Catastrophic Events as Threats to Society: Private and Public Risk Management Strategies*

Martin Nell[1] and Andreas Richter[2]

[1]University of Hamburg, Institute for Risk and Insurance, Email: *martin.nell@rrz.uni-hamburg.de*
[2]Illinois State University, Department of Finance, Insurance and Law, Email: *arichter@ilstu.edu*

Abstract: Dramatic events in the recent past have drawn attention to catastrophe risk management problems. The devastating terrorist attacks of September 11th, 2001 incurred the highest insured losses to date. Furthermore, a trend of increasing losses from natural catastrophes appears to be observable since the late 1980s. The increase in catastrophe losses triggered intensive discussion about risk management of catastrophic risk, focusing on three issues. First, considering the loss potential of certain catastrophic events, the insurance markets' capacity does not seem to be sufficient. An approach to address this capacity issue can be seen in passing certain catastrophic risks to investors via securitization. Second, after the events of September 11, 2001, the government's role as a bearer of risk became an increasingly important issue. Finally, as has been recently demonstrated by the floods in Europe of August 2002, problems of protecting against catastrophic threats do not only exist on the supply side but also on the demand side. Thus policymakers are considering the establishment of mandatory insurance for fundamental risks such as flood and windstorm. This paper will address aspects of these three issues. In particular, we are concerned with the extent to which state or government involvement in the management of catastrophic risk is reasonable.

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1. Introduction

Dramatic events in the recent past have drawn attention to catastrophe risk management problems. The devastating terrorist attacks of September 11th, 2001 incurred the highest insured losses to date. According to current estimates, property and business interruption insurance losses alone amount to 19 billion USD. Estimates of the total insured losses (including, in particular, life and liability insurance) range from 30 to 77 billion USD.[1]

The extent of these consequences leads to a reassessment of a risk category that had been, until that point, either ignored or underestimated. An intensive discussion was triggered among insurance practitioners and economists about ways to reorganize the financing of terrorism-related risks.[2] This discussion, on the one hand, indicates open questions with respect to the optimal design of risk management tools for a given individual catastrophe risk situation. On the other hand, from a more fundamental point of view, it highlights the problem of how a society should in principle deal with such risks, particularly how *man-made* disaster risks should be allocated. Aspects of both, individual management of catastrophic risk as well as societal decisions regarding the allocation of man-made catastrophe risk, will be tackled here.

Prior to September 11th, the highest insured losses had, by far, been incurred by natural catastrophes. In particular, one has to mention the accumulation of major natural disasters at the beginning of the 1990s, including Hurricane Andrew in 1992 and the Northridge earthquake in 1994.[3] Furthermore, while the (yearly) man-made disaster losses, before 2001, seemed rather flat, a trend of increasing losses from natural catastrophes appears to be observable since the late 1980s (see Fig. 1.1.).

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[1] See Zanetti et al. (2002).

[2] See, e.g., Nell (2001), Rees (2001).

[3] The total insured consequences (excl. liability) of hurricane Andrew, according to current estimates, amount to 20.2 billion USD, and losses resulting from the Northridge earthquake to 16.7 billion USD. The most dramatic (in terms of insured losses) man-made catastrophe before the World Trade Center and Pentagon terrorist attacks was the explosion on platform Piper Alpha in 1988 (3 billion USD), the thirteenth-biggest event in the list of insured events from 1970 through 2001. See Zanetti et al. (2002), p. 23.

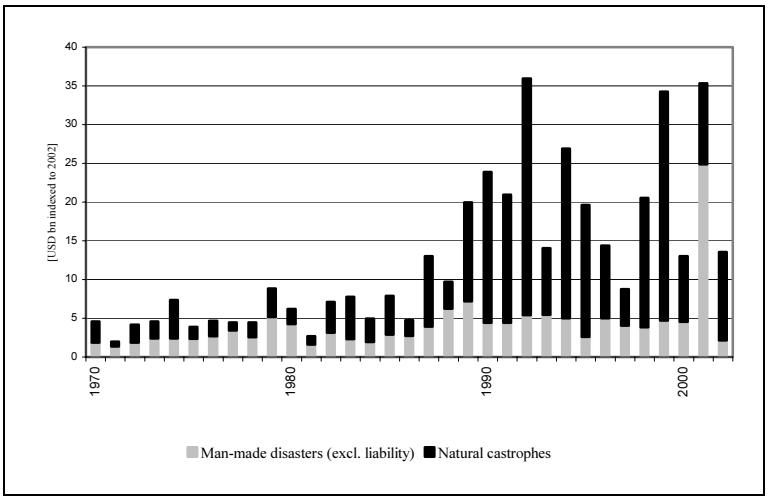

Fig. 1.1. Natural and Man-made Catastrophes 1970 – 2002

(Data: Swiss Re, Economic Research & Consulting; Zanetti et al. 2003)

One could detect an increasing frequency of catastrophic events as well as an increase in the average amount of loss per event. In particular, the increase in size can largely be attributed to the growing density of population and the geographic concentration of values in catastrophe-prone areas.[4] With respect to the apparent increase in number of such disasters, one might refer to implications of climate change as well as to stochastic factors. Certainly, a part of the recent accumulation of natural catastrophes was due mainly to random influence or coincidence. This becomes obvious for the case of earthquakes in 1999: Although the number of severe earthquakes was not unusual, these events were perceived as a very singular accumulation, since in a short time span several densely populated areas were hit.[5]

