



Coping with climate change

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The role of financial markets

The economic repercussions of climate change are far-reaching:

(1) A rise in extreme weather events will cause increasing wealth destruction and earnings fluctuation; financing costs for corporates and governments are likely to rise. (2) A global boom in climate protection and adjustment will be set in motion; corporates and consumers will have to bear the resulting costs. (3) Customers and investors will be increasingly sensitive to climate issues; firms will be challenged to respond.

Financial markets can help reduce overall economic costs of abatement as well as adjustment strategies. With the aid of suitable financial instruments it is possible to create incentives for more climate protection, finance climate protection and climate adjustment strategies, and share unavoidable risks efficiently.

The market for weather and natural disaster risk allows for efficient risk sharing. It provides reliable price signals concerning environmental threats and helps to reduce individual cost of coverage. Meanwhile, investors can benefit from low correlation with existing assets classes. Appropriate financial instruments are already being used today – e.g. in the form of catastrophe bonds or weather derivatives. Growing climate risks would further fuel the development of these markets.

International emissions trading can be used to reduce abatement costs. In addition the market for certified emission reductions (CERs) allows mobilising further resources, integrating emerging markets and developing countries in the global climate protection efforts, and accelerating the transfer of know-how.

Climate related investment markets help lower the cost of debt and equity financing for climate protection and adjustment technology. The number of climate related certificates, public funds, private equity funds but also debt financing schemes is growing. Rising popularity of such products ensures that favourable funding conditions will be available for the most promising abatement and adjustment strategies.

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Introduction

Is the global climate changing and do man-made greenhouse gas emissions have anything to do with it? Not long ago, these issues were frequently contested in academia and public debate. Meanwhile, the discussion has entered another stage. The latest IPCC¹ report has made it clear: the climate is changing and most probably we ourselves are largely to blame. The pressing question no longer is whether to act or not, but how to respond to climate threats in a sensible and efficient way.

By now, the issues of “climate protection” and “climate adjustment” rank high on the political agenda and are deeply embedded in people’s minds. It is becoming more and more obvious that climate change and related regulatory or market-driven reactions will have far-reaching economic consequences. Some consequences are unavoidable; others can be prevented or mitigated through appropriate measures.

How can financial markets help to meet the economic challenges of climate change? How can the impact of rising natural disaster and weather risks be efficiently distributed with the aid of suitable financial instruments? And what role does emissions trading play in financing global climate protection efforts? These are the key issues addressed in this study.

What are the economic implications of climate change?

According to the latest IPCC report general warming of the earth’s atmosphere is almost certain. Most probably, rainfall patterns will change and heat waves will become more frequent. Severity and frequency of extreme weather events, such as cyclones, floods and droughts are likely to increase too.

Residents of emerging markets and developing countries will probably be hit worst. They often are highly exposed to natural catastrophe risks, yet badly protected. In terms of human losses countries such as India, Bangladesh, South and Central America will suffer the most, while the greatest economic losses will be sustained – at least initially – in the developed world. It is here, too, that the volume of insured risks is the highest. However, given the strong growth of many emerging economies, potential property losses will play an increasingly important role in these countries as well.

Besides climate-induced natural catastrophes, daily and seasonal fluctuations in rainfall, temperature and wind speed are also on the rise worldwide. For Central Europe, for instance, it is predicted that the summers will tend to be drier and the winters wetter, with the winter snows melting faster, more frequent gales and more storm tides in the coastal areas. The weather will become generally more volatile hence less calculable.

Both aspects – an increase in weather volatility and extreme weather events – may result in income losses and property destruction. However, economic losses will not only arise through

Weather trends

Phenomena and likelihood of future trends

Warmer and fewer cold days and nights	Virtually certain
Warmer and more frequent hot days and nights	Virtually certain
Frequency of warm spells/heat waves increases	Very likely
Frequency/proportion of heavy precipitation events increases	Very likely
Area affected by droughts increases	Likely
Intense tropical cyclone activity increases	Likely
Increased incidence of extreme high sea levels	Likely

Source: IPCC, 2007

1

¹ The Intergovernmental Panel on Climate Change (IPCC) compiles the research findings on climate change from various scientific disciplines and publishes them in a report – the latest in 2007.



Property losses, earnings fluctuation and higher financing costs

the destruction of *existing* plant, buildings and stocks. Weather related uncertainties will also affect the planning of *future* economic activity. With increasing uncertainty over future income flows, those providing capital expect higher risk premiums. This means that a company that has to reckon with heavy losses for weather reasons will be confronted with higher costs of debt and equity than a company whose future cash flows are less exposed to such risk. In the worst case, weather-induced uncertainties, and the related financing costs, may be so high that business activities are abandoned altogether in certain areas or sectors. This applies similarly also to households living in or moving to endangered areas. There, house and property insurance premiums can become unaffordable.

Growing abatement and adjustment efforts

Second round effects from regulatory and market responses most likely will have much greater economic impact compared to direct effects from physical exposure. By now, governments can no longer afford to ignore potential climate threats and will be compelled to press further on this issue. Policy responses in turn will result in growing abatement and adjustment efforts, which will lead to higher costs. A point in case is the introduction of (costly) emission rights for energy utilities and large industrial enterprises in the EU² that is intended to transform the affected industries towards the use of low carbon technologies. Also, regulation that aims at e.g. improving heating efficiency, insulation of buildings or the use of low carbon technology in cars, will add to higher costs. While there are certain industries that are likely to benefit: e.g. construction, renewable energies, mechanical and electric engineering,³ it is mainly households who bear the ultimate costs via higher prices for energy and "low or carbon" products.

Increased consumer and investor awareness

Finally, climate change has an economic impact through changed consumer behaviour. Consumers' heightened awareness of climate issues is already reflected in increased efforts to conserve energy, trim back on climate harming activities and support compensation measures. Consumer awareness extends even to investment decisions, as investors take into account the risks and chances associated with climate change.

