things. The empirical work here thus provides a rationale for the combination of theoretical insights and the epistemological plurality suggested by the theoretical comments in chapter 2.

8.2.2. THEORETICAL CONTRIBUTIONS

This thesis has put together a framework that allows for an empirical study of weather derivatives, even if at times this framework lacks an over-arching unity. It is important to do this, because there are very practical outcomes of this understanding, particularly as weather derivatives become increasingly important financially, meteorologically and also for government policies.

Commodifying science or nature is not inconsistent with the actual, contextualized enrolment of interests to support any particular project. That profit is constructed in specific ways does not deny the corporate regulations that inspire a necessity to create profit by an individual trader and the implications of this desire for profit on the framing of the industry. Without doubt the corporate institutional environment at Enron was innovative, but new products had to become profitable quickly if the innovators were to retain their positions and their product. Weather traders, similarly, have to meet sales targets in order to keep their jobs, and the rising value of meteorological expertise has also led to increasing levels of income meteorologists can expect to earn in this industry if they supply better information. Commodifying weather data, regardless of the individual context of this development, implies a requirement to make profit, whether this is the weather derivatives market trading on weather data or the ways in which meteorological service providers espy rising profits on this data. Yet the pragmatism with which data accuracy is sometimes treated also points towards the importance of finance over meteorology. The most pervasive conclusion that can be drawn from the empirical material, therefore, is that at the core of weather derivatives has been a need to make profit. Weather derivatives speak to wider concerns about the profitability of 'nature'.

Is the story of weather fundamentally different from other products, for example, Cronon's (1991) account of the commodification of grain? Grain had to be made standardized, knowable, conformable to allow a speculative trading market whereby paper futures became distanced from physical grain. This distance also allowed some opportunities for exploitation including the mixing of different grains to circumvent the grain measurement system. So too with weather, where meteorological data is standardized into a product that is eminently tradeable and takes on a life separate to physical weather. At the same time knowledge of moved thermometers becomes critical to understand the product being purchased. Though the context is different, commodifying weather in this market seems to bear many of the same hallmarks as prior commodifications, suggesting that there might be some continuity and persistence in the networks creating new monetary opportunities. It is inconceivable to say that this persistence could be used to explain the development of weather derivatives now in this manner, but there is some unerring repetition in the stories. This suggests that the macro-analyses of Marxism can be held in tension with the micro-analyses of STS to produce detailed empirical analyses that tie to wider occurring themes.

Understanding the networks of actors that combined to create weather derivatives and the constant re-configuring of this network highlights the practical applicability of STS techniques to the understanding of new products. This thesis has highlighted that the stories of weather derivatives illustrate the ways in which actors translate their interests to achieve a settlement on the new product in a variety of ways, from the negotiations with meteorological data suppliers, to debates over financial options pricing theory, to the enrolment of other institutions that could strengthen the case that these products are indeed derivatives. Enrolment of allies, the concept of translation and centres of calculation provide intuitive and important ways of analyzing the development of weather derivatives. It also highlights the continued negotiations ongoing in 2005 to establish weather derivatives as a *bona fide* commercial product, illustrating the fact that weather derivatives are still in a process of becoming; the science or product is not yet settled. Yet if settlement is concluded to be the end of debate, then weather derivatives may never reach that cherished ideal, as the knowledges contributing to the trading of these products are thoroughly pluralist. The networks are also being extended beyond the initial range of actors and as they are extended they are having a host of practical and policy implications. The next section thus shows that STS approaches can also highlight practical outcomes; they do not just have to tell stories.

The example of weather derivatives traders also emphasizes epistemological plurality and that this is actually efficacious in creating liquidity in the market. Different conceptions of knowledge may be equally valid as they are assessed within different communities. That some traders prefer statistics and others physics does not mean that only one can contribute to an understanding of the problem. Business models may be instrumental in nature as they serve particular purposes, but this does not make them any less credible *per se* than publicly produced models. All knowledge creation is arguably goal-oriented in one way or another (Longino, 2002). Thus, to speak to broader debates on commercializing science, it is important not to simplistically reject private funding of science, but rather to tease out in more detail than available here exactly how funding influences the generation of knowledge, both historically and in the present day. It is not clear that private science is necessarily less diverse than public science. The sciences are therefore conditional, the best currently available, rather than one monolithic truth

(Demeritt, 2001a; Longino, 2002). Diversity and pluralism should be acknowledged because the world is dappled and multiple understandings are possible (Cartwright, 1999).

