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Weather Derivatives: A Risk Management Tool for Weather-sensitive Industries

by Andreas Müller and Marcel Grandi*

"Everybody talks about the weather but nobody does anything about it" – Mark Twain

1. Introduction

Different though they may be, the business and production processes of utility companies, breweries, fashion houses, ice-cream manufacturers, building companies and sports goods manufacturers all have at least one thing in common: owing to the weather-dependence of their sales, their turnover – and thus their business success – is highly dependent on the prevailing weather conditions. According to an estimate by meteorological research institutions, more than 80 per cent of the business activity in the world is weather-dependent.[1] Virtually every sector of the economy, however, is directly or indirectly subject to the influence of the weather in some form or other. For instance, results obtained by the British Met Office show that daily beer consumption increases by 10 per cent if the temperature rises by 3°C.[2] However, weather risks are of particularly great importance for the energy and power supply industry.[3]

Unusual weather patterns in particular, such as the El Niño effect, have increasingly prompted companies whose results are affected by the prevailing weather conditions to seek protection against effects of this kind. An internal study conducted by the Chicago Mercantile Exchange (CME) provides a far more significant figure, estimating the weather-related risk for the U.S. economy as a whole as US$2 to 9 trillion.[4]

2. The weather hedge idea

If we knew how the weather was going to behave in the future, there would be absolutely no basis for the existence of tools which make it possible to improve and stabilize results against the backdrop of changeable weather conditions. It can be assumed that better

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[1] Lloyd's List Insurance Day, "Hedging Your Bets to Beat Weather", 5 January 1999.

[2] Ibid.

[3] Richard Bernero, "The Insurers Move In", *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 22.

[4] Udo Rettberg, "Eine Versicherung gegen schlechtes Wetter" [Insurance against bad weather], in *Handelsblatt*, 22 April 1999.

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knowledge, or better quality information concerning future weather conditions, would entail a substantial improvement in the success of weather-sensitive sectors. In December 1997, for example, the Chief Financial Officer of the Minnesota Gas Company stated: "Warm weather will result in lower fourth-quarter earnings this year".

Moreover, greater turnover stability and a predictable business can result[5] in increased shareholder value, an aspect which has been attributed great importance on the investor side, particularly in recent years. A revealing statement by the Chief Executive Officer of a Texan utility company can also be quoted in this context: "A dramatic difference in weather conditions affected sales and reduced our earnings per share by US$0.15 in the second quarter of 1997."

Abstracted from speculative intentions, it is particularly the energy and power sector that benefits from tools for hedging weather risks. A weather hedge enables weather-sensitive sectors to achieve weather-dependent result stabilization or, in the context of integrated risk management,[6] protection of their balance sheets in this respect. Consequently, what could be more obvious than to look for tools that make it possible to bet on the weather, as it were? And what could be more obvious than to exploit the possibilities offered by the capital market for this purpose?

3. Objective

Weather derivatives differ from conventional derivatives in that there is no original, negotiable underlying or price of an underlying that normally forms the basis of any derivative. For example, financial derivatives are based on shares, share indexes, bonds or exchange rates or currencies which are in themselves negotiable objects, something that cannot be said of the weather in view of its numerous facets. The underlying of weather derivatives is based on data such as temperature, which influence the trading volume of other goods.[7] This in turn means that the objective of weather derivatives cannot be to hedge the price of the underlying, as it is impossible to put a monetary value (price) on the various facets of the weather. Consequently, weather derivatives are suitable for other objectives, e.g. for hedging other risks on which the weather has a major influence, such as the risk of declining sales in the energy and power sector as a result of a change in the weather and the price changes possibly resulting therefrom.[8]

The primary objective of weather derivatives is thus to hedge volume risks, rather than price risks, that result from a change in the demand for goods due to a change in the weather. Even though the changed demand can have an effect on the price of these goods, the price risk of goods of this kind can be hedged more effectively by means of futures or options based on

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[5] "AIG Issues Weather Risk-financing Cover", *Alternative Insurance Capital,* April 1999, p. 4.

[6] See in this context Andreas Müller, "Integriertes Risk Management – Herausforderung oder unverzichtbares Geschäftsfeld für die Rückversicherungsbranche?" [Integrated risk management – Challenge or indispensable field of business for the reinsurance industry?], *Versicherungswirtschaft*, 10, 1999, p. 686ff. and 11, 1999, p. 765ff. or the English version, "Integrated Risk Management – A Holistic Risk Management Approach for the Insurance Industry", not yet published.

[7] "A Cure for Power Price Spikes?", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 4.