The just-mentioned increase in catastrophe losses triggered intensive discussion about risk management of catastrophic risk, focusing on the following three issues:

1. Considering the loss potential of certain catastrophic events, the insurance markets' capacity does not seem to be sufficient. One example is the series of insurer bankruptcies following Hurricane Andrew. Hurricane Andrew, of course, was a major natural disaster. Still, it incurred losses much smaller than the amounts today's estimates assign to certain scenarios: Catastrophic events resulting in insured losses of 100 billion USD or more, which might lead to a partial collapse of insurance markets, are considered possible. An approach to address this capacity issue can be

[4] See, e.g., Zanetti et al. (2001) or Berz (1999).
[5] See Nell and Richter (2001), pp. 237-238.

seen in the so-called *alternative risk transfer (ART)* transactions, which emerged after the late eighties' and early nineties' severe natural disasters. These transactions would directly pass certain catastrophic risks to investors via securitization. Therefore, a significant share of the earlier work on the management of catastrophic risk concentrates on ART and its potential to cover catastrophic risk.

2. After the events of September 11, 2001, the government's role as a bearer of risk became an increasingly important issue. This development was mainly triggered by the fact that insurance companies around the world cancelled contracts with airlines and airports. The terrorist attacks of New York and Washington had induced a major reassessment of air traffic-related liability exposure, such that insurance companies were only willing to offer coverage at significantly increased rates. As aircrafts without sufficient liability coverage would not be given permission to take off, air traffic was in danger to cease more or less entirely. Facing this scenario, many governments provided state guarantees for airlines based in their countries. Additionally, many states participate in the different types of risk-sharing arrangements recently introduced to cover terrorism risk in various countries. This again triggered a political debate on the advantages and disadvantages of such state intervention with respect to the insurance of terrorism risk.
3. Finally, as has been recently demonstrated by the floods in Europe of August 2002, problems of protecting against catastrophic threats do not only exist on the supply side but also on the demand side. In Germany, for instance, the proportion of insured victims was quite small, although coverage would have been easily available in almost every affected region. As a result, policymakers are now considering the establishment of mandatory insurance for fundamental risks such as flood and windstorm.

This work will address aspects of these three issues. In particular, we are concerned with the extent to which state or government involvement in the management of catastrophic risk is reasonable. As, in principle, we are in favor of public-private partnerships, one goal of this paper is to identify key elements of a meaningful division of labor between public and private institutions.

We will proceed as follows: Section 2 addresses recent approaches to financing catastrophic risk via the capital markets. Problems of covering terrorism risk are discussed in section 3. In section 4 we deal with potential inefficiencies in the demand for catastrophe coverage and their implications, and section 5 concludes with a brief assessment of our findings.

2. Insurance-linked securities

The extreme losses from natural catastrophes in the early 1990s lead to a temporary shortage of catastrophe reinsurance, as reinsurers became more cautious and therefore limited the supply, withdrew from the catastrophe risk market or (espe-

cially after Hurricane Andrew) even went bankrupt.[6] In addition to this, one could easily imagine natural disaster scenarios producing even much higher losses. For instance, the estimated insured loss potential is about 60 billion USD for a severe hurricane hitting the U.S. east coast and 100 billion USD for a major California earthquake.[7] Especially, when reference is also made to the enormous potential of economic losses – 100 billion USD for the former, 300 billion USD for the latter event – these scenarios seem to show the capacity limits of traditional insurance markets.

Furthermore, it has to be assumed that an event of this size would again cause a series of insolvencies in the reinsurance market. Therefore, a significant part of the currently provided capacity might not be available when needed.[8]

The seemingly existent reinsurance capacity gap, combined with an increase in catastrophe coverage prices that followed hurricane Andrew,[9] set off a search for ART solutions. The focus was primarily on tools that would enable the direct transfer of risk using the financial markets, via so-called insurance-linked securities. Contributions with respect to an extension of capacity could be expected if, for example, the issuance of marketable securities was able to attract additional capacity from investors who are not otherwise related to the insurance industry.[10]

Capital market insurance solutions could be observed since 1992. The following provides a brief overview of some basic forms of insurance-linked securities.[11]

At the end of 1992 the Chicago Board of Trade (CBOT) started trading futures on catastrophe loss indexes and related options.[12] These instruments were based upon underlying indexes representing the development of losses for certain regionally defined markets.[13] An index was computed using actual loss data from a subset of insurance companies having business in the respective area. The deriva-

[6] Holzheu and Lechner (1998), p. 11.

[7] See Durbin (2001), pp. 298-299.

[8] For an approach to measuring the (re)insurance markets' capacity for catastrophe risk, see Cummins et al. (2002).

[9] See, in particular, Froot (2001), p. 540.