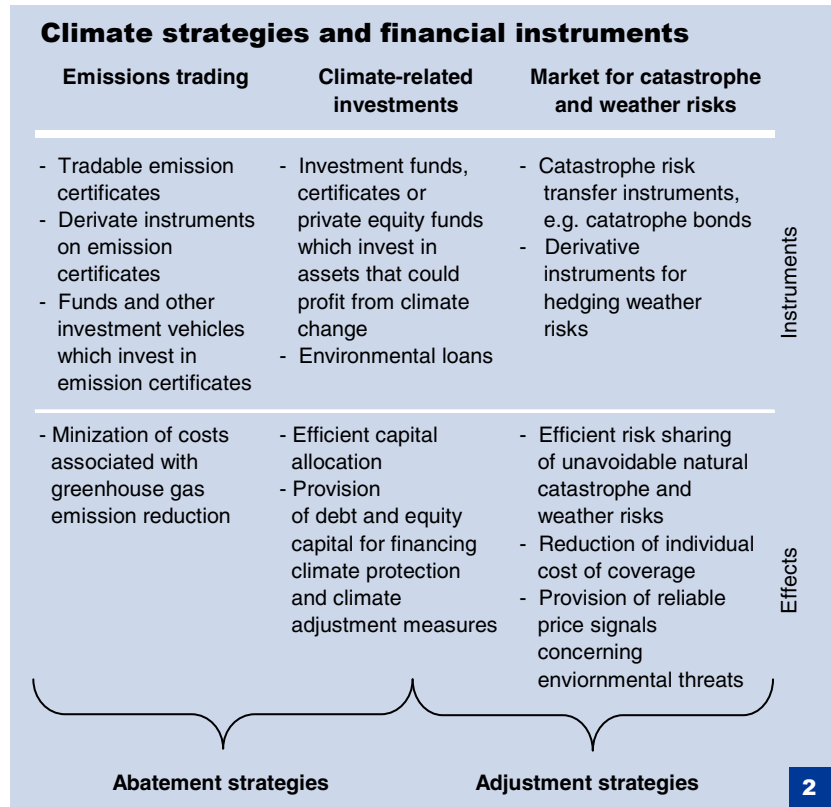
These trends are likely to persist or even become more pronounced in the coming years.

How can financial markets help coping with climate change?

The current climate debate entails two approaches: The so-called *abatement* strategies are intended to act preventively and abate climate change as best possible. *Adjustment* strategies, on the other hand, are intended to react intelligently and effectively to unavoidable consequences of climate change. Financial markets can play an important role in both strategies. With the aid of suitable financial instruments (see chart 2 on page 4) it is possible to finance climate-related technological advances, to minimise the costs of greenhouse gas reduction, and to distribute weather risks efficiently.

² Prices almost dropped to zero within the EU trading system, as too many emission rights were issued in the first trading period.

³ For a survey on gainers and losers from climate change see Heymann, Eric (2007). Climate Change and Sectors: Some like it hot! Deutsche Bank Research. Current Issues. July 5, 2007. Frankfurt am Main.



Hedging costs fall

(1) Market for catastrophe and weather risks

The following discussion (Part 1) focuses on the use of financial instruments for the efficient distribution of natural catastrophe and weather risks faced by corporates, households and governments in connection with climate change. The key question is how financial markets can help reduce the cost of hedging such risks by distributing them efficiently.

Climate protection at minimum cost

(2) Emissions trading

Financial markets also play a pivotal role in achieving agreed climate protection targets at relatively low cost (Part 2). With the distribution of a limited supply of emission certificates, corporates and consumers receive a (monetary) incentive to keep the emission of greenhouse gases (GHGs) as low as possible. As emission rights can be traded, companies that find it easy to reduce their GHG emissions can sell emission rights to companies for which measures to reduce GHG emissions would be more costly. Through this approach (cap and trade) it is theoretically possible to achieve a politically defined reduction target at minimum cost.

The economic functioning and the benefit of emissions trading as a policy instrument have been and still are subject to widespread public debate.⁴ We will focus on one aspect that has received less attention, namely the newly created markets for related emission certificates. In particular, we look at the so-called *Clean Development Mechanism* (CDM) of the Kyoto Protocol. This mechanism enables climate protection projects to be realised in emerging markets and developing countries and the emission reductions achieved to be converted into tradable emission credits.

⁴ Heymann, Eric (2007). EU emission trading. Allocation battles intensifying. Deutsche Bank Research. March 6, 2007. Current Issues. Frankfurt am Main.



(3) Climate-related investments

Driven not least by the growing awareness of climate issues and the related economic impact, there is a rising propensity among investors to consider climate aspects in their investment/credit decisions. At the same time, banks and asset managers are discovering climate change as a promising investment theme. They identify the sectors and companies that profit from the implications of climate change and those that are affected adversely. The spectrum of sectors affected is broad and, besides the energy industry, also includes companies, which are developing, producing or applying climate protection-relevant technologies, as well as companies that offer solutions for adapting to climate change.

Supporting technological change

Given the right political and regulatory framework, growing investor interest reduces the cost of debt and equity financing for these companies. As a result, advances in low carbon technologies and the adjustment to climate change can be financed more cheaply. The competition for available funds thereby ensures that it is mainly those technologies and projects that make economic sense, which are supported. For less efficient solutions, on the other hand, it will be difficult to obtain low-cost funding. Ultimately, this will reduce the cost of climate protection and climate adjustment.

A raft of recent studies analyse the opportunities and risks of climate change for private and institutional investors. We will not be going into these issues in more detail here but merely refer your attention to related studies on this subject.⁵

1. Market for catastrophe and weather risks

Volatile weather and extreme weather events can be a threat to all corporate sectors. While certain sectors – such as energy, agriculture and tourism – are particularly exposed, sovereigns can be affected too. In the case of natural catastrophes, the economic impact on sovereigns can be very severe. Not only does rebuilding of the infrastructure have to be financed, tax revenues are lacking, too, because of the population's restricted productive capacity.

Therefore, for corporates and sovereigns it often makes sense to cover these risks by seeking a collective risk sharing solution rather than by resorting to capital reserves or government budgets. With the aid of suitable financial instruments it is possible to achieve an efficient risk sharing solution and minimise the individual cost of coverage. In the following, we will briefly review the underlying economic rationale for having such instruments:

Coverage of large volumes

— Natural catastrophes and extreme weather events generally affect a whole region or an entire country. Losses can assume huge dimensions, which eventually rise beyond the financial capacity of individual companies or sovereigns. Owing to the sheer size of global financial markets, they can, in principle, mobilise sufficient capital to finance even extremely large risks.

Efficiency and transparency

— Financial instruments enable risks to be widely spread. This is done by breaking down concentration risk into smaller pieces, which can be distributed in turn to a broad investing public, often beyond country and industry boundaries. As a consequence, risk

⁵ For a broad perspective on this issue see for instance Deutsche Bank (2007). Investing in Climate Change. An Asset Management Perspective. Deutsche Asset Management. October 2007.

diversification takes place at the level of the investors' portfolios not within an unbalanced insurance portfolio. The market mechanism ensures that risks are born by those participants who are best able to bear them. In addition, pricing can be used to derive reliable signals concerning environmental threats.

Uncorrelated asset class

— From the investor's point of view, investing in climate and weather risks presents additional possibilities for diversification. Since climate and weather risks are largely uncorrelated with general market risk, the risk-return profile of investors can often be improved. The benefits from diversification are particularly large in times when markets for traditional assets are very volatile.

Macroeconomic benefits

— The possibility for companies to cover themselves against weather related income fluctuations leaves them leeway to enter into additional business risk. This increases macroeconomic potential if the incremental income generated is greater than the hedging costs. A liquid and transparent market for weather and catastrophe risk furthermore ensures the efficient distribution of risks, potentially reducing overall hedging costs to a minimum.

Criteria for appropriate financial instruments

For the benefits from risk sharing to materialise, a number of criteria need to be fulfilled. Most of these criteria are familiar from finance theory as basic requirements for risk-hedging instruments. In the case of weather related risk transfer instruments a number of specific requirements need to be added.