[8] For example, an increase in energy prices as a result of increased energy consumption in summer months with below-average temperatures.

the price of these commodities (classical commodity derivatives).[9] The notion behind a weather (volume) hedge is that the results of weather-sensitive sectors can be subject to great volatility, even if prices remain unchanged, due to a change in demand or volume. The ice-cream industry can again serve as a plausible example here: it is highly unlikely, and hardly anyone will have seen it happen to date, that ice-cream will be offered at lower prices in a cool, wet summer than in a comparatively hot summer. The decline in turnover of the ice-cream industry is thus exclusively due to the inadequate sales volume and not to a price reduction as a result of the market mechanisms of the national economy. This example is intended to illustrate that the primary objective of a weather hedge is volume compensation.

In contrast to the ice-cream industry, there are, of course, also industries where demand exerts a greater influence on the supply price. Generally speaking, the energy and power supply industry can be quoted here. For example, in cold winters not only is there a greater demand for fuel oil, but experience has shown that the prices rise as well.

Depending on the sector in question, the logical consequence of this is that a perfect hedge needs to hedge both the price risk by way of conventional commodity derivatives and the volume risk by way of weather derivatives. This hedge combination will be referred to as a cross-hedge and is illustrated in Figure 1. Consequently, which type of hedge (single volume,

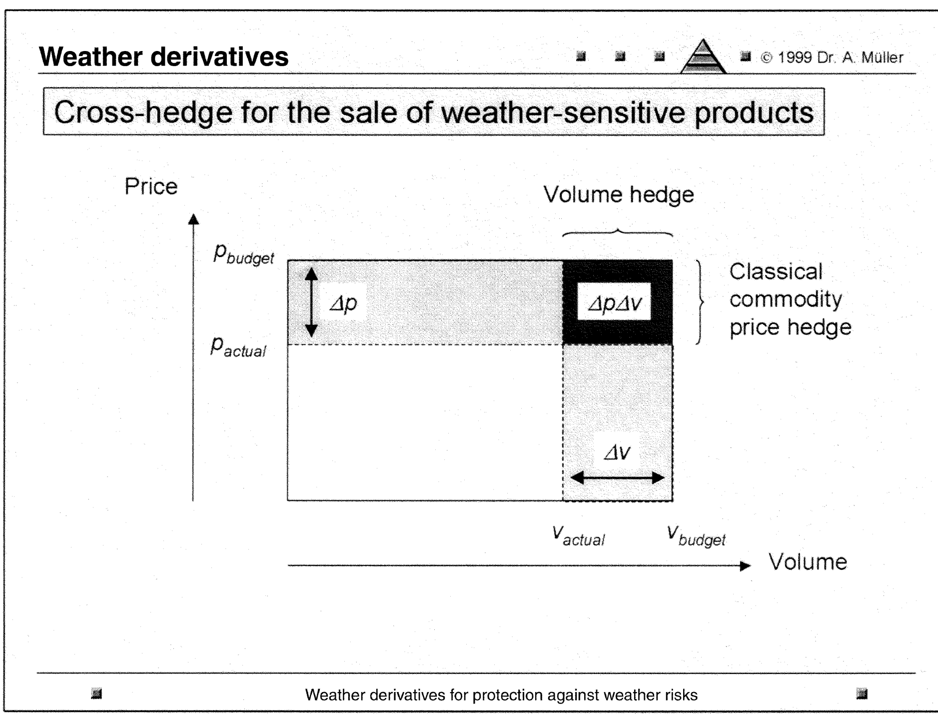

Figure 1: Cross-hedge for the sale of weather-sensitive products

[9] Note 7 above, p. 4.

single price, or cross-hedge) makes most sense depends on the behaviour of the market mechanism in the respective sector and how it affects sales volumes and supply prices. Recently, however, an increasing number of structured cover concepts has been seen on the U.S. market, offering protection against both the weather and price risks. In this case, commodities are combined with weather risks. These concepts exist both in the form of derivatives and as insurance products (e.g. Multiple Trigger concepts).

4. Techniques

Although some initial thought has been given to using precipitation, sunshine and snowfall as the underlying,[10] most of the weather hedges realized to date refer to just one facet of the weather, i.e. temperature. Thus, 95 per cent of all the weather business transacted in the U.S. to date has been based on the weather.[11] The problem that arises when using an underlying in the form of a weather component is that there are so far no adequate possibilities for unequivocally recording or measuring these components.

Needless to say, extremely flexible concepts are conceivable in this context. For instance, different weather risks can be combined with each other or even with different types of financial and market risks, as well as insurance risks, in the framework of Multiple Trigger concepts, thus enabling comprehensive and efficient risk management (e.g. protection of the drinks industry against excessively cool, wet weather: temperature/precipitation hedge; protection of the aviation industry against snowfall and a simultaneous increase in aviation fuel prices: both parameters are important indicators for the turnover of the aviation industry[12]).[13] As a result of the double- or multiple-occurrence cover, the premium will also turn out more favourable than for separate one-time cover (multiplication of probabilities of occurrence).

