

Applications of Risk Financing Techniques to Manage Economic Exposures to Natural Hazards

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Inter-American Development Bank

Washington, D.C.

**Sustainable Development Department
Technical Papers Series**

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Andersen, Torben Juul.

Applications of risk financing techniques to manage economic exposures to natural hazards /
Torben Juul Andersen.

p.cm. (Sustainable Development Department Technical papers series ; ENV-147)
Includes bibliographical references.

1. Natural disasters--Prevention--Finance. 2. Risk management--Finance. I. Inter-American Development Bank. Sustainable Development Dept. Environmental Division. II. Title. III. Series.

363.34 A341—dc22

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The contributions of Caroline Clarke, Kari Keipi, Kim Staking and Ian Webb of the Inter-American Development Bank, Vijay Kalavakonda of The World Bank/Munich Re, Frederick Loeloff of Standard & Poor's, Christopher McGhee of Guy Carpenter & Company, and David Heike of Lehman Brothers. The author is grateful for the constructive feedback received from Guillermo Collich and Eloy Garcia to a draft version of this paper. Preliminary results were presented in a Disaster Risk Finance Seminar held in Washington, D.C. in September 2004. Pietro Masci and Edgardo Demaestri deserve special recognition for their ongoing engagement and support of the project through all its stages.

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October, 2005

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Foreword

The countries in Latin America and the Caribbean face high financial, socioeconomic and human vulnerabilities to natural hazards. Total reported economic losses associated with natural hazard related disasters have been increasing steadily over the past two decades, in excess of population and per capita economic growth rates. A reduction of vulnerability is needed to ensure sustainable economic growth and development in the region. Disasters can have a negative impact on productive assets, public sector investments, and social development and generally disrupts economic activity.

The most common strategy of the countries in the region has been to practice patience, and make preparations to face disasters through early warning and contingency planning. They have invested very little in reducing risk. This ex post, reactive approach to financing often means high losses. Lags in the post-disaster recovery period occur as financing options are evaluated to determine the most appropriate and effective means of intervention. Making estimates of damages for which financing is required also takes time. Additionally, the rise in the occurrence of natural hazard events could put a strain on already diminishing resources available for international aid and development, since international entities have been a significant source of reconstruction financing. Assistance through lending also results in increased indebtedness.

The countries in the region are starting to balance such ex post funding with prevention investments. Financial protection for potential losses is also gradually emerging through catastrophe risk transfer instruments. International capital markets are increasingly being highlighted as potential funding sources. Risk coverage allows reconstruction after a disaster without forcing countries to engage in disruptive reallocations of resources away from economic development programs. The combination of different risk transfer approaches and the utilization of diverse risk-linked financial instruments provide an opportunity to establish more effective coverage for catastrophe exposures.

This study follows an analytical risk management process that begins by identifying the major hazards to which the countries of Latin America and the Caribbean are exposed. It then outlines the risk exposures related to these hazards, evaluates opportunities for risk transfer and presents examples of financing options in various countries.

The document forms part of a series of studies that the Inter-American Development Bank's Sustainable Development Department is undertaking in the area of financial planning for natural hazards. As part of the overall Bank strategy for proactive disaster risk management, this document focuses on the use of alternative financial instruments to cover different layers of risk.

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Executive Summary

Direct economic exposures to natural disasters have been increasing significantly throughout the world and have hit the developing countries, including Latin America and the Caribbean, disproportionately hard. This development is partly a function of an expanded base of economic assets in a growing global economy that has increased direct economic exposures. It also reflects a shortage of effective efforts to mitigate the implied risks and, possibly, a higher frequency and intensity of certain natural phenomena. In the face of mounting direct losses associated with natural disasters, countries throughout the region have received help also from multilateral institutions to provide the needed funding for post-disaster reconstruction. The availability of such ex post funding constitutes a moral hazard issue as it favors political inaction and displaces the need to consider the socioeconomic consequences of natural disasters before they happen.

The direct losses from catastrophe events have been expanding at a much higher rate than average GDP growth over the past decades. In addition, international aid flows in general and those dedicated to disaster recuperation efforts, specifically, have not grown. Consequently, the current situation is likely to have repercussions sooner or later for exposed countries unless they seek increased action in prevention and a more pronounced participation of the private sector in the funding of disaster reconstruction projects. There seems to be a need to take a more proactive approach to assess, manage, and finance underlying catastrophe risk exposures. In this process governments should assess a country's overall catastrophe risk exposures on an ongoing basis, evaluate potential payoffs from risk mitigation efforts, and establish reasonable funding arrangements for retained risk exposures to obtain reasonable financial cover in advance. Such an approach represents an opportunity to turn potential future disaster situations into positive economic growth scenarios, as the catastrophe financing arrangements allow faster replacement of old capital investment with new more productive assets.

The catastrophe risk financing approach can be applied effectively to country settings by adopting simulation techniques or other methodologies to analyze catastrophe risk exposures and, using different risk transfer and financing instruments available in international financial markets, to shield nations from the extreme economic effects of these exposures. Governments can approach this challenge in practical terms by establishing different insurance vehicles to create reasonable and affordable covers for excessive economic effects associated with natural hazards. This implies that governments should consider different types of insurance vehicles geared to cover public and private asset exposures respectively.

As the supply of insurance in Latin America and the Caribbean grows, so should the coverage of public assets. This could take place partly through local insurance companies as well as by exploiting risk transfer opportunities available in the international financial markets. This coverage can be combined with financial protection through conventional calamity funds, especially for higher risk situations.

Insurance pools backed by governments may be established to deal with economic exposures of private assets, notably housing, because they provide the means to offer commercially based insurance policies to the public without any direct operational involvement by the government. The insurance pools could work closely together with local insurance companies, whenever possible, and take advantage of new international risk financing solutions. Ideally, these insurance vehicles have the potential to support local insurance industry development while instituting more viable practices in the national insurance markets.

For the multilateral institutions an increased focus on risk management practices and alternative risk financing instruments through the establishment of different insurance vehicles provides an opportunity to make existing catastrophe risk exposures more transparent than currently is the case. As a

de facto lender-of-last-resort to the region, the IDB is already exposed to the economic effects of natural catastrophes. However, these risks are not currently being treated explicitly as financial exposures in the institution's lending practices. This

situation creates disincentives to engage in risk mitigation and has a potential adverse effect by increasing economic exposures to natural catastrophes throughout the region.

Introduction

The Latin American and Caribbean region is increasingly exposed to the socioeconomic repercussions from natural catastrophes that disrupt economic activities and social stability, and redirect public development investments. However, different risk management approaches and use of alternative risk transfer instruments can facilitate post-disaster reconstruction and thereby reduce socioeconomic disruptions. This study identifies several viable risk financing instruments and approaches and concludes that market opportunities exist to establish effective catastrophe risk financing programs across the region. Tax financed calamity funds and government sponsored insurance pools are recognized as possible risk financing vehicles in exposed countries across the region. The establishment of calamity funds can provide incentives for governments to mitigate a country's economic vulnerability to natural catastrophes, although it often is politically difficult to capitalize the funds sufficiently. Government sponsored insurance pools (e.g., using local insurance companies as agents to distribute property insurance) are an alternative way to provide cover for otherwise uninsurable catastrophe risks. The insurance pools can manage different risk layers through mutual insurance arrangements, cedance in the global reinsurance market, and issuance of risk transfer and financing instruments in the international financial markets. In either case, the countries may use alternative risk financing vehicles and different risk-transfer instruments on a complementary basis to reach more effective risk coverage of the countries' natural catastrophe exposures.

Each of the risk financing markets provide less than perfect solutions on their own, which suggests that pooled risk financing vehicles that integrate access to different risk transfer and financing instruments constitute the best response. The global reinsurance market is a viable source of risk transfer arrangements but premiums on catastrophe reinsurance contracts are influenced by historical loss experiences and have been highly cyclical. Furthermore, the short-term claims fre-

quency in the market has a direct impact on market capacity (i.e., reinsurance is a viable source of risk transfer but is not necessarily a stable source of catastrophe risk coverage). However, other types of risk-linked and contingent capital market instruments may complement the existing risk transfer and financing techniques. By combining different risk transfer solutions within suitable risk financing vehicles, it may be possible to establish more effective coverage for catastrophe exposures.

The financial market techniques have yet to be applied in practice to cover catastrophe risk exposures in Latin America and the Caribbean. The primary insurance markets are generally underdeveloped across the region, and insurance penetration is well below the norm for industrialized economies. In most cases, the poorest segments of the population have limited access to formal insurance coverage and, consequently, remain exposed to the economic and social effects of catastrophes. Therefore, there is a need to engage countries in the development of their local insurance markets, which might be achieved in conjunction with the introduction of insurance vehicles that engage in risk transfer solutions in the international financial markets. Such risk coverage programs would allow the governments to fund reconstruction of important economic infrastructure after natural disasters without being forced to perform disruptive reallocations of financial resources from current economic development programs on the fiscal budget or impose an excessive future debt burden on the country.

Catastrophe risks in the region are largely uncorrelated with other risk exposures in the international reinsurance and financial markets and, therefore, represent diversifiable risks that may attract incremental demand from reinsurance companies and institutional investors that maintain a global perspective. The general outlook in the global capital markets remains favorable to new risk-linked investment instruments as institutional investors seek alternative investment oppor-

tunities to consolidate their portfolio returns. This represents an opportunity for the issuance of new types of risk-transfer instruments. Hence, the study outlines relevant approaches to catastrophe risk coverage that draw on access to risk transfer instruments available in the international financial markets and provides a template to assess the feasibility of alternative risk financing solutions for application in regional economic settings.

A FRAMEWORK FOR DISASTER FINANCING

The current study is framed around a rational analytical risk management process, which first identifies the major hazards that might affect a country, outlines the resulting risk exposures, evaluates opportunities for risk transfer and financing solutions, and then arranges financial cover for residual risks that are deemed to go beyond a prudent risk profile. The report assumes the perspective of a national government in its aim to cover public and private assets. Each step of the general model is briefly described in figure 1, although the main focus of the study relates to the risk financing issues depicted in the lower half of the figure.

Identify major natural hazards. The first step in the risk management process entails the identification of the natural hazards that expose important economic and social assets in the country. It is important to consider trends and changing fre-

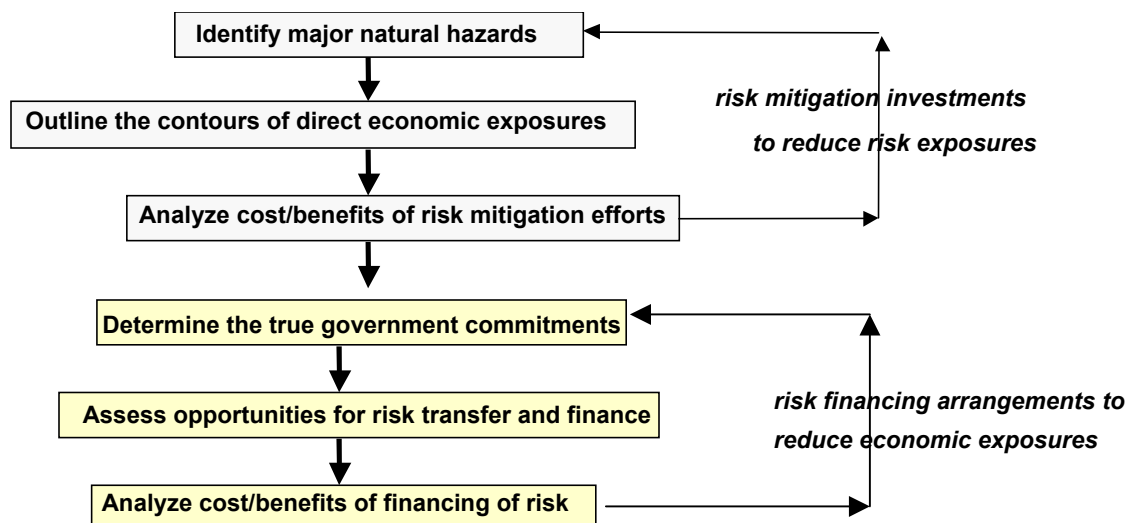
quencies and patterns in this analysis while remaining aware that occurrences of catastrophe events are extremely volatile and hence difficult to predict.

Outline the contours of direct economic exposures. Based on the identification of the major hazards and predicted future hazard frequencies and intensities, vulnerability models can transpose the hazard analyses into probabilistic estimates of likely direct economic losses associated with natural catastrophes. These analyses can use model specifications with different levels of sophistication.

Analyze cost/benefits of risk mitigation efforts. Better construction and building techniques and protective infrastructure, for example, can reduce direct economic vulnerability, but there is a trade-off between the need for up-front investments and the subsequent reconstruction savings. Risk mitigation should be pursued as long as the future benefits are expected to exceed the up-front costs.

Determine the true government commitments. Once there is a sense of the potential devastation that could affect economic assets in the country, there is a need to determine what public and private assets the government will and should cover in a disaster situation. In practice private buildings receive government compensation even though these exposures rarely are considered up front.

Figure 1. A Framework for Catastrophe Risk Analysis



Assess opportunities for risk transfer and finance. There are limits to the potential benefits from various risk mitigation efforts, and the government must search for ways to transfer and finance the remaining catastrophe risk exposure that is deemed excessive. In this process, the government should monitor reinsurance prices and new financing opportunities in the international financial markets.

Analyze cost/benefits of risk financing solutions. Based on the vulnerability analyses, assessments of the government's true economic exposures, and market opportunities for risk transfer and financing, the government should establish insurance vehicles to offer cover for specific risks and engage in up-front financing arrangements within realistic cost parameters. This analysis is based on the comparative pricing of alternative solutions and basic policy trade-offs between advance financing arrangements and ex post funding from multilateral institutions after disaster.

The subsequent sections provide underlying rationales for the proposed framework and develop the process elements of a general template for the assessment of alternative risk financing solutions in specific country settings and evaluations of related policy issues. Political and socioeconomic trade-offs are important elements in the government's considerations. We must accept that there are no perfect solutions for risk financing but rather some realistic assessments of the political and economic consequences of ignoring up front risk-financing arrangements.

We are here dealing with risk financing approaches that have been absent from the region so far and have been largely ignored in most other developing countries. As a consequence, the report makes deductions based on analytical reasoning. Few case studies exist to give practical country specific insights because the proposed techniques so far have had few applications in emergent markets.

Background

A natural disaster occurs when an extreme natural event overwhelms a region and seriously disturbs social conditions and economic activities in the surrounding society. Natural catastrophes can inflict human casualties and invoke economic losses as productive assets and economic infrastructure are destroyed. There is a general assumption that natural catastrophes have an adverse effect on economic development in exposed countries. Anecdotal evidence describing the immediate hardships following disasters supports this claim (e.g., Anderson, 2001; Alexander, 2000; Charveriat, 2000). However, despite the possible human devastation associated with disasters, these incidents also represent opportunities to replace affected capital assets with a more resistant and efficient economic infrastructure. Therefore, to the extent that exposed countries have the necessary financial resources to replace the economy's productive assets, catastrophes may also induce growth over time. The empirical evidence based on observations over the past four decades seems to indicate a largely positive impact on macroeconomic growth after disasters (Albala-Bertrand, 1993, 2000, 2003; Andersen and Kalavakonda, 2003). In other words, there is a potential economic windfall from the occurrence of natural catastrophes as it may allow economic agents in the exposed countries to introduce more resilient and productive assets to replace the old economic infrastructure.

There are, however, a number of caveats to this phenomenon. It assumes that there is ready access to the financial means for funding reconstruction efforts and that the catastrophe events happen relatively infrequently. Hence, an increase in the frequency of catastrophes will inevitably impose further strains on government budgets. Studies observe that insufficient financing in highly exposed countries leads to diversion of investment funds in public budgets and, thereby, can be expected to have adverse effects on long-term growth (e.g., Benson and Clay, 2002).

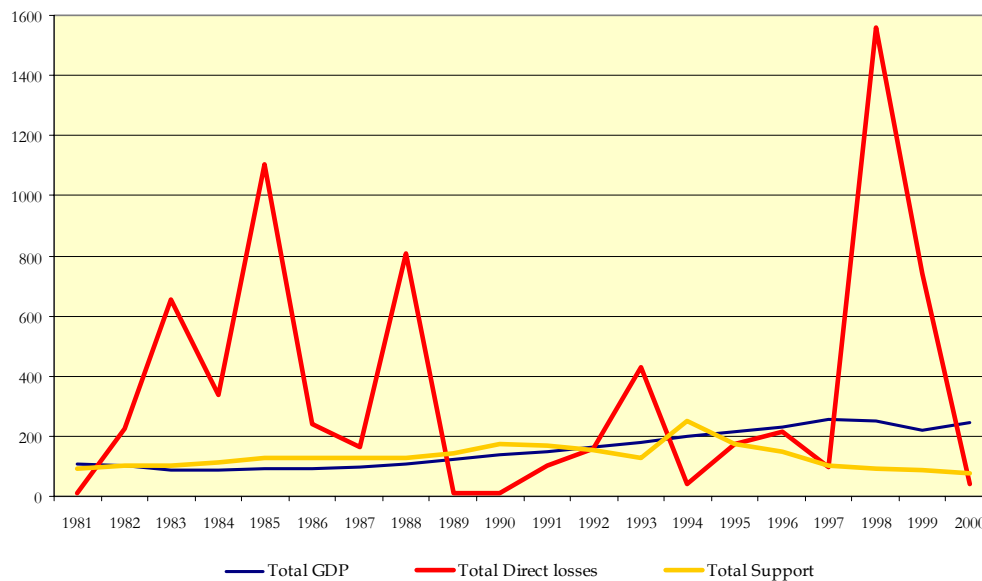
Insurance penetration remains relatively low in developing countries¹ and it seems to be an observed fact that countries in Latin America and the Caribbean rely on multilateral institutions, including the Inter-American Development Bank (IDB), to provide the needed financing after major disaster events (Freeman and Martin, 2002). This situation has the potential to create a moral hazard issue because over-reliance on multilateral aid reduces the political incentives to consider and deal with catastrophe risk exposures before the disasters happen (Andersen and Masci, 2001). By the same token, it may be wishful thinking to continue to count on the multilateral institutions, and the international community in general, to provide the funding needed for post-disaster reconstruction efforts in the future. The economic losses associated with natural catastrophes seem to be increasing at an excessively high rate,² particularly in developing countries. Moreover, this is happening in a global environment where development funds remain limited (Freeman and Martin, 2002). Looking at the Latin American and Caribbean region, it is clear that reported direct losses from natural disasters are evolving in a highly erratic manner, which also makes it extremely difficult to make reliable predictions about future loss developments³ (figure 2).

¹ Casualty insurance premiums typically range between 0.6 and 1.3 percent of GDP across countries in the region compared to 3 to 3.5 percent of GDP in the United States.

² The Red Cross *World Disasters Report 2001* stipulated an exponential increase in total catastrophe losses from around US\$700 billion during the 1990s to between US\$1,500 and 2,000 billion over the coming decade.

³ This analysis is highly dependent on which time-buckets are used for comparison. Nineteen eighty-one was an unusually low loss year whereas losses in 1982 were twice the average of the previous ten-year period. Here, we use the average annual losses experienced during the 1971-1980 period as the base for comparison to display a reasonable time-series profile. Using different moving averages to dampen the effect of year-to-year volatility in the data does not change the interpretation of the annual loss figures.

Figure 2. Development in 100 = Average 1971-1980 GDP, Direct Losses, and Financial Support in Latin America and the Caribbean, 1981-2000
(includes data for 28 countries exposed to natural catastrophes during the period)



Sources: Centre for Research on the Epidemiology of Disasters (CRED), IMF, and the World Bank.

Compared to the economic growth experienced in the region during the same period, it is not evident that exposures have expanded out of control. However, consistent with the global experience, funding made available by the international community (including loans from multilateral institutions, official development assistance, and bilateral aid) has fallen significantly over the past decade. Given the outlook for multilateral support and the extreme uncertainty associated with catastrophe losses, it would seem to be for exposed countries to manage natural hazard exposures more actively and establish appropriate funding solutions in advance. If they fail to do so, it is not inconceivable that there will be a shortfall in financial resources available from the international community to cover the mounting needs for reconstruction investments. Engaging in risk analyses that take account of major disaster exposures allows governments to consider risk mitigation programs and establish reasonable risk transfer and financing arrangements to cover excessive risk exposures. Hence, by assuming a more proactive risk management approach, exposed countries can bring themselves into a better position to recoup economic momentum after disasters and avoid the need to negotiate funding arrangements

when they are in a weak financial position after major hazard events.