[10] To motivate the interest in financial market solutions for the transfer of insurance risk, authors often refer to the size of the financial markets or their daily fluctuations in comparison to the size of a major natural catastrophe (see, e.g., Durbin, 2001, p. 305, Laster and Raturi, 2001, p. 13, or Durrer, 1996, pp. 4-5). For example, a 250 billion USD event would only represent less than 0.5% of the total market value of publicly traded stocks and bonds of 60 trillion USD (Laster and Raturi 2001, p. 13).

[11] For a more comprehensive discussion of insurance risk securitization design possibilities as well as for data concerning transactions in this field see, e.g., Durrer (1996), Baur and Schanz (1999), Belonsky et al. (1999), and Laster and Raturi (2001).

[12] See Durrer (1996), pp. 9-11.

[13] Contracts based upon catastrophe losses in the entire U.S. were available as well as contracts based upon loss data collected for smaller regions, in particular the states characterized by extremely high natural catastrophe risk (see Durrer 1996, p. 9).

tive tools were primarily aimed at insurance companies as a means to hedge their individual catastrophe losses. [14]

The CBOT options turned out not to be very successful.[15] Over the past few years, transfer of insurance risk via the financial markets has mainly been carried out using over-the-counter securities, such as, for example, catastrophe bonds (cat bonds) or contingent capital, instruments that enable a direct transfer of risk to investors.

A cat bond is a bond in which the interest and/or – depending on the specific design – the principal is (partially) forgiven when a pre-defined catastrophic event occurs. The typical structure of a cat bond issue is as follows:[16] A special purpose vehicle (SPV) is set up, usually as an offshore reinsurer, which is located, for example, in the Caymans, its purpose solely being the handling of that specific securitization. The SPV reinsures the primary and backs up this contract through the issuance of the cat bond. The principal invested is held in trust. If no loss occurs, principal and interest are paid back to the investors, whereas in case of a loss this amount is reduced by the reinsurance coverage that goes to the primary.

Contingent capital could, for instance, be provided through equity put options:[17] A primary issues put options on its own equity, i.e., it purchases the right to sell shares to a counterparty at a pre-specified price in the case of a certain event, such as the individual catastrophe losses exceeding a threshold. This put option would enable the primary to recapitalize, at conditions negotiated ex ante, after major losses, which might be crucial since a catastrophe would typically reduce the surplus of many insurers in the affected region. It may, therefore, also create a shortage of capacity, implying that access to capital would be particularly attractive in that situation.

Cat bonds have had the biggest market share among recent insurance risk securitization transactions.[18] These bonds are mainly used by primary insurers and reinsurers to substitute or supplement traditional reinsurance or retrocession[19].

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[14] The typical insurance derivatives transaction at the CBOT would be so-called "call spreads" which enable a primary insurer to duplicate the structure of a typical nonproportional reinsurance contract, but based upon the underlying index. In a nonproportional reinsurance contract the primary bears losses up to a certain amount – called retention – and is compensated by the reinsurer for the exceeding part of the losses. Additionally, the reinsurer's share of the risk is usually limited by an upper bound.

[15] See Müller (2000), p. 216, and Laster and Raturi (2001), p. 5. However, it seems likely that, medium-term, derivative instruments can play an important role for catastrophe risk transfer (see Laster and Raturi, 2001, p. 17). At the moment, similarly structured instruments receive attention in a related field: The hedging of weather risk. In areas of business for which success heavily depends on weather conditions, companies, as for example energy providers, try to hedge these risks through weather derivatives (see Müller, 2000, pp. 217-221).

[16] See, e.g., Belonsky et al. (1999), p. 5.

[17] See, e.g., Doherty (2000), pp. 615-616.

[18] See Laster and Raturi (2001), p. 19.

[19] Retrocession is the reinsurance purchased by a reinsurance company.

It has to be emphasized, however, that such instruments can, of course, also be attractive risk management tools for companies from other branches. As an example, reference can be made to the cat bond hedging earthquake risk that was issued by Tokyo Disneyland in 1997.[20]

As in traditional (re)insurance, the trigger mechanism for a cat bond can be the actual individual losses from certain catastrophic events. For instance, a transaction can be designed in such a way that no or only reduced interest is paid to the investors, implying that coverage is available for the hedging party, if the latter's actual catastrophe losses exceed a pre-negotiated threshold. Naturally, a contract could define more than one threshold, triggering different amounts of coverage.

Another possibility would be to tie the contingent payment from a cat bond to a market index, as in the above-mentioned CBOT options. Obviously, a market index can be useful as the underlying for a cat bond or other kinds of insurance-linked securities, if the individual portfolio structure is a sufficiently good representation of the entire market. The main advantage of an index, besides its contribution to alleviate standardization, is the fact that, compared with reinsurance, it is largely out of the primary's control.[21]

If, finally, a risk securitization transaction is based upon technical parameters describing the intensity of a catastrophic event (parametric trigger), manipulation can be completely excluded. Examples for this kind of an underlying are the Richter scale reading of an earthquake or the strength of a hurricane, observed in a certain region over a certain period specified by the contract. The usefulness of such parameters arises from their correlation with an event's insured consequences. A parametric trigger has the additional advantage that the relevant numbers are usually available very quickly. Contrasting this, a market index typically needs a long time until it is fully developed, in particular due to time-consuming problems of loss-settling.[22]

A special case of the parametric trigger is a modeled trigger, for which the procedure would be as follows: In the case a relevant event happens, a simulation is run, based upon certain observed parameters, that generates an estimate for the losses from the primary's actual portfolio. The simulation result then determines the amount to be paid to the primary. If the model is completely specified ex ante, this underlying can also not be influenced ex post by the primary. A modeled trigger can be helpful, e.g., for situations where the number of combinations of potential parameter realizations and outcomes does not allow for every single case to be explicitly mentioned in the contract.