If the market mechanism of supply and demand is to work optimally, it is essential that, for reasons of sales or turnover, different sectors and end-users have different, diametrically opposed, attitudes towards certain weather conditions, although this will only rarely be absolutely the case in practice. Consequently, the ideal case of a Pareto Optimum[14] with an acceptable cost structure will only rarely be achievable. The fact that certain weather conditions constitute positive prerequisites for the result trend of one sector, while at the same time having a negative effect on the business development of another sector, provides an opportunity to develop derivatives, such as options or swaps, which can be used to the benefit of both parties and thus result in enhanced efficiency on both sides.

So far, several techniques have been developed for weather hedging,[15] a few of the tools of which will be described in more detail below.

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[10] Ibid., p. 5, and Lynda R. Clemmons, "Weather Hedges Shield Companies from Inclement Sales", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 6.

[11] Robert Muir-Wood, "Reinsurers Learn to Test the Temperature", in *Reinsurance*, February 1999, p. 18.

[12] Ibid., p. 19.

[13] Note 5 above, p. 4.

[14] See in this context Hall R. Varian, *Grundzüge der Mikroökonomik* [*Principles of Micro-economics*], Munich and Vienna, 1991.

[15] David Turner, "Clearing Away the Clouds", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 28.

Degree Day options/swaps/collars

The clear focus in dealing with weather derivatives is in the field of options designed to afford protection against fluctuating temperatures. Options of this kind are based on so-called Heating Degree Days (HDD) and Cooling Degree Days (CDD). These indices represent the average temperature for a given period of time.

In this context, the Degree Days are calculated as the absolute difference between a reference temperature (in this case: 65°F or 18°C) and the actual average temperature *T*. The Degree Days determined in this way are added over the underlying period *t*. If the average temperature is above 65°F, the Degree Days calculated in the above manner are referred to as Cooling Degree Days (CDD); if the opposite is true, they are known as Heating Degree Days (HDD):

$$CDD = \sum_{t=1}^{n} (T(t) - 65) \quad \forall T(t) > 65$$

$$HDD = \sum_{t=1}^{n} (65 - T(t)) \quad \forall T(t) < 65$$

As a rule, HDDs measure the average temperature for the winter half-year, while CDDs usually measure that for the summer half-year. While HDD options can be used to obtain

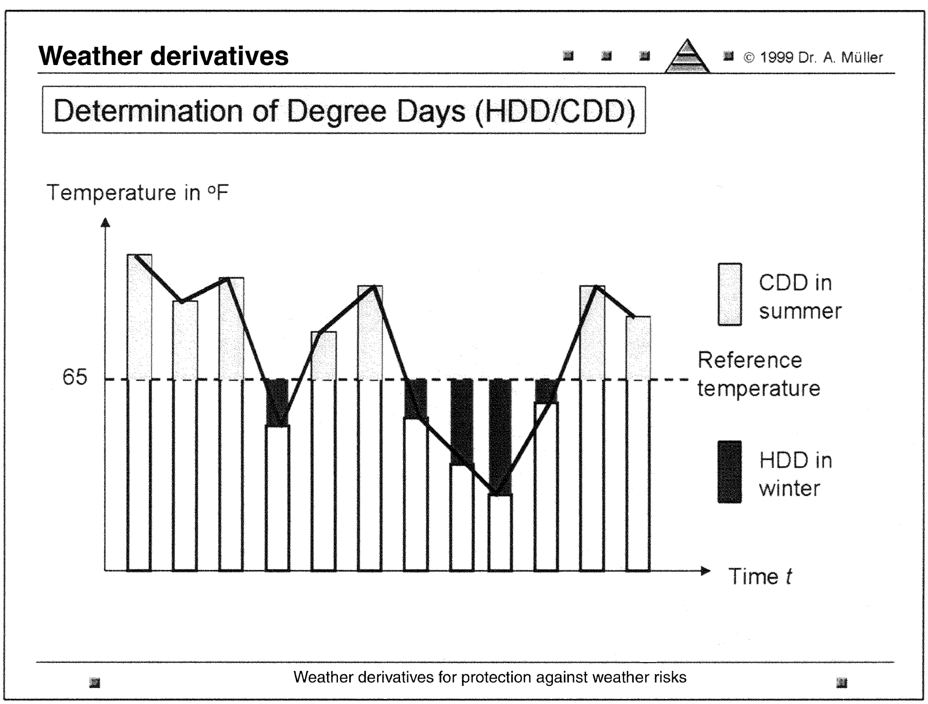

Figure 2: Heating Degree Days (HDD) and Cooling Degree Days (CDD)

Table 1:
System for temperature options

Option type	**Protection against . . .**	**Exercised when**	**Payout**
HDD call	. . . overly cold winters	HDD $>$ strike value	tick size $\times$ (HDD $-$ strike value)
HDD put	. . . overly warm winters	HDD $<$ strike value	tick size $\times$ (strike value $-$ HDD)
CDD call	. . . overly hot summers	CDD $>$ strike value	tick size $\times$ (CDD $-$ strike value)
CDD put	. . . overly cool summers	CDD $<$ strike value	tick size $\times$ (strike value $-$ CDD)

protection against excessively warm winters, CDD options afford a safeguard against excessively cool summers. The option strategies available in this context are HDD/CDD calls and puts, as well as combination strategies (collars, strangles, spreads, straddles). The system for HDD/CDD calls and puts, for example, shown in Table 1.

