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A Catastrophe Insurance System for the European Union

Milton Nektarios

Abstract

This paper proposes an integrated risk management plan for catastrophe risks in the European Union, consisting of three layers. The private markets would have the first layer of responsibility, while the National Catastrophe Insurance Organizations would represent the second layer. This layer would in turn be supported by the European Group of National Catastrophe Organizations (EUROCAT), a new organization operating under the auspices of the European Commission. An approach that utilizes a pan-European reinsurance program is proven to be the most efficient solution for minimizing the total cost of catastrophe risks in the European Union. EUROCAT would be a reinsurer of last resort and provide reinsurance to qualified state or regional catastrophe insurance funds. Member-state funds would be required to adopt adequate disaster response and management mechanisms and enforce reasonable building code, land use, and mitigation efforts to minimize the amount of insured losses. As the reinsurance premiums charged by EUROCAT would be risk-based, the pricing mechanism would be used to encourage active development and enforcement of these standards.

KEYWORDS: catastrophe insurance, European Union

I. INTRODUCTION

The impact of natural, as well as man-made, catastrophes on societies and economies has increased considerably in recent years: prior to 1986, the number of catastrophes rarely reached 150 per year; but since 1993, there have been at least 270 catastrophes per year (Cummins, 2006).

In 2005, economic losses from natural catastrophes hit a record high, with direct financial losses of about $ 230 billion. This represents 0.5% of total worldwide GDP. Despite a record insurance payout of more than $ 83 billion world-wide, uninsured direct losses of $ 150 billion had to be carried by individuals, companies and the public sector (SwissRe, 2006).

Most recently, in 2007, a total of 335 natural catastrophes led to overall economic losses of $ 64 billion across the globe, of which $ 40 billion were uninsured (SwissRe, 2008).

Europe was hit particularly hard, with winter storm Kyrill causing an insured loss of $ 6.1 billion – making it the third most expensive winter storm on record – while the UK was hit twice by extreme rains and flooding, resulting in a total insured loss of $ 4.8 billion.

In relation to world GDP, catastrophe losses were less than 0.05 of 1 percent until the late 1980s and have fluctuated around 0.10 of 1 percent in more recent years. This suggests that catastrophe losses are large and volatile from the perspective of the insurance industry but are more manageable from an economy wide perspective (Cummins, 2006).

In the near future, this trend is likely to grow further as a result of two complementary trends. Firstly, climate change is expected to increase the scale and frequency of major weather-related catastrophes. Secondly, the economic severity of mega-catastrophes is growing due to a rise in both population and economic activity in areas with a high risk exposure. Also, the nature of risks is changing; buildings have become more expensive to build and rebuild, and higher interdependencies in the production process have increased the likelihood of business interruptions following a flood or a storm.

These developments have led some catastrophe modelers to identify a number of possible natural disasters that would dwarf the damages caused by major catastrophes in the past. For example, if the 1906 San Francisco earthquake had occurred today, it would create damage of $ 400 billion with over $ 200 billion in uninsured losses (NAIC, 2009).

Natural disasters have a significant financial impact on individuals, businesses and insurers. However, such events place huge burdens on the public sector, which not only shoulders the cost of relief efforts, but is also responsible for rebuilding public infrastructure. Depending on the level of insurance

penetration, governments may also be expected to support private rebuilding efforts. Traditionally, the public sector has adopted a post-event approach to disaster funding. This includes increasing taxes, reallocating funds from other budget items, accessing domestic and international credit, and borrowing from multi-lateral finance institutions. Many developing countries also rely on assistance from international aid.

Pursuing a post-disaster financing strategy has several disadvantages, well-known in the insurance economics literature. Clearly, there is significant value in shifting the traditional "disaster relief" approach - raising scarce funds after the event hits - to an approach that accumulates funds and funding sources before a disaster occurs. The financial and insurance markets can play a key role in preparing for the impact of extreme natural events and can also help to spread risks.

No country can fully insulate itself against extreme events. Transferring catastrophic risk has to be a key element in the financing strategy of every disaster-prone country in order to enable and sustain growth - just as corporations and individuals pass on peak risks to insurers. This is where the insurance industry can offer its expertise in developing innovative solutions. A new generation of sovereign insurance instruments can make it easier for national governments to cope with disasters.

The central question is whether the private insurance industry can reasonably handle future catastrophe risks. Froot (2001) argues that there is evidence of market failures, such as the skewness of reinsurance toward the coverage of relatively small catastrophes and the thinness of reinsurance for mega-catastrophes. Cummins (2006) argues that the private sector – including reinsurance and the nascent catastrophe linked securities market – can be expected to provide adequate coverage at affordable premiums for mega-catastrophes. Litan (2006 a, b) believes that there is a kind of market failure for the catastrophe risks that only a formal government reinsurance program can remedy; only if the government takes on this role will it in the long run minimize the costs it bears for disaster relief and the large social costs that natural disasters inevitably impose on the private sector.