> These observations ought not issue in a rejection of the concept of knowledge, but a recognition of the complexity of the situations we seek to know and the uncertainty that accompanies our best efforts.
>
> Longino (2002: 213)

8.2.3. POLICY IMPLICATIONS

There are clearly dangers in drawing policy implications from research into new and emerging areas as the practices are still yet to be settled. Nevertheless this section provides a brief overview of some potential conclusions that may influence climate change policies, in particular, mitigation policies. There is a tension in climate change policymaking between suiting policies to particular model outputs and yet avoiding some of those model outputs. Though this thesis cannot attempt to answer this question, there is an irony in that policies designed to mitigate climate change may be inappropriate under future climate change scenarios. This is particularly the case in renewable energy. Regardless of this caveat, the thesis has raised a number of issues in relation to current climate change projections derived from the IPCC and the policies used to prevent these projections becoming reality. Three will be discussed here.

The first is the concept that markets are the answer to environmental issues, or as McAfee (1999) puts it, the idea of selling nature to save it. Undoubtedly markets are often the preferred options for businesses facing specific environmental issues, not least because they can slowly adjust to these concerns, but they may also be one of the only ways of getting businesses to do something about the environment. As this thesis has shown, and Fiddaman (2002) highlights, the dangers of market solutions to environmental issues is that other markets provide solutions to the original market solution. The ways climate change policy is utilized within the weather derivatives market is clearly one example. Though more research is needed, the evidence in this thesis suggests that weather derivatives are having implications for the future success of climate change policy. For all the interesting ways in which they have been created as a series of enrolments of actors and subsequent trials (Latour, 1987), this effect is very real. This is a key issue for policymakers as regardless of the way the market is created, people are inventing new products to manage those costs and extract profit in the process.

A second policy implication is found in the role of weather derivatives in financing renewable energy, where the political targets to increase production from these energy sources is offset with the difficulties of financing these ventures. Here weather derivatives are enrolled as a means of financing an industry, which raises questions about how policies are actually implemented financially. Finance is not a black box (Pollard, 2003) that materializes to support policy, rather it has to be created or engineered, and the role of financial markets in this process may be neglected or may be subject to large assumptions. This thesis has showed that derivatives can be used to finance an industry, but that this is not a direct government intervention from the policy, rather it is a market solution to the problem. For policymakers this poses interesting questions about the way that policies are implemented and the financial channels exploited for this purpose. There is, however, the caution that derivatives cover can be relatively easily withdrawn and also the issue that future climate change could directly influence the future profitability of these projects. Though wind farms may seem an ideal mechanism for mitigating climate change by reducing carbon emissions, they may not be practicable if climate change leads to situations where renewable energy is less productive. The relationships between science, finance and policy are thus exceedingly complex.

Third is the relationship between emissions markets and weather derivatives. As emissions markets' have such a short data series available it is difficult to create a financial derivative based on emissions. Therefore the search for alternatives to manage the costs of emissions credits is already underway, especially in the energy sector, and weather derivatives present a possible source. Weather is undoubtedly a key component in the price of emissions and thus trading products that mitigate the weather risk can be used to manage volatility in the prices of these credits. Is this about companies managing the short-term volatility to aid long-term investment, or is this about finding a temporary fix to the costs of emission credits, or is this about circumventing climate change mitigation policy? The thesis has suggested that actors within the weather derivatives market are not actively trying to undermine climate change policies, rather they are setting up arbitrage opportunities, but the implications of these practices are to focus attention away from the spirit of emissions reductions arguably intended in emissions trading. Emissions trading is an unwanted burden for energy companies (Byers, 2004), but circumventing this scheme has repercussions for the future directions of energy and climate change policy. In fact, more draconian regulations could be worse for energy and other companies, so they may not want to advertise too much weather trading. What is at stake here is not just trading on weather, but the connected policies targeting reduced carbon emissions.

