CATASTROPHE RISK MODELLING AND INSURANCE PENETRATION IN DEVELOPING COUNTRIES

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ABSTRACT:

The highest economic losses caused by natural catastrophes usually burden developed countries, as they have much more assets exposed to natural hazards, despite being less vulnerable. For example, events such as Kobe earthquake (1995) and Hurricane Katrina (2005) with economic losses of over $100 billion each, are known as biggest economic disasters in history. However, the adverse effects of natural hazards on the developing countries are far more destructive given their small-sized economy and the lack of proper risk management framework. Due to lack of proper catastrophe risk management strategies in the developing countries, sourcing the necessary financial funds for reconstruction and rehabilitation remains as the government's responsibility, resulting in great pressure on the country's economic structure. If governments are to pay for these losses, they have to either divert funds already assigned to other development projects or request help from international donors. This article tries to open discussion on how natural catastrophe loss modelling can help natural catastrophe risks in developing countries to be absorbed in the wider market, with resulting financial benefits to households, local industries, governments, domestic insurers and international reinsurers.

KEYWORDS: Catastrophe loss modelling, developing countries, seismic risk,

1 INTRODUCTION

Population in many of the large cities in the developing countries has seen rapid growth in recent years mostly as a result of economic and social migration. The urban population in developing countries has increased from less than 18 percent in 1950 to more than 40 percent in the year 2000. These cities therefore, had to be extended in order to cope with such rapid increase in demand for more residential buildings. A healthy increase in population capacity in big cities should take place by geographical extension of the city borders, or sometime by the establishment of satellite suburban regions in the vicinity of major cities, taking into account other land use planning considerations. Although such extension sometimes may have adverse impact on the environmental factors and city green belts, it certainly requires governmental investment in land preparation, infrastructure implementation and lifeline and utility development.

However, experiences in some of the unplanned fast growing cities in the developing countries show that such extension is not usually happening horizontally, instead higher rise buildings are developed in already densely populated areas. On the other hand, in the absence of proper mitigation measures, the vulnerability of such buildings remains a big concern, which could result in potential economic and humanitarian disaster. The damages and loss of life associated with the 1999 Izmit earthquake in Turkey highlighted this issue in conjunction with the high vulnerability of such buildings.

This article tries to open discussion on how natural catastrophe loss modelling can help natural catastrophe risks in developing countries to be absorbed in the wider market, with resulting financial benefits to households, local

industries, governments, domestic insurers and international reinsurers. Results of a pilot study for one of the city district in Tehran, the capital city of Iran are presented in this paper too.

2 DEVELOPING COUNTRIES AND NATURAL CATASTROPHES

Natural catastrophes, due to their unpredictable nature on one hand, and potential implications for the built environment and human activity on the other, have long caused disruption to communities and damage to economies, especially in underdeveloped and developing countries. Such events, in addition to the short-term humanitarian and social disruptions, usually entail long-term economic and financial consequences that survivors must endure for months, if not years and years, after the catastrophe. A brief review of the natural catastrophe financial and economic effects of events in the last couple of decade reveals an increasing trend in the annual average losses related to natural catastrophes, from almost $20b in 1990 to almost $70b in 2004 (Munich Re, 2002). The year 2005 happened to break such records, with the economic losses of more than $220 billion related to hurricanes Katrina and Rita in the United States and a few other earthquake and flood related catastrophes in Europe and Asia (Swiss Re, 2005).