Aside the academic deliberations, a review of the actual government natural catastrophe insurance programs reveals that sixteen OECD countries have enacted a variety of programs to manage the economic consequences of catastrophic events (Freeman, 2004). The programs differ in their structure based on underlying premises of the nature of the risk. Consequently, the roles of the private insurance market and government entities vary considerably across countries. In the USA, the National Association of Insurance Commissioners (NAIC) has actively examined, for the last four decades, various approaches to

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insuring against natural disasters. NAIC's position is that the insurance industry cannot be expected to provide comprehensive catastrophe coverage without adequate financial backstops for the most extreme events, and it has made the proposal of creating a comprehensive national plan for natural catastrophe risks; such a proposal passed the US House of Representatives in 2007 (NAIC, 2009), but it did not become official legislation. A similar proposal, H.R. 2255 "The Homeowners Defense Act" of 2010, had the same fate.

In this paper we propose an integrated catastrophe insurance scheme for the European Union, which is structured at three levels. The first level consists of the national private insurance markets for property risks. The second level will comprise the National Catastrophe Insurance Organizations (let's call them NATCAT). And the third level comprises the pool of all NATCATs, which is the European Union Group of National Catastrophe Insurance Organizations (let's call it EUROCAT).

The logic of this proposal is that as long as we continue to do nothing except to provide after-the-fact disaster relief, the European nations will have an inefficient and unfair policy toward large-scale natural disasters. It is inefficient because the common prospect of disaster relief by the state, coupled with inadequate loss mitigation incentives, will result in more damage, and therefore more state assistance. And the ex-post disaster approach is unfair to taxpayers in parts of the country who at some point end up subsidizing those who voluntarily choose to live and work in high-risk areas.

It is suggested that the successive redistribution of catastrophe risks within nations (public-private partnerships) and among nations of the European Union may result in the optimization of the risk management process of catastrophe risks, by minimizing the "total cost" of catastrophe risks at the European Union level.

The next section of the paper reviews the literature in relation to dealing with catastrophe risks at the national and international level. The third section analyses the insurance issues involved in the risk management of catastrophe risks. The fourth section provides a description of the proposed pan-European catastrophe insurance scheme. The fifth section develops an economic model that supports the efficiency of the proposed scheme. The final section contains the main conclusions.

II. OVERVIEW OF CATASTROPHE INSURANCE

For more traditional risks, insurers can accurately estimate premiums and the equity capital needed to reduce insolvency probabilities to acceptable levels, and the amount of required equity does not lead to excessive prices. However, there are significant questions about the ability of the insurance industry to deal with the largest catastrophic events. For various reasons, it is inefficient for the industry to hold sufficient capital to finance losses arising from low-frequency, very-high-severity events (Jaffee and Russell, 1997).

Cummins, Doherty, and Lo (2002) investigated the capacity of the U.S. property-casualty insurance industry to respond to large catastrophic events during the late 1990s. The results indicated that the industry could pay more than 90% of the losses in a case of a $100 billion loss event. However, a loss of this magnitude would have caused the failure of about 140 insurers. This would be by far the largest failure rate in the post-1900 history of the US insurance industry and would significantly destabilize insurance markets.

Cummins (2006) has estimated the aggregate equity capital of the global reinsurance industry. He found that equity capital increased from about $ 250 billion in 1990 to about $ 377 billion in 2004. He then compares the catastrophe losses from Swiss Re (2006) as a ratio of the equity capital of global reinsurers; catastrophe losses can amount to a significant proportion of equity, exceeding 15% in 1999 and reaching 13% in 2004.

Another study (Guy Carpenter, 2005) has shown that the global reinsurance market is subject to underwriting cycles. It is shown that the index of the rate-on-line (price measure for reinsurance, defined as the reinsurance premium divided by the maximum possible payout under the reinsurance policy) increased from 100 in 1990 (base year) to approximately 375 in 1993 (Hurricane Andrew), then declined steadily to 150 in 1999, and then increased sharply to 260 in 2003 following the WTC terrorist attack. The conclusion is that capacity shortages can occur even in high frequency, low-severity lines of insurance (due to cycles and crises), emphasizing the difficulty faced by the industry in consistently providing capacity for low-frequency, high severity losses.

Given the shortage of insurance capacity for catastrophe risks, it is interesting to analyze the public and private sector solutions to financing the risk of natural catastrophes. The private market solutions developed on the basis of the securitization of catastrophe risks. The public solution was the development of government insurance and reinsurance schemes.