The economic effects associated with natural catastrophes are considered to have a *direct* and an *indirect* component. The direct economic losses refer to the immediate physical destruction of essential economic assets, comprising private dwellings, small business properties, industrial facilities, semi-public assets (e.g., power plants, harbors, airports, etc.), and government assets, including economic infrastructure (such as roads, bridges, telecommunication, etc.) and public facilities (such as hospitals, administration, universities, schools, etc.). The indirect economic losses refer to the subsequent disruption of economic activities that follow in the wake of natural disasters caused by, for example, production stops, fading market demand, or failing business interactions. In short, the direct effect refers to the destruction of capital *stock* and the indirect effect refers to the subsequent impact on income *flows*. Normally, we assume a certain relationship between the destruction of productive assets and a subsequent drop in the level of economic activity. The direct losses are reasonably well docu-

mented,⁴ particularly in the case of insured economic assets, but there is little consensus on the size of the indirect economic effect. The indirect effects are usually determined by economic modeling and assessed in empirical studies of macro-economic variables in representative cross-sections of exposed countries.

NATURAL DISASTERS IN A GLOBAL CONTEXT

The number of registered natural catastrophe events is increasing rapidly across the globe. This development is a function of growth in the number of people, general expansion of economic assets, higher vulnerability of the socioeconomic environments, and possibly the intensity with which natural hazards hit human settlements. As a consequence, the increasing frequency of disasters is not a purely natural phenomenon (by some referred to as “Acts of God”). It is as much a function of the vulnerability of the socioeconomic infrastructure in the wake of economic growth as an environmental phenomenon. This also means that mitigation efforts, if pursued successfully, can reduce the vulnerability of key capital assets and thereby reduce economic exposure to natural catastrophes.

Total reported economic losses associated with natural disasters have been increasing steadily over the past two decades, rising faster than population and per capita economic growth rates.⁵ At

the same time, the development in losses year by year has displayed a high and increasing volatility that exacerbates the uncertainty of future loss predictions. Insured losses have increased as well, but not as fast as indicated by the aggregate loss data (figure 3). This trend partly reflects that catastrophe losses are rising faster in developing countries than in industrial economies, since most of the risk exposures remain uninsured in the developing world. The volatility in total losses may also partly reflect the inadequacy of the emergency database to capture the true losses arising from natural disasters in developing countries. Loss estimates in developing countries are clearly underrepresented in the aggregate loss indications. For example, the peak in losses observed in 1995 relates primarily to underinsurance of the estimated losses from the Kobe earthquake in Japan.⁶ Hence, the depicted volatility does not necessarily reflect a phenomenon in developing countries, although the upward trend in total losses emanating from natural disasters most likely is underestimated in emerging markets.

DISASTER EXPOSURES IN LATIN AMERICA AND THE CARIBBEAN

The predominant natural hazards throughout Latin America and the Caribbean are storm events (predominantly hurricanes), *El Niño*-related incidents causing flood and drought, and geological phenomena like earthquake and volcano. The relative intensity of the natural disasters is normally captured by the number of people affected by the

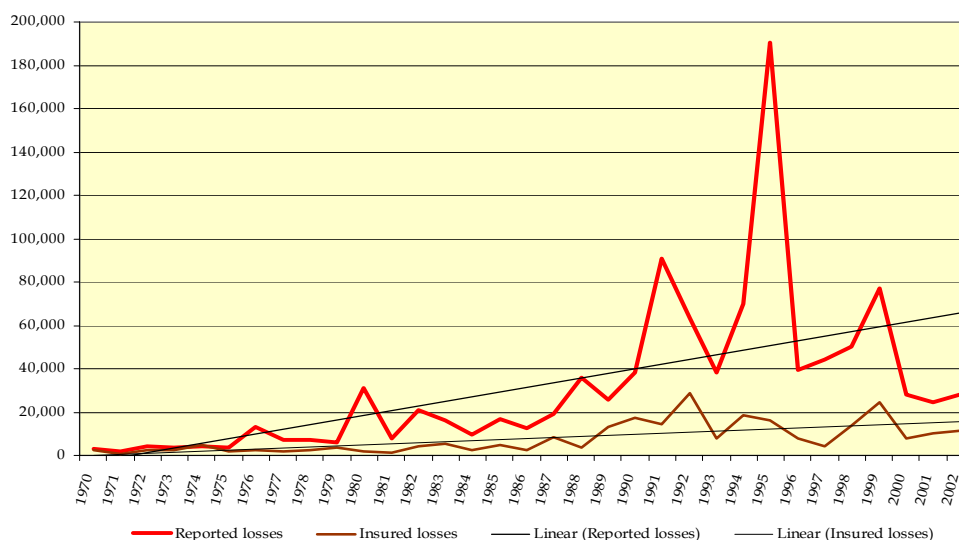
⁴ The major sources of direct economic losses arising from natural catastrophes include the major global reinsurance companies, such as Munich Re and Swiss Re, as they obtain detailed information in connection with their handling of insured claims. Another major source is the Centre for Research on the Epidemiology of Disasters (CRED), *Université Catholique de Leuven*, Belgium. CRED has updated the emergency data since 1900 and now maintains the database in cooperation with WHO and with support from the Belgian government. The data are collected from all publicly available information sources including major insurance companies, various multilateral organizations, news media, etc.

⁵ The loss statistics are less than perfect as the data are collected from a variety of public sources including insurance companies, multilateral institutions, and the new media. However, there is a higher focus on insured

losses because these events have the attention of the major global reinsurance companies and their local partners as they deal with post-disaster claims. Losses in developing countries, however, remain largely uninsured and therefore get relatively limited attention. Consequently, only about 25 to 30 percent of the events registered in developing countries receive formal loss estimates that are included in the global loss statistics.

⁶ That is, when extreme disaster events happen in developed economies a smaller share of the total risk exposure will be covered by insurance. This relates to the normal practice of excess-of-loss insurance contracts and also reflects a certain degree of underinsurance for extreme natural disaster events also in major industrialized countries.

Figure 3. The Development in Global Losses from Natural Disasters 1970-2002 [US\$ millions]



Sources: Centre for Research on the Epidemiology of Disasters (CRED) and various issues of *Sigma* (Swiss Re) 2/2000.

event and the direct losses ascribed to the destruction of economic assets. The Centre for Research on the Epidemiology of Disasters (CRED) provides estimates for affected people in approximately 75 percent of the reported incidents in the region, as well as loss estimates in around 34 percent of these cases. However, there is less than perfect co-variation between the two types of intensity indicators.⁷ Part of the seeming discrepancy relates to the incompleteness of the data, particularly the lack of loss estimates on many of the uninsured disaster events. Even though the reporting is less than complete it is probably the best and most comprehensive database available.

Earthquakes represent the most costly natural hazards in the region in terms of reported losses. The highest single losses are ascribed to the Mexico earthquake of 1985, with a loss estimate of US\$4 billion; the 1999 earthquake in Colombia, with a US\$2.9 billion loss estimate; and the 2001 earthquakes in El Salvador, which had a total loss estimate of US\$2.8 billion. Storm events are comparable contributors to the major reported natural catastrophe losses. The largest single losses relate

to hurricane Georges, which caused estimated damages of US\$2.2 billion in the Dominican Republic in 1998. The same year, Honduras and Nicaragua were hit by tropical storm Mitch, which caused collective damages of US\$3 billion. Hurricane Gilbert hit St. Lucia, Jamaica, and Mexico during 1988 and caused collective damages of around US\$3.4 billion. Major flood events took place in Venezuela in 1999, causing estimated losses of US\$2 billion, and in Peru in 1997-98, with estimated damages around US\$1.2 billion. Drought events appear to be less dominant loss contributors. The major drought event over the past decade took place in Mexico during 1996 with estimated losses of US\$1.2 billion. Assessing the impact of disaster from different natural hazards, drought and flood have affected the largest number of people across the region.

Although one should not expect complete comparability in the socioeconomic effects across different types of natural hazards, the differences in assessment may also be influenced by potential shortcomings of the underlying catastrophe reporting. For example, it is more difficult and uncommon to provide loss estimates in long-term drought situations than in the case of the more dramatic so-called “rapid onset” events like earthquakes and hurricanes (table 1).

⁷ The correlation coefficient between the total number of people affected and reported losses is 20.8 percent and the correlation coefficient between number of people killed and reported losses is 27.2 percent, i.e., it might seem like events with more human devastation are more likely to be associated with a loss estimate.

Table 1. Major Disaster Exposures in Latin America and the Caribbean, 1971-2001
[percentage distribution]

[percent]	Number of Events	People Dead	People Affected	Reported Losses
Drought	17.2	10.9	39.1	12.1
Earthquake	10.7	31.6	12.2	25.3
Flood	48.0	35.2	31.3	34.1
Storm	24.1	22.3	17.4	28.5
Total	100.0	100.0	100.0	100.0

Source Centre for Research on the Epidemiology of Disasters (CRED).

When a natural catastrophe occurs, productive assets and economic infrastructure investments are destroyed, which inevitably disrupts economic activity. In most cases countries exposed to a natural catastrophe will experience a drop in GDP during the year of the event. However, economic growth tends to spur over the subsequent year as reconstruction efforts reactivate the economy. Retrofitting the productive assets may, in some cases, improve productivity as better technology is installed. However, the disruption in economic activity may also have profound effects on the welfare of individual citizens. On the whole, low-income groups are deemed more vulnerable to catastrophe events (because, for example, their housing is more fragile, they are less likely to receive early warning information, they have inadequate shelter and emergency care facilities, etc.) (Charveriat, 2000). The poorest segments of the population are not likely to have personal savings or affordable insurance to help reinstate their lost property. Hence, natural catastrophes are expected to have longer-term adverse effects on income distribution. Consequently, countries with high poverty levels are more exposed to disruptive social effects and also tend to experience more fatalities and higher direct losses when disaster strikes.

However, there is not necessarily a direct relationship between the destruction of capital stock indicated by the reported direct loss estimates and the subsequent impact on income flows (i.e., the economic activity level, in the country). First, many of the affected economic assets do not constitute capital stock that has a direct relationship to productivity. For example, private dwellings, personal belongings, and certain regional infrastructures may have little impact on the overall economic activity level within the region or the country. Loss of private property often constitutes a

significant portion of the registered losses after disasters (e.g., Lahiri et al., 2001). Furthermore, public loss assessments in the immediate aftermath of disasters often tend to overestimate the magnitude of the physical devastation by anywhere between 20 and 50 percent (Albala-Bertrand, 1993; Lahiri et al., 2001). Finally, the conversion from changes in the capital stock to effects on the economy's income flows should take a variety of factors into account, such as, the pre-disaster capacity utilization, the efficiency of replacement assets, and the economic depreciation of old capital stock (see box 1).

In an effort to assess the indirect economic effect of natural disasters across Latin America and the Caribbean during the past decades, the annual economic growth data in the years after major disaster events were analyzed in the exposed countries. To this effect, a comprehensive statistical analysis of all countries across the region that have been exposed to one or more natural catastrophes over the past twenty years was performed. This entailed a comparison of annual real per capita GDP growth and the annual frequency of different natural disaster events in all the exposed countries.⁸ The results of this comparative analysis are summarized in table 2 (see also Annex 1).

⁸ The comparative analysis was performed as a linear regression using the countries' annual real per capita GDP growth as the dependent variables and the annual frequency of different natural disaster events (categorized as flood, storm, earthquake, and drought) as independent variables. The relative size of the regression coefficients expresses the impact of disaster events on economic growth over time, and significance tests determine whether these effects can be considered material. Information related to the catastrophe events was extracted from the CRED database and key economic data was obtained from the IMF and the World Bank.

Box 1.
The Effect of Natural Catastrophes on Economic Growth

The models applied to analyze the indirect economic effects from natural disasters usually extrapolate the existing relationship between the country's capital stock and economic output (the capital-output ratio) onto the direct loss suffered on the capital stock after a disaster.

This approach implies a number of simplifying assumptions (Albala-Bertrand, 1993), for example, that all losses relate to productive capital stock and that the capital stock is homogeneous, i.e., we are dealing with productive private assets and public economic infrastructure, such as, factories, roads, telecommunication, educational facilities, etc., whereas dwellings, private household items, etc., are not supposed to have the same direct relationship to economic output.

Hence, in connection with catastrophe events, the model determines the economic growth rate as:

$$y = d/c$$

where; $y = \Delta Y/Y$, $d = D/Y$, and $c = K/Y$
and; D = direct economic loss, i.e., the damage to capital stock
 Y = GDP, K = capital stock

However, this denotes an upper limit of the potential loss associated with damage to the capital stock, because (i) the direct losses often are overestimated at the time of the disaster; (ii) losses may affect economic assets differently, e.g., the least efficient assets are often the most vulnerable; (iii) replacement cost should take the previous asset depreciation into account; (iv) the economy might not operate at full capacity so a capital loss does not translate directly into lost income generation; and (v) the new invested assets may be more productive than the assets they are replacing, i.e., they may have a higher economic multiplier that induces economic growth.

When considering these factors, the net effect on economic growth can be considerably less than the initial estimate using the simple formula, and may even support economic growth if the international community provides financial means for reconstruction investment.

Another approach is to assess the government's resource shortfall in funding the required post-disaster reconstruction investment (Freeman and Martin, 2002) and calculate the economic growth path assuming application of different risk transfer and financing arrangements. In this analysis the current national revenue (Rev_t) is determined by:

$$Rev_t = rok * Kap_t$$

where; Rev_t = GDP, Kap_t = capital stock, and rok = return on capital = $\Delta Y/\Delta K = y/D = y/I$

if the replacement investment (I) has the same capital-output ration as the previous capital stock.

The same approach is assumed in other recent analyses of indirect catastrophe effects (Freeman et al., 2002), where the change in economic growth is determined as:

$$\Delta GDP = \text{Investment}/ICOR$$

where; $ICOR$ = incremental capital-output ratio, i.e., c in the equation above

The analysis may also be based on a Cobb-Douglas production function (Freeman et al., 2002), in which case a change in capital assets as a key productive input factor will have an adverse effect on production output provided the capital stock is considered homogeneous, i.e., the production elasticity of the replacement investment is the same as the previous capital stock:

$$GDP = AK^\alpha L^{(1-\alpha)}$$

where; K = capital stock, L = labor, α = production elasticity of capital

The results of this analysis indicate negative relationships between economic growth and earthquake and draught events during the year of the events. However, when the analysis is controlled for other economic influences, the adverse economic relationships of the disaster events are no longer statistically significant. Conversely, the results indicate a positive relationship between economic growth and storm events one year after the events have occurred and the effect remains statistically significant when other economic factors are taken into consideration. In other words, the analyses do not find significant negative effects on economic growth after major catastrophe events. In fact, the results seem to illustrate the potential growth enhancing effects associated with storm events. From a political perspective, this phenomenon represents a moral hazard issue. The evidence should induce policymakers to ignore the potential adverse socioeconomic effects of

natural disasters since, by experience, catastrophe events are associated with increased support from the international community and higher economic growth.

The analysis reveals that multilateral development assistance and international aid flows have a positive relationship to economic growth after one or two years. This indicates that multilateral development contributions have supported post-disaster economic development.⁹ However, the central questions here are whether the dependence on multilateral aid flows to finance reconstruction is a prudent policy and whether reconstruction efforts could be effectuated more efficiently by making the underlying catastrophe exposures more transparent and establish risk-financing arrangements in advance.

Table 2. Relationship Between Disaster Events and Real Per Capita Economic Growth in Countries Across the Latin America and Caribbean Region, 1981-2000 (Summary of Regression Results)

[standardized coefficients]	---- Annual Real Per Capita GDP Growth(t) ----		
	MODEL I	MODEL IV	MODEL V
Flood Events _t	-0.051	0.335	0.007
Flood Events _{t-1}	-0.014	-0.002	0.001
Storm Events _t	0.021	-0.009	0.005
Storm Events _{t-1}	0.098	0.091	0.098
Earthquake Events _t	-0.095	-0.032	-0.041
Earthquake Events _{t-1}	0.029	0.083	0.057
Drought Events _t	-0.082	-0.012	-0.011
Drought Events _{t-1}	0.050	0.056	0.061
GDP Growth _{t-1}	.	0.166	0.142
Gvt. Consumption _t	.	0.610	0.835
Corruption _t	.	-0.174	-0.149
Dev. Assistance _{t-1}	.	.	0.328
Aid Flows _{t-2}	.	.	0.105

Note: The figures in bold indicate statistically significant regressions coefficients.

Sources: Data for the regressions were obtained from WDI GDF database, the World Bank/IMF and the Centre for Research on the Epidemiology of Disasters (CRED).

⁹ Economic assistance and aid flows are highly correlated with the number of people affected by the disasters, which indicates that the allocation of economic assistance is affected by the size of reported human devastation.

Risk Management, Risk Transfer and Financial Markets

The global catastrophe risk exposures seem to be developing at an excessive rate compared to the economic growth experienced in different economic regions.¹⁰ The average compound rate on total reported catastrophe losses over the past thirty years shows a growth rate well above 20 percent per annum,¹¹ whereas GDP has grown at rates between 2 and 5 percent over the same period in different parts of the world.¹² Provided this trend in global catastrophe losses continues, there is likely to be a shortfall of funding for post-disaster reconstruction from the international community, that is, direct losses from catastrophes are increasing while international aid flows are stagnant (Andersen, 2003). Hence, it appears shortsighted for countries with exposures to natural catastrophes to rely on multilateral support as the only way to replace capital stock destroyed by disasters. Nonetheless, governments across the region have ignored catastrophe risk exposures in their planning processes and relied almost exclusively on multilateral support for post-disaster reconstruction (Freeman and Martin, 2002).

The majority of governments in the region ought to be more conscious about the natural hazards that expose the socioeconomic assets in their countries and focus on alternative ways to fund the need for future post-disaster reconstruction investments. Post-disaster investments can normally be covered through risk sharing arrangements effectuated through formal insurance contracts, but most developing countries face a dilemma of monumental proportions in doing so because insurance coverage continues to be low in emerging markets and the local insurance indus-

tries remain relatively underdeveloped. Lack of formal building codes and urban planning, for example, create moral hazards that often constitute insurmountable hurdles in the efforts to introduce affordable property insurance.

Large international insurance and reinsurance companies do provide risk transfer products with provisions for catastrophe risk exposures to entities in developing countries. But these insurance policies are offered selectively to larger institutional customers and are generally not available to small businesses and low-to-medium income households. In reality, access to the international insurance market is only viable for large industrial enterprises and government-related entities. The productive assets in large business enterprises are usually reasonably well covered through international insurance arrangements, whereas government entities, despite their effective access to the international insurance market, largely refrain from doing so at least on an organized basis (Freeman and Martin, 2002). As a consequence, semi-public and government sponsored economic infrastructure is frequently not covered by formal insurance contracts. There is also a general shortage of affordable insurance products for small business owners and low-income families.

The low penetration of local insurance markets in developing countries accentuates the need for some type of government involvement to arrange insurance coverage for essential economic assets on a commercially viable basis. Furthermore, since disaster risks, by definition, constitute exposures that threaten the solvency of insurance companies (e.g., Cutler and Zeckhauser, 1999), there is a general need for some government intervention to provide cover for these otherwise uninsurable risks, a pattern observed in virtually all developed countries with sizeable exposures to natural disasters.

Governments throughout Latin America and the Caribbean generally accept many insurance claims from the public that normally could be

¹⁰ The trend in disaster losses seems to follow an exponential growth path (Red Cross World Disasters Report, 2001).

¹¹ Again, the analysis is dependent on the choice of comparative time-bucket, but using different time intervals to calculate the compound rates does not affect the 20 percent indication, which is a rather conservative estimate.

¹² See, e.g., *World Economic Indicators*, The World Bank/IMF.

covered by commercial insurance arrangements if the insurance market was sufficiently developed (Freeman and Martin, 2002). These claims include damages to private property and dwellings as well as workman's compensation and other post-disaster relief payments. Many of these frequently sizeable claims do not seem to have any direct relationship to the country's productive capacity, but rather relate to *social* costs associated with disasters that often carry significant political recognition. Whereas there may be a need for some type of government intervention, it is generally not in society's interest to involve government agencies directly in claims coverage. The often politically loaded task of distributing claims to needy electoral constituents creates moral hazard issues and, experience shows, is associated with inefficient and bureaucratic resource allocation processes.

Government run systems of claims coverage as public goods do not have a reputation of high efficiencies (e.g., Epstein, 1996; Priest, 1996). This is not just a phenomenon in developing economies but a universal issue applying to developed countries as well. For example, the U.S. federal government has provided direct catastrophe insurance through disaster relief programs like the Federal Emergency Management Agency (FEMA), small business loans, and various congressional appropriations. However, these arrangements tend to foster misappropriations and moral hazards. Accordingly, US federal disaster assistance has been highly correlated with whether or not the president is running for reelection (Downton and Pielke, 2001). FEMA has dispensed relief money and loans in the wake of hurricanes, floods, fires, and other disasters but the interventions have often created an unhealthy reliance on federal resources and have thereby inadvertently contributed to the continued increase in annual flood losses (CRS, 1998; Larson and Plasencia, 2001). As a consequence, government sponsored insurance schemes should be based on commercial and actuarially sound contractual terms.¹³

¹³ This means that insurance policies establish up front what is covered and what is not, under what conditions covers are paid out, and how payments are made. Insurance premiums are determined on the basis of actuarial calculations and could be graduated according to

Lacking advance assessments of catastrophe risk exposures and appropriate risk transfer and financing arrangements to cover excessive risk levels, a normal government response to the unexpected funding needs resulting from large disasters is to divert funds from the public investment budget. Barring new financial support from the international community, other funds may be sourced from higher tax revenues, issuance of new domestic government debt, and assuming additional debt obligations from the international financial markets including multilateral credit facilities. Diverting funds from public development investments will often have adverse longer-term economic effects (Benson and Clay, 2002), just like a higher international debt burden can strain future economic growth. Hence, the increase in catastrophe exposures and reported disaster losses combined with overdependence on international aid flows in a global setting of scarce public resources does not seem to constitute a reliable route in the longer term.