Despite significant scientific and technological achievements made in recent years with regard to the assessment and mitigation of natural hazards, one may point to several reasons for continuing upward trend in the catastrophe related casualties and economic losses. The increase in the frequency and severity of natural catastrophe losses is the direct result of human actions. While geo-related hazards are considered natural phenomena, their losses are not completely natural and are correlated to the development growth. The rapid and unplanned urbanization in the developing world in the recent decades has exposed a growing proportion of the world's population to natural hazards. Factors such as population growth, concentration and exposure of more assets to natural hazards, improvement in life conditions and expectations, greater dependency on technology and infrastructures, and the extended development of vulnerable buildings into more hazardous areas are principal reasons for this trend (*e.g*. Gurenko, 2004)

Fast-growing populations and inappropriate socioeconomic and governmental policies have created more demand for residential and commercial buildings in many large cities in developing countries. The urban population in developing countries has increased from less than 18 percent in 1950 to more than 40 percent in the year 2000. These cities have recently experienced rapid extension in order to accommodate more people immigrating form other underdeveloped regions. However, such city extensions have been taken place more vertically rather than horizontally due to certain social, economic, political and land use management factors. On the other hand, in the absence of proper mitigation measures, the vulnerability of such buildings remains a large concern, owing to the potential economic and humanitarian impact. The damage and loss of life associated with the 1999 Izmit earthquake (*e.g*. EERI, 1999 and Erdik, 2000), the 2003 Bam earthquake (Zolfaghari, 2004) and quite recently the 12 May 2008 Sichuan (China) earthquake highlighted this issue together with the high vulnerability of such buildings.

3 ROLE OF GOVERNMENTS

Governmental disaster management agencies have traditionally focused on actions that can be taken immediately before, during, or shortly after disasters to reduce the loss of life and economic damage. Effective natural catastrophe risk management is becoming a legitimate responsibility for many government and development agencies around the world and the approach to disaster management has recently evolved towards the wider concept of risk management principles. Governments in developing regions have become greatly concerned about the fiscal implications of total responsibility for natural catastrophe losses. Many governments in the developing countries have begun to take proactive measures to minimize their exposure to natural catastrophe through a number of risk management principles such as risk assessment, vulnerability reduction and risk transfer:

3.1 ***Risk Assessment***

The first step towards any rational risk management efforts is the thorough understanding of spatial and temporal distribution of natural catastrophe risk. This is usually achieved through assessment of regional natural hazard, built environment inventory and their vulnerability. Natural catastrophe risk modelling has been under significant improvement in the last 10-15 years. Recent development in computer technology, information quality and need for natural catastrophe models provide necessary requirement for further investment and development of user-friendly catastrophe computer loss models. Probabilistic loss estimates from such models are ideally suited to risk management entities as well as to the growing insurance and reinsurance industries.

3.2 ***Risk Reduction***

Risk reduction measures are considered to mitigate damage from natural hazards. Such measures for existing buildings address reduction of vulnerability through measures such as retrofit, strengthening and relocation. Other actions could be taken in order to reduce the vulnerability of the new buildings, through the implementation and enforcement of building standards, environmental protection measures, and land use planning that recognizes hazard zones and resource management practices. Despite such measures there are several factors which still remain outstanding in the developing countries which have resulted in a lack of improvement in the vulnerability of new buildings. In countries with proper implication of seismic design code, better performance is expected for newer buildings.

3.3 ***Risk Transfer***

For potential losses which could not be mitigated through structural or preventive damage reduction measures, or those exposed to very low frequency but high severity hazard, insurance mechanisms are used to transfer risks to other parties, including standard insurance and reinsurance contracts as well as the creation of contingency funds to build up economic and fiscal resilience in the face of natural hazards. Financial authorities in developing countries are seeking ways to transfer risk responsibility for the necessary coverage to households and businesses in exposed areas. This approach has shown to be effective in many developed counties with well established private sector insurance structure in place, capable of spreading risks nationwide and internationally. Risk transfer is considered an important step towards transferring responsibility for post-disaster recovery from the government to households in risk zones, and in doing so provides incentives for property owners to retrofit their apartments and take other mitigation measures (Gurenko & Lester, 2004). Due to the low frequency and high severity of natural hazards, natural catastrophe poses a unique challenge to the insurance industry, both for developed and developing countries. The diversification of catastrophe losses is difficult, sometime even at the global level, as some of these events have the potential of absorbing large quantities of capital and beyond those of regional or even international insurance capacities.