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The application of securitization in insurance resulted in the development of catastrophe (CAT) bonds. CAT bonds are issued to cover the so-called "long tails" or reinsurance protection; the higher layers of protection often go unrerinsured by ceding companies for two reasons - for events of that magnitude, ceding insurers are more concerned about the credit risk of the reinsurer, and high layers tend to have the highest reinsurance pricing spreads above the expected loss (Cummins, 2007). Moreover, CAT bonds also can lock in multi-year protection, unlike traditional reinsurance; this fact allows sponsors to spread the fixed costs of issuing bonds over a multi- year period.

Cummins (2008) has provided a detailed account of the evolution of the market for CAT bonds, in the period 1997-2007. The main conclusions are:

- The CAT bond market has grown from less than $ 1 billion per year in 1997 to more than $ 2 billion per year in the first half of 2005, and then accelerated to nearly $ 5 billion in 2006 and nearly $ 6 billion in 2007.
- The number of transactions has increased from 5 per year in 1997 to about 25 per year in 2007.
- Risk-capital outstanding (the face value of all bonds still in effect in each year) has increased from $3 billion in 2002 to nearly $ 14 billion by mid 2007.
- Average maturity periods are about 3 years.
- Financial ratings of CAT bonds have been below investment grade (ratings below BBB, they usually have BB and B ratings) for the vast majority of such bonds. But, although it is important for CAT bonds to be issued with financial ratings, the modeling firm's analysis drives the price of the bond issue than the actual rating.
- In 1999, insurers and reinsurers accounted for about 55 percent of the market for CAT bonds. In 2007, insurers and reinsurers accounted for only 7 per cent of demand, suggesting that substantial external capital has been attracted to the market.
- CAT bond prices are determined as spreads over LIBOR (risk premium). The ratio of the risk premium to the expected loss has declined from about 8 percent in 2001 to about 2.3 percent in 2007.
- Since 2006 (after hurricane Katrina), CAT bonds do not appear to be expensive relative to catastrophe reinsurance.

There is no doubt that CAT bonds have been an innovative financial solution. However, although there have been approximately 120 bonds issued to date, the amount of risk capital that has been raised remains small (about $ 14 billion in 2007) relative to the global reinsurance market (close to $ 400 billion in 2007).

However, the potential for the use of securities markets to finance catastrophe risk is significant; the amount of asset-backed securities outstanding was close to $ 2 trillion in 2006 (Bond Market Association, 2006).

Next, we provide an overview of the government catastrophe insurance schemes in the world (Gurenko, 2004; OECD, 2005; GAO, 2005).

The first group includes countries that use tax revenues to establish prefunded disaster-relief funds. Such countries are: Australia, Denmark, Mexico, the Netherlands, Norway, and Poland. In these countries, the government provides compensation only for losses that cannot be insured privately.

Spain has established government insurance programs to provide coverage for natural disasters. The government scheme collects premiums in return for the coverage; private insurers generally market the policies and handle claims settlement and other administrative details. The catastrophe coverage is mandatory and is provided as on add-on to private property policies.

In France and Japan, the government acts as a reinsurer. Catastrophe coverage is mandatory and is added on the property insurance policies; premium surcharges are set by the government. All catastrophe insurance written by private insurers is reinsured with the government reinsurance company, which essentially serves as reinsurer of last resort.

Switzerland mandates natural catastrophe coverage bud does not provide any explicit government financial guaranty. In the United Kingdom, flood coverage is typically included in private property insurance policies.

In the U.S.A., the various States intervene in the private insurance market in order to secure catastrophe coverage at affordable prices for windstorms (in the South) and for earthquakes (in the West). The federal government has provided subsidized flood insurance since 1968 and entered the market for terrorism insurance as reinsurer of last resort in 2002. Moreover, currently the federal government is exploring the issue of establishing a comprehensive national plan for natural catastrophe risks (NAIC, 2009).

Finally, Klein and Wang (2009) have undertaken a comprehensive comparative study of the regulatory approaches for catastrophe risk financing in the United Sates and the European Union.

III. ISSUES IN CATASTROPHE RISK MANAGEMENT

Insurance markets tend to respond adversely to mega-catastrophes. They respond to large events, particularly those that cause them to reevaluate their estimates of the probability and severity of loss, by restricting the supply of insurance and raising the price of the limited coverage that is made available. Because insurance

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plays an important role in the economy, instability in the availability and price of coverage generally leads to pressure for government intervention in insurance markets. In this framework, there are three topics to be addressed:

- Why do private markets for catastrophe risks fail?
- Should the government pick up the slack?
- And, if so, how is this best done?