At the core of renewable energy financing and emissions trading, however, is a search for maximising profit opportunities and there can be little doubt that if these contracts were not likely to be profitable then they would not be undertaken. It may not be a direct commodification of nature or information that has ‘negative’ implications, it may instead be in the implications that they have on other things or markets. A key question that follows from this, and this thesis cannot attempt to answer, is can environmental issues be reconciled with the need to make short-term gains? If they could, would the fact that profit was being made from environmental protection matter (and to whom)? Future research projects will need to investigate these kinds of questions.

Weather derivatives may also gain support from changing patterns of weather associated with, and constitutive of, climate change. Fears of climate change are undoubtedly leading to a re-examination of companies’ weather sensitivity and the ways in which climate change could affect their business. Adverts for the weather market mobilize the concept that normal weather no longer exists and that companies must take control of their weather risk. Weather derivatives become an answer to growing financial fears over climate change, a financial ‘fix’ to the environmental problem, even if they cannot prevent or mitigate the costs of climate change. This may allow companies to buy time from the environmental issue at stake to either invest money in infrastructures that will aid adaptation to a changing climate or to at least make profit during the process. They may, however, increase the potential that “the world kicks back” (Barad, cited in Whatmore 1999: 5).

8.3. END NOTES

Some directions for future research can also be envisaged. With the rapid increases in notional value, the weather market is also rapidly expanding into new patterns of trade, which may be different from those recorded in this research. Clearly as the weather market develops it would be interesting to research other economic sectors as energy presents a very specific element of weather derivatives and other sectors might experience the market quite differently. In addition the role of hedge funds should be researched further as they are increasingly important in this rapid market growth. With weather derivatives being predominantly an energy product it may be challenging for other companies to enter the market or to find the right products to mitigate their risks. Energy is thus a unique sector at present and offered the only opportunity for a case study, but this is not to deny the ways other sectors might use weather derivatives differently.

There is also scope for further analyses within the social studies of finance tradition. This thesis has only touched in a rudimentary basis upon the use of Black-Scholes and the creation of financial models and doubtless, with the work of Pryke (2005), for example, many more studies of weather derivatives from these perspectives will emerge. Weather derivatives clearly not only present challenges for the pricing community they also present opportunities for watching the science of finance in action.

On a longer temporal scale, one future direction will be to examine the use of weather derivatives as the renewable energy and emissions markets grow and stabilize. Though this thesis has focused upon many well-prepared plans for this, a few years may provide concrete examples of how companies are actually putting these plans into action and what the implications might be for climate change mitigation policy. Should weather derivatives be used to hedge emissions costs, questions may also have to be asked about the viability of market-based schemes as a vehicle for environmental governance.

With the World Bank also encouraging farmers in India to use weather derivatives, future research could analyze in more detail this use and potential use in ‘developing’ countries. Here there are different challenges and different types of products required yet the transfer of risk from local farmers to a global marketplace is a challenging political-economic issue. Not just this, but proposals to use weather derivatives to mitigate climate change could create very distinct geographies of protection. Who benefits from this, the profits of banks or the local farmers or companies, is a moot point. Thus more research may be needed to establish the potential of financial markets to aid adaptation to future climates by mitigating the costs from the losers of a changing climate.

Further work could also explore new product areas for the weather derivatives market including the more extended use of snowfall contracts and proposed river ice contracts. Not only this, but in chapter 6 ISDA were quoted as suggesting that the weather derivatives market will take a more active role in the future in crop and flood markets, more typically the province of insurance contracts. What would the imposition of new financial products into these areas mean for the protection against risk and where would the lines be drawn between derivatives and insurance? As noted in the methodology chapter, engaging in a new project in the future may also result in different conclusions, due to the greater familiarity with the weather market, the interviewing of participants a second time and an increased temporal understanding of changes in the weather industry.

Other research could focus on different types of trading on the weather derivatives market, so instead of primarily looking at end-users (some of whom also engage in speculative activities) and the risk-capacity providers, it would also be useful as the market expands to examine the increasing importance of hedge funds or traders actively looking at weather as a market uncorrelated with other financial markets. These traders may have different motivations and trading patterns to those interviewed as part of the present research.