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[20] See Müller (2000), pp. 215-216.

[21] See the next section for a more detailed discussion of this point.

[22] Parametric triggers are also typically used in securitizing weather risk (see footnote 15). In this context, in particular the temperature and the amount of rain are useful as underlying random variables. As an example, one can refer to a transaction recently carried out by a German energy provider hedging against excessive rainfall. A large number of this energy provider's customers are farmers and therefore need greater amounts of energy for their watering systems when rainfall is not sufficient.

As was mentioned above, the demand for ART solutions is usually explained via the supposedly limited supply of traditional hedging tools. According to this rationale, the total capacity of the world's (re)insurance markets would not be sufficient for covering certain catastrophe risks.[23] This explanation, however, seems to be of only limited validity. Additional risk financing capacity could also be generated through extending capital funds held by the insurance industry or through market entries in the insurance markets. The latter, in fact, could be observed during the 1990s following hurricane Andrew: Immediately after this event reinsurers were very reluctant and in particular the Lloyd's reinsurance market went through a heavy crisis, leading to a decline in the supply of catastrophe coverage.[24] Nevertheless, the available reinsurance capacity definitely increased over the next few years as more capital flowed into the industry. In particular, reinsurers located in the Bermudas were a major source for additional capacity provided during this period. Companies specialized in natural catastrophe reinsurance were set up and the Bermudas quickly became a very important market.[25]

According to these considerations, the attractiveness of insurance risk securitization cannot be convincingly explained via capacity shortages in the reinsurance industry. Thus, for further insight one needs to turn to the specific economic advantages these tools might have, compared with insurance.

Risk transfer through the financial markets can be carried out in many different ways. Naturally, the economic assessment of such instruments depends to a great extent on the specific design chosen, and in particular on certain institutional characteristics. The following, however, will not be concerned with the very details of institutional design, but rather with certain basic features defining important criteria for an economic comparison of risk securitization and traditional (re)insurance.[26]

A first interesting economic explanation for risk securitization is the fact that, depending on the underlying random variable, certain kinds of these tools offer an instrument to address *moral hazard*. A typical insurance or reinsurance contract is an indemnity contract, i.e., it is designed in such a way that contingent payments are connected directly to the insured's, or respectively the primary's, stochastic actual losses. Therefore, (re)insurance coverage can be perfectly correlated with the losses – at least so far as a monetary equivalent of the actual consequences can be determined. This, however, also implies that moral hazard is a major problem

[23] See, e.g., Durrer (1996), Cholnoky et al. (1998), Bantwal and Kunreuther (2000), Cummins et al. (2004).

[24] See Holzheu and Lechner (1998), p. 14.

[25] For example, the global market share of the Bermuda reinsurance market developed from 0% to 5% between 1992 and 1997. Being specialized in natural catastrophe risk, it benefited from increased premiums in this segment and from relatively lower natural catastrophe losses between 1995 and 1997 (Holzheu and Lechner, 1998, pp. 12-21).

[26] For an introduction to the economic comparison of risk securitization and insurance see, in particular, Doherty (1997), Froot (1997), Croson and Kunreuther (2000).

of insurance markets:[27] In most cases insured risks can be influenced by the insureds who would also usually have a significant unobservable discretion with respect to their actions. Thus, insurance coverage induces changes in the insureds' behavior. This phenomenon can be observed in primary insurance, but also in the relationship between a primary insurer and its reinsurer. A primary is in charge of risk selection and monitoring as well as settling losses with its customers. Considering the fact that it would normally be impossible or prohibitively expensive for the reinsurer to monitor these activities, reinsurance relationships will usually be characterized by asymmetric information. As a consequence, a primary's carefulness can be expected to decrease in the amount of its reinsurance coverage.

As was mentioned above, the coverage from many risk securitization transactions does not directly depend on the actual losses but on some other random variable, which is correlated with the losses. If the trigger is a market loss index, moral hazard is limited to the primary's contribution to the index. By making use of a parametric trigger the moral hazard problem can even be avoided. However, the reduction or elimination of moral hazard incurs a certain cost. Typically, the less the underlying random variable can be influenced by the primary, the less useful is the contingent coverage as a hedging vehicle. The resulting mismatch between the loss and the coverage is called *basis risk*.[28] For instance, an earthquake might not trigger the payment from a cat bond, since its strength is too low, even though substantial damages are caused in the primary's portfolio. On the other hand, a realization of basis risk could be that coverage from the cat bond is actually paid to the hedging primary although no significant individual losses are observed from that particular event.

Another aspect important for the comparison of risk securitization and reinsurance are the *transaction costs* incurred by the respective instruments. A product that ties its payments to an exogenous index reduces or avoids administrative costs such as costs from loss handling or monitoring. One advantage for the case of a parametric trigger can be the above-mentioned fact that determination of due payments is fast and less problematic. But also acquisition costs might be partially spared by making use of the financial markets.