We shall deal with the firs two issues here, and will take up the third issue in the next section.

There is an extensive insurance literature dealing with the issue of market failures in insuring catastrophe losses. Cummins and Weiss (2000) and Cummins (2006) have formalized this discussion and provided the theoretical background for explaining the existence of insurance and reinsurance. They call insurance markets with independent risks, moderate standard deviations per risk, and large number of risks "locally insurable". When the assumptions under which risks are locally insurable are relaxed, then the motivation for reinsurance arises. Risks that are "locally dependent" may be "globally independent" and, therefore, risks that are globally diversifiable through reinsurance are called "globally insurable".

The violation of any of the principal insurability conditions (e.g., covariances among the individual risks making up a portfolio are relatively high) may create situations where risks are neither locally nor globally insurable. However, such risks may be "globally diversifiable" through capital markets. The resulting securitization of risks extends the scope of diversification from insurance and reinsurance markets to the entire securities market, thus breaking down the problem of small numbers, large variances, and intra-insurance market correlations, in much the same way as reinsurance can reduce the problem of non-insurability on the local level.

The market failure of private insurance in case of catastrophe risks has been recognized by Jaffee and Russell (1997), who argue that catastrophic risks require insurers to hold large amounts of liquid capital, but institutional factors make insurers reluctant to do this. This is the so-called "timing risk", which implies that insurers raise premiums sufficiently high to cover not just the expected losses, but the possibility that the catastrophic event occurs well before insurers have collected sufficient premiums to cover the claims they ensure. It is reported that reinsurers of hurricane risks in the U.S.A. charged risk loads as high as five to six times expected losses and, it is argued that, even the issue of CAT bonds cannot resolve this problem (Litan, 2006a).

On the issue of government involvement in taking up the slack in the operation of private insurance for catastrophe risks, there is much debate. Cummins (2006), as mentioned above, considers that CAT bonds is a more efficient private market solution than government involvement; instead,

government should facilitate the development of the private market by reducing regulatory barriers; a federal role may be appropriate only to insure against mega-terrorist events.

Proponents of government intervention in the insurance of catastrophe risks extend the above reasoning and argue that the timing risk is as much a problem for buyers of CAT bonds as it is for primary insurers and reinsurers (Litan, 2006a and b). The critical question is at what level timing risk becomes so much of a problem that either homeowners reduce their insurance coverage (by purchasing policies with much larger deductibles, to make them more affordable) or insurers withdraw from writing any coverage at all, viewing the risk of remaining in the market not to be worth it at any price.

Even if someone is skeptical about arguments that there is insufficient private capital to cover the risk of natural catastrophes, it is suggested that there are strong policy arguments for government reinsurance based on other considerations. One could be the 'fickleness" of private investors who would demand higher prices for putting up capital to cover catastrophe losses after major events. Another argument would be that government mechanisms could serve as efficient aggregators of cat risk. Perhaps the most compelling argument for a government –driven catastrophe insurance system would be that it could be designed to encourage (perhaps even compel) adequate cat risk coverage for most or all property owners, provide appropriate incentives for mitigation, and reduce the risk of insolvency for insurance and reinsurance companies that cover catastrophe risks. The insurance should be available only for upper-tier losses; below the threshold, private reinsurance, regional insurance plans, and primary insurance should continue to operate; but all such parties should be allowed to purchase reinsurance beyond some attachment point from the government reinsurer.

IV. A CATASTROPHE INSURANCE SYSTEM FOR EUROPE

Natural disasters take a heavy financial and emotional toll on Europeans every year. Recent experiences show that the EU is not well prepared to handle large natural disasters; this includes the initial emergency response as well as the financial aftermath. Europeans need to be better prepared for natural disasters both logistically and financially; insurance has an important role to play in this equation.

The discussion in the previous sections has shown that the appropriate perspective for analyzing catastrophe risks should not be restricted to the national framework.

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The most efficient way to deal with mega-catastrophes is to maximize diversification across regions / nations (by means of reinsurance) and across time (securitization of risks). The USA is already considering the establishment of a federal catastrophe insurance plan, which shall operate as a reinsurer of last resort for the State catastrophe insurance plans; the total insurance capacity of the federal program will be in the range of $200 billion (NAIC, 2009).

The EU is not, of course, a federation, but there are many examples of pan-European cooperation schemes in various areas of common interests among all member–states.

It is suggested that the pan-European framework is the appropriate one for considering efficient ways for managing catastrophe risks in each member–state. This approach offers the additional advantage that the particular catastrophe risks of each member–state may be diversified more adequately at the pan-European level.