Measurable and calculable risk

At first, the risk to be covered must be definable and measurable. Any loss quantifiable in monetary terms is thus essentially insurable.⁶ The loss must not be foreseeable for any of the parties. However, the probability of its occurring (but not the timing) should be predictable. The more extreme the risk to be covered is, and the more rarely it occurs, the more difficult it is to determine the expected size and probability of a potential loss. After all, estimates of these variables are usually based on historical data.⁷

Affordable risk premium

Finally, the risk premium must be affordable for the party seeking protection but at the same time cover the securing party's risk costs. In regions that are particularly prone to catastrophes, risk premiums might reach a level that makes covering the risk no longer attractive. Hence, the expected loss relative to income or property value, but not absolute volume of coverage, defines the limits on insurability.

Reliable payment trigger

Another requirement stems from a conflict in interest between the party covering the risk (investor) and the party seeking cover (sponsor). While the sponsor wishes to closely cover his loss, i.e. to minimise his basis risk⁸, the investor demands a payment trigger that is transparent, reliable and difficult to manipulate. In order to minimise such conflicts of interest, special importance must be attached to a precise definition of the event covered and its accurate measurement.⁹

⁶ Conversely, the loss of emotional values or human suffering will not be insurable.

⁷ The limits of insurability are particularly manifest in the risks from terror attacks. Such risks are difficult to calculate as they do not follow any natural laws and loss experience has a relatively short history. In addition, there is the danger that terrorists could exploit their information advantage.

⁸ Basis risk denotes the sponsor's risk resulting from the fact that the hedge instrument only approximately covers the sponsor's economic risk.

⁹ Argentina is an example of how great the temptation might be to manipulate the payment trigger. Recently, investors claimed that government agencies were



Avoidance of moral hazard and adverse selection

For an efficient solution it is also necessary that the information asymmetry between the investor and the sponsor is kept to a minimum. If the sponsor knows more than the investor about the securitised risk, there is a danger that he will use this knowledge against the investor's interests and will seek to sell bad risks at the price of average risks (problem of adverse selection). In addition, the sponsor generally may have the incentive to make the reported losses appear as high as possible ex post – irrespective of the actual losses – or not help to minimise them (problem of moral hazard). In the extreme case, the problems of moral hazard and adverse selection can cause a market to break down or not emerge at all.

Development of adequate pricing models

A specific challenge is extending traditional pricing models to allow for the valuation of catastrophe and weather risks. Weather data behave in a fundamentally different way than, say, share prices. For instance they embody a seasonal element. They are random but not statistically independent, and in the long term incline towards their arithmetical mean (barring long-term trends associated with climate change). Hence, they require distinguished statistical treatment. In addition, the statistical characteristics of weather data can diverge significantly according to where they are captured and may make quite different models necessary. With catastrophe risks, valuation is made still more difficult by the fact that very few historical data points exist. Here, valuation uncertainty is particularly high due to the lack of history. Finally, there is no spot market for catastrophe and weather risks on which market participants can base their expectations.

All this gives rise to uncertainties, which make it difficult for investors to assess a "fair value". And the greater the valuation uncertainties are, the higher the premium that is demanded for bearing the risk.¹⁰

Transfer of catastrophe risk

Covering catastrophe risks is traditionally the business domain of insurers and reinsurers. These have long offered property insurance contracts, i.e. building or industrial property insurance, which include losses caused by natural catastrophes. The idea of offloading extreme risks to the capital markets was considered for the first time in the early 1990s when hurricane Andrew imposed heavy compensation payments on the insurance and reinsurance industry.

This marked the birth of so-called catastrophe bonds and other risk transfer instruments with which peak risks from insurance contracts were passed on to the capital markets. Securitisation was a novelty for the insurance industry at that time, although banks, for the transfer of credit risk, had introduced similar instruments several years before. The advantages for insurers were obvious. Additional capacities could be mobilised. As risk was genuinely offloaded, lower capital requirements led to higher returns on equity. Finally, the trading of catastrophe risks could be used to reduce cluster risks in the insurer's own portfolio.

What instruments do exist?

Despite rapid rates of growth in the past three to five years the market for cat risk transfer as a whole is still fairly small.

Catastrophe risks

Catastrophe risks are economic peak risks resulting from natural catastrophes such as cyclones, earthquakes, tidal waves etc. By definition, catastrophes are rare events that occur in the range of once-a-century or once-a-decade.

Once-a-century risks

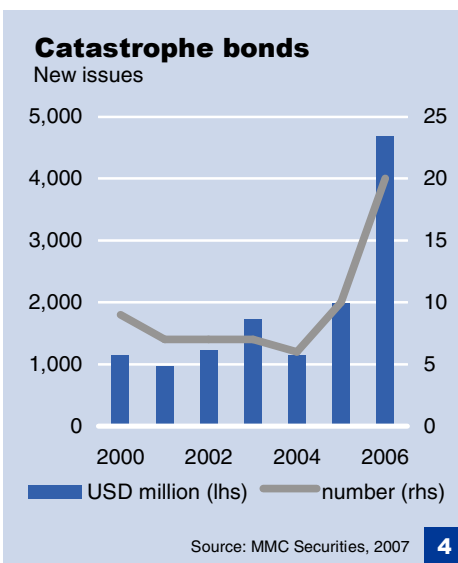
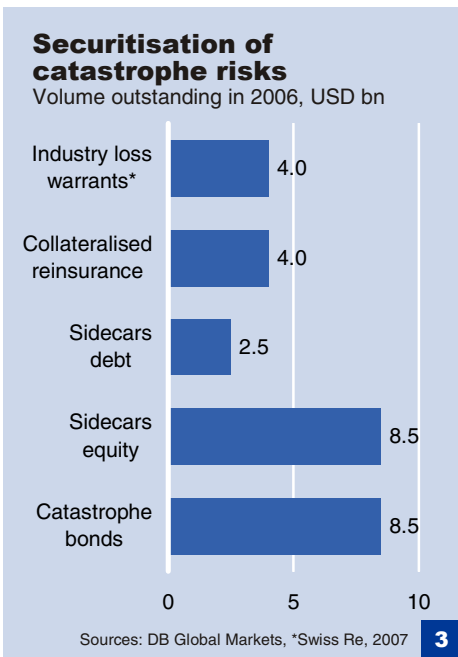
Extreme events which occur rarely, i.e. with a frequency of around 1% – or, statistically, once every 100 years. A catastrophe bond is based typically on once-a-century risks.

Once-a-decade risks

Losses that occur with a 10% probability or, statistically, once every 10 years. Recently, such risks have also been securitised in the form of "earnings protection" and passed on to the financial markets.

manipulating the inflation index that determines the rate of interest paid on index-linked bonds.

¹⁰ The market for derivative instruments in other "exotic" underlyings such as commodities or credit risks shows, however, that these obstacles are not insurmountable.