However, as long as the multilateral institutions, including the IDB, serve as *lenders of last resort* to countries exposed to natural catastrophes, and effectively provide backstop facilities without charge, it encourages national politicians to disregard future financial contingency plans. If multilateral institutions always can be counted on to provide catastrophe financing, it constitutes insurance provided free of charge, and then there are obviously no incentives to establish financial covers on commercial terms in the financial markets. Given the apparent trend of increasing direct catastrophe losses and a shrinking pool of international support, this might not constitute a viable option in the future. Since the multilateral institutions de facto are assuming sizeable undisclosed catastrophe risk exposures, they are, sooner or later, likely to make these risks more transparent and charge for them accordingly. Even though it still may be politically convenient to ignore the potential future economic effects of disaster risks, there should be good reasons to consciously rec-

the risk profile of the customers' insured assets to encourage risk mitigation efforts. It also means, that no political favoritism is displayed when the claims are covered equally for all policyholders in accordance with publicly available terms and conditions.

ognize the countries' risk exposures and impose formal risk management practices to deal with them.

RISK MANAGEMENT PERSPECTIVES IN A COUNTRY CONTEXT

Risk relates to the adverse economic and social impacts inflicted by uncertainty and unexpected events that are beyond political and managerial control. The risk concept is, however, somewhat subjective because the level of uncertainty and the degree of unexpectedness depends on how risk is approached. A society that ignores its environment will be taken by surprise when disasters happen and hence will be more exposed to the associated uncertainty. But, a society that recognizes potentially adverse events, and tries to stipulate causes and effects of these events will not be taken by surprise to the same extent, and with some ingenuity, might be able to reduce the downsides associated with the uncertainty. In other words, the more effort a society devotes to identify, understand, measure, and mitigate the causes of potentially adverse events, the more it can reduce the element of surprise and the better it can manage the inherent risk exposure.

The practical application of the risk concept developed by the financial industry, which has increasingly been adopted in the corporate sector, can also be transposed to a country setting to deal with the country's risk exposures. Risk management has progressed through an ability to quantify the risks and thereby allow the institutions to measure, monitor, and manage their financial and economic risk exposures. It also provides an opportunity to consider different risk exposures simultaneously, such as financial, casualty, and economic exposures. This can be important as many risk factors are interrelated and therefore should be analyzed within an overall risk management framework. A country is exposed to a variety of risk factors just like an enterprise. As many casualty risks represent independent events (e.g., auto accidents, fire incidents, etc.), large institutions with a diversity of exposed entities may want to self-insure. Conversely, small firms and households, that are unable to diversify their risks, should obtain cover in the primary insurance market. As a country's public assets are exposed

to many independent risks, a government may be better served by self-insuring these risks and maintain an actuarially determined financial reserve to cover future funding needs.

The real challenge relates to exposures to highly uncertain catastrophe events. Natural catastrophes happen relatively infrequently and have the potential to create economic havoc. These loss incidents cannot be diversified in a regional insurance portfolio, but to some extent the risk exposures can be covered in the global reinsurance market. The global reinsurance sector may, in turn, diversify these risk exposures among international reinsurance companies through various retrocession arrangements. Hence, it can be argued that a country's risk management concerns constitute a two-pronged challenge to develop an effective local insurance market to deal with smaller independent risk exposures that represent normal business conditions in the economy, and implement risk transfer and financing schemes that provide financial resources to replenish important economic assets after natural disasters.

To deal with these risk management challenges, a government and its relevant regulatory agencies, could take steps to identify and survey the key risk factors that may affect different capital assets in the country. Assessments of the possible impacts on economic infrastructure allow the government to determine how exposures to certain risk factors may be reduced through active mitigation efforts and how residual risk exposures may be covered through various risk transfer schemes in the global financial markets. If the vulnerability to natural catastrophes is reduced (e.g., by enforcing building codes, property registration, etc.), insurance premiums can be reduced considerably. It might also be possible to find hedging solutions in the global capital markets, but the associated premiums would be proportional to the potential losses they cover. Therefore, it is in a country's interest to mitigate the risks and reduce the economic vulnerability associated with natural catastrophes.

It seems reasonable to hedge against extreme catastrophe effects to shield the country's essential long-term investment initiatives. It is argued that financial hedging should be pursued to such an

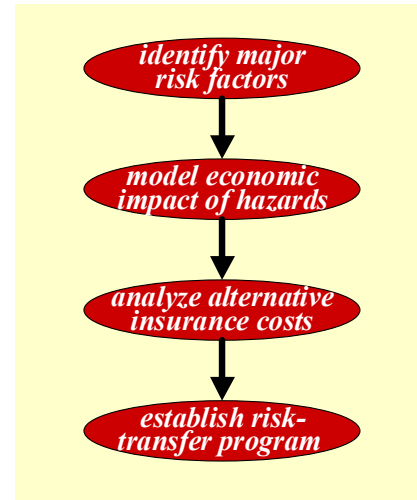
extent that it ensures cash availability for all sound investment propositions (Froot, Sharfstein and Stein, 1994). Others argue that hedging should be pursued to the extent that it stabilizes relationships to all essential stakeholders (Miller, 1998). In a country context, this means that hedging should be pursued to ensure that financial resources remain available to the country at reasonable costs and that global business relationships can be maintained even if the country is exposed to extreme natural catastrophes. A country that is adversely affected by natural catastrophes, and lacks the necessary response capabilities, could be faced with a significant credit downgrading that reduces access to important funding sources. Conversely, a country with a stable economic development path attracts foreign direct investment and facilitates needed long-term business partnerships, including essential research and development ties.

THE APPLICATION OF FORMAL RISK ANALYSIS TO MANAGE EXPOSURES

A formal country risk management process starts with the identification of the significant risk factors that expose the economy. Once the important risk factors are identified, the country's vulnerability to the various risks should be analyzed and the implied economic exposures measured to consider effective mitigation efforts. Risk measurement provides a basis for ongoing monitoring of the direct economic exposures in the context of environmental changes that may require responsive actions. The monitoring process helps determine excess exposures that should be covered through different risk-transfer arrangements. Hence, efforts to identify, measure, and monitor essential risk exposures provide a better decision framework for investments that can promote economic growth. In practice the application of the risk management process builds on a systematic analysis of all significant risk exposures. Preliminary analyses of loss records provide background information to pinpoint major hazards, such as flood, storm (hurricanes), earthquake, and drought. Next, the economic impact of the identified hazards can be determined from computerized model simulations or other simpler means. The risk exposure profile determined by a model simulation can provide a basis to establish rele-

vant risk transfer and financing programs that secure availability of funds for post-disaster reconstruction (figure 4).

Figure 4. Sequential Catastrophe Risk Analysis



The direct economic impact of natural hazards can be determined by using relatively advanced computer-based simulation models that stipulate the likely hazard intensities, economic assets exposed to the hazards, the vulnerability of the exposed assets, and the replacement cost of damaged assets (Lester and Gurenko, 2003). The model simulations incorporate hazard occurrence parameters that identify the intensity of events and the probabilities of their occurrence derived from statistical distributions of historical events data.¹⁴ A stochastic set of hazard events determined by relevant occurrence parameters can be derived from historical observations of the hazards.¹⁵ Given the environmental characteristics of a country or region, the intensity of the hazard events can then be simulated at different locations where site conditions may amplify or reduce the impact of the hazard. The magnitude of the economic exposure to natural hazards can be derived from data

¹⁴ Occurrence parameters characterize the hazards. For example, location, magnitude, and depth can describe earthquake events, and central pressure, forward velocity, and direction of landfall can describe hurricane events.

¹⁵ A simulation may incorporate, for instance, a set of 10,000 hazard events.

sources that list public infrastructure or, in the case of private housing, derived on the basis of regional population distributions. The size of the direct economic exposures, that is, the capital loss or value at risk, can be found by multiplying the asset inventory list with the average cost of each asset type. Given the simulated intensities of the stochastic set of hazard events, the model can quantify the potential damages that are inflicted on different asset types across various sites as a function of the relative quality of assets. The quality of economic assets can be determined by a classification of vulnerability, expressed in a vulnerability ratio that takes a variety of factors into consideration, such as, building material, construction type, usage, size, and age. The hazard intensity in combination with the vulnerability of the exposed structure determines the degree of damage inflicted by the event. The economic damage is measured as the ratio of repair cost to total replacement cost for the structure at different hazard intensities expressed in the damage ratio, technically determined as the product of the vulnerability ratio and the hazard intensity of the natural events.

Total losses are derived from the damage ratio converted into a dollar amount by multiplying it with the value at risk for the asset type. The expected losses can then be found by considering the probability of the hazard events against the total losses associated with the events. This can be done for all the exposed asset classes at each site and aggregated into regional and country levels as needed. Hence, the calculation of economic exposures is typically done in sequential modules where the *hazard module* determines the potential intensity of different hazards at exposed sites in the country, the *exposure module* outlines the exposed economic assets at these sites and determine the value at risk, the *vulnerability module* determines the damage ratio ascribed to assets classes of different quality, and finally the *loss analysis module* calculates the total direct economic losses of the simulated hazard events (figure 5).

The calculation of the direct economic risk exposure, the expected loss (EL), can be formalized as follows:

$$EL = p * v * h * ICL$$

where; p = probability of the hazard event
 v = vulnerability factor of capital asset
 h = hazard intensity factor
 $d = v * h$ = damage ratio
 ICL = insured capital loss or value at risk

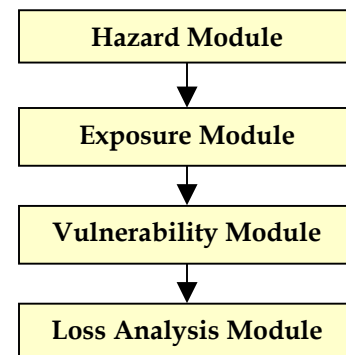
The exposed economic assets may fall within different categories. There is a broad distinction between public and private assets. The vulnerability of public assets such as educational institutions (e.g., schools and colleges), medical facilities (e.g., hospitals and health centers), and infrastructure (e.g., roads and bridges), obviously constitute important societal and government concerns. Private assets may include industrial compounds, small business facilities, and residential dwellings, among others. In many cases, industrial assets are covered through insurance contracts obtained from international insurance companies. In contrast, small businesses and individual dwellings are rarely insured and therefore in practice often turn into significant government obligations after major disasters (Freeman and Martin, 2002).

The key objective in the risk assessments is to quantify the economic risk exposures of specific regions and the country as a whole. For this purpose the model simulations develop a number of key measures for use in ongoing risk exposure assessments: the average annual loss, the probable maximum loss, and the loss cost.

The *average annual loss* (AAL) is the expected loss per year measured over an extended period of time. The annual loss figure can be calculated as the sum of the products between all the event losses and the associated event probabilities.

The *probable maximum loss* (PML) measures loss

Figure 5. The Catastrophe Risk Simulation Model



severity expressed in US dollars or a percentage of the value at risk. Event losses can be considerably higher than the PML, but the measure provides a comparative statistic of underlying risk exposures. PML is not universally defined, but is frequently defined as the largest likely loss corresponding to a 150-year return period.¹⁶

The *loss cost* is the part of the insurance premium that pays for the expected repairs or rebuilding of damaged assets. It corresponds to the *pure premium* charged by an insurance company, but it does not take administration, adjusting, and underwriting expenses into account nor does it consider requirements for a return-on-capital that insurers must include to quote a *total premium*.

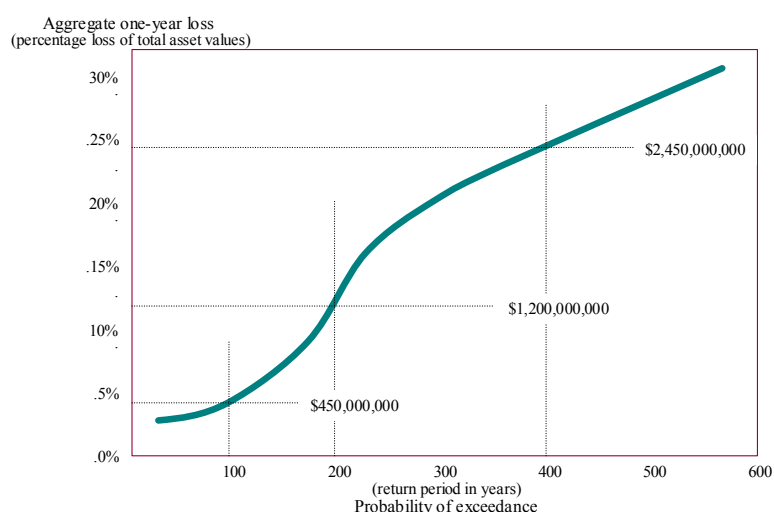
Further outputs from the model simulations include two types of *loss exceeding probability curves*, that is, cumulative distributions indicating the probability that losses will exceed a certain amount from a catastrophe event. The *aggregate exceeding probability* (AEP) curve shows the probability that aggregate losses from all hazard events in a year will exceed a certain amount. The *occurrence exceeding probability* (OEP) shows the annual probability that the losses for the single largest hazard event will exceed a certain amount.

Since the use of catastrophe simulation models is rather complex technically, simulations are usually performed by specialized consultancies and, as a consequence, are also rather costly. However, there are alternative and cheaper ways to stipulate loss expectancy relationships, such as, based on historical loss records maintained by major interna-

tional reinsurance companies¹⁷ (Freeman et al., 2002). Although these methods are less sophisticated, and therefore most likely less precise, they may provide sufficient insights to establish proactive risk management practices and assess alternative risk financing policies.

The discussion of the significance of the expected loss profiles to the national economy takes place once these profiles are stipulated. The discussion might center on whether the loss estimates represent significant economic exposures. As an example, if the aggregate exceeding probability curve (AEP) indicates a 1 percent likelihood of a US\$450 million loss from catastrophes in a single year (a 100-year event), should that exposure be insured or could it be partially retained? (Figure 6). To some degree, the answer is subjective and

Figure 6. The Aggregate Exceeding Probability Curve (AEP) - Example



depends on what is deemed politically acceptable. However, if the size of the risk exposure is such that it would reduce the level of economic activity and distort the country's public development investments, then the exposure is probably excessive.

Hence, it can be argued that the government should try to shield the country's long-term investment programs from extraordinary catastrophe

¹⁶ A 150-year return period event refers to a hazard impact that occurs with an annual likelihood of $1/150 = .67$ percent. The definition may also differ for different natural hazards. For example, A.M. Best, a leading insurance rating agency, considers hurricane PML to be a 100-year return period and earthquake PML a 250-year return period.

¹⁷ Given the historical loss profiles for different natural hazards different software programs can be used to 'fit' the parameters of the probability functions that provide the best match to the historical data.

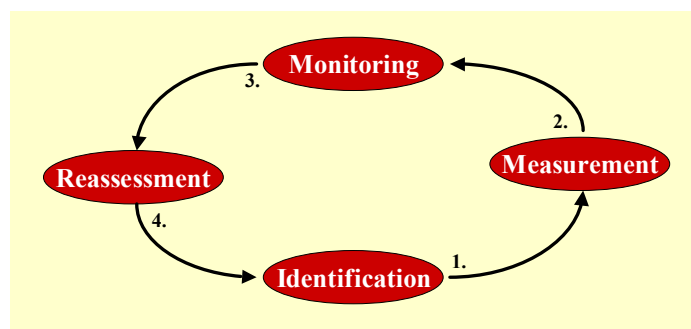
losses, in which case the measure of reasonable exposure should be determined in relation to the size of the approved capital budget. For example, if the risk assessment indicates a 1 percent likelihood that total catastrophe losses could exceed 25 percent of the annual budget allocation in a single year, that might be considered too large a risk exposure. The risk managers may therefore suggest that the government engage in insurance or other excess-of-loss risk transfer arrangements so the potential loss is reduced to, say, 10 to 15 percent of the investment budget, which would be more manageable, possibly by increasing taxes or domestic and international borrowing. An engagement in insurance contracts would require payment of up-front premiums reflecting the size of the expected loss,¹⁸ however it would allow the government to obtain cover for catastrophes that otherwise might jeopardize the country's long-term investment programs.

Once it has been determined what constitutes a reasonable risk profile given the natural hazards that expose key economic assets in the country, the next task is to set up appropriate risk transfer and financing arrangements. This entails an analysis of the costs associated with various ways to transfer and finance excessive risk exposures while assessing different risk management vehicles. Establishing the ideal risk transfer programs is not a clear-cut task and will entail trade-offs between the level of risk cover and the cost associated with alternative insurance and credit arrangements. If risk transfer prices are too high, it might be better to accept slightly higher risk levels, at least for some interim period. A key issue here is to ensure the long-term viability of the risk management plan. In other words, if the ideal coverage appears excessively expensive, the program may have to accept slightly higher initial risk exposures.

The entire risk management process should be conceived as dynamic and ongoing. Since the environmental conditions continue to change, the profile of the country's economic exposure to ca-

tastrophe risks should be updated to reflect changes in climatic patterns, economic infrastructure, and financial prices, among other variables. The ongoing efforts to monitor the changing contours of the risk exposure should also entail continuous evaluations of alternative risk transfer solutions and adjustments to the coverage structure to take advantage of opportunities in the international financial markets. The dynamic character of the risk management process implies that the identification of significant risk factors is an ongoing exercise (figure 7). Simple environmental awareness or use of more advanced computerized simulation models can help assess the changing profile of the economic risk exposure and support the reassessment of the frequency of risk events and their economic impacts. It also provides the risk managers with an ability to evaluate the potential advantages of different risk mitigation, prevention, and preparedness efforts and thereby provide the underpinnings for more effective risk management decisions.

Figure 7. The Dynamic Risk Management Process



Source: Adapted from Culp (2002)

The ongoing monitoring of the country's overall catastrophe risk profile provides the means to assess the aggregate effects of identified catastrophe risks. This makes it possible to determine whether the country is moving toward an excessive level of risk and identify needs to modify existing risk transfer arrangements. By monitoring and maintaining risk exposures within acceptable limits, the government can protect essential investment programs from unwarranted disruptions and benefit long-term economic growth. By establishing reasonable risk transfer arrangements, the government can also secure funds for reconstruction of key economic infrastructure after disasters and avoid time consuming and potentially excruciat-

¹⁸ The insurance premium would also require some additional compensation for administration, capital costs, and the uncertainty (risk load) associated with the exposure and administration costs.

ing negotiations to obtain funding after major disaster events. Natural disaster risks are usually not managed in a proactive manner because the likelihood of disaster events may seem too distant for poorer countries that are faced with many other pressing issues, such as delivering basic infrastructure services (Andersen and Masci, 2001). As a result, disasters are often dealt with in a reactive manner, incurring higher human and social costs in the wake, while recovery becomes dependent on the availability of international aid and multi-lateral credit facilities.

DIFFERENT RISK TRANSFER APPROACHES AND INSTRUMENTS

From the government's perspective the initial task is to determine the type of economic assets that must be covered through government intervention¹⁹ following a disaster (e.g., public assets like educational and health facilities and economic infrastructure like roads and bridges), and to what extent the government should be involved in coverage for damages to private dwellings, social compensation, and other such things. Cover for different types of economic assets are likely to require different risk transfer approaches. For example, economic infrastructure is considered a public good. As a result, it probably should be dealt with directly by the appropriate government entities and covered through a government risk management office. Conversely, private dwellings do not necessarily call for direct government coverage, but may be managed more effectively through specialized insurance entities operating on an actuarial and commercial basis. However, regardless of the choice of institutional structure to provide coverage, they can all employ three principal ways to arrange funding for post-disaster reconstruction:

- Disaster funds,
- Insurance and other risk transfer arrangements, and
- Committed credit facilities and contingent capital structures.

¹⁹ Assuming that large commercial enterprises are able to manage their risk exposure on their own.

The sections that follow briefly discuss the possibilities and conditions in each of these market areas.