The proposed catastrophe insurance system for the EU consists of three successive and well coordinated layers: the first layer consists of the local insurance markets for property risks; the second layer is based on the optional establishment of the National Catastrophe Insurance Organization (NATCAT) in each member-state; and the third layer is formed by the European Group of National Catastrophe Insurance Organizations (EUROCAT), which is a consortium of the national organizations.

The organization and operation of the proposed insurance scheme is based on several guiding principles that underlie the structure of all three layers:

- National programs should promote risk awareness and personal responsibility among policyholders
- National programs should support risk mitigation policies
- National programs should maximize the risk-bearing capacity of the local property insurance markets
- National programs should cooperate in the establishment of an effective risk-sharing structure for maximum amounts of losses

The First Layer: Local Private Insurance Markets

The primary objectives in the organization and operation of catastrophe insurance at this level is the promotion of risk awareness among consumers, the support of wide-ranging mitigation policies, the enhancement of the insurance product, the option of mandatory coverage, and the strengthening of insurance capacity. The main points are briefly described:

- Current as well as prospective homeowners should be educated about how specific mitigation efforts can increase property values and give

consumers greater security in knowing their property is better protected to withstand the forces of nature.

- Mitigation policies should provide property owners with meaningful mechanisms for effective mitigation measures. Such mechanisms could include low-interest loans, grants, and premium credits to upgrade existing properties strengthen and enforce building codes, and improve land use plans in the development of communities located within hazard-prone areas.
- In addition to meaningful mitigation mechanisms, catastrophe insurance should employ risk-based premiums. Also, the policy should contain a deductible for catastrophic losses based on a percentage of the insured property value. For an additional premium, a policyholder could choose to purchase a lower catastrophe deductible.
- Enhancement of the insurance product requires that policyholders fulfill their expectation that their residential insurance policy will indemnify them in case of damage to their property, regardless of the cause. Thus, catastrophe coverage should be offered as an endorsement to the basic property insurance contract. It would be very useful to offer policyholders the option of an all-risk policy, provided that they have the right to exclude the coverages they do not wish to buy.
- Each member-state should examine the option of establishing gradually the compulsory coverage of catastrophic risks, in order to reduce antiselection.
- Strengthening the capacity of local private insurance markets requires that insurance companies be allowed to set aside, on an objective basis, some additional reserves for future catastrophic events; accumulation of reserves would take place on a tax-deferred basis and subject to a maximum amount.

The Second Layer: National Catastrophe Insurance Organizations

Each member-state of the European Union has to decide whether its exposure to catastrophic risks warrant (a) the voluntary creation of a state catastrophe organization, or (b) participation in a regional catastrophe pool. These organizations would be responsible for (a) creating the actual operating structures to best fit the particular catastrophic risks of the state and (b) coordinating with the local private insurance market. The operation of the state funds should mimic as closely as possible what operating private markets would have been expected to do (Jaffee, 2006). Based on this principle, state or regional funds would generally be expected to do the following:

- Define the qualifying catastrophic loss event and any trigger point.

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- Determine the appropriate retention amount between private insurers and the state fund. Private insurers will have to decide individually on the level of retention and the amount of private reinsurance they will secure. The state fund will accept all ceded reinsurance, and will have to decide on its own retention and on its own reinsurance with the EUROCAT. Such reinsurance should be available only for upper-tier losses or annual losses beyond some admittedly arbitrary threshold (defined either as a percentage of premiums, as in the case of terrorism insurance, or for damages above some probability, such as 1 in 50 or 1 in 100). Below the threshold, private reinsurance, state insurance plans, and primary insurers should continue to operate. But all such parties should be allowed to purchase reinsurance beyond some attachment point from EUROCAT.
- Choose the appropriate financing mechanism by using risk-based premiums, which create the proper incentives for policyholders to take actions to mitigate the underlying risks. Picard (2008) rightly argues that risk-based premiums inevitably penalize the individuals who cannot escape risk at reasonable cost and he provides very useful guidelines for improving the equity-efficiency trade-off: (a) premiums should be risk-based, (b) the government should categorize individuals or areas, and (c) the government offers conditional grants to the local communities to implement costly risk management programs.
- Establish and implement effective mitigation measures. States should be required to use effective building codes, and develop high-hazard land use plans.
- Maintain a rigorous anti-fraud program to ensure that claims are attributable to an insured catastrophic loss.
- Require liquidity loans and emergency loans from EUROCAT, in order to: (a) ensure the solvency of the organization, (b) improve the availability and affordability of homeowners' insurance, (c) encourage risk transfer to the private capital and reinsurance markets, and (d) spread the risk of catastrophic financial loss resulting from natural disasters and catastrophic events.
- Maintain risk-based capital in accordance with the requirements established by the Solvency II regime, for the part of risk assumed by the state fund.
- Take into consideration asset risk, credit risk, underwriting risk, and other relevant risks.
- Phase-in gradually the compulsory coverage of catastrophic risks, because it is well known that individuals underestimate catastrophic risks (Kunreuther, 1984, 1996) and, therefore, would buy less coverage or no coverage at all. Therefore, reduction in uninsured loses may be attained by making catastrophe insurance compulsory for certain risks (Cummins,

2006). The important point here is that the state should make it clear that those not insured will not get any government assistance in case of catastrophe damage; otherwise, the moral hazard problem will cause a reduction in the percentage of homeowners purchasing catastrophe insurance, as it has happened in Turkey and in many developing countries (Freeman, 2004).