As is often argued, insurance risk is not or is only weakly correlated with market risk, implying that the price for insurance risk securitization should include just small risk premiums. This results in a potential advantage over reinsurance for the following reasons: By purchasing reinsurance shares an investor participates in the company's entire risk portfolio, including, e.g., its investment performance or the risk of mismanagement. As opposed to this, risk securitization enables investors to assume a pure position in the very specific catastrophe risk category and in that sense expands their opportunity set.[29] Furthermore, as empirical evidence indi-

[27] For a discussion of moral hazard problems in insurance markets, see, among many others, Holmström (1979), Shavell (1979), or Nell (1993).

[28] For an analysis of the trade-off between moral hazard and basis risk in a combination of an index-linked securitization product and an insurance product that covers a part of the basis risk, see Doherty and Richter (2002).

[29] See, e.g., Froot (1999).

cates,[30] an important cause for high cost of reinsurance is risk-averse decision-behavior of reinsurers, particularly when it comes to dealing with catastrophic risk.[31]

A further potential advantage of certain types of catastrophe risk securitization is the fact that with these tools *default risk* can be more or less completely avoided.[32] This is important since, in particular, certain natural disaster hazards impose a significant insolvency risk for reinsurance companies active in that business, implying that their contracts are subject to default risk. This is due to the potential of a regional accumulation of losses as it is typically incurred by catastrophic events. The threat of loss accumulation leads to high correlation between the different local primaries' portfolios and, therefore, between claims from different contracts in a reinsurer's portfolio. For the single primary insurer, this leads to an increased default risk or credit risk with respect to catastrophe reinsurance.[33] In contrast, risk securitization can be carried out in such a way that it is free of or subject to only very little default risk: The funds invested in a cat bond, for instance, are collected ex ante which implies that the credit risk for the primary insurer is reduced to the default risk connected with the investments made by the trustee.[34]

So far, insurance-linked securities have not been as successful in the market as was first expected. For instance, the total volume of transactions carried out until 2001 amounts to about 13 billion USD.[35] Compared to the size of the reinsurance market, this is not very significant. The catastrophe excess of loss coverage pur-

[30] See Froot (2001), who looks at catastrophe reinsurance data. He finds, for example, that the average ratio of premiums over expected losses between 1989 and 1998 was higher than 4.

[31] In a perfect market the risk premiums included in the price of a risk securitization product would not differ from the risk premium for the same risk held by a reinsurer. For a discussion of the various imperfections explaining additional cost of risk originating from a (reinsurance) company's risk averse decision-making, see among others Greenwald and Stiglitz (1990), Dionne and Doherty (1993) or Nell and Richter (2003).

[32] See, e.g., Croson and Kunreuther (2000), pp. 30-31, Laster and Raturi (2001), p. 14.

[33] As was mentioned before, an illustrative example for the realization of default risk was hurricane Andrew, which led to a number of insolvencies in the reinsurance market. The following years were also characterized by a massive drop of the number of reinsurance companies due to a series of mergers and acquisitions (see Holzheu and Lechner, 1998). Considering that major factors determining a reinsurer's risk of insolvency are its worldwide spread and financial strength, this tendency of consolidation might – among other issues – also be a consequence of a growing awareness of default risk. See also Laster and Raturi (2001), p. 14: That default risk is an issue in reinsurance contracting is also reflected by market shares. In 1999, for example, among the world's 100 biggest reinsurance companies, only 20% of premiums were written by companies rated (by Standard & Poor's) below AA.

[34] The use of catastrophe options also avoids default risk to a great extent, as usually obligations are guaranteed by the exchange (see, e.g., Laster and Raturi 2001, p. 18).

[35] Munich Re ART Solutions (2001), p. 11.

chased in the worldwide reinsurance market in the year 2000, e.g., amounted to 107 billion CHF.[36]

The at first rapid increase in the use of new financial risk transfer instruments halted in the late 1990s after a decrease in reinsurance prices.[37] Consistent with our discussion, insurance-linked securities do not seem to play a major role as a means to expand the available catastrophe risk financing capacity. However, these products have introduced new tools to address problems of default risk and in particular moral hazard, and in that sense can indirectly help to expand the limits of insurability. Although recent transactions favor index triggers, the resulting basis risk of such securitizations seems to be the primary explanation for the reluctance of many risk-managers in the use of alternative risk transfer products.

Nevertheless, the impact of future major disasters on reinsurance capacity and pricing might cause the growth of the market for insurance-linked securities gain speed again – as private risk management tools, but also as a component of a public risk management strategy. Terrorism risk is one example of a risk category where coverage generated through cat bonds can be an interesting alternative or addition to traditional insurance solutions. Kunreuther (2002), for instance, suggests incorporating federal cat bonds as an element of a public-private approach to covering terrorism risk.[38] As will be discussed in the next section, government involvement became an issue after the events of September 11, since the terrorist attacks caused another capital and capacity shock for the insurance and, in particular, the reinsurance industry.[39] Generally, the resulting increase in catastrophe reinsurance prices again provided a framework for a medium-term gain of the insurance-linked securities' market share, as insurers might reconsider the structure of their risk management portfolio.