DISASTER FUNDS

When insurance companies receive premiums from customers against coverage for losses arising from future risk events, they place a significant amount of these funds in liquid financial assets as a prudent invested reserve for future claims²⁰. If the insurance companies at any point in time have insufficient funds to cover the accruing insurance claims, they go bankrupt, which is why reserve funds of a reasonable size are important to the long-term viability in this industry. As discussed earlier, if institutions and/or governments are faced with a large pool of independent risk obligations, the risks can be diversified, and self-insurance is a realistic possibility. To make this economically beneficial, however, the self-insuring institutions/governments should be able to manage the insurance portfolios at least as efficiently as the existing commercial providers in the insurance market. If that is not the case, it would be more beneficial to outsource the insurance service. Furthermore, disaster funds must have access to the necessary financial means when potential claims arise to remain effective.

The funds can be made available in advance before the disaster events occur by establishing sufficient invested reserves earmarked for disaster coverage. Alternatively, future claims may be covered by assuming additional debt burdens after the events have taken place or through tax-increases in the case of the government. A certain amount of ex ante means is probably needed to avoid excessively disruptive effects from unplanned restrictive fiscal policy initiatives. There are often quite finite opportunities for the incremental tax revenues that can be obtained in an ex post disaster situation, and therefore, it may not be a viable route in practice. By the same token, it may be politically just as difficult to establish funds with sufficient ex ante cover for all future risk financing obligations.

²⁰ The major concern of insurance regulators is to ensure that commercial insurance providers maintain sufficient reserves to enable coverage for future claims.

INSURANCE AND OTHER RISK TRANSFER ARRANGEMENTS

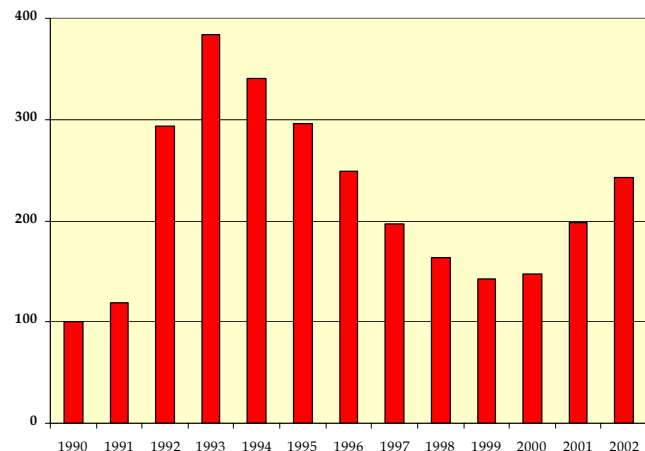
Primary insurance companies insure things like homes, factories, inventory, and crops, by means of comprehensive policies that usually include some cover for catastrophe exposures.²¹ Since the base of these risk exposures represents independent event risks, they can be diversified across large insurance pools and losses can be determined actuarially. Excessive risk exposures to natural hazards may be covered through primary insurers in facultative reinsurance arrangements. Parts of the insurance portfolio may also be ceded to reinsurance companies on a proportional basis so the exposures are diversified further across the global insurance community. The insurance companies use their reserves to cover extreme claims as is the case in the aftermath of a natural disaster.²² After major events the market participants must increase the insurance premiums to rebuild their reserve positions. Some of the weakest insurance companies may go bankrupt, which will reduce the capacity for catastrophe insurance. Consequently, prices for catastrophe insurance are highly cyclical and influenced by the occurrence of major disasters. Hence, premiums rose after hurricane Andrew in 1992 and eased in the subsequent years (1995-1999). Severe windstorms caused prices to firm again in 1999, while the September 11 terrorist act strained the market capacity further from 2001 onward (figure 8).

The tighter market conditions for reinsurance of catastrophe risk in the mid-1990s induced the development of alternative risk-transfer opportunities in the capital market. Large institutional investors are familiar with market risk and diversify their portfolios to optimize the implied risk-return relationship. Hence, they can absorb sizeable natural catastrophe risk exposures in their portfolios. The catastrophe risks are uncorrelated with existing market risk and provide a basis to further diversify the invested portfolio and thereby furnish higher returns for given levels of portfolio

²¹ In regions that are highly exposed to natural catastrophes these exposures could, however, be explicitly excluded in the policies.

²² Natural catastrophes constitutes relatively rare events with extreme loss potentials.

Figure 8. Catastrophe Reinsurance Prices 1990-2002
(Rate on line, ROL) [1990 =100]

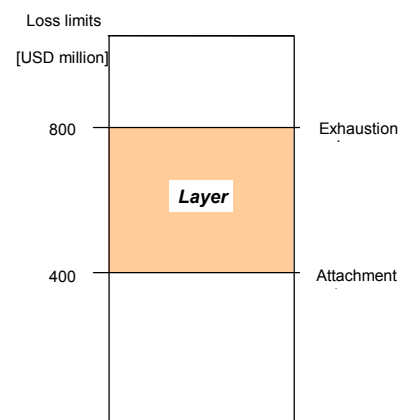


Source: Guy Carpenter (2002)

risk (Heike and Kiernan, 2002). This led to the introduction of catastrophe bonds (cat-bonds for short) and other types of risk-linked securities that now constitute a well-established niche in the capital market.

Large unbalanced risk exposures, such as catastrophe risks, are often ceded in the reinsurance and capital markets as facultative nonproportional treaties. Facultative treaties provide cover for individual risk factors (e.g., flood, windstorm, earthquake, etc.). A nonproportional treaty typically defines a deductible, net retention or *attachment point*, up to which the ceding insurer will cover all losses. The reinsurer is then committed to cover losses in excess of the deductible up to a certain amount referred to as the *exhaustion point*. Coverage within the attachment and exhaustion points is commonly referred to as a *layer* (figure 9).

Figure 9. Reinsurance Layers



The cost of reinsurance coverage is typically indicated by the rate-on-line (ROL) derived as the premium divided by the covered insurance limit (e.g. Froot, 1999; Guy Carpenter, 2000):

$$ROL = \text{Premium} / \text{Cover limit}$$

In turn, the price of the reinsurance cover can be indicated in relation to the actuarial probability that the full loss within the covered limit will occur:

$$\begin{aligned} \text{Price} &= ROL / \text{Actuarial probability} - 1 \\ &= \text{Premium} / (\text{Actuarial probability} \times \text{Cover limit}) - 1 \end{aligned}$$

Hence, a price of zero means the insurance cover can be obtained at a premium equal to the expected loss or loss cost. A positive price means that there is a charge in excess of the expected loss. This premium over the expected loss reflects the high uncertainty associated with losses from catastrophe events:

$$\text{Premium } (P_{cat}) = p_x \sigma_{cat} / \sigma_{non-cat} \times \text{Cover limit}$$

where; p = probability of catastrophe event
 σ_{cat} = standard deviation of catastrophe losses
 $\sigma_{non-cat}$ = standard deviation of non-catastrophe losses

Due to the high dependence on recent event losses, the premium relation can be further expressed as:

$$P_{cat, t} = p_x \sigma_{cat} / \sigma_{non-cat} \times \text{loss}_t / \text{loss}_{t-1} \times \text{Cover limit}$$

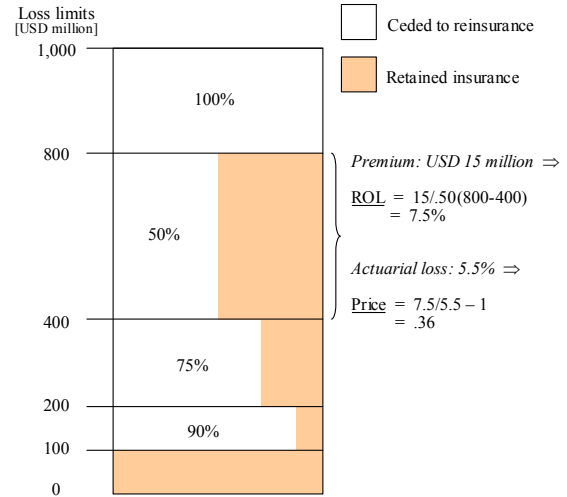
where;
 loss_t = loss claims in current period t
 loss_{t-1} = loss claims in previous period $t-1$

Hence, the excess-of-loss premiums (XL rates) will increase for the higher insurance layers where the occurrence of catastrophe losses is considerably more uncertain even though the likelihood of events decreases (Pollner, 2001a).

The catastrophe insurance cover can be organized within different layer structures where a ceded risk exposure may cover a portion of the total loss

between the attachment and exhaustion point (figure 10).

Figure 10. Layered Reinsurance Program - Example



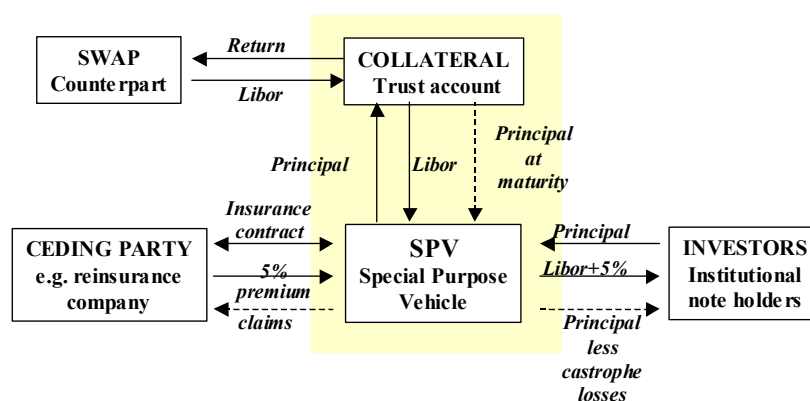
Asset securitization has become an important funding alternative for banks and the securitization technique has been widely applied to mortgage loans, automobile loans, and credit card debt. The asset securitization technique has also been transposed to the market for catastrophe insurance so catastrophe risk exposures can be transferred to investors in the capital market (e.g., Litzenberger et al., 1996; Froot et al., 1998). This approach has been widely adopted in the issuance of catastrophe bonds and risk-linked securities. The catastrophe risk transfer opportunities in the capital market have primarily been exploited by the major insurance and reinsurance companies as a way to obtain complementary coverage when cedance in the reinsurance market has been restrictive, but has also occasionally been applied directly by corporate entities.²³

²³ E.g., Oriental Land Co. (Tokyo DisneySea®, Disney hotels and the Disney Resort Line) and more recently Vivendi covering its Universal Studio assets against earthquake risk.

A *cat-bond* or *risk-linked security* is typically structured around a special purpose vehicle established in a tax favorable jurisdiction²⁴ (e.g., ISO, 1999; Standard & Poor's, 2000). The SPV issues the securities and receives cash from the investors' initial purchase. The SPV engages in an in-

receive a favorable spread above Libor to compensate for the inherent catastrophe risk, that is, they are not sure to receive the full principal back at maturity if there is a catastrophe event in the interim (figure 11).

Figure 11. Risk-linked Security (Cat-Bond) Structure - Example



insurance contract with the ceding entity, which in turn, pays a lump sum or periodic insurance premium. The insurance contract typically provides the cedant with a risk cover on an excess-of-loss (XL) basis corresponding to common practice in the catastrophe reinsurance market. Hence, the ceded risk exposure may cover losses associated with a particular insurance layer. The SPV places most of the initial proceeds in liquid low risk securities held in a trust account as collateral for the debt service. The SPV is rated by a credit agency such as Standard & Poor's, Moody's, or Fitch. Most tranches are rated BB/Ba (i.e., below investment grade), although other tranches may receive a higher rating if there is a lower potential loss of the collateralized trust account. In general, the ratings are graded in accordance with the implied loss probability (McGhee and Eng, 2003). The SPV may engage in a fixed-floating interest rate swap that converts the fixed coupon payments into Libor-based floating rate payments and thereby reduces the implied interest rate risk of the cat-bond. Investors in risk-linked securities

The analysis of the underlying catastrophe risk exposure is a critical element in the investors' evaluation of the cat-bonds. The probabilistic simulation analysis is normally performed by a specialized consulting firm, such as Applied Insurance Research (AIR), EQE International, or Risk Management Solutions (RMS). The cat-bonds use different criteria to trigger compensation under the reinsurance contract. Indemnity contracts provide compensation based on claims for actual losses incurred by the ceding party. The cedant obtains close to perfect coverage for losses, but the cat-bond investors incur risks related to *moral hazard* and *adverse selection*, because there is no guarantee that the cedant will mitigate losses once the cat-bonds are placed, and as an insider, the cedant may know more about the risk exposure than the investors. The trigger could also constitute a predefined loss index, such as the Guy Carpenter Catastrophe Index or the PCS Index. This would eliminate the moral hazard and adverse selection issues because the index is well defined and objectively determined, but a standardized index exposes the cedant to an element of *basis risk*, because the index may be less than perfectly correlated with the actual losses. The triggers could also build on indicators of the event intensity (i.e., occurrence parameters, such as, wind speed, wave height, rainfall, etc.). These indicators can be measured objectively and con-

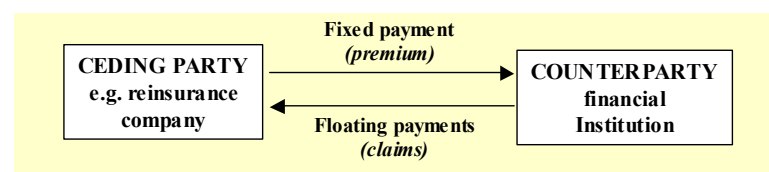
²⁴ There are several tax issues related to the establishment of SPVs in the United States. Hence, most SPVs have been established in Bermuda, the Cayman Island or Ireland, which allow reinsurance companies to establish the SPVs as separate entities that maintain zero or favorable tax status.

strued to closely resemble the parameters of the underlying catastrophe simulation model. They may, therefore, better accommodate both cedant and investors. In effect, this constitutes a parametric approach where triggers are developed to reflect the cedant's exposure as defined by objective and measurable catastrophe indicators. There has been a trend toward index-based and parametric formulas in recent years. There have been numerous risk-linked securities transactions since 1997 that provide total risk coverage in excess of US\$6 billion. The market for risk-linked securities is now well-established and constitutes a steady element of the global capital market targeted toward risk transfer at layers with loss probabilities between 0.4 and 1.0 percent, corresponding to 250- to 100-year events. The two dominant catastrophe risks covered by risk-linked securities are earthquake and storm, which are both rapid onset events. More emergent events like flood and drought so far have received little notice in this risk transfer market.

The risk transfer characteristics of the cat-bond structure can be replicated in *catastrophe risk swaps*, where the cedant commits to make regular fixed payments equal to the insurance premium against receipt of variable compensation payments for loss claims (figure 12). This structure resembles the payment flows in a conventional insurance contract and the insurance agreement included in a cat-bond. Like these contracts, the catastrophe risk swap can incorporate different triggers, such as claims, indexes, and indicators in parametric formulas. The potential benefit of the risk swap is that it can be established directly with a counter-party based on standardized swap documentation that may make it faster and cheaper. However, the catastrophe risk swap also entails a direct counter-party risk.

A variety of financial *derivatives* on catastrophe risks were introduced during the 1990s as a promising venue to manage catastrophe losses (e.g., Cummins and Geman, 1995; O'Brian, 1997). The initiatives included futures and options contracts based on the Guy Carpenter Catastrophe Index (GCCl) offered by the Bermuda Commodities Exchange, and contracts based on catastrophe losses reported by the Insurance Services Office (ISO) and the Property Claims Service (PCS) ca-

Figure 12. Catastrophe Risk Swap Structure



tastrophe index, all of which are offered by the Chicago Board of Trade (CBOT). However, these contracts were not able to establish sufficient liquidity and the markets have since closed due to insufficient interest.²⁵

COMMITTED CREDIT FACILITIES AND CONTINGENT CAPITAL

Other instruments, such as committed credit facilities and contingent capital, provide financing rather than risk transfer solutions. In other words, they ensure that funds can be drawn down on predetermined conditions in case a need arises after a major disaster. So, the funding availability is guaranteed, but even though the immediate terms of credit are known, the loan proceeds must be repaid, and inevitably adds to the country's debt burden. This is in contrast to insurance arrangements where funds covering extreme losses in case of disaster have no requirement of repayment. Obviously there is a need to make advance payment of insurance premiums that partially reflect the probability of future losses. However, advance credit commitments are not free either. Financial institutions may offer committed revolving term facilities that provide funding by rolling over short-term credits at a fixed spread over a variable rate indicator like Libor. These committed facilities typically require a commitment fee to cover the implied interest rate, liquidity, and credit risks associated with the commitment.

²⁵ The Chicago Mercantile Exchange (CME) has introduced very successful futures and options contracts based on the Heating Degree Day (HDD) and Cooling Degree Day (CDD) indexes that provided opportunities to hedge against the *volumetric* risk effects associated with changes in weather conditions. Successful contracts have also been established on energy prices, e.g., crude oil, natural gas, electricity, etc. that may be correlated with meteorological events.

Contingent capital arrangements are typically offered by insurance affiliates and guarantee the issuance of medium term debt instruments on predetermined terms when certain risk related triggers are activated (Colarossi, 1999). Contingent capital instruments, such as surplus notes, constitute put options that give the holder the right to place securities on predetermined conditions once a catastrophic event triggers exercise. The issuer of the options requires payment of option premiums to retain the commitment. So far, contingent surplus notes have been issued to an aggregate market value of around US\$8 billion, primarily in cover of the commercial risk of private insurance companies. At this point, none of these facilities have been issued to cover credit to developing countries in case of catastrophe events. In practice, contingent capital instruments have been largely irrelevant to developing countries, because the multilateral institutions have been willing providers of credit when natural disasters hit. If it is true that catastrophe funding normally can be expected to be forthcoming, the multilateral institutions are de facto providing contingency capital to developing countries, but without any charge.

INSTRUMENT CONCERNS AND TRADE-OFFS

The government's choice between risk financing and risk transfer and the specific structure of the instruments will be influenced, among other

things, by concerns about moral hazard, adverse selection, basis risk, and counter-party risk issues. *Moral hazard* can arise when an insured party has obtained cover and no longer has an incentive to mitigate future losses. *Adverse selection* can arise when the insured party knows more about the risk exposure than the insurance company and tries to take advantage of it. *Basis risk* can arise when the indicators used in the insurance instruments differ significantly from the value of the risk exposure it is intended to cover. *Counter-party risk* arises when the insured party depends on the future solvency of one or more counterparts that cover the obligations under a hedging contract. Disaster funds, insurance treaties, risk-linked securities, catastrophe risk swaps, and contingent capital instruments have different attributes vis-à-vis these issues (table 3). All insurance contracts and catastrophe risk swap agreements are exposed to counter-party risk, because future coverage depends on the solvency of the insurance and reinsurance companies that underwrite the contracts and back the swap obligations. Conversely, the issuance of cat-bonds and risk-linked securities are not prone to counter-party risk, because the institutional investors that buy the securities pay cash up front and the proceeds are placed in trust to cover any claims under the embedded insurance contract.

Engagement in conventional insurance treaties based on actual losses and indemnity claims are

Table 3. The Relative Importance of Risk Concerns in Instruments and Structures

[+] = important [-] = not important		----- Relative Importance of Concern -----			
		Moral Hazard	Adverse Selection	Basis Risk	Counterparty Risk
1. Disaster Funds		-	-	-	-
2. Insurance Treaties¹					
- actual claims		+	+	-	+
- standard index		-	-	+	+
- parametric formula		-	-	(+)	+
3. Risk-Linked Securities					
- actual claims		+	+	-	-
- standard index		-	-	+	-
- parametric formula		-	-	(+)	-
4. Contingent Capital		-	-	+	+

¹ including catastrophe risk swap agreements

exposed to moral hazards and adverse selection because once the contracts are written there are no incentives for the insured party to pursue risk mitigation efforts. However, they are not exposed to basis risk because coverage corresponds with actual claims. Using instead index-based triggers to call the insurance coverage eliminates the moral hazard and adverse selection issues, but it also creates a basis risk because the index may develop differently from the actual losses incurred. Adopting a parametric formula as a trigger reduces the implied basis risk, and may almost eliminate it if done appropriately. The insurance contracts incorporated in the risk-linked securities are exposed to the same concerns as formal insurance contracts, but have the potential advantage of not being exposed to any counter-party risk. Subscribing to contingent capital, including contingent surplus notes is not exposed to moral hazard and adverse selection because these arrangements do not entail any claims coverage, but only pro-

vide financing facilities that must be repaid according to a predetermined indenture agreement. However, contingent capital may be exposed to a basis risk to the extent that the trigger for exercising the underlying option only is loosely associated with indicators characterizing the catastrophe events. There is also an element of counter-party risk because the holder of the surplus notes depends on the issuing financial institution for its ability to honor the contract on the agreed terms. There are obviously other factors that influence the choice of financial instruments, such as the comparative cost of different alternatives, the need for aggregate cover, and the affordability of available covers. The structure of the financial instruments may also exert some influence on costs. Moral hazard and adverse selection issues increase the uncertainty of catastrophe exposures and therefore make the insurance premiums more expensive.