In this context, one tick corresponds to exactly one Degree Day. An amount (tick size) is defined per tick, this determining the level of the payout. The strike value determines the amount (Degree Days) upwards of which the option can be exercised. In the case of a call, the strike value for the relevant period must be *below* the total number of actual Degree Days in order to obtain a positive result from the option, whereas a strike value *above* the total number of actual Degree Days is the target for a put.

Every weather option is limited in terms of amount (cap or maximum payout). A typical Degree Day contract may, for instance, provide for US$5,000 per tick or Degree Day with a maximum payout of US$2 million. The average contract value at the moment is in the region of US$2–5 million on an open-ended scale and will rise very rapidly as expertise and confidence in the weather business increase.[16]

Depending on the estimation of the meteorological situation, options can also be used to build up combination strategies. A market player who does not expect any noteworthy weather fluctuations can get himself twice the risk premium by way of a short straddle (simultaneous selling of a call and put option with the same strike value). A collar (buying of a put option and selling of a call option with the same strike value) enables a market player to minimize his hedging costs.

In the case of a weather swap, the level of the variable interest payment can be made contingent on the occurrence of certain weather conditions, whereas the payment of the fixed interest (which can be interpreted as an insurance premium) remains unchanged. It is also possible to link both payment flows to certain weather conditions (swap of the cash flows from an HDD option and a CDD option).

From the purely economic point of view, a weather hedge only makes sense in short-term cases, the reason for this being that, in the event of long-term contracts, there is a risk of the extreme values to be hedged being levelled out by the application of averages.[17] This risk increases with the length of the contract period, substantially reducing the effectiveness of a weather hedge. The longer the selected contract period, the more the above options resemble Asian options (average rate options), where the value of the underlying is determined not at a specific point in time, but as an arithmetic mean over several periods of time. Options of this kind were developed in order to put the distorting effects of chance mavericks into perspective. Nevertheless, most contracts refer to a single season comprising several months, such as the winter season from November to March.[18]

Weather/nature-linked bonds

In addition to the weather derivatives presented above, there are also so-called weather or nature-linked bonds, although these have so far enjoyed far less popularity than options and

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[16] Thus, for example, the largest transaction in 1998 had a volume of US$75 to 100 million. Cf. Note 11 above, p. 18.

[17] Note 7 above, p. 4.

[18] Robert Muir-Wood, Note 11 above, p. 18, and Udo Rettberg, Note 4 above.

swaps. In the case of weather or nature-linked bonds, the interest payments and the repayment of the nominal amount are made contingent on a meteorological index, on which the definition of the trigger is based. The possible indices include precipitation or temperature indices. A bond construct or issue of this kind can be particularly attractive for (re-)insurance companies wanting protection against high weather-induced claims for compensation.

As with insurance-linked bonds, great importance is also attributed to weather-linked bonds in the context of portfolio management, as they also offer attractive risk/return-characteristics,[19] meaning that, owing to there being no correlation with other asset classes of an asset portfolio, they can contribute to a vertical shift in the efficiency line in the context of Markowitz' portfolio theory and thus to a more efficient μ-σ structure of the investment portfolio.

5. Example of a weather transaction

The following example is intended to illustrate the purpose and technique of a weather hedge. Let us assume that a utility company operating primarily in Ohio wants to protect itself against a loss of turnover in the event of a slump in energy demand owing to an overly cool summer where little use is made of air-conditioning systems.

In this case, the utility company will buy a CDD put option for the summer half-year (long put). By way of example, the specifics of this option contract will be as shown in Table 2.

The strike value of 985 CDDs taken as the basis here corresponds to an average temperature, calculated over 180 days, of 70.47°F (= [985/180] + 65). If the contract specifications given above are also assumed, the option price of US$ 335,000 and a tick size of US$15,000 can be used to determine the break-even point X^*_{CDD} of this option on the basis of the following linear relationship:

$$15,000 \times (985 - X^*_{CDD}) - 335,000 = 0$$

$$985 - X^*_{CDD} = 335,000/15,000 = 22.3\overline{3}$$

$$X^*_{CDD} = 985 - 22.3\overline{3} = 962.6\overline{6}$$

The break-even point of 962.66°F for this option contract can furthermore be used to calculate a corresponding average temperature of 70.34°F (= [962.66/180] + 65), which can

Table 2:
Specifics of an exemplary weather option contract

City	State	Start	End	Deal	Strike value*	"Tick size" in US$	Limit in US$	Price in US$
Cincinnati	Ohio	1/5/99	31/10/99	CDD put	985	15,000	3 million	335,000

*Measured in CDD, determines the exercising of the option.