Nonetheless, there is an astounding variety of different constructions, although some are of negligible volume. A common feature of available instruments is that they cover certain peak risks which are more or less tailored to individual cases. With the exception of cat bonds and exchange-traded contracts, there is usually no liquid secondary market, i.e. after placement contracts are held until maturity. Among the more important instruments are:

- *Catastrophe bonds (cat bonds)* so far represent the biggest segment of the market for catastrophe risks with an outstanding volume of almost USD 8.5 bn (2006). A total of 20 catastrophe bonds with an aggregate volume of USD 4.7 bn were issued in 2006.¹¹ The coupons on catastrophe bonds are mostly based on LIBOR plus an appropriate risk premium. If a predefined loss occurs, the investor forfeits the capital invested. The bond is issued by a so-called special purpose vehicle (SPV), which concludes an insurance contract with the sponsor (the insured party). The SPV invests proceeds from the bond issue in fixed-income securities,¹² which, in turn, serve to cover contingent claims by the sponsor.
- A current securitisation variant, which was first used in 2006, is the so-called *cat-risk CDO (collateralized debt obligation)* transaction. In contrast to the traditional/plain-vanilla cat bond, with a *cat-risk CDO* various catastrophe risks are bundled and sold in individual risk tranches. According to the tranche, one or more events have to occur before the investor suffers a loss.
- An important segment of the still young market is capital market-financed quota share reinsurance, known as *sidecars*. The investors share proportionally in a loss according to a predetermined quota. A distinction is made between a debt and an equity tranche according to the ranking of the collateral. Estimates for 2006 put the total volume at USD 8.5 bn for the equity portion and USD 2.5 bn for the debt portion.
- A market that has already existed for some time is the market for *industry loss warrants (ILW)*, a form of capital market-financed loss (re-)insurance that is linked to an industry loss index. Market volume can only be estimated, however, as they are usually private placements which are only partly published. Estimates by Swiss Re put the total volume of ILWs outstanding last year at USD 4 bn or USD 500 m premium income,¹³ which is roughly the same size as the market for *collateralised reinsurance*.
- So-called *event loss swaps (ELS)* are a further development of conventional ILWs. They are more highly standardised and more readily tradable than ILWs, and have been offered by Deutsche Bank since the end of 2006.
- Pure *cat swaps* are used occasionally. These enable largely uncorrelated catastrophe risks, e.g. in different regions, to be swapped between two insurers.
- Another financing source for catastrophe risks is what is often referred to in the literature as *contingent capital arrangements*. This includes all options evidencing the right to raise equity or

¹¹ MMC Securities (2007). The catastrophe bond market at year-end 2006, p.5 ff.
¹² To exclude the investor's interest rate risk the payment stream from a fixed-income investment is mostly exchanged with a variable rate investment through a swap transaction.
¹³ Swiss Re (2007). Market loss index for Europe – Expanding capital market capacity, p. 3. This volume is concentrated in the USA as a reliable loss index, a basic prerequisite for floating an ILW, does not exist as yet for Europe.

debt capital or sell assets at predetermined terms and conditions in the event of a loss (*equity put*). After initial successes in the 1990s, such instruments probably play little role today as the pricing of such instruments proved difficult.

- Finally, exchange-traded contracts in catastrophe risks are also offered. So-called *cat futures and options* were first used back in the early 1990s. As turnover was small, the contracts underwent a number of modifications. Two new initiatives have been launched since the beginning of this year (see page 11 f), but no figures on trading volumes have been published as yet.

Potential sponsors

Insurers and reinsurers

Insurance companies are the “natural” sponsors for catastrophe risk transactions, since they are exposed to natural catastrophe risks on a large scale by virtue of their business model. Hence, instruments for the transfer of catastrophe risks have primarily been used by private insurers and reinsurers to expand their underwriting capacities.

Corporates with high risk exposure

Also for companies whose business activities expose them to catastrophe risks on a major scale it can make sense to seek cover through capital markets. Last year Dominion Resources, for instance, insured its oilrigs off the coasts of Louisiana and Texas against hurricane damage for the first time through a USD 50 m catastrophe bond. In 1999 Disneyland Tokyo floated a catastrophe bond to cover earthquake risks.

Government insurance and development funds

Government aid and development funds and state insurance funds comprise another important group of potential sponsors. Prominent examples include France’s natural catastrophe insurance scheme (NatCat) and Mexico’s natural catastrophe fund FONDEN that last year transferred a total of USD 160 m of earthquake risks to the capital markets for the first time through catastrophe bonds. Other examples include Ethiopia’s drought insurance scheme or the planned Caribbean catastrophe insurance scheme.¹⁴

Potential investors

The appraisal of catastrophe risks requires very special know-how, which in turn limits the circle of potential investors. In fact, only a relatively small group of sophisticated and well-informed investors – typically insurers and reinsurers, institutional investors and hedge funds – participate in this market. While the ones – insurers and reinsurers – wish to hedge their own positions by taking on complementary risks, for the others – hedge funds and institutional investors – it is the opportunity to earn attractive risk premiums.

Few private investors participate in the market for catastrophe risk since suitable investment products for the retail market are lacking to date. The still comparatively small market volume and the limited tradability of the instruments have so far prevented a further broadening of this investment possibility, for instance in the form of retail mutual funds. An exception is the products offered by the Swiss private banks Clariden Leu and AIG Private Bank, which offer mutual funds that invest into catastrophe bonds. Also, Pioneer’s Diversified High Income Trust, a US fund that, among other things, also invests in catastrophe bonds has been traded on Amex since May 2007.

Is investing in catastrophe risks worthwhile?

Can investing in catastrophe risks be a good proposition if these risks are expected to increase in connection with climate change?

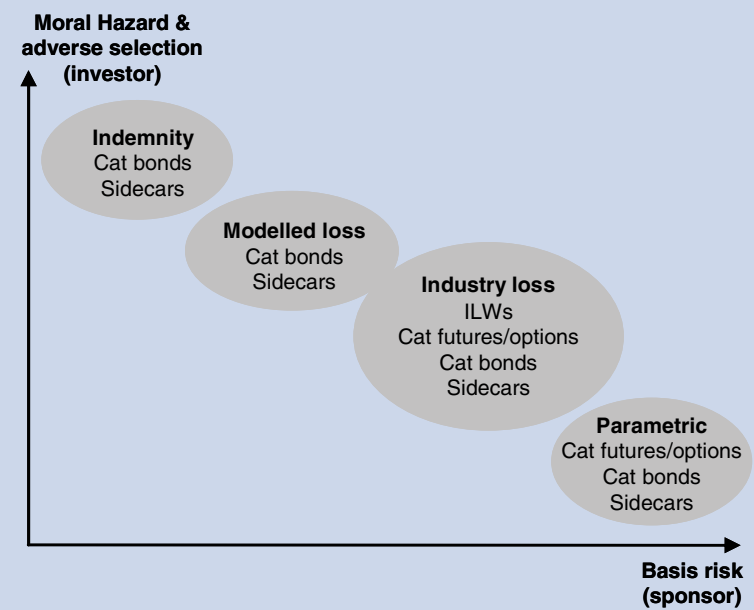
If the horizon chosen is short enough, the risk for each individual investment is predictable. And that is normally the case: a typical cat bond issue has a life of 3 to 5 years. The loss probability does not change or changes little during this relatively short period of time, so the investor’s risk calculation remains intact throughout the life of the bond. Nonetheless, an investment in catastrophe risks is a high-risk transaction, which can lead to a total loss.