There are still many theses to be written on the weather derivatives market, particularly if it continues to expand. This one is a necessarily dated, partial attempt to grapple with some of the fundamental questions that are at the heart of weather derivatives trading and the practical implications of this. Trading on weather indexes may have been inconceivable in the past, particularly without sufficient trust in data and forecasts to create the market. Weather derivatives are a distinct product of this post-modern society, one in which risk is commercialized and traded upon. Weather and climate are no exception, especially as they are endowed with political, economic and scientific meanings in the wake of growing concerns about a changing climate. Weather risk can no longer be left to providence; it *must* be actively managed.

Whilst Mr Henchard in *The Mayor of Casterbridge* (Hardy, 1994) aimed to make hay while the rain fell with a gamble on the price of wheat, the sun shines upon Mark Tawney (Swiss Re advert, chapter 6) who can mitigate the costs of the weather upon businesses. With weather indexes traded in a financial market, the risks of the weather have been brought within the realms of finance, no longer as an externality, but as a controllable risk. The weather, however, has frustrated many plans throughout history (Durschmied, 2000) and its capriciousness provides both a rationale for weather derivatives and potential dangers of speculating with them. As Henchard states "... you can never be sure of weather till 'tis past" (Hardy, 1994: 217).

APPENDIX 1: RESEACH MATERIALS

Formal Interviews (referenced by number in the text)

Number	Date	Type[1]	Nat[2]	Position/Company
1	24/04/03	N		Product Manager, Exchange A
2	15/05/03	TR		Weather Trader, Energy Company A
3	15/05/03	TR		Managing Director, Service Provider A
4	15/05/03	TR		Chief Executive, Service Provider B
5	28/05/03	TR		Director, Service Provider C
6	19/06/03	TR		Analyst, Energy Company B
7	19/06/03	TR		Trader, Energy Company B
8	24/06/03	N		Seller, Broker
9	02/07/03	BRF		Analyst, Energy Company C
10	12/11/03	TR		Vice President, Seller A
11	01/12/03	TR		Seller, Bank A
12	05/12/03	TR		Partner, Law Firm
13	20/02/04	N		Analyst, Energy Company D
14	Multiple	E		Analyst, Energy Company E
15	23/03/04	N	US	Project Manager, Exchange B
16	30/03/04	N	US	Executive Vice President, Seller B
17	31/03/04	N	US	Forensic Meteorologist, Consultancy
18	31/03/04	N	US	Managing Director, Seller C
19	02/04/04	N	US	Managing Director, Seller D
20	02/04/04	N	US	Meteorologist, Seller D
21	02/04/04	N	US	Independent Consultant
22	27/05/04	TEL	US	Consultant, International Institution
23	Multiple	E	US	Market-maker
24	05/11/04	BRF		Seller, Bank B
25	05/11/04	BRF		Business Manager, Energy Company F
26	02/12/04	N		Former Meteorologist, Seller E

[1] TR – tape recorded face to face interview, N – note recorded face to face interview, E – e-mail interview, TEL – telephone, note recorded interview, BRF – brief personal communications face to face often conducted at conferences

[2] Country that the interviewee was based in if not UK and hence where the interview took place (with the exception of interviewees 22 and 23, where the telephone or e-mails officiated over international exchange)

Personal Communications (not referenced by number in the text)

	27/01/04
[Title, Organisation]	27/01/04
	27/01/04
	Multiple occasions
	14/09/04
	15/09/04
	09/10/04
	10/12/04

News and websites

A systematic survey of news articles on weather derivatives conducted using Lexis-Nexis and websites such as www.artemis.bm

Subscription to the industry journal *Environmental Finance*

Presentations from WRMA conferences made available on www.wrma.org

Conference materials

Comprising note-written records of and, frequently, powerpoint slide handouts from two conferences. Text boxes (1) and (2) provide details of the presentations given at these conferences.

(1) 27th January 2004. Environmental and climatic trading seminar, Clifford Chance, London

Presentations by:

Howarth, N. (Clifford Chance) Environmental trading – an overview of trading schemes and products

Redman, M. (Clifford Chance) The EU Greenhouse Gases Directive and the UK Emissions Trading Scheme compared and contrasted

Elshorst, D. (Clifford Chance) The German experience in environmental trading

Panel discussion. The impact of the EU Scheme on local Markets

Reumann, U. (Clifford Chance) Environmental trading and its regulation

Brown, C. (Clifford Chance) Documentation and legal issues of environmental trading

Turing, D. (Clifford Chance) Effective risk management for emissions allowances and renewables portfolios

Brown, C. (Clifford Chance) Weather products overview

Boening, J. (Entergy-Koch Trading) The role of wind hedging in wind farm project financing

Tretheway, N. (XL Weather and Energy) Using weather hedging as part of a corporate financing strategy – a case study

Johansen, L. (Clifford Chance) Documentation and regulation of weather risk management products

Other conference materials including three short reports on emissions trading and the WRMA/ISDA weather derivatives and confirmations and appendices booklet.