[19] Eric Briys, "Pricing Mother Nature", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 16.

be interpreted as follows. If the buyer is to obtain a positive result from this option, the average temperature during the 180-day period under review may not exceed a maximum of 70.34°F. If the average temperature is above 70.34°F, this option will be exercised by the buyer up to an average temperature of 70.47°F (amortisation of the optimum premium). With an average temperature above 70.47°F the option lapses and nevertheless entails expenditure of US$335,000.

Based on the above calculation method, the payoff of the long put option contract described can be formalized as follows:

$$Payoff = \text{Min}(L - OP,\ TS \times \text{Max}[0,\ SV - CDD] - OP)$$

$$\text{where } CDD = \sum_{t=1}^{180} (T(t) - 65) \quad \forall T(t) > 65$$

(L: Limit, TS: Tick Size, SV: Strike Value, OP: Option Price.)

If, for example, a total of 800 CDDs is determined over the 180-day period used as a basis here, the buyer of the above option achieves the following result:

$$\text{Min}(3{,}000{,}000 - 335{,}000,\ 15{,}000 \times \text{Max}[0,\ 985 - 800] - 335{,}000)$$

$$= 15{,}000 \times (985 - 800) - 335{,}000 = 2{,}440{,}000$$

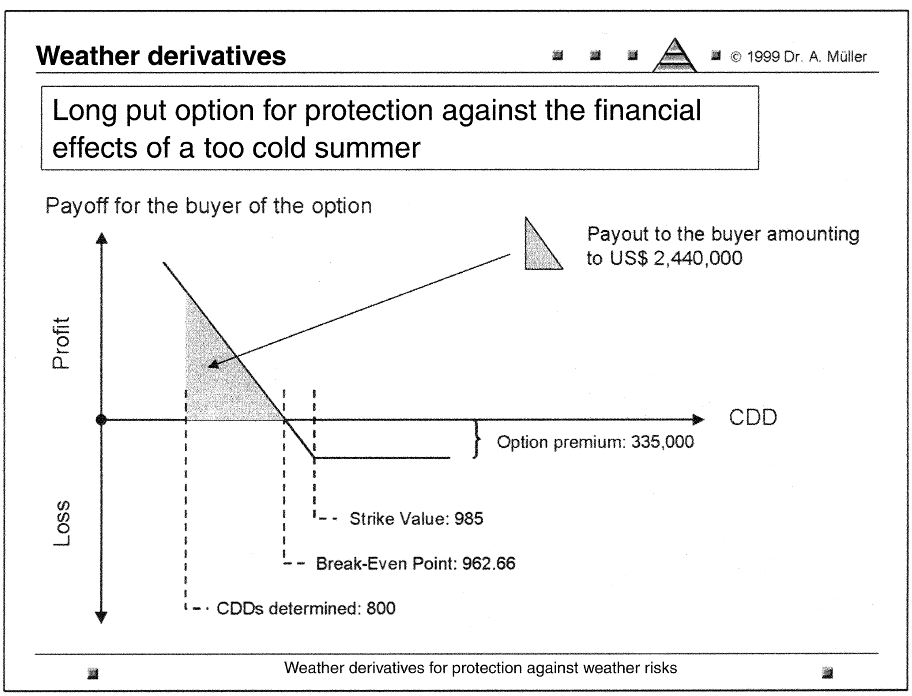

Figure 3: Exemplary payoff diagram of a long put

This positive result for the buyer of the option means that – depending on the number of options he buys – he can partly or even fully compensate for the revenue lost due to the weather conditions and, in extreme cases, possibly even pocket windfall profits.

6. Comparison of weather hedge and (re-) insurance

At first glance, it seems fairly obvious that the possibilities of weather hedging described above have very little to do with insurance in the classical sense, although both tools can be used with a comparable objective in mind. One essential difference compared to insurance is that no drop of turnover (comparable to losses) need actually occur in order to meet the preconditions for receiving a compensation payment. The decisive elements here are the contractually stipulated terms (contract type, region, reference period, tick size, strike value, prevailing weather conditions, etc.).

Moreover, a hedge of this kind need not relate directly to the buyer's own situation, i.e. a weather hedge can be used not only to protect the buyer's own sales, but also to profit from the consequences of certain weather conditions for the situation of other market players (competitors, for example). For example, wine-growers in Region A could protect themselves against a (weather-induced) record crop in Region B which, as a result of the increased supply of grapes at the supraregional level, could lead to a dramatic slump in prices. A classical insurance policy could merely and only protect the wine-growers in Region A in relation to their own crop; conventional insurance does not offer the possibility of taking the situation of the competition into account.