¹⁴ See Hoffman and Brukoff (2006). Insuring Public Finances against Natural Disasters – A Survey of Options and Recent Initiatives. IMF Working Paper 06/199. Washington D.C.

Payment triggers

One of the biggest challenges in the structuring of risk transfer solutions is the choice of a suitable payment trigger (see box). In recent years, various solutions have evolved in parallel, covering the whole spectrum between high transparency, on the one hand, and low basis risk for the sponsor, on the other. However, no industry wide standard has been established yet.

Payment triggers – risks for investors and sponsors



Sources: Swiss Re 2006, DB Research **5**

Various payment triggers

Compensation

Payment trigger is based on the sponsor's actual losses.

Modelled loss index

Insurance risks are modelled on the basis of different weather characteristics. In the event of a weather event the modelled loss is determined on the basis of actual weather data.

Industry loss index

Industry-wide loss index which is determined in the USA by information services provider Property Claim Services (PCS). There is as yet no generally accepted industry loss index for Europe.

Parametric index

Based on physical characteristics of a weather event (e.g. location and wind speed of a hurricane).

Hybrid forms

Combination of at least two different approaches.

Source: MMC Securities, 2007

With standardised and highly parameterised payment triggers the problem of moral hazard and adverse selection is mostly lower than with individual solutions. Investors therefore prefer such solutions. Sponsors, on the other hand, favour solutions that are linked more strongly to their own losses. Which payment trigger is ultimately selected depends on the two parties' respective negotiating power and the possibilities for dealing with the information problems discussed earlier through supplementary agreements. So-called industry loss indices are a very promising compromise. However, here, too, the neutrality and quality of the figures determined are crucial.

Over half of the entire cat bond transactions since 2003 are based on an industry index.¹⁵ This requires a neutral body, which determines the industry-wide loss reliably in each case. In the USA this role is assumed by the Property Claim Services (PCS), a private information services provider which enjoys the confidence of sponsors and investors alike. There is no comparable institution so far for Europe. In part, the big insurance companies, Swiss Re and Munich Re, provide corresponding indices but they command only limited confidence among potential investors because of their low transparency and lack of neutrality.

Exchange-traded contracts

Major drawbacks of the risk transfer instruments discussed above are the relatively high transaction costs and the limited possibilities

¹⁵ Swiss Re (2007), *ibid*, p. 2.

to sell them again. Exchange-traded catastrophe options and futures offer an alternative which looks convincing in theory but which has been of marginal practical relevance so far.

First generation failed

Initiatives to establish a market for standardised catastrophe futures were already launched back in the early 1990s. With the introduction of such instruments on the Chicago Board of Trade (CBOT) it was hoped that a liquid market would quickly evolve and that transaction costs would be reduced. However, the new products did not take off. After modifying the underlying payment trigger in September 1995 volumes initially rose, but eventually died up altogether within less than five years.

Greatest challenge: Lacking spot market

The greatest challenge in establishing a liquid market in exchange-traded catastrophe derivatives was the lacking of a spot market. Hence, market participants had little guidance when forming expectations. Back then, an industry loss index served as a payment trigger that was calculated at irregular intervals and could be subsequently corrected. Because of the index's irregular calculation and the low liquidity of the markets a regular price quotation was not possible. In part, there was little correlation between the actual losses sustained and the prices of the hedging instruments that could be realised. This increased the basis risk until maturity of the contract and final settlement. Low market liquidity led to higher risk premiums, which considering additional basis risk that had to be borne made a traditional insurance solution the better option.

Merits of exchange-traded contracts

Still, a viable market in exchange-traded contracts can offer a number of advantages: compared with individual solutions, it allows scale effects to be realised through standardisation and high volumes. Assuming sufficient liquidity, transaction costs can be reduced and the benefits of dynamic portfolio risk management can be realised. However, the counterparty risk in of exchange-traded contracts is generally not excluded.

Recent initiatives

Very recently, a number of initiatives set out to revive the market for standardised contracts. Since March 2007, for instance, NYMEX has been offering futures and options based on the PCS industry loss index. In September 2007 the Chicago Climate Futures Exchange (CCFE) in collaboration with Deutsche Bank announced the planned offering of catastrophe event-linked futures (ELF). These contracts will also be based on the PCS index. In contrast to the above mentioned exchanges, the CME offers futures and options based on a parametric index. This index tracks the radius and strength of hurricanes in certain endangered US coastal regions. The futures and options offered are comparable to other weather derivatives.

Key to success: transparency and confidence

Whether the new instruments will be successful depend on how far the pitfalls of the first generation can be avoided. The growing interest in industry loss warrants shows that the PCS indices meanwhile command confidence in the market and that the insurance industry is able to calculate its basis risk accordingly. Low transaction costs and the ability to liquidate them at any time are key advantages of PCS-based exchange-traded contracts.

With parametric contracts the basis risk is somewhat higher, at least for the insurance industry. Here, it still has to be seen whether the potential sponsors are willing to live with that. Ultimately, the success of exchange-traded contracts will depend on whether the exchanges succeed in mobilising a critical mass of active market participants. This is conditional upon acceptance among investors as well as sponsors.

Current and future trends	
Product diversity in future, too	The development of the market for catastrophe and weather risks is primarily driven by demand from sponsors: where there is no need for coverage, there is no market. A broad range of solutions has developed, since the requirements of potential sponsors differ very widely. This will not change in the future either. Still, considering the conflicting demands of transparency, basis risk, transaction costs and fungibility, some solutions will prove more beneficial than others. Investor acceptance is a crucial factor here. Catastrophe bonds, industry loss warrants and standardised contracts will be first choice, as they satisfy investors' preferences in terms of transparency and/or fungibility. On the other hand, continued use will be made of individual solutions, which can be tailored to the sponsors' specific needs. This includes sidecar arrangements and collateralised reinsurance for instance.
Growing securitisation of cat risks	Given rising natural catastrophe risks and insurers' limited risk underwriting capacity, the demand for capital market-based risk transfer solutions will generally grow. This trend will be reinforced especially by the capital adequacy rules of Solvency II ¹⁶ also in respect of other risks. Similarly to the development in banks' commercial lending business, insurers' and reinsurers' business model will shift from a "buy-and-hold" to an "originate-repackage-and-distribute" strategy. Though not the initial trigger, the effects of climate change will tend to accelerate this development.
Minimum lot sizes decline	Owing to the high transaction costs and minimum lot sizes of several million euro, it is unlikely that tailor-made capital market coverage will be suitable for a wide range of individual companies. A conventional (re-)insurance solution will still be the more favourable option for the majority of small insurer or other exposed companies. However, as the business becomes more and more standardised and as the number of transactions grows, the (fixed) costs of direct coverage through the financial markets will fall. This option should then become increasingly attractive also for insurers that previously covered their exposure through conventional reinsurance. At the same time there will also be growing demand for capital market solutions from individual companies whose business exposes them to catastrophe risks (e.g. oil industry or tourism).
New business opportunities for banks	The growing market for catastrophe and weather risks presents new business opportunities for banks, too. They play an active role as issuing bank, advisor and structurer in securitisation transactions, such as cat bonds or sidecar arrangements, and make the necessary capital market know-how available to potential sponsors. Often they can draw on long experience in structuring and placing similarly structured debt securitisation transactions. In addition, they develop and trade in standardised contracts and thus help broaden the circle of potential users.
Growing investor appetite	The incidence of natural catastrophes is independent of financial market crises and, conversely, natural catastrophes usually have little impact on financial markets. Hence, the correlation between catastrophe risk and market risk of alternative asset classes is low. A similar argument holds for weather risks. This makes investing into catastrophe or weather risk very attractive especially at times when bond or stock markets are volatile. In addition, catastrophe bonds usually offer returns that are three to four times the expected