Alternative Risk Financing Vehicles

The first issues to consider before making assessments about the need for particular risk management approaches is to determine the major natural hazards that expose the country's economic assets. Assuming that the largest commercial enterprises are capable of managing their own catastrophe risk exposures through access to domestic and international insurance markets, the major concern relates to the financial commitments governments assume directly or on behalf of individuals and small to medium-sized businesses after major disasters. Hence, the exposed economic assets of importance to government involvement can be broadly classified into public and private assets. A significant portion of the governments' commitments after disasters relates to private assets, primarily houses and dwellings, although other private obligations might arise from agricultural and other business losses and support programs for the poor (Lahiri et al., 2001; Freeman and Martin, 2002; Pettersen et. al., 2005). Governments do not have formal obligations to cover private sector losses, but reimbursements for losses on private housing seem universally accepted as a public obligation of high political significance.

The low penetration of property insurance is a function of underdeveloped private insurance markets in most developing countries, which in turn has its roots in moral hazards associated with un-enforced building codes, uncontrolled urban expansion, poor building quality, insufficient infrastructure, etc. These are tough obstacles, but in addition to those, it is also recognized that exposures to extreme catastrophe events are uninsurable on commercial terms, also in developed economies. Hence, the private insurance market is often unable to provide cover for pure catastrophe risks, so other methods must be found to make insurance protection available to the public in cover of these risk exposures, for example through public insurance pools and different private-public

partnerships.²⁶ In this case, there should be an appropriate balance between the government involvement and commercial insurance practice. Public nonactuarially determined allocation processes usually turn out to be ineffective ways to manage reconstruction in the post disaster period, which applies to developing as well as developed countries (please refer to the discussion above). However, the coverage of catastrophe risks could be furnished through insurance vehicles that operate in accordance with commercial and actuarial principles with arms-length government involvement or a stated commitment from the government to act as *insurer of last resort*, if, for example, losses exceed the capacity of an insurance pool.

The exposure to different types of public sector assets is clearly a central government obligation and normally does not need the same degree of market intervention as the insurance coverage of private assets, because the government already has full control over the exposed economic assets. Nonetheless, many public assets in Latin America and the Caribbean remain uncovered and existing insurance covers are not effectively executed, coordinated, and monitored (Freeman and Martin, 2002; Pettersen et. al., 2005). In short, there does not presently appear to be any significant consideration of direct catastrophe risk exposures to the public economic infrastructure or other government obligations arising in connection with natural disasters. This underlines a need to engage in formal risk management processes at the central government level to determine the contours of the major public economic exposures and analyze the need for different risk transfer and financing ar-

²⁶ It should also be recognized that "uninsurability" may relate to the willingness of agents to insurance at prevailing costs. For example, homeowners might not be willing to insure even if private insurance were available if it is considered too expensive or if the government is expected to eventually bail out the unfortunate. In this situation a government may want to consider mandatory insurance schemes that are managed professionally on an arms-length basis.

rangements. These arrangements would most likely have to be adapted to serve the specific economic assets they seek to cover. For instance, insurance of private housing exposures should be established in a manner that makes it possible to distribute insurance policies on a commercial and actuarially sound basis to the public, while cover for the public infrastructure can be arranged directly by government entities. Under all circumstances, the government's overall risk obligations should be managed within an integrated management system that takes all catastrophe exposures into account.

GOVERNMENT INTERVENTION AND INVOLVEMENT

As discussed, there is general consensus that governments must play a role to ensure that risk-transfer opportunities are available to the public for otherwise uninsurable catastrophe risks. However, there is no final agreement on what the government role should be. It is argued that government imposed catastrophe insurance schemes are needed because the uninsurable catastrophe risk exposures constitute excessive loss potentials that cannot be covered through normal commercial insurance arrangements. It is further argued that governments should be willing to cover a large part of the uninsurable risk exposures as the *insurer of last resort*. Supposedly, government debt has no default risk within the country, so the government can, at least theoretically, issue risk-free local currency denominated debt instruments and thereby obtain funding for excessive catastrophe losses at the lowest possible costs. Government supported insurance schemes arguably have better access to risk capital compared to commercial counterparts, but in practice governments are also subjected to financial constraints (Freeman and Martin, 2002).

There are also potential downsides associated with excessive government guarantees for catastrophe risk exposures, because it can encourage aggressive behaviors among commercial insurers to the detriment of the solvency of the domestic insurance industry (Bohn and Hall, 1999). The government could intervene more indirectly by supporting primary insurers in the country. For example, this can be done through the issuance of

catastrophe call options that cover losses on an excess-of-loss basis (Cummins et al., 1999). Under this structure, the insurance companies would have to pay an up-front option premium to the government as compensation for the expected future payouts under the contract. The option structure could extend the insurance capacity in the market and yet limit direct government involvement in claims distributions after major natural disasters. The latter solution, however, assumes that the commercial insurance sector is otherwise capable of covering all the insurance needs of the public, which may be a stretch in many country settings.

In its quest to cover economic assets of public concern, the government may use a variety of approaches, such as, calamity funds, insurance schemes, and public insurance pools, and possibly combine them to provide better cover for different economic assets with different catastrophe exposures. In principle, government induced insurance schemes can be classified in three major approaches to deal with uninsurable public catastrophe risk exposures; namely, *tax-funded calamity funds*, *national insurance programs*, and *government-backed insurance pools*. For the government, it is not necessarily a question of choosing one approach over another. Rather, the issue is to adopt an approach that is suitable for particular economic assets and structure it to deal effectively with the identified catastrophe exposures. This may well mean that different approaches can be combined while using a variety of available risk transfer and risk financing instruments to accomplish the task.

TAX-FUNDED CALAMITY FUNDS

The government can establish disaster funds intended to deal with the adverse effects observed in connection with natural disasters. For example, risk mitigation funds are introduced, for among other reasons, to finance investments for structural improvements to government buildings and public economic infrastructure (like roads and bridges, etc.) that will help reduce their vulnerability to catastrophe events. A mitigation fund can facilitate new initiatives that support disaster prevention. Other funds may be established to focus on mitigation of the adverse effects on the poor by

supporting social investments that improve living conditions (Siri, 2001). Such mitigation funds can be useful by providing the financial means to reduce the economic exposures of natural catastrophes, but they cannot eliminate the risk exposures.²⁷ The aggregate loss potential can be significantly reduced through conscious mitigation efforts, but a sizeable residual exposure will remain on essential economic assets that must be repaired or rebuilt after major disasters. The government can establish calamity funds to provide funding for these reconstruction purposes. The basic idea is for the government to establish a financial reserve that, for instance, could be invested in a liquid securities portfolio, earmarked for specific reconstruction purposes after major catastrophes. The government can make the needed funds available from tax revenues and assign them to the fund with the specific purpose of financing economic restitution after natural disasters. The fund can make the financial means available for post-disaster reconstruction as direct disaster relief or in the form of low-interest loans. The fund must be sufficiently provisioned in advance to the guarantee availability of the means needed for reconstruction, which often represents a major challenge.

Tax-funded calamity funds are based on the principle that governments, as self-insurers, provide the financial means needed to cover the economic losses associated with disasters. However, in many cases the funds remain undercapitalized and therefore may not be as effective as intended. The establishment of tax-funded calamity funds with a sufficiently large capital requires political commitment, which often is difficult to muster in practice. The consequence of insufficiently capitalized funds may inadvertently be to weaken investment for economic development, because the country's tax base and debt capacity is finite. Therefore, the government may try to deflect

funding from other parts of the government budget to finance needed reconstruction efforts. Hence, tax-funded calamity funds must receive adequate ex ante funding provisions to remain effective stand-alone vehicles for catastrophe risk financing. The establishment of calamity funds to support post-disaster reconstruction efforts does not in itself pose any issues with moral hazard, adverse selection, basis risk, or counter-party risk because the government pays up-front and the fund retains ownership of the invested means as a reserve for future investment needs in accordance with the statutes of the fund. However, the way the fund manages loss claims and appropriates the financial means to the public after disasters can be wrought with moral hazard issues.

When people can expect the government to cover catastrophe related risk exposures there is no longer a motivation to improve the quality of exposed assets and reduce their vulnerability to disaster events. This may cause higher aggregate losses than would otherwise be the case. It might also reduce the incentives for households and small businesses to buy insurance policies to the detriment of the commercial insurance industry. If the government can be expected to cover the brunt of private losses without any advance or ex post costs to the exposed private parties, there is no logical reason why households and business entities should pay commercial insurance premiums to obtain coverage that is already made available by public means. Therefore, to the extent a government decides to provide some form of comprehensive coverage for catastrophe risks, it may be wise to consider a compulsory insurance scheme to increase public risk awareness and reduce the moral hazard issues.

NATIONAL INSURANCE PROGRAMS

The underlying rationale of insurance schemes derives from the ability to diversify the risk exposures and spread the implied loss claims across a large number of constituents. In the case of independent risk events, regional insurance portfolios may provide sufficient diversification and establish an actuarial base to determine appropriate insurance premiums. Catastrophes that represent a series of highly dependent event risks at the regional level may be diversified on an international

²⁷ Risk mitigation investments are exposed to the laws of economics, that is, initial investments may lead to significant exposure reductions, but subsequent initiatives will face diminishing returns. As the marginal effect in risk reduction diminishes, the country will eventually reach a point where new mitigation initiatives are too costly compared to the potential benefits (Freeman and Martin, 2002).

scale by global reinsurance companies that spread different catastrophe risk exposures across the reinsurance industry through various retrocession arrangements. As discussed previously, different probabilistic simulation techniques can be used to determine appropriate premiums on catastrophe insurance, although prices may be highly influenced by the uncertainty associated with the loss potential of catastrophe events and the short-term loss history in the catastrophe insurance market.

Once the insurance premium has been paid, the insurance contract will recover losses without any obligation to repay. This is clearly an advantage. However, the up-front insurance premium will reflect the underlying probability of the catastrophe events and the relative vulnerability of exposed economic assets. Hence, insurance may be very expensive for a highly exposed country that has placed limited emphasis on risk mitigation. In practice, therefore, excess-of-loss catastrophe insurance contracts may be adopted to shield the government finances from the brunt of losses associated with major catastrophe events. Hence, a government may want to establish coverage through some combination of calamity funds, self-insurance funded through tax increases and new debt issuance complemented by excess-of-loss insurance treaties to cover higher-layer risk exposures (figure 13).

It may be possible to cover a certain part of the lower risk layers through insurance contracts with local insurance companies. To the extent that the country has an insurance industry with sufficient capacity and reasonably developed operational skills, buying insurance contracts may be more economical for the government than self-insurance and could serve to support the development of the insurance sector. Higher risk layers that exceed the local market capacity could be ceded to global insurance companies. In some cases government backed cat-bonds might represent a realistic opportunity.²⁸ The highest risk layers are often too expensive and go beyond general

market capacity.²⁹ Therefore, in practice, various multilateral credit arrangements would be needed to cover the highest risk layers. Since, the government has full control over the publicly owned economic assets (such as, hospitals, schools, roads, bridges, etc.), use of national insurance programs established to provide an upper-layer cover for the government's aggregate risk exposure would make sense. However, when it comes to the potential commitments associated with losses on private assets, particularly houses and dwellings, there is a need for more extensive risk management vehicles that can operate on a stand-alone basis to ensure that insurance coverage is distributed to the public on a commercial and actuarial basis.

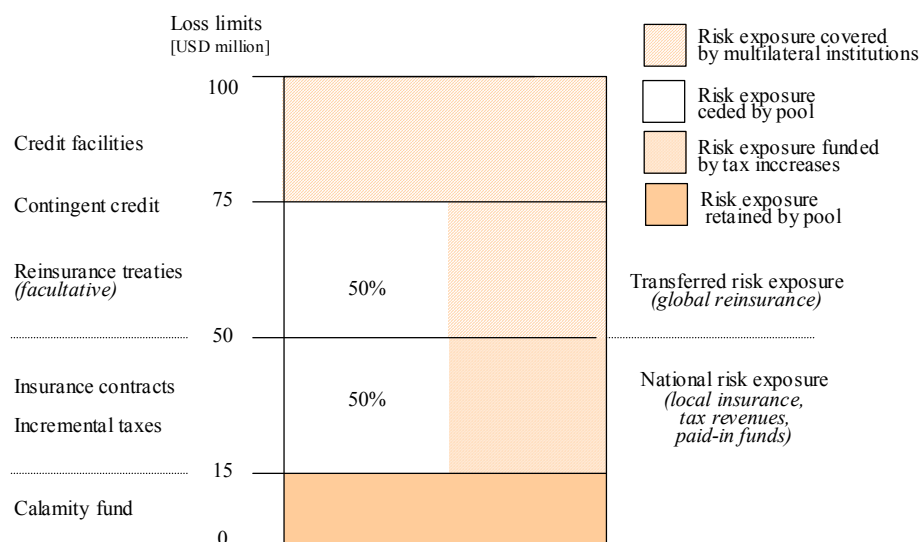
GOVERNMENT-BACKED INSURANCE POOLS

The government can offer insurance policies to the public with cover for major catastrophe risks through national insurance vehicles that pool together exposures of all risk holders across the country. This may, for example, allow catastrophe property insurance to be extended widely to households and small businesses and make protection available throughout the nation for otherwise uninsurable risks. By pooling the insurance obligations in an insurance vehicle that operates as an independent economic entity, it becomes possible for the government to manage the catastrophe risk exposures on an arms-length basis and thereby avoid politicized interferences in claims distribution. The insurance scheme could offer mandatory property insurance policies required by law as a condition to register property ownership or get certification for compliance with prevailing building codes, for example. It could also be a precondition for the extension of mortgage loans from the country's authorized financial institutions. This type of public-private cooperation is practiced in many countries, but only guarantees that insurance cover is maintained as long as the prop-

²⁸ There has not yet been any issuance of cat-bonds linked to catastrophe risk in developing countries. This represents an opportunity for institutional investors to further risk diversification, and for a known national issuer this could represent a distinct opportunity.

²⁹ The potential loss is higher at higher risk layers, but the likelihood of loss occurrence is correspondingly lower. However, the uncertainty surrounding loss expectancy is considerably higher at higher risk layers and therefore tends to make the insurance premium proportionally higher than the loss cost.

Figure 13. National Insurance Program with Layered Risk Transfer Structure - Example



erty is financed through debt. In other words, once the mortgage loan is repaid the insurance policy can no longer be enforced (Pettersen et al., 2005). Alternatively, insurance policies could be offered voluntarily. In this case, critical mass in the insurance pool must be obtained through massive advertising to the public. However, this approach does not guarantee that all households are provided insurance cover. It may limit the advantages of risk pooling and still expose the government to political pressure to provide cover for the uninsured after disasters.

The insurance pools can be managed in cooperation with local insurance companies; for example, by contracting them as national sales agents of the insurance policies and by outsourcing major operational tasks. The insurance companies may also be engaged as insurers of the lowest risk layer on a mutual basis to reduce issues of moral hazards associated with their agency role. The establishment of an independent insurance vehicle requires that the government takes initiatives to enforce property registration and existing building codes effectively. The engagement of local insurance companies could also be associated with professional recognition institutionalized through a formal regulatory certification that provides a higher level of prestige and commercial value to an engagement with the insurance pool. In this manner, the establishment of an insurance pool could also serve as a tool to enhance the level of profession-

alism and development in the local insurance industry. Once the insurance pool is established, it would have to manage its catastrophe risk exposure as an independent stand-alone entity. The government must introduce and enforce the necessary legal framework to ensure the effective implementation of the insurance scheme. To make the insurance scheme economical at the initial stage, the government may want to provide some form of upper layer risk guarantees as insurer of last resort. These facilities, in turn, could be supported or complemented by various multilateral commitments. However, the insurance pool must adopt commercial and actuarial principles to manage the vehicle as efficiently as possible and ensure its long-term economic viability.

As the insurance pool is implemented it will proceed to analyze its overall catastrophe risk exposure and determine how to manage this exposure in the best manner possible. In this analysis the managers of the insurance pool would consider the full scale of instruments and tools to structure the most optimal cover for the insurance portfolio. For example, these considerations could comprise an insurance cover by the local agents of the lower risk layers on a mutual basis, cedance of part of the higher risk layers in the global reinsurance market, issuance of risk-linked securities, and possibly government guarantees to cover the highest risk layers as insurer of last resort. The insurance vehicle would probably want to retain

certain parts of the risk layers and cover these through the cash premiums received from outstanding insurance policies paid to a secure fund. It could obtain committed funding from multilateral institutions as deemed necessary to operate within reasonable risk parameters (figure 14).

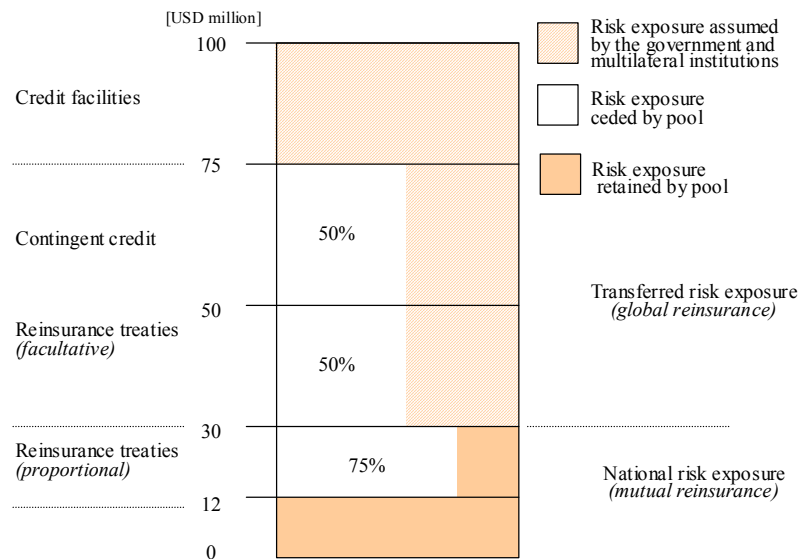
It is possible that higher risk layers could be covered through issuance of cat-bonds and contingent surplus notes. The risk-linked securities may be construed to benefit from the protection of the collateral proceeds held in trust and obtain a favorable credit rating, while contingent capital instruments may need government guarantees to improve their credit standing and enhance investor interest. Issuance of risk-linked securities could be appropriate as cover for higher risk layers, because a higher risk probability may justify the interest rate premium paid on these securities (Froot et al., 1998). Cat-bonds have been issued to cover higher layer risks with loss probabilities between 0.4 and 1.0 percent corresponding to 250- and 100-year events (McGee and Eng, 2003). Contingent capital may be appropriate to cover upper-end higher risk layers to reduce the up-front option premium payable on the implied put contracts. However, decisions on the type of cover (i.e., risk transfer versus risk financing, reinsurance versus risk-linked securities, contingent capital versus committed credit facilities, and so forth) should be based on comparative analyses of price conditions in the respective markets.

It can be a quite complex process to evaluate alternative transactional opportunities in different risk transfer and financing markets, but it is a task that must be pursued on an ongoing basis to make sure that the insurance vehicle continues to operate optimally. Participants in the local insurance markets will clearly not have sufficient capacity to cover all the residual catastrophe risks. As a result, there is a need to analyze alternative risk transfer opportunities available in the international financial markets. These alternatives would include insurance and reinsurance contracts, issuance of risk-linked securities and cat-bonds, issuance of surplus notes and other contingent capital solutions, committed credit facilities, etc. The key to maintaining an efficient risk management program is to choose the most cost effective risk-transfer and financing programs for the type of risk exposure the insurance pool is intended to cover.

COMPARATIVE ANALYSIS OF ALTERNATIVE INSTRUMENTS

Apart from setting up the very structure of suitable insurance layers, a key issue relates to the ongoing monitoring of price developments for different risk transfer and financing instruments. This provides the risk managers with the opportunity to compare prices across different financial markets and find the best financing alternatives in a dynamic process that allows the managers to

Figure 14. Insurance Pool with Layered Risk Transfer Structure - Example



take advantage of favorable market developments. The relevant markets to consider in these comparisons include reinsurance contracts, insurance covers in risk-linked securities, committed credit facilities, and contingent capital instruments. The global market for property catastrophe reinsurance is of a somewhat limited size with a total excess-of-loss capacity estimated around US\$75 billion³⁰ (Guy Carpenter, 2000).

Mutual reinsurance arrangements among primary insurers may provide further coverage but are not likely to expand capacity significantly. The size of this market does not appear high compared to the extreme exposures that can arise from catastrophe events. That is, there seems to be a general lack of coverage for the highest risk layers associated with mega-catastrophes or cataclysms. As the catastrophe risk exposures continue to expand around the globe, underinsurance could become an issue, since the availability of catastrophe reinsurance is highly dependent on recent loss experiences and cause cyclical developments in supply conditions.