3. State guarantees for catastrophic risk?

After the attacks of 9/11, an intensive discussion set off about the role of the state in managing terrorism risk. On the one hand a topic was the temporary issuance of state guarantees concerning the risk of "war and terrorism" for airlines and airports, on the other hand a general involvement of the state in covering terrorism was discussed. In this context, two questions deserve particular attention: First, we need to determine when and for which type of risk there would not be sufficient insurance coverage available. Second, it should be analyzed under which condi-

[36] Durbin (2001), p. 301.

[37] See Laster and Raturi (2001), p. 18.

[38] Sovereign cat bonds have also been discussed in a different problem context: For instance, Croson and Richter (2003) discuss the usefulness of sovereign cat bonds issued by developing countries for the primary purpose of generating conditional funds for infrastructure emergency repairs after catastrophic events.

[39] See, e.g., Doherty et al. (2003).

tions (if at all) the state should assume risk. These questions will be discussed in the following.

The development of modern industrialized societies is inseparably connected with the emergence of insurance markets and the supply of coverage for new risks. Since the majority of people are risk-averse, the opportunity of transferring risk to risk-taking institutions such as insurance companies enables them to engage in risky activities they otherwise would avoid. In a world of risk-averse individuals undertaking risky activities is productive, such that insurance supply enhances welfare.[40]

Such positive influence of insurance, however, can only occur under the condition that insurance companies posses sufficient information to be able to at least approximately price risks based upon their expected losses. If this information is not available or if it has to be ignored, for instance due to a political decision that prohibits certain premium discrimination, the following inefficiencies are unavoidable: Individuals' decision-making will display an insufficient level of care, since higher effort would not be reflected in a lower insurance premium. Closely related to this phenomenon is the problem that production technologies would be chosen that are too risky from a welfare economics point of view – technologies which yield rather high returns if no loss occurs but which are suboptimal due to their high risk.[41] These unfavorable implications of non-risk based pricing constitute major moral hazard problems (see section 2). As was emphasized before, moral hazard cannot be completely resolved in insurance markets. However, competition in these markets forces insurance companies to include any available relevant information in their pricing of insured risks. Where insureds still possess unobservable discretion in choosing their level of care, incentives can be set via instruments such as, for instance, coinsurance or deductibles.

For most risks coverage is provided through private insurance markets. Yet, it can be observed that insurance companies do not supply protection at all for certain types of risk or that they are reluctant to offer the desired level of coverage. Two main reasons explain why in such situations no or only insufficient coverage would be available: First, for certain categories of risks moral hazard problems can become too severe because, e.g., the insureds' influence on the risk is very significant. Obviously, state intervention cannot be considered a useful tool to solve this issue: Typically the state would not have the better information concerning insureds than the insurance companies, and therefore would not be better in dealing with moral hazard.

Second, problems with the supply of insurance can also arise where the loss potential of a single event is so enormous that the entire industry cannot provide sufficient capacity to cope with it. This can be the case for some types of catastrophic risk which are characterized by high correlation and therefore a tendency to incur cumulative losses (see section 2). Examples are, in particular, natural disasters such as floods, windstorms and earthquakes, but also war and terror-related risks.

[40] See Sinn (1986) for an explanation of the importance of risk as a production factor and the welfare-increasing effect of insurance coverage.

[41] See, e.g., Nell (1990).

Furthermore, areas exist in which even single losses – if entirely covered – could exhaust the insurance markets' capacity, as, e.g., the liability risk connected with nuclear power plants. Typically, insurers would offer only rather low amounts insured and thus very limited coverage for these hazards.

Where the private markets' supply of insurance is insufficient due to capacity restrictions of the entire industry (including alternative sources, as discussed in section 2), state supplied protection may be considered as an option. The state would usually be able to provide much more capacity than the private sector.

For terrorism risk obviously this kind of scenario materialized. Right after September 11, the coverage offered in the insurance markets did not meet the demand for protection. The motivation for state guarantees granted to airlines and airports was the fact that insurance companies quite uniformly cancelled existing policies. Thus, private markets were only offering limits that would, for many routes, not even be sufficient to fulfill the minimum requirements. Serious trouble for the airline industry was imminent. Negotiations between airlines and airports on the one side and insurers on the other side were particularly difficult: The insurance industry, in the aftermath of the terrorist attacks, completely reassessed their liability exposures in the context of air traffic. Therefore, liability coverage in this area was, if at all, only offered at drastically increased premiums. While up to that point the collision of two passenger aircrafts had been considered the worst case scenario, now the focus was shifted to the possibility of even much more dramatic events. Additionally, in the political context following September 11, a significantly increased likelihood was commonly assigned to attacks on aircrafts and skyjackings.

In this situation, in which contracts needed to be fundamentally adjusted, a temporary issuance of state guarantees was adequate, as they helped to keep air traffic going and to give the involved parties enough time for negotiations. Nevertheless, state liability can only be useful if expected costs of terrorism risk are still internalized by the air traffic industry. Under no circumstances these guarantees should be utilized as a means of subsidizing an industry whose structural problems have not been initialized by September 11 but existed before. Costless guarantees, as have been provided by the British government, are certainly the wrong way to address the problem. Contrasting their approach, the price of such state protection for the industry should rather be much higher than insurance premiums paid before September 11, considering the dramatically changed risk situation.