The Third Layer: The EUROCAT

The proposed European Group of National Catastrophe Insurance Funds (EUROCAT) is in essence a consortium of the national funds of the member-states. It is suggested that EUROCAT takes the form of a European non-profit organization, which shall operate under the auspices of the European Commission and should be endowed with the current available amount of one billion euros of the EU Solidarity Fund for supporting member-states in case of natural disasters. Members of the EUROCAT would be the national or the regional catastrophe organizations of member-states. The main functions of the proposed organization would include the following:

- Acts as a centralized repository of risk information of member-states, accessible by private-market participants.
- Serves as an inventory of catastrophic risk obligations held by state organizations.
- Sets terms and conditions of qualified reinsurance programs for state catastrophe insurance funds (certification process), including: (a) a minimum attachment point, and (b) 90% coverage of insured losses in excess of retained losses.
- Makes contracts for reinsurance coverage available to qualified state catastrophe insurance organizations, provided that such reinsurance coverage: (a) shall not displace or compete with the private insurance or reinsurance market, (b) shall minimize administrative costs, and (c) shall provide coverage based solely on insured losses covered by the state organizations.
- Collects amounts from the sale of reinsurance contracts, appropriations, and any amounts earned on investments.
- Sets the maximum aggregate potential liability for payment of claims under all reinsurance contracts sold in any single year. For example, the relevant limit for the proposed federal natural catastrophe reinsurance fund in the USA is $200 billion.
- Issues CAT bonds and other financial instruments linked to catastrophe risks insured or reinsured through Consortium members, on a conduit basis.

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- Makes liquidity loans and catastrophic loans to qualified state reinsurance programs, under certain circumstances. It is clear that all loans must be repaid in full.
- Invests any surplus funds in sovereign securities of any member-state.
- Performs research and analysis that encourage standardization of the risk-linked securities market.
- Establishes and maintains effective mitigation measures, which should be adapted by the state organizations to the special circumstances of the risk profile of the member-state, in order for the national organization to qualify for participating in the consortium.

V. THE ECONOMIC MODEL

In this section we shall show that the proposed pan-European catastrophe insurance scheme (EUROCAT) is economically optimal and that it is efficient for national catastrophe schemes (NATCATs) to trade risks. We shall employ the theory of optimal risk sharing of Borch (1962) as it has been applied in a market of mutual insurance syndicates by Aase (2007). Each NATCAT comprises a mutual insurance syndicate and the EUROCAT comprises the market of mutual insurance syndicates. The members of each syndicate share catastrophic losses beyond the amount placed in the private insurance market. Then, we find the conditions for optimal risk sharing among the national syndicates; in essence, we describe the reinsurance transactions among the national syndicates. These transactions secure for each syndicate a certain amount of reinsurance; beyond that level, each syndicate has to opt for additional reinsurance. This is the domain of the proposed EUROCAT mechanism.

Homeowners of a certain country face a catastrophe risk represented by a random variable $u_i, i \in I = \{1,2,...I\}$. Each homeowner has a random endowment X_i

$$X_i = w_i - u_i \tag{1}$$

where w_i = the wealth of homeowners i (assumed to be a constant), and u_i is the potential loss facing homeowner i. Equation (1) is supposed to hold after the homeowner has insured his risks in the regular insurance market; the residual u_i can be viewed as the risk not covered above some cap.

Homeowners are assumed to be risk averse with individual marginal utility functions: $u_i'(x) = e^{-x/ai}$, iEI (displaying constant absolute risk aversion), and therefore they seek further insurance. Not being able to obtain this insurance in the regular market, these homeowners are forced to share these

residual risks between themselves. The random endowment of homeowner i is denoted by Y_i after the exchange has taken place. Let us denote the sum of the initial endowments X_i by X_M, where $X_M = \sum_{i=1}^{I} X_i$. Then, the Pareto optimal sharing rules are known to have the following form:

$$Y_i = \frac{a_i}{a} X_M + b_i \ , \quad \text{where } b_i = a_i \cdot \ln \lambda_t - a_i \frac{k}{a}, \qquad i \in I \tag{2}$$

where λ_t are positive constants, $k = \sum_{i=1}^{I} a_i \cdot \ln \lambda_i$ and $a = \sum_{i=1}^{I} a_i$.