The good news is that the catastrophe covers obtained from risk-linked securities seem to be maturing into a relatively stand-alone risk transfer market segment with limited dependency on the traditional reinsurance market (McGee and Eng, 2003). This market development will help reduce price volatility in the global reinsurance markets and expand the reinsurance capacity. The ability to diversify catastrophe risks in invested portfolios primarily exposed to market, default, and interest rate risks makes the risk-linked securities interesting for a wider audience of institutional investors. The return from catastrophe risk exposures are unrelated to the returns on conventional financial assets, so diversified investors can improve the portfolio's risk-return characteristics by including cat-bond exposures in the portfolio. The market for risk-linked securities has matured in recent years so institutional investors have become increasingly familiar with the underlying analysis of catastrophe risks and a secondary market has emerged to provide trading prices in the securities. This development has made risk-linked securities

a relatively steady element of the capital market that now constitutes a realistic alternative for catastrophe risk-transfer market.

Insurance cover for catastrophe risk requires payment of an up-front insurance premium but once the premium is paid, the coverage under the insurance contracts is fully paid-in. This is an advantage because it limits post hoc interference with government budgets and fiscal policies.³¹ However, insurance premiums for higher risk layers can become excessive due to the higher level of uncertainty associated with mega-catastrophe events. This may make it worthwhile to consider committed credit facilities and contingent capital structures as alternative ways to arrange funding for reconstruction. The commitment fees imposed on credit facilities and option premiums charged on surplus notes are considerably lower than the premiums charged on insurance contracts, but the loans must be repaid at maturity. Nonetheless, there is trade-off between the affordability of high-level excess-of-loss insurance treaties and more economical credit commitments.

Under simplifying assumptions, it is possible to make direct comparisons between the implied costs associated with reinsurance contracts, whether obtained via the reinsurance or risk-linked securities market, and the effective costs of committed credit facilities and contingent capital (e.g., Pollner, 2001b). The comparative cost analysis is useful when choosing between different market alternatives as the initial cover is established, and in ongoing market monitoring that allows for dynamic adjustments to the existing insurance and financing structure. When setting up an appropriate coverage for the catastrophe risk exposure, it is important to incorporate the most advantageous market instruments. However, it is equally important to adopt an appropriate and affordable insurance structure matched to the specific characteristics of the risk profile it is trying to hedge. One way to accomplish this is to adopt

³⁰ This figure indicates the aggregate loss coverage from the ground up.

³¹ Under common country settings and market conditions, formal insurance arrangements seem to emerge as a more effective risk-transfer and financing instrument compared to consecutive risk-mitigation investment and contingent capital arrangements (Freeman and Martin, 2002).

risk simulation techniques to determine the type of coverage that will provide the best economic outcomes given the probabilistic nature of event occurrences. The relevant outcome measures in this analysis could include the risk of a government budget shortfall, the likelihood of a post-disaster resource gap, or the country's economic growth potential. Such analyses could extend the catastrophe risk models performed initially to outline the underlying catastrophe risk profile and build on the results from the derived loss analysis modules.

POLICY CONCERNS IN GOVERNMENT INTERVENTION

Most developed economies that are exposed to catastrophe risk have introduced different types of government induced insurance schemes to deal with the associated uninsurable exposures. These schemes include different types of tax-based calamity funds, national insurance programs, and government-backed insurance pools. The fund structures typically provide short-term catastrophe relief and subsidized reconstruction loans that, more often than not, are distributed through the government administration. The national insurance programs are primarily established to cover major public infrastructure investment, central government buildings, and other public assets, but could also extend the coverage of conventional calamity funds. The government-supported insurance pools facilitate the availability of commercially based catastrophe insurance to the public. This is often partially supported by government-backed credit facilities and reinsurance commitments. To the extent calamity funds and national insurance programs are managed as government administered public support and distribution vehicles, they are wrought with moral hazard issues. However, government-backed insurance pools provide an opportunity to offer insurance services to the public on commercial and actuarial terms without any government interference in administrative and distribution practices. Insurance programs established solely to cover public infrastructure investment are not exposed to moral hazards, because the government already controls the assets.

Insurance pools require a high level of enrollment to reach a balanced and well-diversified risk portfolio that makes it possible to offer affordable policies to the public. This level of enrollment can be achieved by making catastrophe insurance *compulsory* for all registered homeowners, or *voluntary* through active public education and marketing campaigns. Specific country settings may require unique solutions adapted to local market conditions and needs, but the choice of approach should consider the trade-off between general insurance participation through compulsion and public tax-financed coverage (e.g., through government run calamity funds), that may cause moral hazards and induce adverse risk management behaviors on private households and small businesses. To avoid such problems, it is important that mandatory insurance arrangements are structured on commercial and actuarial principles and not as purely tax-financed and public insurance schemes free of charge. Insurance pools can be structured as insurance providers to the final users, but can also be set up as pure reinsurance vehicles to cover the exposures of primary insurance companies operating in the country. This type of risk pooling serves to encourage the local insurance industry to offer insurance policies to the public. In this case, the insurance vehicles act solely as reinsurer and, consequently, leaves all operational aspects of the direct insurance management to the private insurance companies. This model may be appropriate in country settings with relatively well-developed insurance sectors.

The establishment of different types of risk pooling vehicles can create additional insurance capacity for otherwise uninsurable catastrophe risk exposures in disaster prone countries. However, to maintain the economic efficiency of these vehicles, it is crucial to ensure that managerial decisions remain commercially and actuarially sound. This implies that claims are covered on predetermined contractual terms without any political interference. It also means that all surplus funds accumulated during the pool's operating life only can be used to pay claims associated with insured exposures. Hence, the insurance vehicles must be governed within an effective *legal and regulatory environment* that keeps a clear separation between the government budget and the reserve funds maintained by the insurance pools.

The insurance penetration remains low in most developing countries due to significant moral hazard issues associated with a lack of enforced building codes, and other such issues. Hence, the introduction of insurance pools to enhance the catastrophe insurance capacity should not be done in competition with local insurance companies, which would make it even harder to pursue commercial insurance business. The insurance pools should *cooperate rather than compete* with otherwise sound private insurance businesses. The risk transfer vehicles, such as insurance pools, should be structured to cover only the natural hazards that otherwise would be underinsured, and sound local insurance companies should be engaged as contractors for operational activities. In countries with fairly developed insurance services, the private insurers could perform major business functions (e.g., distribution, claims settlement, loss control, risk management, etc.). If, however, the capabilities of domestic insurers are limited

there is a need to develop further distribution channels and claims adjustment expertise.

The catastrophe insurance vehicle (e.g., an insurance pool) should outline a set of realistic risk management objectives in the initial phases of establishment. The catastrophe exposures are theoretically infinitely large and, as a result, it could be prohibitively expensive to cover for the highest loss layers associated with megacatastrophes. In practice, therefore, *affordability* is an important concern when an insurance vehicle is introduced. This means that new insurance pools most likely would try to fund aggregate claims from events with up to 100- to 150-year return periods and probably no higher. The affordability of reinsurance coverage is obviously an important determinant of the insurance premium the pool must charge, but it is important that the premiums are determined on an actuarial basis to ensure the financial sustainability of the insurance vehicles.

Box 2.
Comparison Between Alternative Risk Transfer and Financing Opportunities

Reinsurance

The reinsurance companies would consider a pure premium (PP) of a size no less than the expected loss (EL).

$$PP = EL = p * EPL = p * d * ICL$$

where; EPL = expected probable loss estimate

p = probability (frequency) of natural hazard

d = damage ratio = $v * h$

v = vulnerability factor of capital asset

h = hazard intensity factor

ICL = insured capital loss

The total premium (PT) actually charged by the reinsurance company takes other operational cost elements into consideration.

$$PT = PP + exp + u + \pi + R$$

where; exp = administrative expenses associated with the insurance business

u = uncertainty factor (risk load) reflecting the unpredictability of disaster events

π = the required rate of return (profit) of investors in the insurance business

R = the reinsurance cost associated with the ceded share of the exposure

Assuming unchanged market conditions in perpetuity the present value of all future reinsurance premiums is:

PT/r where; r = risk free rate

Note: this valuation applies equally to the effective insurance premium charged in risk-linked securities transactions.

Credit Facility

The comparable present value of the funding cost associated with a committed credit facility (CF) is:

$$CF = [(1-p)(l_c EPL)] + p \sum [(l_r (EPL - i/m EPL) (1+r)^{-i} + (EPL/m)(1+r)^{-m}) / r]$$

where; l_r = interest rate applying to the committed credit facility

l_c = commitment fee charged on the committed credit facility

i = the current loan repayment period

m = the final maturity of the committed credit facility

Note: this equation assumes that the loan is repaid in equal installments from year 1 to m and that the final maturity date of the credit facility corresponds to the final repayment date of all needed loans.

Contingent Capital

The comparable present value of the funding cost associated with contingent capital (CC) is:

$$CC = [(1-p)OP] + p \sum [(l_r (EPL - i/m EPL) (1+r)^{-i} + (EPL/m)(1+r)^{-m}) / r]$$

where; OP = annual option premium paid for underlying put contract

Note: this assumes that the funding arrangement furnished by the contingent capital contract is the same as the loan structure of the committed credit facility illustrated above.

The comparative formulas should be adjusted to reflect changes in the credit facility (e.g., inclusion of arrangement fees, different repayment schedules, bullet payments, etc.).

Country Applications of Risk Management Approaches

The insurance coverage for catastrophe risk exposures in Latin America and the Caribbean is marginal. Countries rely on multilateral institutions, including the IDB, to provide the post-disaster financing needed to rebuild the economic infrastructure. Consequently, catastrophe risk issues are not ranked high on the governments' planning agendas, if at all (Freeman and Martin, 2002). The insurance penetration remains low across the region. In the absence of enforced building codes, vulnerability is high and risk mitigation minimal. Insurance policies are expensive for ordinary people and prevent them from buying coverage. The supply of comprehensive insurance policies is distributed on a selective basis due to moral hazard and adverse selection problems. Catastrophe exposures constitute uninsurable risks where coverage is in short supply in high exposure countries. The economic vulnerability to natural disasters in Latin America and the Caribbean has been exacerbated by the general underdevelopment of insurance markets (e.g., property insurance has been limited to institutional entities and secluded groups of wealthier households).

Countries in the region are exposed to all the major natural disaster risks. Mexico, Central America and the Caribbean are exposed to hurricane and storm events. Certain subregions of Mexico and Central America are exposed to earthquakes. South America is exposed to flood, drought, storm, and landslide events caused by El Niño-related phenomena. Four major natural hazards affect the region; namely, flood, storm, earthquake, and drought. Total disaster losses have been significant. Over the past 30 years losses are estimated at close to US\$100 billion (Charveriat, 2000), and the frequency of natural disasters seems to be increasing. In view of this development a number of studies have been commissioned in recent years that have documented potentially significant adverse socioeconomic effects associated with large catastrophe risk exposures in the region if they are left unmatched (Freeman and Martin, 2002; Freeman et al., 2002; Pettersen et al., 2005). These studies demonstrate how ca-

tastrophe risk modeling techniques can be applied to map the contours of the aggregate risk exposures of the countries,³² and discuss how different risk transfer and financing instruments may be used to dampen the indirect economic effects of productive assets destroyed by natural catastrophes. The overwhelming conclusion seems to be that there is a dire need for higher awareness of the catastrophe risks that expose countries in the region, and that appropriate use of financial instruments can help alleviate the potentially adverse economic effects from natural disasters by making financial means more readily available for reconstruction efforts.

There is a general recognition that natural catastrophe risks are special because the sheer size of their direct economic effects make them uninsurable on commercial terms in the national markets. This has prompted governments in most exposed developed countries to establish different types of insurance vehicles to provide cover for these hazard events to the general public. In the wake of major catastrophe losses some developing countries have taken initiatives in recent years to increase risk awareness and further risk mitigation and preparedness efforts. However, only one country, Turkey, has so far introduced a stand-alone insurance vehicle to offer property insurance coverage to the public for otherwise uninsurable risk. The following provides an overview of some of these initiatives.

³² None of these studies have been able to make a clear distinction between the relative importance of public and private asset exposures and their relative indirect economic effects. This distinction might be important, and this paper argues that the two types of assets exposure have different economic effects and their risk coverage should be managed differently. This reflects a general shortcoming with the available loss statistics, which fail to provide a clear classification of losses ascribed to different asset classes.

CATASTROPHE INSURANCE VEHICLES IN DEVELOPED COUNTRIES

North America

In the United States, the states of Florida, California, and Hawaii have introduced special insurance programs to deal with major regional catastrophe exposures. Joint Underwriting Associations (JUA), the Florida Hurricane Catastrophe Fund (FHCF), the California Earthquake Authority (CEA), and the Hawaii Hurricane Relief Fund (HHRF) were established by the respective state authorities after major catastrophe experiences.

The Windstorm Joint Underwriting Association (WJUA) and the Florida Residential Property and Casualty Joint Underwriting Association (FRPCJUA) were established by the Florida legislature as property insurance pools to provide comprehensive coverage for homeowners unable to buy policies in the private market. The Florida Hurricane Catastrophe Fund (FHCF) is a catastrophe reinsurance fund established after hurricane Andrew in 1992 to provide mandatory cover for primary property insurers doing business in the state.

The California Earthquake Authority (CEA) was established by the state in the mid-1990s to provide residential earthquake insurance partially funded by the insurers. Primary insurers choosing not to participate in CEA must make their own earthquake policies available to their customers. There is a 15 percent deductible on total loss on property and content with a US\$5,000 limit on contents coverage.

The Hawaii Hurricane Relief Fund (HHRF) provides hurricane cover through participating insurance companies that exclude hurricane cover in their normal homeowner policies. The fund receives revenues from insurance premiums and property assessments by the insurance companies. The first 10 percent of losses are borne by the homeowners through deductibles with a higher layer covered by the insurers. The next level is reinsured in the market, and the top layer is covered by a line of credit secured by future surcharges on premiums (figure 15).

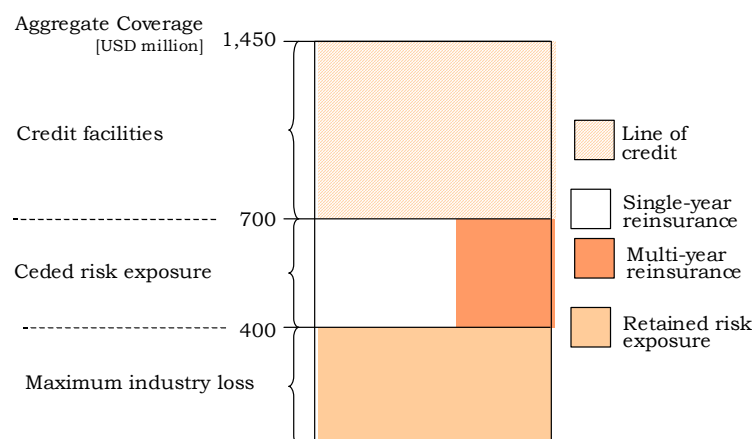
The Federal Emergency Management Agency (FEMA) was established to provide publicly administered disaster relief and subsidized loans after the President has declared a major disaster area. The government also makes some funds available for emergency planning and disaster assistance programs. FEMA administers the National Flood Insurance Fund, a provider of flood insurance to residential and commercial properties in approved areas. The insurance fund is paid through premiums set by the government and subsidized loans provided by the US Treasury.

Europe

Belgium

Legislators have been working on a national program imposing a compulsory cover for earthquake, floods and landslides in all small and medium-sized fire insurance policies. Primary insurance companies are expected to retain 10 percent of the claims, while a reinsurance fund will cover residual exposures through a combination of

Figure 15. Insurance Cover of the Hawaii Hurricane Relief Fund (HHRF)



earned reserves, reinsurance contracts, and guaranteed state funding.

France

Flooding and earthquake damages are covered through a special program (*Catastrophe Naturelle*, Cat Nat for short), which mainly is reinsured with the government-owned reinsurance company (*Caisse Centrale de Réassurance*, CCR). Insurance companies are allowed to establish two tax deductible reserves, one for windstorm and one for other natural catastrophes to smooth cash flows over longer time spans.

Germany

The individual German Länder and the federal government can declare a natural disaster and thereby authorize public assistance in the form of grants and low interest loans to the victims hardest hit by the disaster.

Iceland

Property fire insurance policies have additional cover against earthquake, volcanic eruption, snow avalanche, landslide, and flood events provided by a government fund (Icelandic Catastrophe Fund).

Norway

Property insurance policies must cover residential and commercial properties against natural catastrophes. *Norsk Naturskadepool*, a government-supported insurance pool, provides reinsurance for these risk exposures.

Spain

The *Consortio de Compensación de Seguros* is an independent state fund providing cover for uninsurable property exposures to earthquakes, tsunamis, floods, volcanic eruptions, cyclonic storms, falling meteorites, terrorism, and civil unrest. The fund is only financed by premiums, but carries a government guarantee. The catastrophe reserve is tax deductible.

United Kingdom

Experience shows that floods and subsidence risks are recurring in 3-4 year cycles and are considered manageable within the private insurance market.

The Far East and the Pacific

Japan

The government-owned Japanese Earthquake Reinsurance Company (JER) provides reinsurance for damages to residential property from earthquake and volcanic activities. JER, in turn, retrocedes part of its exposure to private insurance companies, while the government retains the rest. The coverage in the Japanese earthquake reinsurance program is an example of a mixed structure that combines earned funds, reinsurance, and government commitments in different ways (figure 16).

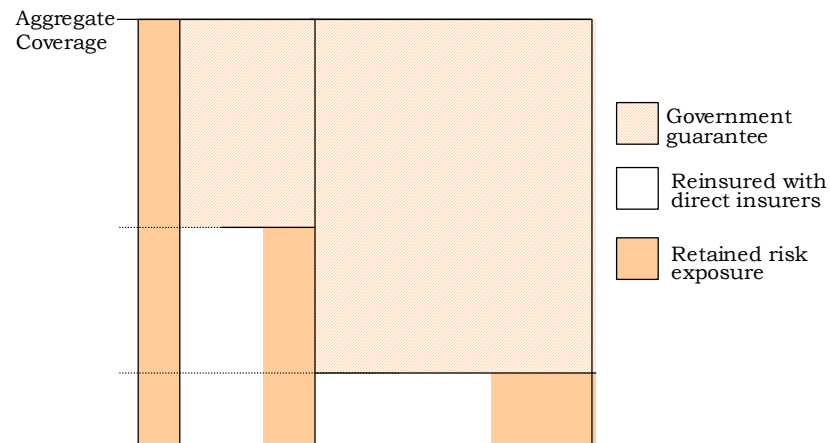
New Zealand

A government insurance fund managed by the Earthquake and War Damage Commission (EQC) offers actual cash coverage (as opposed to replacement cost) against catastrophe risks associated with earthquakes, tsunamis, volcanoes, and hydrothermal activities.

Taiwan

Taiwan introduced the Taiwan Residential Earthquake Insurance Pool (TREIP) in April 2002. A new insurance law requires that earthquake cover be included automatically in domestic fire and homeowners' policies, while purchase of the basic policy is voluntary. The exposures are covered through a government-supported insurance pool. This insurance vehicle covers its exposures in four layers. The local insurance companies and Central Reinsurance Company cover the first level (US\$65 million), a government guarantee fund the next level (US\$600-900 million), the following level is ceded to global reinsurance companies (US\$300 million), while the government covers excess losses as insurer of last resort. The insurance covers private dwellings, with some temporary accommodation, but not contents. There is a

**Figure 16. Japanese Earthquake Reinsurance Company (JER)
(mixed funding structure)**



maximum per dwelling coverage limit (US\$39,000).

CATASTROPHE INSURANCE VEHICLES IN DEVELOPING COUNTRIES

Latin America and the Caribbean

Honduras

The government is planning to introduce a national system for catastrophe risk prevention, mitigation, and preparedness under a standing committee (COPECO).

Jamaica

Jamaica established a centralized disaster management organization (ODPEM) to coordinate the country's risk mitigation and disaster preparedness efforts. Whereas these efforts may serve as a source of inspiration, it is too early to tell whether these initiatives could be replicated elsewhere. Nonetheless, they reflect an awareness of the impending threat posed by losses from natural catastrophes and illustrate political actions taken to circumvent the problem of underinsurance in developing countries.

Mexico

The government established the National Civil Protection System under the Ministry of the Inte-

rior in 1986 to coordinate public disaster protection and recovery efforts. The National Council for Civil Protection (SINAPROC) was established in 1990 as an ad hoc committee to monitor the nation's disaster preparedness. The National Center for Disaster Prevention (CENAPRED) was established to develop and disseminate mitigation technologies in cooperation with university-based research on risk assessment and modeling.

The Mexican government established a tax-based calamity fund (Fonden) in 1996 for disaster relief and reconstruction of basic infrastructure. Fonden provides funding for reconstruction directly to federal agencies, and state and municipal governments, which are required to provide matching funding and insure public buildings. The idea behind the fund was to reduce the adverse effects from unexpected appropriations under the federal budget and smooth fiscal effects over time. Fonden has received advance annual budget allocations of around US\$1 billion per year, but, so far, the funding has been inadequate to cover the accruing financing needs. It has been recommended that the coverage capabilities of the fund be extended by gradually converting it into a formal national insurance program where loss layers in excess of the paid-in funds will be covered through reinsurance treaties and other risk transfer instruments (Guy Carpenter, 2000).