¹⁶ Solvency II (aligned to Basel II) reforms the solvency rules for insurance companies' capital backing.



Weather risk

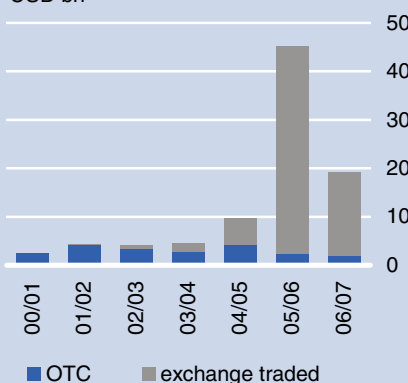
The term “weather risk” groups together sales or procurement risks which can arise as a result of unforeseen weather fluctuations.

In contrast to the (natural) catastrophe risks described above, these are not rare extreme events but daily fluctuations in temperature, rainfall or wind.

Particularly widespread are contracts on temperature indices which are usually measured in HDD (heating degree days) and CCD (cooling degree days). However, meanwhile there are also contracts on rainfall, snowfall and storm risks.

Weather derivatives

USD bn



Source: PwC/WRMA, 2007

6

losses.¹⁷ If securitisation volume grows in future, this is likely to attract broader groups of investors. As the example of the first cat bond mutual funds shows, investments in catastrophe risks – if professionally managed – can also be suitable for the retail market. The key to success is the know-how in valuing catastrophe risks. So players who position themselves in this market early on stand to benefit.

Weather derivatives

While the market for catastrophe risks covers extreme costly events with low likelihood, the market for weather derivatives is concerned with relatively low cost high probability events. Similar to the market for catastrophe risk, the emergence of the weather risk market was initiated by one of the industries most exposed to such risks, namely the US energy sector.¹⁸ Energy utilities face significant volume risk due to temperature fluctuations. Unusually low temperatures in summer for instance lead to low energy consumption owing to reduced demand for air-conditioning. Likewise, a relatively warm winter may result in low energy consumption due to reduced heating. Such volume risks may be hedged via an appropriately structured temperature contract.

OTC versus exchange-traded contracts

An agreement between the US energy utilities Enron and Koch in 1997 to swap opposing weather risks is noted as the onset of the weather derivatives market. Weather derivatives could hence be used to hedge weather-related income or procurement risks.

At first, such contracts were negotiated individually as so-called over-the-counter (OTC) deals. However, parallel to OTC transactions a market for standardised, exchange-traded contracts quickly emerged. In 1998 the Chicago Mercantile Exchange (CME) introduced tradable weather-related futures and options. In August 2001 the London International Financial Futures Exchange (LIFFE) followed suit with its own product offering. Currently, weather derivatives are traded only on the CME – aside from the OTC market. Due to a lack of demand, LIFFE has abandoned its activities for the time being, and so has the European futures and options exchange Eurex, which was also planning to offer weather derivatives. Meanwhile, CME is constantly looking to expand its product range. More recently, it newly introduced contracts on hurricane risks – mentioned earlier – and extended the regional spectrum to include a number of European cities. In fact, the turnover in exchange-traded contracts at CME has grown strongly in recent years, while volume on the OTC market has somewhat contracted.

Contributing to the rising popularity of exchange-traded contracts is the fact that transaction costs are lower and that contracts are more easily tradable compared to the OTC market. Exchange traded contracts can thus be used more flexibly as a risk management tool and for speculative purposes. Furthermore, the underlying risks are quantified exclusively with the aid of parametric indices, such as temperature, rainfall or wind speed indices. The parametric underlying, which is transparent and not easily manipulated, makes

¹⁷ The conspicuously high yield is due to the high degree of uncertainty in estimating the expected losses. Hence, the yields observed represent the price that makes investors accept these risks in the first place.

¹⁸ Compare Auer, Josef (2003). Weather derivatives heading for sunny times. Deutsche Bank Research. Frankfurt Voice. February 25, 2003. Frankfurt am Main.

weather derivatives particularly suitable for standardised trading on an exchange.

On the downside, basis risk can be a particular problem with exchange-traded weather contracts. Not only can the correlation between weather fluctuations and the volatility of the income hedged be high, the distance from the nearest weather station can also influence the basis risk to a considerable extent. Exceptional weather risks or risks which do not relate to regions that are traded on a standardised basis are therefore covered through individual solutions (OTC). Often, this requires the development of a customised weather index that takes account of the sponsor's specific needs.

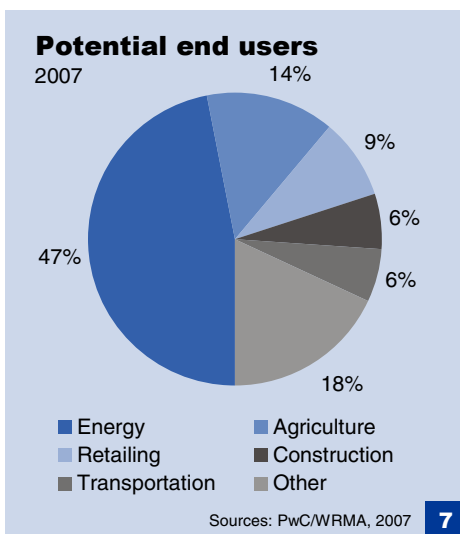
Potential users

The list of potential end users is long and ranges from the retail trade, via the tourism industry, to agriculture. While the market for weather derivatives is still dominated by the large US utilities, other sectors – such as agriculture – are about to increasingly discover the advantages of hedging weather related volume risks.¹⁹

Strikingly, the discrepancy in contracted volumes between the US and Europe has not closed but rather widened in recent years. Yet, it is not clear why European companies are less inclined to make use of weather derivatives relative to their US counterparts. One reason may be less the volatile weather in Europe compared to the US, hence a reduced need for hedging; another could be the difference in risk perception or simply the availability of alternative forms to balance fluctuation in sales volumes.