As mentioned above, the state guarantees were meant to provide the negotiating parties with some time for adjusting their contracts. A more fundamental issue, however, is the question whether a general state guarantee for terrorism risk is necessary. Due to the quite high and difficult to estimate loss potential, the insurance industry was only willing to supply rather limited coverage. This would have led to losses from terrorist attacks remaining uninsured to a great extent. This, in turn, would have caused efficiency losses: Socially beneficial activities threatened to not be carried out, since investors would not be willing to take the risk associated with these activities. Thus, it can be reasonable for a state to provide additional protection. However, pricing must be based upon the actual risk: Otherwise, terrorism risk would not sufficiently be taken into account in decision-making,

which would lead to underinvestment in security technologies and excessively risky construction and production investments.

The German approach to solving the problem of terrorism risk coverage is one way of involving the state in catastrophe risk financing. In 2002, an insurance company by the name of *Extremus* was formed whose task it is to supply protection for large-scale losses from terrorist attacks. *Extremus* insures exposure units with amounts insured exceeding 25 million EUR. It offers coverage for losses up to 13 billion EUR per year, which, according to current estimates, should be sufficient. Private insurers and the state provide the capacity jointly. The German insurance industry covers the first 1.5 billion EUR. International reinsurers are responsible for the second layer of 1.5 billion EUR. In excess of this, the state is liable for 10 billion EUR.

A major drawback in the *Extremus* structure is the fact, that, at least up until today, it does not apply any premium discrimination based upon major risk factors such as location and type of a building. So, given its current design, this solution subsidizes highly exposed buildings by charging insufficient premiums while owners of low risk properties would be overcharged. However, considering the amount of thought that has been put into assessing terrorism risk since September 11, this shortcoming of the current solution certainly does not need to be permanent. Changes in the rating schedule could make *Extremus* an example of a socially beneficial state guarantee approach.

Many examples can be found of obviously not very helpful state intervention in the insurance markets. In some instances, the just-mentioned subsidization of high risks even is an expressed goal of such an instrument. In these cases, premiums for certain high-risk exposures are basically considered "too high". An interesting example can be seen in homeowners insurance in the state of Florida. Here, one could recently observe a strong increase in construction on the coast, although these areas are characterized by a particular severe windstorm risk exposure. One reason for this development seems to be that, because of state regulation, premiums for homeowners insurance in this area are far below the adequate risk-based level. As a consequence, the risk of windstorm damage is not or not sufficiently internalized when settlement decisions are made.[42] Furthermore, homeowners typically underinvest in protection measures against windstorm. The deficit resulting from inadequately low insurance premiums for buildings in the coastal area is compensated through premiums charged in other regions or for other insurance products. So, on top of the above-mentioned problems, insurance regulation here also subsidizes the above-average income group of people who tend to settle in the coastal area.

Moreover, there are forms of state intervention that imply systematic exploitation of the state through the private sector. In France, for instance, fundamental risks such as flood and earthquake are insured on a mandatory basis at uniform premiums. French primary insurers have the right to pass these risks to a state-run reinsurer that is furnished with an unlimited state guarantee. Obviously, this cre-

[42] On state regulation of homeowners insurance and its consequences see, e.g., Klein and Kleindorfer (1999). See also Russell (1999), pp. 227-244.

ates a severe adverse selection problem, as it provides strong incentives for insurance companies to pass on only the bad risks. Not surprisingly, the reinsurer experienced significant losses, although in total insurance of fundamental homeowners risks was highly profitable.

These considerations allow for the following conclusion: State intervention in the context of catastrophe risk financing can be socially desirable, if insurance capacity provided by the private sector is not sufficient. Recent experience, however, teaches that regulation in this area is often based upon the wrong motivation or designed poorly. Therefore, economic advantages and disadvantages need to be analyzed thoroughly for every specific case of state intervention in insurance markets.

4. Problems with catastrophe insurance demand

The floods of August 2002 in Central Europe demonstrated that problems in catastrophe risk management do not only exist on the supply side but also on the demand side for catastrophe coverage. It became obvious that only a small proportion of victims had purchased insurance against these losses and that, for instance, in Germany the density of insurance against these hazards was rather low. In Germany, flood risks can be covered through a fundamental risk („Elementarschaden"-) extension of homeowners and contents policies as well as certain commercial coverages. However, only about 3.5% of German homeowners and roughly 9% of contents policies include this extension.[43] Even taking into account that many buildings are located in areas with insignificant flood risk, it needs to be asked what might be the reasons for this low market penetration.