Nicaragua

Nicaragua has enacted legislation to create a government disaster prevention, mitigation, and management approach. This is the first step toward an integrated civil defense and rapid-response system. A technical team supported by the United Nations Development Program (UNDP) is building the institutional structure (cost estimate of US\$7 million). The effectiveness of this system is yet unknown, but is widely expected to depend on support offered by regional politicians and government officials.

Europe - Middle East

Much of Turkey is exposed to severe seismic risk, but insurance coverage for catastrophe exposures remains low. Hence, the World Bank established the Turkish Catastrophe Insurance Pool (TCIP) in the wake of major earthquake events around Istanbul in 1999. The TCIP required regulatory reforms that made catastrophe insurance mandatory on all residential properties. The local insurance companies sell the insurance policy as agents. In the insurance pool, accumulated reserves provide the first cover, while higher risk layers are supported by reinsurance contracts and World Bank credit facilities (Gurenko, 2000).

TCIP became operational in September 2000 based on a new insurance law. The scheme was compulsory for all registered dwellings while the government's previous commitments to reconstruct such dwellings ceased. TCIP is the sole provider of base-level earthquake coverage and is managed professionally by Milli Re, a leading national reinsurance company. The earthquake pool offers an insurance policy that covers up to US\$20,000 per dwelling with no contents cover. The scheme has 15 rating categories based on hazard zones and construction type with premiums ranged accordingly. Excess cover can be obtained from private insurers, who also distribute TCIP policies as agents. There is a 2 percent deductible on the policy cover and claims handling is carried out by TCIP contracted loss adjusters. The pool holds financial reserves in escrow accounts with at least 50 percent invested in foreign assets.

TCIP is a leading test case for the World Bank in the establishment of active insurance pools in an exposed developing country.³³ The insurance coverage for earthquake exposures has historically been very low in Turkey, and the local insurance industry was not sufficiently developed to handle major catastrophe risks. Underwriting standards, risk estimation, and management capabilities were insufficient, and capital reserves were too low to withstand potential claims. Inadequate construction and building standards combined with weak enforcement of building codes increased the exposure to earthquake events. Prospects of expanding insurance coverage for earthquake risks were further hampered, because replacement of dwellings by law was funded almost free of charge by government sources, and therefore, provided little incentive to engage in insurance contracts. The recent earthquake events exposed these inherent market weaknesses and urged the establishment of the government-backed insurance pool to cover these otherwise uninsurable catastrophe risk exposures.

The laws authorizing the establishment of TCIP made earthquake insurance policies compulsory for all households, enforced risk mitigation efforts, and eliminated government subsidized interest-rate free reconstruction loans to homeowners. The earthquake insurance policies are sold by local insurance companies and brokers, but are covered directly through the TCIP. The professional management of the aggregate exposure in the insurance pool is outsourced to an experienced reinsurance company acting as the pool management company. TCIP covers up to the 99th percentile of expected losses corresponding to a 100-year event (Lester et al., 2003). The World Bank has established a flexible contingent credit facility to support the reinsurance structure of the pool. Combined with fund reserves and obtained reinsurance this should establish cover for total earthquake losses up to around US\$640 million for five years.

³³ The World Bank Insurance practice is involved in several other catastrophe risk management initiatives at the early stages, e.g., India (completed risk management study), Cambodia and the Philippines (risk management studies under way), Iran (technical assistance for risk management), Colombia and Romania (insurance lending programs under preparation).

If claims exceed the pool’s financial reserves financed by premiums from policyholders, the World Bank credit facility may be able to cover higher risk layers. Most of the next higher risk layer is ceded in the global reinsurance market, and the highest risk layer, may again be funded by a World Bank credit facility (figure 17).

Of the various insurance approaches listed above, most of them refer to direct government-supported insurance pools (e.g., TCIP, JUA, CEA, HHRF, EQC, and TREIP) some of which provide reinsurance or incorporate a reinsurance component (e.g., CCR, FHCF, and JER). There is one example of a calamity fund (FONDEN), two examples of direct government managed approaches (FEMA, Germany), and several recent attempts to introduce risk management principles (e.g., ODPEM and COPECO).

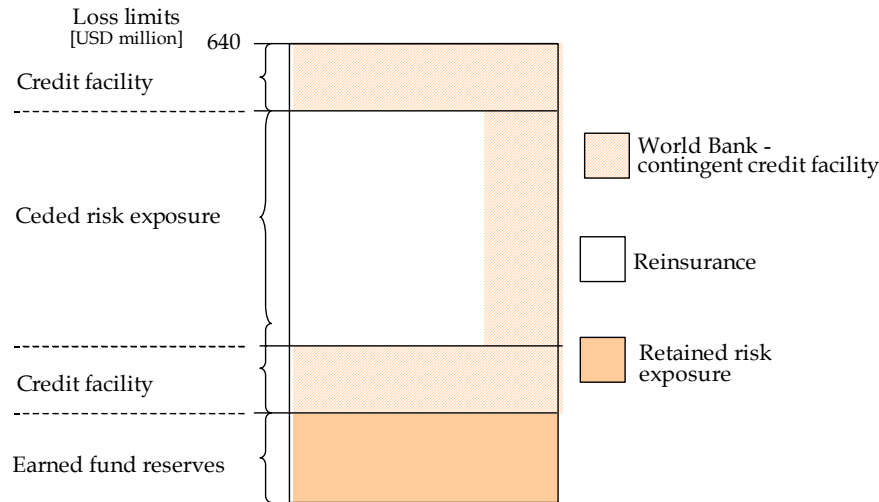
ESTABLISHING INSURANCE VEHICLES IN LATIN AMERICA AND THE CARIBBEAN

So far, no catastrophe risk insurance pools have been established in the region, although several studies have investigated the applicability of risk pooling arrangements to cover hurricane risk in the Caribbean, for example (Pollner, 2000, 2001a). There have been efforts to establish mitigation and vulnerability reduction funds to promote investment in structural improvements in buildings and infrastructure, and the IDB has promoted credit facilities for innovation in disaster prevention. Some social investment funds have

furnished funding for the reconstruction of public infrastructure after disasters, in the same way that the IDB’s emergency reconstruction facility for natural and unexpected disaster support (ERF) has provided funds to support temporary post-disaster rehabilitation. However, these initiatives have not been conditioned around formal risk management approaches aimed at assessing the comprehensive risk profile of the countries that are exposed to natural catastrophes. Public calamity funds, such as Fonden in Mexico, have been established with the aim of smoothing the volatility of economic activity caused by natural disasters, but so far with mixed success (Guy Carpenter, 2000). These funds are based on the principle that governments as self-insurers should reserve the financial means needed to cope with emerging disasters. Although the funds can provide significant financial relief in disaster situations, the general experience has been that the funds remain undercapitalized in many instances and therefore are ineffective risk financing vehicles on a stand-alone basis.

The general observation across the region is that governments rely on the multilateral institutions, including the IDB, to make financing available after major catastrophes on relatively favorable terms. Apart from the potential for moral hazard issues arising from the treatment of disaster funding as a public good, this policy de facto places the multilateral institutions in the position of lenders of last resort. Since much of the incremental funding from the multilateral institutions is used to cover post-disaster reconstruction, they are de facto also assuming the role of insurers of last re-

Figure 17. A Sketch of the Turkish Catastrophe Insurance Pool (TCIP)

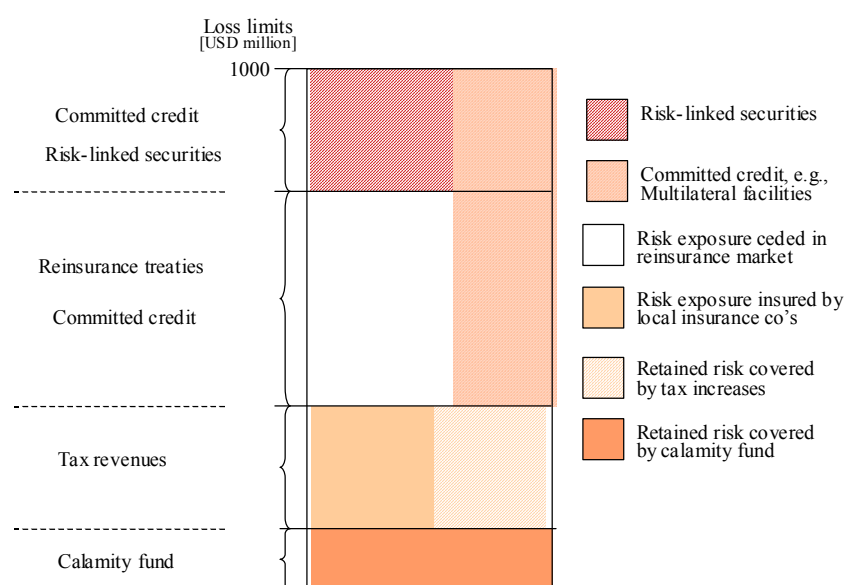


sort without realizing it, or at least without making the exposures transparent. In effect, the international community implicitly makes committed credit facilities and contingent capital structures available to exposed developing countries for free, without imposing any formal requirements about prudent risk management practices. With the seeming increase in global catastrophe exposures, this situation represents a fundamental challenge to the multilateral institutions, including the IDB, as to how they intend to manage the catastrophe risks they assume. There is a need to assess more thoroughly the catastrophe risk exposures of governments across the region and consider the appropriateness of different insurance vehicles to cover the uninsurable catastrophe exposures on public and private assets.³⁴ It seems that the centrally managed insurance programs are the most appropriate to cover public assets that are under the central government's control, whereas insurance pools appear more appropriate to cover government commitments on private assets.

A national insurance program to cover public assets could have at its core the same annual committed payments from the government's fiscal budget as would supporting a stand-alone calam-

ity fund. The difference is that total coverage is considerably extended by establishing insurance covers for higher risk layers to protect against adverse economic effects of, say, up to 100-year events. The higher layers could be structured to include coverage through a marginal increase in tax revenues and direct insurance covers from the local insurance industry. Higher risk layers could be ceded in the global reinsurance market in combination with different types of committed credit facilities. Realistically, a significant part of the credit commitments at higher risk layers would have to be provided by the multilateral institutions against payment of reasonable commitment fees. For the multilateral institutions this approach can help make the underlying catastrophe risk exposures transparent on the balance sheet while they incur up-front charges for the implied loan commitment provided as lenders of last resort. For the countries, this approach would create incentives to mitigate underlying risk exposures whenever economically feasible. It might also be possible for recognized government entities to issue risk-linked securities in the international financial market and thereby possibly exploit favorable price conditions (figure 18).

Figure 18. A National Insurance Program - Example



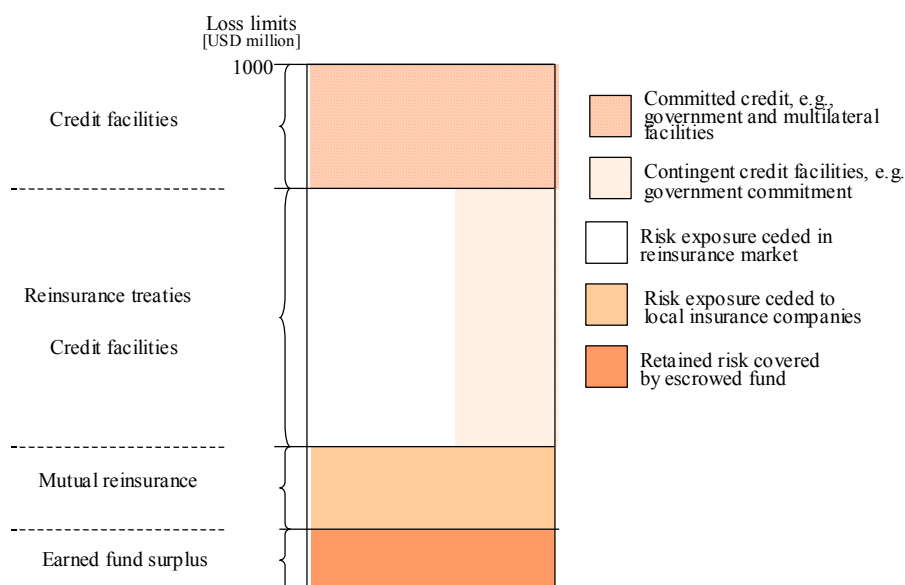
³⁴ Incidentally, such studies would also provide an overview of the aggregate exposures the IDB, and other multilateral institutions, assume across the region.

In order to manage the government's informal commitments to cover economic exposures on private assets, such as housing, there is a need to establish independent insurance vehicles that are able to provide insurance policies to the public on commercial terms without any direct government interference. These insurance pools would, in turn, manage the assumed catastrophe risks using all available risk transfer and financing instruments applied within an appropriate structure of risk layers. For example, the lower risk layers may be covered by paid-in funds held in escrow accounts financed primarily by the premiums received from policyholders. The next higher layer could be covered by the local insurance companies already engaged in the insurance pool as authorized insurance agents. The involvement of local insurance companies would give an opportunity to support the local insurance industry and extend operational expertise. The insurance companies could provide cover on a mutual basis to reduce the direct exposure to individual insurance companies and, at the same time, reduce the potential for moral hazards associated with the agency function. The central layers may be ceded in the reinsurance markets through different excess-of-loss treaties and supported to some extent by government-backed credit commitments. The higher risk layers could conceivably be covered through issuance of risk-linked securities under favorable circumstances, but are probably covered more economically through different committed

credit facilities and contingent capital arrangements. Most likely, these credit facilities need backing from the central government and/or the multilateral institutions in the initial stages of development (figure 19). It is not inconceivable that a well-established insurance pool would be able to place contingent capital instruments in the capital market particularly if sponsored by the multilateral institutions. The direct involvement of the multilateral institutions would, as discussed in the case of national insurance programs, serve to make the inherent catastrophe risk exposures more transparent and establish more realistic pricing for the implied risk financing arrangements.

The overall insurance structure should balance the need for general catastrophe cover and the cost associated with different risk-transfer and financing alternatives. Realistically, the vehicles may not want to cover total loss exposures in excess of the 100-year event, because it otherwise becomes too expensive to reinsure. The insurance commitments may also be reduced somewhat by imposing certain deductibles, exclusion clauses, and maximum reimbursement limits. Since the uncertainty of the expected losses increase significantly at higher risk layers, the reinsurance premiums may increase substantially above their loss cost and, thereby, become excessively expensive. Therefore, it is expectedly more economical, at least for a start-up vehicle, to use committed credit facilities to cover the upper risk layers. In

Figure 19. A Government-Backed Insurance Pool – Example



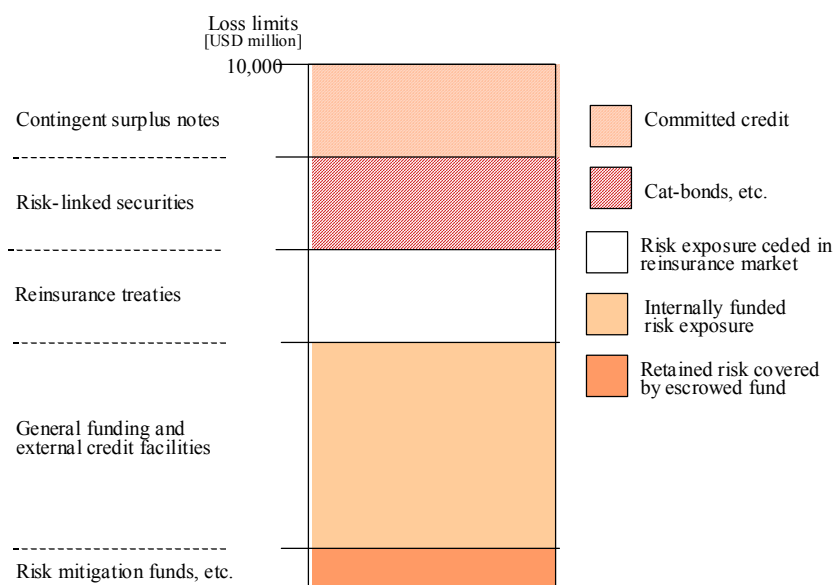
reality that may mean that vehicles established in developing countries would need committed facilities from multilateral institutions for these purposes, at least initially. The multilateral institutions may, in turn, want to cover the aggregate risk financing exposures they assume from their engagements with various insurance vehicles established throughout the region. Whereas this may seem like inviting new risk exposures onto the institutions' balance sheets, it only converts the already existing commitments as the de facto lenders of last resort to transparent financing structures that can be appropriately priced. In the current situation the multilateral institutions are really providing substantial catastrophe risk financing covers to developing countries without charging for this commitment and thereby skews the incentives to engage more proactively in sensible risk mitigation efforts.

As a multilateral institution faces its aggregate catastrophe exposure it has even better opportunities to use various catastrophe risk financing instruments because of their generally high credit standing in the international financial markets. From the perspective of a multilateral institution, it may want to cover the lower catastrophe risk level in its overall exposure through budgeted risk mitigation funds and the institution's general funding base. This would make sense up to a certain funding level as long as it does not create ad-

ditional strains on the institution's general capacity to fund itself in the capital market. However, out of prudence it may also consider coverage of higher-level risk exposures through reinsurance treaties, issuance of risk-linked securities, and contingent capital arrangements that would allow the institution to cover excessive funding needs in advance (figure 20).

These arrangements would allow the multilateral institutions to cover higher level catastrophe risks in the region, while promoting more proactive risk management practices, without any major changes in commitments to other development projects. Today, the reality is somewhat different, because the multilateral institutions often have to redirect credits approved for development investment to support rehabilitation after major disasters. From an overall perspective, the multilateral institutions will be the more likely users of advanced risk financing instruments like risk-linked securities and contingent capital structures available in the global capital market. For example, the reinsurance cover obtained through cat-bonds typically relates to the higher risk layers (i.e., around the 100-year event and beyond), which would exceed the need for an initial start up insurance pool, but would be quite appropriate for a multilateral institution with an extensive aggregate catastrophe risk exposure. Furthermore, the contingent capital market is not appropriate for an exposed country

Figure 20. Insurance Scheme for Multilateral Exposure – Example



under the current market conditions where governments depend on the multilateral institutions for catastrophe funding. In practice, these instruments must be introduced to the region through the back-door as the IDB starts charging for its actual catastrophe credit commitments and in turn might cover its aggregate exposure in the international financial markets. The IDB might want to analyze its overall exposure as de facto lender of last resort and hence insurer of last resort to countries in the region with exposures to natural catas-

trophes. The IDB does not have a formal obligation to finance catastrophe rehabilitation in the region, but in reality the needs of exposed countries will urge the eventual approval of loan commitments. Hence, the IDB has a real catastrophe risk insurance exposure across countries in the region. It may be useful to analyze these catastrophe risk exposures and think about how they can be managed more effectively while inducing more effective risk management practices in exposed countries throughout the region.

Box 3.
A Template for Catastrophe Risk Management

Governments in developing countries that are exposed to major catastrophe risks should be conscious about these risk exposures and manage them on a proactive basis. This process may follow a number of sequential steps based on initial catastrophe risk analysis coupled with economic simulations of the economic effects of major hazards. The steps could comprise the following actions.

- Identify the major natural hazards that expose economic assets in regions across the country.
- Determine the contours of the direct economic exposures from the identified natural hazards.
- Classify the affected economic assets into relevant categories, e.g., public and private.
- Decide on the government's intended roles as public insurer and insurer of last resort.
- Plan appropriate insurance vehicles to provide cover for government supported assets, e.g., insurance schemes for public assets and national insurance pools for private assets.
- Analyze alternative risk-transfer and financing instruments available in the domestic and international financial markets.
- Consider and assess the potential economic benefits from different risk mitigation efforts.
- Determine appropriate coverage structures in the proposed insurance vehicles.
- Monitor changes in catastrophe risk exposures and risk-transfer and financing prices and adapt coverage structures on ongoing basis.

Setting up appropriate coverage structures in the proposed catastrophe insurance vehicles could be enhanced by extending relevant elements of the catastrophe risk exposure models and determine the potential economic effects of different coverage structures based on stochastic simulation models.

Conclusions

This report discussed the signs of an increasing trend in the global catastrophe frequency that also characterizes developments in Latin America and the Caribbean. One consequence of this development is that the direct economic losses associated with natural catastrophes seem to be increasing at very high, possibly exponential, rates. This poses a number of challenges to developing countries with exposures to natural disasters. By experience countries in the region rely on the multilateral institutions to provide the financial means needed to complete post-disaster reconstruction, but this is not likely to remain a viable option as the funds available for international development remain scarce. In view of this situation there seems to be a clear need to focus on ways to manage more proactively the potentially adverse economic effects of natural catastrophes. Assuming a formal risk management process at the central government level can arguably help smooth the economic impacts from natural catastrophes by identifying the major risks in a given country and setting up ways in which the central government can facilitate covers against those risks. Although natural hazards represent significant uncertainties, there are ways in which to model the potential direct effects on the country's economic infrastructure through stochastic simulation models. This approach can provide risk managers with reasonable assessments of the potential reconstruction costs a country could face after major disasters. On this basis, it is possible to set up various risk transfer and financing schemes that allow the country to establish financial protection well in advance of a catastrophe. This can have clear advantages as the reconstruction process can take place faster and more effectively after disasters without having to engage in cumbersome negotiations with external lenders in an unfavorable economic situation.