Nonetheless, there are certain parallels between basic option strategies (HDD/CDD calls and puts) and excess of loss/stop loss reinsurance treaties with a fixed attachment point (priority) and a treaty limit (see Figure 4). In addition to the experience some reinsurers have built up in weather and climate research, this may be another reason why reinsurers are also becoming involved in this new field of business. In this context, the reinsurers involved in the weather derivatives business predominantly prefer short positions (option seller), which corresponds to the traditional role of the reinsurer as a bearer of risk.

7. Pricing

When it comes to the assessment of weather derivatives, it is not yet possible to refer to a standardized procedure. This factor obviously makes it harder to market this type of derivative. The familiar option price model of Black–Scholes[20] cannot be applied in the case of weather derivatives, simply because this model presupposes the existence of a negotiable underlying, or in other words derives the price of the derivative from the price of the actually existing underlying. This prerequisite is obviously not fulfilled in the case of weather derivatives – after all, what does weather cost? The Black–Scholes model is nevertheless used for pricing to a certain extent; in this case, log-normal distributions are assumed for HDD/CDD forms and options are priced by means of Black–Scholes. However, it must be mentioned at this point that this procedure does not give consideration to the seasonal nature of the weather, nor are the assumed log-normal distributions always reconcilable with data from historical observations.

[20] See in this context Manfred Steiner and Christoph Bruns, *Wertpapiermanagement* [*Securities Management*], 6th ed, Stuttgart 1998, p. 297ff.

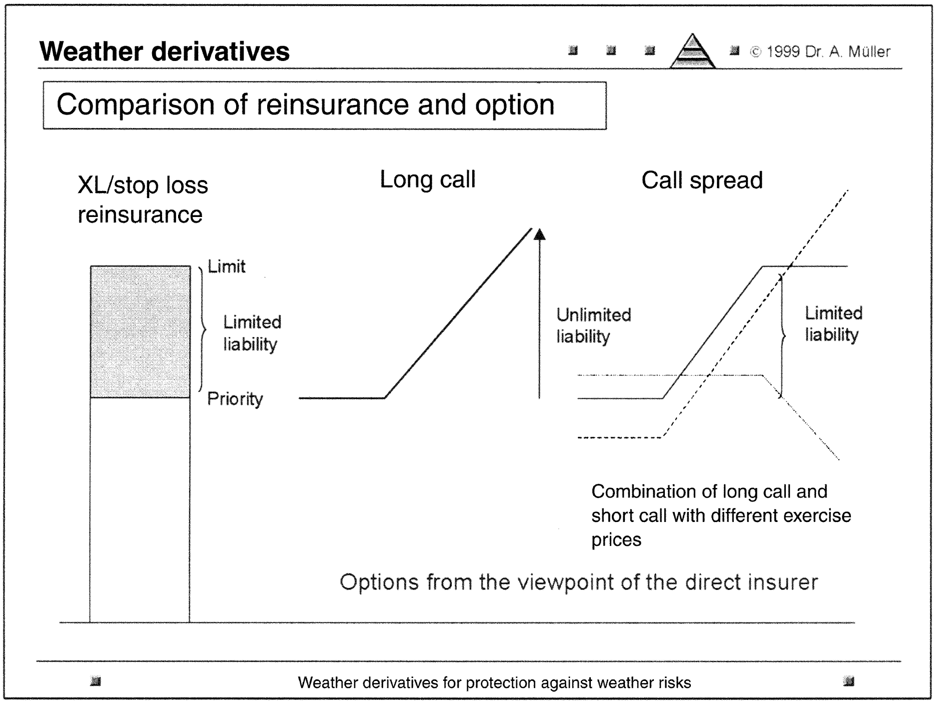

Figure 4: Comparison of reinsurance and option contracts

The simplest method for pricing weather options and swaps is the Burning Cost method (Historical Burn). In this context, the historical payout of the transaction per year is determined for a specific period (strike – Degree Days for puts, Degree Days – strike for calls, multiplied by the tick size in each case). The mean plus a multiple $\nu > 0$ of the historically determined standard deviation of the payouts is used to calculate the so-called Burning Cost premium. However, the Burning Cost method fails to give adequate consideration either to the dynamism of the weather (trends) or to current meteorological developments (greenhouse effect, global warming, El Niño, La Niña).

At the moment, pricing appears to consist of a mixture of Burning Cost and standard option price models in combination with actuarial weather forecast information; it is interesting to note that no pricing models have been published to date.[21] When pricing, professional weather traders use models based on the Black–Scholes formula (HDD or CDD as the underlying) or fall back on highly complex stochastic models, such as component models based on stochastic processes.

[21] Note 7 above, p. 4. An initial approach can be found in Dischel, who develops a pricing model based on a stochastic Monte Carlo simulation. See in this context Bob Dischel, "Black–Scholes Won't Work", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 8f. See also, "Pricing – How Much History is too Much History?", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 12, and Eric Briys, Note 19 above, p. 16ff.