For the agricultural sector in emerging and developing countries, the use of weather derivatives is a very promising option too. Often, it is farmers in these countries that are particularly exposed to weather risks, while alternative forms of hedging are lacking, e.g. via the accumulation of reserves. In such cases, weather derivatives can be used either to counter-finance government safety nets or as micro-insurance for risk-exposed farmers.²⁰

Finally, hedging need not be the only motive for participating in the weather risk market. It can also be arbitrage or speculation. As the example of the CME shows, with maturing markets other groups of investor are also attracted. Thus, the large volumes in the trading season 2005-06 could partly be attributed to so-called cross commodity trades, i.e. to positions betting concurrently on a given weather and commodity price trend. Such investment strategies are not necessarily harmful. On the contrary, speculation or arbitrage makes for higher liquidity and enhances the price finding process. After all, the risks of speculatively driven exaggeration on the weather market are limited. Since weather data incline towards their mean values in the long term (apart from obvious trends associated with climate change), boom-and-bust cycles of the kind regularly witnessed on the property and equity markets are far less likely.



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¹⁹ See Roth, Michael, Christina Ulardic and Juerg Trueb (2007). Critical success factors for weather risk transfer solutions in the agricultural, sector – A reinsurer's view. EAAE Seminar. Berlin.

²⁰ The World Bank's Commodity Risk Management Group (CRMG) assists in developing appropriate solutions and conducts pilot projects for instance in India, Latin America and Africa.

2. Emissions trading

Greenhouse gas emissions

Greenhouse gases (GHGs) are gases which contribute to the greenhouse effect and thus to global warming. They can be of anthropogenic or natural origin.

The *Kyoto Protocol* regulates carbon dioxide (CO₂) as well as methane (CH₄), nitrous oxide (N₂O), sulphur hexafluoride (SF₆) and fluorocarbons. The anthropogenic sources of emission from the combustion of fossil fuels (coal, oil and gas) are claimed to be responsible for the greenhouse effect.

For emissions trading purposes greenhouse gas emissions are converted into CO₂-equivalents.

Emissions trading can be an effective *policy instrument* that is used to increase the efficiency of global climate protection efforts (see above). At the same time, with the introduction of tradable emission certificates and trading systems innovative *financial products and markets* are created which present opportunities but also harbour risks for the actors involved. The market for emission certificates is already worth almost USD 30 bn today²¹ and its volume is expected to multiply in the coming years.

But what is actually traded in the emissions market? Who are the potential market participants? And what role does the political and regulatory framework play in the market's development? These and other questions are the focus of this chapter.

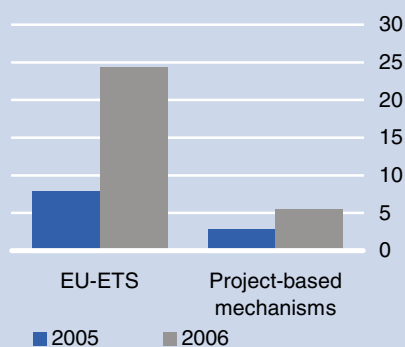
EU-emissions trading

The EU emissions trading system (EU-ETS) is by far the biggest market for greenhouse gas emissions.²² According to calculations by the World Bank, emission rights worth over USD 24 bn were traded in 2006. On top of that there were USD 5.5 bn of certificates from project-based mechanisms (see below).²³

EU emissions trading implements the targets of the Kyoto Protocol which came into force at the beginning of 2005 and provide for greenhouse gas emissions in the industrial countries to be reduced on average by 5.2% versus the 1990 level by the first commitment period (see box). As a signatory to the Kyoto agreements in its own right, the EU committed to a reduction of 8% (Germany 21%). The negotiations on a successor agreement are already under way. An official resolution on the start of comprehensive negotiations is due to be passed at the climate summit in Bali at the end of 2007. It is then planned for an international trading system to be established under the Kyoto successor protocol.

EU emissions trading

USD billion



Source: The World Bank, 2007

8

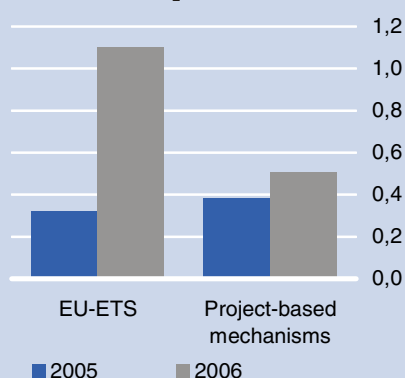
Phases of EU emissions trading

2005 - 2007	2008 - 2012	from 2013
1 st allocation phase „test period“	2 nd allocation phase 1 st commitment period	Kyoto successor 2 nd commitment period

9

EU emissions trading

billion tonnes CO₂



Source: The World Bank, 2007

10

What types of emission certificates do exist?

The Kyoto Protocol and the supplementary agreements define a number of different emission certificates. First of all, a distinction is made between emission *rights* and emission *credits* from project-based mechanisms. In the first case, there is an allotment of a limited supply of emission rights, which can be traded among the emitters of greenhouse gases (cap and trade). This includes the EU allowances (EUAs) that are traded in the EU emissions trading system (EU-ETS) and the assigned amount units (AAUs) that are intended for international trading. In the second case, investors can have credits from additional climate protection projects in third countries credited to their own reduction target (baseline and credit). A distinction is made according to whether the projects are realised in another industrial country (Joint Implementation, JI) or in a developing country (Clean Development Mechanism, CDM). If the

²¹ The World Bank (2007). State and Trends of the Carbon Market 2007.

²² There are other voluntary systems in Australia, Japan, the USA and Great Britain.

²³ The World Bank (2007), *ibid*.

reductions take place in an industrial country, the resulting certificates are called emission reduction units (ERUs). Those obtained from emerging markets and developing countries are called certified emission reductions (CERs).

Another option provided for in the Kyoto Protocol is the realisation of carbon-sink projects at home, for instance in the form of afforestation. This results in so-called removal units (RMUs). Finally, it is possible to generate tradable project-based credits in the form of verified emission reductions (VERs). Unlike CERs and ERUs, these can only be used for voluntary CO₂ compensation.

	Emission certificates	Source of the certificates
Emission rights trading	EU Allowances (EUAs)	Allocation of emission rights under national allocation plans (NAPs)
	Assigned Amount Units (AAUs), not traded as yet	Allocation of emission rights within the framework of the Kyoto Protocol
Trading in emission credits	Certified Emission Reductions (CERs)	Project-based reduction in emerging markets and developing countries: Clean Development Mechanism (CDM)
	Emission Reduction Units (ERUs)	Project-based reduction in industrial countries: Joint Implementation (JI)
	Verified Emission Reductions (VERs)	Project-based reduction within the framework of voluntary compensation
	Removal Units (RMUs)	National carbon sink projects

The range of different instruments under the Kyoto Protocol is also mirrored in the diversity of the market for emission certificates. Besides the trading in emission rights (EUAs), a market has also become established in credits from project-based mechanisms (CERs) on which we will be focusing in the following paragraphs.