Thus, the optimal sharing rules are affine in X_M. The constants of proportionality a_i / a are simply equal to each homeowner's risk tolerance, measured relative to the other members. In order to compensate for the fact that the least risk-averse homeowner will hold the larger proportion of the total risk, zero-sum side payments occur between the homeowners; these side payments are here represented by the term b_i.

We may estimate the side payments by employing the budget constraints:

$$E\left[Y_i \cdot e^{(k - X_M)/a}\right] = E\left[X_i \cdot e^{(k - X_M)/a}\right] \tag{3}$$

from which side payments b_i are found as:

$$b_i = \frac{E\left[X_i \cdot e^{-X_M/a} - \frac{a_i}{a} \cdot X_M \cdot e^{-X_M/a} \right]}{E\left[e^{-X_M/a}\right]}, \tag{4}$$

Now the optimal sharing rules Y_i are completely determined in terms of the given primitives of the model.

In this model market prices are given by:

$$\pi(Z) = \frac{1}{1+r} \cdot \frac{E\left[Z \cdot e^{-X_M/a}\right]}{E\left[e^{-X_M/a}\right]}, \text{ for any } Z \in L^2, \tag{5}$$

where Z is any risk having a finite variance (i.e., being in the set L^2).

Now, let's consider a market of N different "national catastrophe schemes" which operate like the representative scheme above. We should note that we do not impose a utility function on the national schemes. Rather the objective function $U_n(X)$ is endogenously determined through the formation of

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the national scheme. As indicated above, $a = \sum_{i=1}^{I} a_i$, so the risk tolerance is the sum of the risk tolerances of the individual homeowners that participate in the scheme.

Each "national catastrophe scheme" has an objective function $U_n(X)$ of the form $U_n'(X) = e^{-X/a_n}$, $n \in N$. That is, the objective for each national scheme is to solve:

$$\sup E[U_n(X) \quad \text{subject to: } \pi(Y) \le \pi(X_i),\ Y \in L^2 \qquad (6)$$

Equilibrium in the market of N national schemes means the simultaneous determination of a linear price functional $\pi(\cdot)$ and optimal portfolios $(Y_1, Y_2, ...Y_n)$, such that Y_n solves the problem (6) and the markets clear: $\sum_{n=1}^{N} Y_n = \sum_{n=1}^{N} X_n = X_M$.

The motivation behind this construction is that the residual risks the homeowners retain, after regular insurance coverage, cannot be further insured in commercial insurance market. If the national catastrophe schemes are going to trade risks, it seems like a logical consequence of these market structures that this trade will have to take place among themselves. Viewed this way, the national schemes can be thought of as members of a syndicate, and we may apply the theory of optimal risk sharing in a syndicate.

The portfolio X_n of national scheme n is:

$$X_n = W_n + m_n \cdot p_n - U_n,\ n \in N \qquad (7)$$

where W_n is the volume of reserves, m_n is the number of catastrophe loss exposures, p_n is the premium, and U_n is random loss, where $E(U_n) = \mu_n,\ n \in N$.

To make the role of size predominant, we may assume that the catastrophe loss exposures are homogeneous. The initial premiums p_n are by definition varying with n, and the mean losses $\mu_n = m_n \cdot \mu$, for all $n \in N$. Also, we do not need any independence assumptions of the various random losses U_n, which are assumed to have an arbitrary joint distribution.

The optimal portfolios Y_n, after trade among the national insurance schemes, are given by:

$$Y_n = \frac{a_n}{a}(W + M \cdot p - U) + b_n, \qquad n \in N \tag{8}$$

where $M = \sum_{n=1}^{N} m_n, p = \sum_{n=1}^{N} m_n \cdot p_n, W = \sum_{n=1}^{N} W_n, a = \sum_{n=1}^{N} a_n, U = \sum_{n=1}^{N} U_n$, and b_n are the side payments.

The market portfolio X_M is: $X_M = W + M \cdot p - U$, and $EU = \mu \cdot M$, where $\mu = \frac{1}{M} \cdot \sum_{n=1}^{N} \mu_n$.

In this formation, the original risk u_n of national scheme n has been replaced by the fraction a_n / a of the diversified risk U, and the reserves and premiums have been replaced by smooth versions at this same ratio. The fraction a_n / a is to be interpreted as a national scheme's risk tolerance relative to the risk tolerance of the market.