However, the essential prerequisites for well-founded pricing are the analysis of historical weather data and the resultant forecasting of the future weather. In order to guarantee a high standard of quality as regards the necessary data, the Degree Day Index in the U.S., for example, is determined by the daily recording of the temperature at roughly 200 weather stations of the National Weather Service.[22]

8. Market players

The market for weather derivatives arose in the U.S. in mid-1997 as a result of the liberalization of the energy and power sector, which led to the national supply monopolies being converted into separate, legally independent utility companies operating on the principles of the market economy. The effects of the El Niño and La Niña phenomena further accelerated the development of the market. The U.S. utility companies saw themselves exposed to the risk of a loss of turnover in the event of warm winters and cool summers and looked for new ways of protecting themselves.[23]

In the U.S., the sales of the utility companies to private households (excluding industrial customers) amount to US$70 billion. In contrast to industrial business, business with private customers is characterized by highly susceptible demand. Warm winters where less heating is used, and cool summers where air-conditioning equipment is used less, have a direct impact on sales. Following the deregulation of the U.S. energy and power market, drops in sales resulting from a decrease in consumption can no longer be made good by price increases. Deregulation of the energy and power industry has led to growing demands on the optimization of risk management among the utility companies. Insurance and financial risks are no longer considered in isolation, but always in context and as regards their economic significance for the whole company (Multiple Trigger concepts)[24]. The optimum protection tools for the company are sought in the framework of an integrated risk management approach,[25] and weather derivatives are a part of this.

Today, there are some 70 market players in the U.S. who engage in trading in weather derivatives. The overall market can be divided into two classes.

Weather hedges for the end-user are structured and traded on the so-called primary market. In this context, the term “end-user” means institutions that faced weather risks in their original business, such as utility companies, construction companies, amusement parks, agricultural businesses, etc. The secondary market is predominantly the field of investment banks and trading houses specializing in weather derivatives, their objective being to achieve trading and arbitrage profits by trading in weather derivatives.[26] Here, positions are to be closed as far as possible by way of corresponding counter-positions and existing price differences exploited in order to achieve arbitrage profits. It should be expressly pointed out that it is not the aim of secondary market players to assume risk.

The majority of the deals transacted to date involve trading between institutional or professional dealers (secondary market), rather than end-users (primary market), although

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[22] Cf. Muir-Wood, Note 11 above, p. 18.
[23] Cf. Muir-Wood, Note 11 above, p. 18.
[24] Cf. in this context also section 4 of the present paper and Andreas Müller, Note 6 above.
[25] See in this context Andreas Müller, Note 6 above.
[26] Cf. Monte Simpson, “The Phenomenon of Weather Hedging”, in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 10.

there are signs of a growing trend towards deals with end-users.[27] It can generally be assumed that increasing standardization of contracts will lead to a rise in the number of market players and transactions. It should also be mentioned that every transaction with the primary market generally gives rise to several transactions within the secondary market, these deals being concluded as safeguards.

Although trade in weather derivatives to date has been restricted exclusively to over-the-counter trade (OTC market), the market players who are actually active will in future be joined by institutions that provide a kind of trading platform. For example, the Chicago Mercantile Exchange (CME) has applied for a licence to deal in temperature derivatives. The derivatives to be traded on the CME in the future are to be based on monthly CDDs and HDDs with US$100 per index point and working on the basis of a minimum tick size of one index point.[28] In addition to improving transparency, trading platforms of this kind, as opposed to OTC deals, can also enable the professional and efficient assumption or elimination of the counterparty risk by way of special guarantees (in the above case, for example, a guarantee of the CME clearing house).

9. Organizational requirements

Closely linked to techniques and pricing methods are organizational requirements, such as the availability of appropriate know-how. Particularly in the case of weather derivatives, this know-how cannot always be presupposed, even in the financial sector, as geoscientific expertise and a knowledge of statistical methods are required. Although this expertise can be acquired from external project partners, the growing popularity of weather derivatives can be expected to result in the increased employment of natural scientists, particularly meteorologists, in the financial sector.[29]

Certain reinsurers have the expertise and the know-how to analyse and rate weather risks. For example, weather risks have long since been taken into account in the Natural Catastrophe models of the reinsurers. Weather trends, such as global warming or El Niño and La Niña, are explicitly taken into account in these models. Munich Re, for instance, has been offering a comprehensive service in the field of weather and climate consulting for 25 years. For example, a staff of more than ten natural scientists assess more than 500 weather risks per year. However, in addition to the necessary expertise, another indispensable requirement for developing successful business with weather derivatives is the establishment and active management of a sufficiently diversified portfolio.

Like financial derivatives, weather derivatives are concluded as derivative deals. The rights and obligations of the contracting parties are set out in standardized contracts drafted by the International Swap Dealers Association (ISDA contracts), as is customary for financial derivatives. As derivative contracts, weather derivatives place substantial demands on the counterparty risk management of each and every market player (risk of non-payment).

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[27] Cf. Note 7 above, p. 5.