Patents

UK Patent Application GB 2 389 930 A (World Publication Number WO 03/107231 A2) filed by Entergy-Koch Trading for "Method and system for creating wind index values supporting the settlement of risk transfer and derivative contracts"

US Patent Application US 2003/0126155 A1 (World Publication Number WO 03/058379 A2) filed by Daniel J. Parker and Daniel G. Johnson (correspondence: Myers and Kaplan, Intellectual Property Law) for "Method and apparatus for generating a weather index"

Additional patent descriptions accessed with the search facilities provided by the UK Patent Office website.

(2) November 5th 2004. WRMA European conference, Clifford Chance, London
Presentations by:
White, A. (Climate Change Capital) Environmental Legislation – Implications for the European Economy
Goss, N. (Royal Bank of Scotland) Project financing of renewable energy investments – opportunities for and pitfalls of weather derivatives
Byers, C. (Fortis Bank) Weather effects on emissions
Jones, S. (Centrica) Weather Impacts on Emissions Trading
Schippers, A. (ABN Amro) The first 8 years: Charting the Growth of Weather Derivatives Globally and in Europe
Jones, S. (Centrica) Practical Case Study – Centrica's Successful Deployment of Weather Derivatives
McWilliams, D. (Centre for Economic and Business Research) The Impact of Weather Risk on the European Economy – A Special Report
Tomlinson, D. (XL Weather and Energy) and Glajch, M. (Clifford Chance) Weather Risk Management Opportunities in the Accession States
Claquin, T. (CDC-Ixis Capital Markets) PYLON – Securitisation of Weather Risk in French Power Transmission
Windle, B. (Swiss Re) Cross-Commodity Weather Options to Hedge Energy Market Risks
Barnes, R. (Charles River Associates) Accounting for Weather Derivatives under IAS
Bates, C. (Clifford Chance) Recent Developments in EU Legal and Regulatory Framework
Other conference materials include a Clifford Chance report on "ISD2 mandates weather derivative regulation review", Douglas McWilliams report (cited above) and an enclosed "Weather Risk Map" produced by ABN Amro for Euromoney and *Reactions*.

Letters

Csiszar, E.N. (Vice President of NAIC) 2003. Letter to José Montemayor (Texas Department of Insurance), dated November 3rd

ISDA, 2004. Letter to Robert Esson and Ernst Csiszar, dated February 23rd

NAIC, 2003. Weather Financial Instruments (Temperature): Insurance or Capital Markets Products?, dated September 16th

WRMA, 2004. Letter to Rob Esson and Ernst Csiszar, dated January 23rd

APPENDIX 2: SAMPLE RESEARCH QUESTIONS

Interview Questions: Energy Company

Tell me how you personally became involved in weather derivatives
What is the nature of your role on the weather desk?

Could you briefly explain about the business of [company names]?
How did [company name] become involved in weather derivatives?
How did [company name] find out about weather derivatives? Did banks etc approach you or did you approach brokers, banks etc? Could you explain the process behind setting up a contract?

How did [company name] take account of the weather prior to weather derivatives?

What does weather trading give you over gas or power trading?

What types of weather risk are you exposed to?
How important a factor is the weather in your business?
Are there other types of weather derivatives, apart from temperature, that you would consider useful?

What types of contracts does [company name] have?
Hence, what types of weather risks do you try to mitigate?
Who are the key people in the weather derivatives market?

Do you see the dominance of the energy sector changing in the future?

What are the key meteorological data requirements for the market?
How do you analyze this data?
Do you buy in weather forecasts? Do you create your own forecasts? How do forecasts influence prices and trading decisions?

Is [company name] selling weather products to other companies or just engaged in hedging internal weather risk?

Why has the exchange market been slow to develop?

How do you see the weather derivatives market developing in the future?

What effect will this have on the way energy companies perform their business?

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