In addition, we have the side payments b_n, which can be written, on basis of equations (4) and (5):

$$b_n = \left(W_n - \frac{a_n}{a}W\right) + \left(m_n \cdot p_n - \frac{a_n}{a}M \cdot p\right) + \left(\frac{a_n}{a} \cdot \pi(u) - \pi(u_n)\right) \cdot (1 + r) \tag{9}$$

The two first terms adjust for reserve and premium smoothing and the last for costs of diversification. These side payments are transfers that take place within the schemes internally, and between the syndicate and the individual insureds.

Under these circumstances, Aase (2007) has proved that an equilibrium exists in the market of N national catastrophe insurance schemes, where pooling takes place, and the resulting equilibrium allocations Y_n, given in (8), are Pareto optimal; and the optimal premium is :

$$p = \frac{1}{1 + r}\left[\mu + \frac{1}{\mathrm{M}} \frac{\mathrm{cov}(u, e^{u/a})}{E(e^{u/a})}\right] \tag{10}$$

Credit Risk

So far we have ignored the possibility that excessive catastrophe losses may bring one or more national insurance schemes in financial distress or bankruptcy. In this section we consider a situation where the national insurance schemes claim limited liability. The situation is now that a national scheme with a larger risk

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exposure than what corresponds to its relative size in the market may have to offer a discount on its premium.

Let us denote the assets of national scheme n by A_n. Then it is:

$$A_n = \frac{a_n}{a}(W + M \cdot p) + b_n \tag{11}$$

Now let us have:

$$B_n = A_n \cdot \frac{a}{a_n} = W + M \cdot p + \frac{a}{a_n} \cdot b_n \tag{12}$$

Then, the premium for national scheme n is:

$$p_n = \frac{d_n}{M(1+r)} \cdot \left[Eu + \frac{\mathrm{cov}(u, e^{u/a})}{E(e^{u/a})} \right] \tag{13}$$

where $d_n < 1$ is a discount factor. Also, it is d<1, where $d = \frac{1}{N} \cdot \sum_{n=1}^{N} d_n$. Notice from (11) and (12) that when the side payments are all zero, the discount factors $d_n = d$.

The situation here is analogous to a reinsurance market where the reinsurers cannot get coverage above a certain XL-layer; here the insurance amount A_n is the cap for national scheme n. Also, in this case the side payments, after trade, are exchanged only between the national schemes in the syndicate, since within the syndicate each homeowner is accounted for the average premium of the syndicate, $p^{(d)}$, and the various national schemes will "receive" the difference $p_n - p^{(d)}$ per loss exposure. Moreover, under the new circumstances, it is more beneficial for a scheme to increase its risk exposure, because it now enjoys limited liability.

In real life, the syndicate of all national insurance schemes could obtain an umbrella or catastrophe reinsurance cover for this residual risk (or, for that matter, issue catastrophe bonds).

VI. CONCLUSIONS

Mega-catastrophes result in costs that are so large and unpredictable that private insurers either are unwilling to insure, or charge premiums so high that significant numbers of customers do not want or cannot afford the insurance. Member states of the EU have not adopted so far a systematic risk management approach, in order to deal effectively with the problems of availability and affordability in the insurance of catastrophic risks. The European Commission has limited itself in providing after-the-event emergency aid.

The European Union, as well as other major groups of countries around the world, have to come up with a consistent and systematic approach to the issue of risk management for catastrophic risks. All evidence shows that the frequency and severity of natural catastrophes and man-made risks will continue to increase in the future. Without policy solutions, taxpayers in member-states will face unnecessarily large burdens for future disaster relief. The time has come for national governments and the European Commission to convert what is de facto insurance – relief provided "after the fact" – into a formal reinsurance system that assesses the costs of such catastrophic risks before such events occur.

This paper proposes an integrated risk management plan for catastrophe risks in the EU, consisting of three layers. The private markets would have the first layer of responsibility, while the National Catastrophe Insurance Organizations would represent the second layer. This layer would in turn be supported by the European Group of National Catastrophe Organizations (EUROCAT), a new organization operating under the auspices of the European Commission. An approach that utilizes a pan-European reinsurance program seems to be the most economical solution. EUROCAT would provide reinsurance to the state or regional funds, while securing financing through the issuance of CAT Bonds. State funds would be required to adopt adequate disaster response and management mechanisms and enforce reasonable building code, land use, and mitigation efforts to minimize the amount of insured losses. As the reinsurance premiums charged by EUROCAT would be risk based, the pricing mechanism must be used to encourage active development and enforcement of these standards. In short, the best way to minimize future liabilities from natural disasters in the EU is to establish a coordinated system of formal pre-funded reinsurance rather than to continue to muddle through, year after year, with ad hoc supplemental appropriations for disaster relief.

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