[28] Cf. "CME Eyes Weather Derivatives", in *The Re Report,* 4/99, p. 8, as well as "CME Prepares Weather Options", in *Alternative Insurance Capital*, February 1999, p. 10.

[29] Thus, for example the Salomon Smith Barney investment bank employs two natural scientists, who deal specifically with weather forecasting. Cf. David Turner, "Outlook Good for Weathermen", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 3.

Finally, important parameters and reference values need to be contractually stipulated, such as option term, unit of measure, strike value, option premium, payout per unit (tick size), maximum payout, etc., and it must be ensured that the data recorded are of high quality and reliable. As previously mentioned, the data acquisition services in the U.S., for example, are provided by the weather stations of the National Weather Service. The prerequisite for any weather transaction is the contractual stipulation of unequivocally defined reference weather stations and of units of measures on which the structure of every weather hedge is based.[30]

10. Transactions and market development to date

Compared to conventional derivatives markets, the market for weather derivatives, which only came into being in the U.S. two years ago, can still be regarded as relatively illiquid today. Since the first transaction in August 1997, more than 800 deals have been transacted in the U.S. with a total volume in excess of US$1.5 billion. Some estimates even go as high as 1,500 transactions with a volume of approximately US$2.5–3.0 billion.[31] As already mentioned above, the majority of the transactions to date were concluded between dealers (secondary market) and not between or with end-users (primary market).[32] Some 95 per cent of all the weather transactions effected to date are attributable to Degree Day options.[33]

A steady increase in the average transaction volume can be observed on the market. Contracts with a limit of US$2–5 million – the market standard up to now – are a mere drop in the ocean for major utility companies and are generally not sufficient to afford protection against substantial drops in demand. According to an estimate by the Futures Industry Association, the management of weather risks has a greater market potential than that of all the options and futures traded throughout the world (1997: US$1.9 trillion).[34]

In Europe, weather derivatives were first used on the French market. In that instance, the SOCCRAM utility company protected itself by buying weather derivatives with the aim of safeguarding the company against the consequences of excessively warm weather in the winter and thus against the associated decline in sales during this period.[35] If the winters of the two subsequent years display a temperature above a certain, previously defined, point, SOCCRAM will receive an amount dependent on this temperature.

An increase in the volume of weather transactions in the European region can essentially only be achieved by sensitizing both the primary and the secondary market accordingly. For the time being, the continued strong growth will concentrate on the U.S.

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[30] Cf. Muir-Wood, Note 11 above, p. 18.

[31] Cf. D.K.A Mordecai, "A Tool for All Trades", in *Weather Risk*, published by Energy & Power Risk Management, October 1998, p. 25.

[32] Cf. Note 7 above, p. 5, as well as Lynda R. Clemmons, Note 10 above, p. 6. Other estimates are that the worldwide trading volume to date already exceeds US$1,000 million. Cf. Monte Simpson, Note 26 above, p. 10, and Muir-Wood, Note 11 above, p. 18.

[33] Note 11 above, p. 18.

[34] Cf. Clemmons, Note 10 above, p. 6.

[35] Cf. "SocGen Deal Completes French Market's First Weather Derivative", in *Alternative Insurance Capital*, March 1999, p. 1f.

11. Conclusion and outlook

Weather derivatives have already established themselves as a tool for the management of weather risks in the U.S. A similarly dynamic development can be predicted for Europe in the wake of the liberalization of the energy and power industry. However, a prerequisite for a development of this kind is that Europeans, like their counterparts in the U.S., should pay more attention to the importance of the weather in relation to corporate success. On top of this, there are other barriers which have so far impeded the development of this market in Europe, particularly the availability of weather data and the associated costs.

All in all, it can be assumed that the number of transactions and their volume will increase, and that trading in weather derivatives will continue to spread beyond the U.S. However, the primary market must also take on a greater role in order to guarantee the steady development of this growth market.

Finally, it may be noted that weather derivatives, like all derivatives, can in principle be used for speculative purposes, although their declared objective – in particular for participants of the primary market – is to offer weather-sensitive sectors a risk management tool that allows them to efficiently hedge weather risks that were previously uninsurable.

12. Summary

More than 80 per cent of the worldwide business activities are dependent on weather conditions. Corporations, in particular utility companies, may hedge the risk of a drop in their sales and/or profitability due to unfavourable weather conditions by entering into weather derivative transactions. Possible counterparties for these transactions are reinsurers, investment banks and specialized trading houses.

The focus of activities lie in Degree Day options hedging adverse temperature fluctuations. Degree Day options are very similar to XL/stop loss reinsurance contracts with a fixed priority and treaty limit.

The weather derivatives business so far has been preliminary a U.S. business, with a transaction volume of about US$3 billion. With the further deregulation of the energy sector in Europe and other regions of the world and an increasing awareness of the weather as an important factor for companies sales and results, the weather derivatives market is expected to be a fast-growing business segment.