If proactive risk management practice can make reconstruction financing more readily available after disasters, it may actually be possible to turn these otherwise unfavorable circumstances into situations that revitalize the economy as invest-

ments in new infrastructure induce economic growth. Given the rapidly increasing direct economic exposures observed throughout the region, combined with a general over-reliance on multilateral support, it seems essential that exposed countries in the region take a more proactive look at their risk profiles and try to establish financial coverage for these on an ex ante basis. To this end the international financial markets provide new opportunities to access risk transfer and financing instruments that may furnish a better coverage for the identified catastrophe risks. However, before central governments consider any engagement in these instruments, they need to assess the type of economic commitments they should cover after possible disasters and try to set up relevant insurance vehicles to cover more effectively the risk exposures of different types of economic assets against the impact of different natural hazards. In general, governments have direct commitments to repair and rebuild the public assets they own and control. The establishment of different insurance schemes appears appropriate to cover exposures on these assets. In practice, however, governments also assume sizeable commitments to replace private assets, in particular private housing. Cover for these assets require a different set-up (e.g., in the form of insurance pools) that makes it possible to offer insurance policies to the public on a commercial and actuarial basis without distorting government involvement.

The initial establishment of insurance vehicles requires a trade-off between reasonable coverage and affordability. It becomes excessively expensive to obtain full cover for the highest risk levels because, in principle, catastrophe risk exposures are infinitely high in the case of megacatastrophes. Hence, it is only reasonable to establish insurance coverage up to a certain risk level (e.g., corresponding to 100-year events) and introduce national insurance programs and government-backed insurance pools that might also require financial commitments from the multilateral institutions, including the IDB. However, the IDB is already engaged as a de facto lender of last

resort for catastrophe-stricken countries in the region. Therefore, it should be in the interest of the IDB to engage actively in the promotion of

formal risk management processes across the region and provide the needed engagement to furnish this process.

Bibliography

- Albala-Bertrand, J. M. 1993. *Political Economy of Large Natural Disasters: With Special Reference to Developing Countries*. Clarendon Press: Oxford.
- _____. 2000. Complex Emergencies Versus Natural Disasters: An Analytical Comparison of Causes and Effects. *Oxford Development Studies*, 28.
- _____. 2003. Urban Disasters and Globalization. In *Building Safer Cities: The Future of Disaster Risk*, eds. A. Kreimer, M. Arnold and A. Carlin. Disaster Risk Management Series No. 5. Washington, D.C.: The World Bank.
- Alexander, D. 2000. *Confronting Catastrophe: New Perspectives on Natural Disasters*. New York, N.Y.: Oxford University Press.
- Andersen, T. J. 2001. Managing Economic Exposures of Natural Disasters: Exploring Alternative Financial Risk Management Opportunities and Instruments. Washington, D.C.: Inter-American Development Bank.
- _____. 2002. Innovative Financial Instruments for Natural Disaster Risk Management. Washington, D.C.: Inter-American Development Bank.
- _____. 2003. Globalization and Natural Disasters: An Integrative Risk Management Approach. In *Building Safer Cities: The Future of Disaster Risk*, eds. A. Kreimer, M. Arnold and A. Carlin. Disaster Risk Management Series No. 5. Washington, D.C.: The World Bank.
- Andersen, T. J. and P. Masci. 2001. Economic Exposures to Natural Disasters, Public Policy, and Alternative Risk Management Approaches. *Infrastructure & Financial Markets Review*, 7(4). Washington, D.C.: Inter-American Development Bank.
- Andersen, T. J. and V. Kalavakonda. 2003. The Economic Consequences of Catastrophe Events. Working Paper. Washington, D.C.: The World Bank.
- Arrow, K. J. 1996. The Theory of Risk Bearing: Small and Great Risks. *Journal of Risk and Uncertainty*, 12.
- Belonsky, G., D. Durbin and D. Laster. 1999. Insurance-linked Securities. In *Integrating Corporate Risk Management*, ed. P. A. Shimpi. New York, N.Y.: Swiss Re New Markets.
- Benson, C. and Clay, E. J. 2000. Developing countries and the economic impacts of natural disasters. In *Managing Disaster Risk in Emerging Economies*, eds. A. Kreimer and M. Arnold. Disaster Risk Management Series. Washington, D.C.: The World Bank.
- _____. 2002. Bangladesh: Disasters and Public Finance. Disaster Risk Management Working Paper Series. Washington, D.C.: The World Bank.
- Blaikie, P., Cannon, T., Davis, I. and B. Wisner. 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London: Routledge.

- Bock, K. J. and M. W. Seitz. 2002. Reinsurance vs Other Risk-transfer Instruments. The Reinsurer's Perspective. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- Bohn, J. G. and B. J. Hall. 1999. The Moral Hazard of Insuring the Insurers. In *The Financing of Catastrophe Risk*, ed. K.A. Froot. Chicago: The University of Chicago Press.
- Boswell, M. R., Deyle, R. E. and R. A. Smith. 1999. A Quantitative Method for Estimating Probable Public Cost of Hurricanes. *Environmental Management*, 23.
- Briys, E. 1999. Pricing Mother Nature. In *Insurance and Weather Derivatives: From Exotic Options to Exotic Underlyings*. London: Risk Books.
- Canabarro, E., M. Finkemeier, R. Anderson and F. Bendimerad. 2000. Analyzing Insurance-linked Securities. *The Journal of Risk Finance*, Winter.
- Canter, M. S., J. B. Cole and R. L. Sandor. 1996. Insurance Derivatives: A New Asset Class for the Capital Markets and a New Hedging Tool for the Insurance Industry. *The Journal of Derivatives*, Winter.
- Charveriat, C. 2000. Natural Disaster Risk in Latin America and the Caribbean. Washington, D.C.: Inter-American Development Bank.
- Colarossi, D. 1999. Contingent Capital. In *Integrating Corporate Risk Management*, ed. P. A. Shimpi. New York, N.Y.: Swiss Re New Markets.
- CRS Report for Congress. 1998. FEMA and Disaster Relief. Congressional Research Services, The Library of Congress.
- Croson, D. C. 2000. Customizing Indemnity Contracts and Indexed Cat Bonds for Natural Hazard Risks. *The Journal of Risk Finance*, Spring.
- Culp, C. L. 2001. *The Risk Management Process: Business Strategy and Tactics*. New York, NY: Wiley.
- _____. 2002. *The ART of Risk Management: Alternative Risk Transfer, Capital Structure, and the Convergence between Insurance and Capital Markets*. New York, NY: Wiley.
- Cummins, J. D. and H. Geman. 1995. Pricing Catastrophe Insurance Futures and Call Spreads: An Arbitrage Approach. *The Journal of Fixed Income*, March.
- Cummins, J. D., C. M. Lewis and R. D. Phillips. 1999. Pricing Excess-of-loss Reinsurance Contracts Against Catastrophic Loss. In *The Financing of Catastrophe Risk*, ed. K. A. Froot. Chicago: The University of Chicago Press.
- Cummings, J. D., Lalonde, D. and R. D. Phillips. 2002. Managing Risk Using Risk-linked Catastrophic Loss Securities. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- Cutler, D. M. and R. J. Zeckhauser. 1999. Reinsurance for Catastrophes and Cataclysms. In *The Financing of Catastrophe Risk* ed. K. A. Froot. Chicago: The University of Chicago Press.
- Doherty, N. A. 2000. *Integrated Risk Management: Techniques and Strategies for Managing Corporate Risk*. New York, NY: McGraw-Hill.

- Dong, W., H. Shah and F. Wong. 1996. A Rational Approach to Pricing of Catastrophe Insurance. *Journal of Risk and Uncertainty*, 12.
- Downton, M. W. and R. A. Pielke. 2001. Discretion Without Accountability: Politics, Flood Damage, and Climate. *Natural Hazards Review*, 2.
- Dunfee, T. W. and A. Strudler. 2000. Moral Dimensions of Risk Transfer and Reduction Strategies. In *Managing Disaster Risk in Emerging Economies*, eds. A. Kreimer and M. Arnold. Disaster Risk Management Series. Washington, D.C.: The World Bank.
- Epstein, R. A. 1996. Catastrophic Responses to Catastrophic Risks. *Journal of Risk and Uncertainty*, 12.
- Freeman, P. K. and L.A. Martin. 2002. National systems for comprehensive disaster management: Financing reconstruction. Background Study Phase II. Washington, D.C.: The Inter-American Development Bank.
- Freeman, P. K., L.A. Martin, R. Mechler and K. Warner. 2002. Catastrophes and Development: Integrating Natural Catastrophes into Development Planning. Working Paper Series. Disaster Management Facility. Washington, D.C.: The World Bank.
- Froot, K. A., E. Asaff, C. McGhee, P. Sullivan, R. McDaniels, B. Thomas, J. Major, J. Norton and D. BarYaacov. 1998. The Evolving Market for Catastrophic Event Risk. New York, NY: Guy Carpenter & Company.
- Froot, K. A. and P. G. J. O'Connell. 1999. The Pricing of U.S. Catastrophe Reinsurance. In *The Financing of Catastrophe Risk*, ed. K. A. Froot. Chicago: The University of Chicago Press.
- Froot, K.A. 1999. The Market for Catastrophe Risk: A Clinical Examination. Cambridge, MA: National Bureau of Economic Research.
- Froot, K.A. and S. Posner. 2000. Issues in Pricing Catastrophe Risk: A Comprehensive Look at the Pricing of Catastrophe Risk. New York, NY: Special Report. Guy Carpenter & Company.
- Froot, K. A., D.S. Scharfstein and J. C. Stein. 1994. A Framework for Risk Management. *Harvard Business Review*, November-December.
- Gurenko, E. N. 2000. The Role of World Bank in Supporting Turkish Catastrophe Insurance Pool. Presentation at Innovations in Managing Catastrophe Risks World Bank Conference, Washington, D.C.
- Guy Carpenter. 2000. Managing the Financial Impacts of Natural Disaster Losses in Mexico: Government Options for Risk Financing & Risk Transfer. Latin America and the Caribbean Region. Washington, D.C.: The World Bank.
- _____. 2002. The World Catastrophe Reinsurance Market: 2002. New York, NY: Guy Carpenter & Company.
- Heike, D. and V. Samari. 2001. Catastrophe-linked Securities: Will 2001 be the Year of the Cat-bond? Fixed Income Research. New York, NY: Lehman Brothers.
- Heike, D. and J. Kiernan. 2002. Improving Portfolio Performance with Catastrophe Bonds. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.

- Hillier, B. 1997. *The Economics of Asymmetric Information*. New York, NY: St. Martin's Press.
- Hoogeveen, J. G. M. H. 2000. Risk and Insurance by the Poor in Developing Nations. In *Managing Disaster Risk in Emerging Economies*, eds. A. Kreimer and M. Arnold. Disaster Risk Management Series. Washington, D.C.: The World Bank.
- Inter-American Development Bank. 2000. Facing the Challenges of Natural Disasters in Latin America and the Caribbean: An IDB Action Plan. Sustainable Development Department. Washington, D.C.: Inter-American Development Bank.
- Insurance Services Office. 1996. Managing Catastrophe Risk. Insurance Issue Series. New York, NY: ISO.
- _____. 1999. Financing Catastrophe Risk: Capital Market Solutions. Insurance Issue Series. New York, NY: ISO.
- Jaffee, D. M. and T. Russell. 1997. Catastrophe Insurance, Capital Markets, and Uninsurable Risks. *Journal of Risk and Insurance*, 64.
- Kaplow, L. 1991. Incentives and Government Relief for Risk. *Journal of Risk and Uncertainty*, 4.
- Khater, M. and D. Kuzak. 2002. Natural Catastrophe Loss Modeling. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- Kleindorfer, P. R. and H. C. Kunreuter. 1999. Challenges Facing the Insurance Industry in Managing Catastrophic Risks. In *The Financing of Catastrophe Risk*, ed. K.A. Froot. Chicago: The University of Chicago Press.
- Kreimer, A., M. Arnold and A. Carlin. 2003. Building Safer Cities: The Future of Disaster Risk. Disaster Risk Management Series No. 5. Washington, D.C.: The World Bank.
- Kunreuter, H. 1996. Mitigating Disaster Losses Through Insurance. *Journal of Risk and Uncertainty*, 12.
- Lahiri, A. K., T.K. Sen, R.K. Rao and P. R. Jena. 2001. Economic Consequences of the Gujarat Earthquake. New Delhi: National Institute of Public Finance and Policy.
- Larson, L. and D. Plasencia. 2001. No Adverse Impact: New Directions in Floodplain Management Policy. *Natural Hazard Review*, 2.
- Lester, R. and E. Gurenko. 2003. Financing Rapid Onset Natural Disaster Losses in India: A Risk Management Approach. Technical Paper. Washington, D.C.: The World Bank.
- Lewis, C. M. and K. C. Murdock. 1996. The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters. *Journal of Risk and Insurance*, 12.
- Litzenberger, R., D. Beaglerhole and C. Reynolds. 1996. Assessing Catastrophe-reinsurance-linked Securities as a New Asset Class. *The Journal of Portfolio Management*, Special Issue.
- Major, J. A. 1999. The Uncertain Nature of Catastrophe Modeling. In *Natural Disaster Management*. London: Tudor Rose.

- Major, J. A. and R. E. Kreps. 2002. Catastrophe Risk Pricing in the Traditional Market. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- McGhee, C. and J. Eng. 2003. Market Update: The Catastrophe Bond Market at Year-End 2002. New York, NY: Masrsh & McLennan Securities.
- Miller, K. D. 1998. Economic Exposure and Integrated Risk Management. *Strategic Management Journal*, 19.
- Mocklow, D., DeCaro and M. McKenna. 2002. Catastrophe Bonds. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- O'Brian, T. 1997. Hedging Strategies Using Catastrophe Insurance Options. *Insurance Mathematics and Economics*.
- Palm, R. I. 1990. *Natural Hazards: An Integrative Framework for Research and Planning*. Baltimore: Johns Hopkins University Press.
- Pettersen, I, J.M. Skjelvik and N.A. Krokeide. 2005. Exploiting International Financial Markets to Manage Natural Hazard Risks in Latin America. Washington, D.C.: Inter-American Development Bank.
- Pollner, J. D. 2000. The Management of Catastrophe Risks Using Pooled Insurance Structures and Alternative Financing & Risk Transfer Mechanisms: The Insurance Market and the Case of the Caribbean Region. Latin America and the Caribbean Region. Washington, D.C.: The World Bank.
- Pollner, J. D. 2001a. Honduras. Catastrophe Risk Exposure of Public Assets: An Analysis of Financing Instruments for Smoothing Fiscal Volatility. Latin America and the Caribbean Region. Washington, D.C.: The World Bank.
- Pollner, J. D. 2001b. Managing Catastrophic Disaster Risks Using Alternative Risk Financing and Pooled Insurance Structures. Technical Paper. Washington, D.C.: The World Bank.
- Priest, G. L. 1996. The Government, the Market, and the Problem of Catastrophic Loss. *Journal of Risk and Uncertainty*, 12.
- Sejenovich, H. and G. C. Mendoza. 2000. Economic Aspects of Floods: The Case of Argentina. In *Managing Disaster Risk in Emerging Economies*, eds. A. Kreimer and M. Arnold. Disaster Risk Management Series. Washington, D.C.: The World Bank.
- Sigma 5. 1996. Insurance Derivatives and Securitization: New Hedging Perspectives for the US Catastrophe Insurance Market? Zurich: Swiss Re Publishing.
- Siri, G. 2001. Targeting Assistance Toward Those Most Affected by Disasters: The Role of Social Investment Funds. Paper draft for the Wharton-World Bank Conference "Innovations in Managing Catastrophe Risks: How Can They Help the Poor?" January 8-10, Washington, D.C.
- Shleifer, A. and R. W. Vishny. 1993. Corruption. *Quarterly Journal of Economics*, 108.
- Smith, Keith. 1992. *Environmental Hazards: Assessing Risk and Reducing Disaster*. London: Routledge.
- Standard & Poor's. 2000. Insurance Securitization: Weathering the Storm. Sector Report. New York, NY: S&P.

- Takeda, Y. 2002. Risk Swaps. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- Townsend, R. M. 1995. Consumption Insurance: An Evaluation of Risk-bearing Systems in Low-income Economies. *Journal of Economic Perspectives*, 9.
- Vatsa, K. S. and F. Krimgold. 2000. Financing Disaster Mitigation for the Poor. In *Managing Disaster Risk in Emerging Economies*, eds. A. Kreimer and M. Arnold. Disaster Risk Management Series. Washington, D.C.: The World Bank.
- Wang, S. 2002. Pricing of Catastrophe Bonds. In *Alternative Risk Strategies*, ed. M. Lane. London: Risk Books.
- Woo, G. 1999. *The Mathematics of Natural Catastrophes*. London: Imperial College Press.
- Zeckhauser, R. 1996. The Economics of Catastrophes. *Journal of Risk and Uncertainty*, 12.

Annex

Regression Analyses of Indirect Economic Effects of Disasters in the LAC Region, 1981-2000

----- Annual Real Per Capita Growth in GDP _t -----					
standardized coefficients (t-values)	MODEL I	MODEL II	MODEL III	MODEL IV	MODEL V
Constant	1.878** (6.975)	-3.327** (-6.195)	-2.700** (-4.405)	-2.815** (-5.213)	-2.338** (-3.821)
GDP Growth _{t-1}	-	-	-	0.166** (4.048)	0.142** (3.446)
Flood Events _t	-0.051 (-1.026)	0.025 (0.569)	0.015 (0.349)	0.335 (0.335)	0.007 (0.159)
Flood Events _{t-1}	-0.014 (-0.277)	-0.003 (-0.066)	0.000 (-0.005)	-0.002 (-0.048)	0.001 (0.034)
Flood Events _{t-2}	-0.071 (-1.448)	-0.009 (-0.209)	-0.014 (-0.334)	-0.018 (-0.434)	-0.023 (-0.547)
Storm Events _t	0.021 (0.432)	-0.003 (-0.076)	0.008 (0.192)	-0.009 (-0.201)	0.005 (0.114)
Storm Events _{t-1}	0.098* (2.106)	0.098* (2.288)	0.108* (2.569)	0.091* (2.158)	0.099* (2.391)
Storm Events _{t-2}	0.039 (0.795)	0.013 (0.291)	0.003 (0.069)	-0.009 (-0.194)	-0.015 (-0.338)
Earthquake Events _t	-0.095* (-1.985)	-0.040 (-0.985)	-0.048 (-1.191)	-0.032 (-0.808)	-0.041 (-1.045)
Earthquake Events _{t-1}	0.029 (0.615)	0.049 (1.230)	0.044 (1.130)	0.083 (1.603)	0.057 (1.471)
Earthquake Events _{t-2}	-0.043 (-0.897)	-0.029 (-0.719)	-0.031 (-0.774)	-0.040 (-1.002)	-0.039 (-1.004)
Drought Events _t	-0.082* (-1.745)	-1.020 (-0.485)	-0.017 (-0.424)	-0.012 (-0.301)	-0.011 (-0.269)
Drought Events _{t-1}	0.050 (1.068)	0.042 (1.020)	0.049 (1.224)	0.056 (1.384)	0.061 (1.531)
Drought Events _{t-2}	-0.088* (-1.901)	-0.034 (-0.843)	-0.030 (-0.753)	-0.046 (-1.172)	-0.041 (-1.062)
Initial wealth	-	-0.008 (-0.140)	-0.033 (-0.575)	0.003 (0.054)	-0.021 (-0.367)
Gvt. Consumption	-	0.646** (16.461)	0.670** (16.858)	0.610** (15.525)	0.835** (15.719)
Corruption	-	-0.210** (-5.373)	0.175** (4.244)	-0.174** (4.425)	-0.149** (3.600)
Dev. Assistance _t	-	-	0.115 (-1.122)	-	-0.084 (-0.834)
Dev. Assistance _{t-1}	-	-	0.356** (3.039)	-	0.328** (2.839)
Dev. Assistance _{t-2}	-	-	-0.237* (-2.487)	-	-0.243 (-2.588)
Aid _t	-	-	-0.075 (-1.192)	-	-0.079 (-1.289)
Aid _{t-1}	-	-	-0.172** (-2.652)	-	-0.135* (-2.083)
Aid _{t-2}	-	-	0.118* (1.189)	-	0.105* (1.707)
N	339	339	339	339	339
Multiple R ²	0.516	0.536	0.546	0.539	0.564
Adjusted R ²	0.494	0.503	0.507	0.506	0.516
F-significance	0.000	0.000	0.000	0.000	0.000

* p < 0.10; * p < 0.05; ** p < 0.01