Looking at the supply side, we find that insurers would only in extremely flood-prone areas be reluctant to offer this additional coverage. But even there, this insurance is available. Typically, the policy would just include increased deductibles and certain obligations regarding loss prevention measures, and rates would be higher. Still, the fundamental risk extension is in general not very costly: For instance, the premium for an amount insured of 300,000 EUR in a region with medium flood risk (likelihood of a flood of 2%-10%) would be about 50-60 EUR.[44]

Thus, the low insurance density cannot be attributed to insufficient supply, its reasons must be found on the demand side. Two different explanations should be considered in this context:

The first explanation is that people seem to underestimate their exposure to natural disaster risk. For instance, the results of a study carried out in areas with high flood risk suggest that individuals systematically underestimate the likelihood of natural catastrophes.[45] Also, one can often observe that after a major catastrophic event the demand for protection against such hazards significantly expands and during a period without any event decreases, as individuals update their beliefs.

[43] See Schwarze and Wagner (2002), p. 596.
[44] See Schwarze and Wagner (2002), p. 596.
[45] See Kunreuther (1976).

their beliefs. However, justifying government intervention in the form of mandatory insurance on the grounds of this rationale requires a quite paternalistic view of the role of the state.

More important, from our point of view, is the following second explanation: The 2002 floods as well as other catastrophic events have shown that victims to a great extent receive assistance from the state and from private sources. Since this emergency aid is usually based upon the actual loss of a victim, insurance and other sources of compensation are direct substitutes. The low demand for fundamental risk coverage and insufficient loss prevention can therefore be explained by the potential victims' anticipation of (costless) non-insurance assistance.

It can be assumed that state assistance and private help for people who suffer major losses from a natural disaster, are politically and socially unavoidable.[46] However, we need to be aware that this considerably reduces incentives to invest in loss prevention on an individual as well as on a collective basis (such as, in the case of flood risk, risk adjusted development decisions, the creation of flooding areas or the moving of oil tanks to upper floors in a building).

The anticipation of emergency aid and the resulting insufficient loss prevention make a strong case for a regulatory intervention in the form of mandatory insurance against flood risks. This rationale is also quite widely accepted in other contexts: For instance, mandatory savings for the purpose of funding retirement, which exist in various forms in most countries, are usually justified via the potential anticipation of state help in case of old age poverty.

Compulsory insurance, thus, is a useful component of catastrophe risk management.

5. Conclusion

Over the last two decades, the frequency as well as the size of natural catastrophes has increased considerably. Simultaneously, predictions about possible losses from certain catastrophe scenarios have been adjusted to significantly larger amounts. Additionally, the events of September 11 demonstrated the enormous dimension of terrorism risk. These developments initialized a lively discussion among economists as well as politicians on ways of improving catastrophe risk management. One particular concern was the question of how a more comprehensive coverage of consequences of natural disasters could be achieved. Furthermore, approaches were discussed that aimed at limiting the size of losses by means of increased loss prevention.

The discussion on improving financial protection against catastrophic risk at first focused on the supply of insurance coverage. This was driven by the concern that losses incurred by certain disasters could exhaust insurers' capacity and cause

[46] Therefore, the suggestion sometimes expressed in the literature, to not provide any emergency help for individuals in catastrophe-prone areas (see, e.g., Epstein 1996), is politically not feasible.

the insurance markets to collapse. Anticipating this, catastrophe risk underwriting policies became more and more restrictive.

A reduction of this problem seemed to be possible through instruments that directly transfer insurance risks via the financial markets. Such transactions could be observed since the early nineties. Initially, high expectations were placed on the so-called alternative risk transfer, based upon the argument that the assumed low correlation between market risk and catastrophe risk and the resulting diversification opportunities would attract substantial capacity. Up until today, however, these expectations have not been fulfilled: The trade in certain types of alternative risk transfer tools (in particular the CBOT catastrophe index options) has ceased, other instruments, such as cat bonds, are being used in the markets, but the number of these transactions is still rather low. So far, a significant increase of catastrophe coverage through the securitization of insurance risk has not been achieved, and nothing indicates that this will change much in the near future.

September 11 forced discussions to address the role of the state as a potential risk bearer. This was triggered by the fact that many governments decided to provide state guarantees for airlines and airports to keep air traffic up, since insurance companies denied to offer protection at former conditions and/or rates. Additionally, insurers generally were unable to supply sufficient capacity to cover terrorism risk. In several countries, therefore, the state is now strongly involved in the financing of terrorist risk. This kind of state intervention can be beneficial, provided that its sole function is to extend capacity for catastrophe coverage. If, on the other hand, it leads to a renunciation of premium discrimination, state intervention can even be harmful, as it implies the reduction of loss prevention.

Furthermore, catastrophe risk management problems also exist on the demand side. It can be observed that even if sufficient coverage would be available, the demand for certain types of catastrophe coverage is low. This is problematic since the rationale behind the low demand is an anticipation of governmental or private emergency aid that would be granted after the occurrence of a disaster. The Oder flood as well as the August 2002 floods demonstrated that emergency aid can be sufficient to compensate for the entire loss incurred by such natural catastrophes.

Since the individual amount of emergency aid is usually based upon the actual loss of a victim, it can be viewed as a direct substitute for insurance. In this framework, it is rational not to purchase insurance but to rely on catastrophe emergency aid. From the perspective of societal management of catastrophic risk, however, this is highly unsatisfactory, as it destroys any incentive for loss prevention. To solve this problem, policymakers should consider mandatory insurance approaches, which, of course, would also need to utilize risk-based premiums in order to avoid the just-mentioned incentive issues.

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