Project-based mechanisms

The emission of greenhouse gases is a global problem; however, emerging markets and developing countries have been exempted so far from the Kyoto Protocol’s quantitative reduction commitments. All the same, the containment of greenhouse gases can often be realised at much lower cost in emerging markets than in the industrial countries. This is where the Kyoto Protocol’s project-based mechanisms kick in. They allow emission credits (CERs and ERUs) from additional climate protection projects in third countries to be credited to the own reduction target.

However, to prevent the industrial nations from “buying” their way out of any reduction commitment at home, there are limits to how much can be credited to the own reduction targets. In concrete terms this means: industrial *countries*, which have signed and ratified the Kyoto Protocol must achieve at least half of their reduction targets through measures at home. This has to be distinguished from the limit applying to *corporates* that participate in the EU-ETS. In Germany, companies may not compensate more than 22% of

Investment risks with CDM projects

At the time when an investment is made in a CDM project it is not yet certain how many eligible emission credits (CERs) will ultimately be generated. The investment risks can be classified as follows:

Registration risk

The CDM Executive Council refuses registration.

Project risk

The project generates fewer certificates than planned.

Country risk

Permits required from the host country are not issued; losses are caused by political instability or corruption.

Source: Fraunhofer ISI (2005)

Pioneering carbon funds

their reduction commitments in the first commitment phase by purchasing CERs and ERUs.

With the CDM, an investment is made in a project or in a portfolio of various projects, which promises to yield future income in the form of CERs. The proposed projects and their valuation can differ widely. The rights to future CERs are traded at a discount according to the project's stage of progress. The less advanced the project is, the higher the risk and thus the discount (see box). "Tradable" (homogeneous) certificates that are not longer exposed to any investment risks only arise once the emission credits are registered in the central register and are cleared for trading.

The price of certificates from project-based mechanisms are usually a third below that of EUAs and is oriented to the project costs for avoiding one tonne of CO₂ equivalent. Owing to the costly recognition and accreditation process, individual projects usually need to generate at least 25,000 CERs a year to pay off. However, scale effects can be achieved through long-term projects or the repeated use of measures that have already been certified once by the CDM Executive Council.

Potential market participants

So-called carbon funds are playing a pioneering role in the financing of CDM projects. These include government purchasing programmes or private commercial funds, which began investing in emission rights or credits already before the Kyoto Protocol came into force. One of the first carbon funds was the Prototype Carbon Fund (PCF) launched by the World Bank. The intention was, among other things, to gather experience with the new emissions trading instruments and to prepare the market for later funds.

Investing in a carbon fund is an interesting option especially for governments and private enterprises that have to meet reduction targets within the framework of the Kyoto Protocol. However, investors who have no commitments of this kind but hope to earn a positive return on their capital can invest, too. Carbon funds offer a number of advantages over a direct investment. First and foremost, investors profit from the fund's know-how in executing projects. As a rule, realising climate projects in emerging markets and developing countries requires experience and highly specialised technical and organisational know-how. Carbon funds also allow a better risk diversification as they generally invest in various projects, and often in different countries, too. Additionally, by bundling invested funds it is possible to realise scale effects and reduce pro rata transaction costs.

More and more private and...

Initially it was mainly government or quasi-governmental institutions like the World Bank or individual nations that were involved in financing CDM projects. Meanwhile, the private sector has discovered that financing climate protection in emerging markets and developing countries can be an attractive area of business. More and more private investment banks, brokers and institutional investors are buying and selling certificates for own or third-party account. Companies that have to meet reduction commitments within the EU-ETS framework are still the biggest group of end buyers (compliance buyers). There are now also derivative instruments linked to emission certificates available with which they can hedge against future price fluctuations.

... voluntary engagement,...

Companies and private individuals are also buying emission credits to compensate their own emissions on a voluntary basis. There is

growing awareness of climate issues and the market for emission certificates makes voluntary CO₂ compensation possible at no great cost and effort for the end user. A number of major players in the financial services industry have already placed their entire activities on a CO₂-neutral basis. There is also growing interest in initiatives like “atmosfair”²⁴ which offer emission credits to compensate air travel or any other activity that produces GHG emissions.

... also by investors

With increasing product differentiation, new possibilities are also opening up for investors. They can participate in the realisation of CDM projects or bet on rising prices through derivative instruments on emission certificates.

Success factors

The commonly shared political goal is to slow climate change by reducing greenhouse gas emissions. Emissions trading is a means to that end and is intended to help achieve this goal as cost efficiently as possible. Rights and credits are traded, which are defined primarily by international treaties and political agreements. Market growth and price volatility therefore depend – more than in any other market – on political decisions and regulatory framework conditions. For instance, if the reduction targets set at the political level become more ambitious, the prices of emission certificates will rise. If the banking²⁵ options are restricted, they will fall. Hence, for market participants, opportunities and risks emerge not only from the development of fundamental factors but especially from evolving politico-regulatory parameters.

The following can be said from the regulatory perspective: besides incentive compatible rules, a functioning market requires an efficient system design and reliable policy-making. This includes a regulatory impact assessment when setting or modifying market-relevant rules and the management of market expectations. Finally, there must be long-term planning certainty for investors; speedy certification and execution must be assured, especially with project-based mechanisms. Only in this way can the (political) climate strategy be implemented efficiently with the help of emissions trading.

²⁴ <http://www.atmosfair.de>.

²⁵ *Banking* denotes the possibility of using emission rights or credits beyond the end of a commitment period.

Conclusion

Financial markets already play an important role today in coping with climate change. Financial markets contribute towards minimising the cost of reducing greenhouse gas emissions, support (climate-related) technological change, and help to manage the financial consequences of natural catastrophes and weather risks.

In future, financial markets will be called on increasingly to accommodate abatement and climate adjustment strategies. This is indicated by two foreseeable trends: Firstly, there will most likely be rising earnings fluctuation as a result of ever more volatile weather conditions and increasingly frequent and severe extreme weather events. Secondly, global climate protection efforts – whether voluntary or not – will be stepped up as the hazards from climate change grow.

New financial instruments are emerging in response to the mounting climate threat: (1) The market for weather and catastrophe risks enables previously uninsurable risks to be insured against and the hedging costs to be minimised. Prices in these markets can be used to derive reliable signals concerning environmental threats. For investors, weather and catastrophe risks present an investment alternative that is largely uncorrelated with conventional assets classes. (2) The market for emission rights and credits provides an incentive to reduce emissions and helps to achieve this goal cost efficiently. Investors can bet on rising or falling prices, or participate in carbon reduction projects.

The success factors differ appreciably from market to market. While the market for catastrophe and weather risks will hinge mainly on the development of transparent payment triggers and adequate valuation models, the development of the political and regulatory framework conditions will be a key factor for emission trading.

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