4 CHALLENGES FOR INSURANCE MARKET

Despite fast growing urbanization and high concentration of exposure in hazard prone areas, insurance companies in the developing countries retain most of their exposed risks. This is mostly due to undeveloped state of their domestic insurance markets and the lack of enough understanding of their accumulated risk which result in their inability to transfer risk to international reinsurance markets. In most developing countries, providing property insurance coverage on a national scale is still a challenging task for domestic insurance companies which are mainly due to:

- Small size of insurance industry and thin capitalization
- Low property insurance penetration

- Limited range of insurance policies
- Public perception of insurance premium as kind of government taxation
- Lack of a regulatory framework for effective risk pricing and validation of vulnerabilities
- Affordability to pay adequate premium given the level of hazard and vulnerability of existing building stock
- Limited risk transfer alternatives given high costs of reinsurance especially with foreign companies
- Insufficient expertise and capital to adequately protect policyholders
- Insolvency or failure to pay claims in case of a large event

5 PROBABILISTIC CATASTROPHE LOSS MODELLING

Due to the high severity and low frequency of natural catastrophe such as earthquakes, the use of traditional actuarial methods based on historical loss records, are inadequate and incomplete. Computer risk models can be used to evaluate potential losses from future events and provide facilities for better controlling exposure to potential losses. Natural catastrophe risk modelling has been under significant improvement in the last 10 to 15 years. Availability, flexibility and reliability of such models have been under improvement in recent years which made detail risk analyses a routine practice for most insurance, reinsurance and brokers. If created, such tools will help insurance market in the developing countries to rationally quantify their status with regard to catrisk insurance rate, catrisk policy terms based on risk pricing and homeowner affordability, risk mitigation, healthy insurance penetration, risk-based premium, national awareness catastrophe insurance law and many other insurance related factors.

The development and application of a catastrophe risk model for developing countries allow for the design of sound property insurance solutions for better risk sharing between households, local insurers and international reinsurers. In general, an insurance-based catastrophe risk model consists of several main components as shown in Figure (1). There are certain parameters defining natural event characteristics at it source, in the case of earthquake for example, earthquake locations, earthquake magnitudes and energy released patterns. Several factors control the severity and frequency of building damage caused by natural hazards. Geographical distribution of natural event and their induced hazards can be categorized under hazard factor and modelled by hazard models. Translation of natural hazards to physical or monetary damage is performed by vulnerability functions. Inventory of building stock is also required in order to estimate financial impact of natural hazard on built environment.

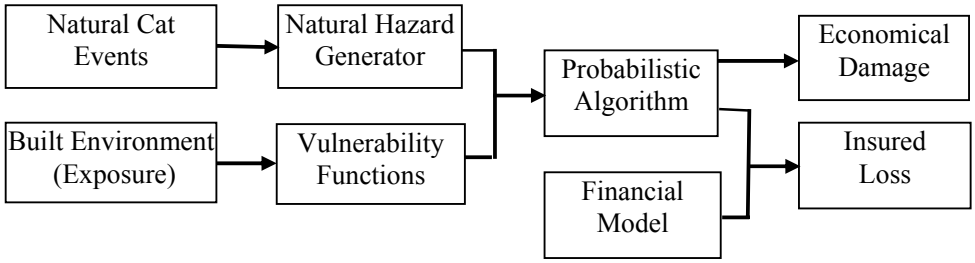


Figure 1: Main components of an insurance-based catastrophe risk model (modified from Zolfaghari, 2008)

5.1 How Catastrophe Modelling Can Help

Development of catastrophe risk model based on engineering, science and real experience are well established in the insurance and reinsurance market for the developed countries, with an overall expense of 200-300 million dollars a year. However, due to low penetration of catastrophe insurance in the developing countries, there has been no or little interest to develop such model for the developing countries. The author believes that creation of such tools not only help the governments in the developing countries to step into classic risk management

principles, but also helps higher penetration of property insurance which in turn helps the development of domestic insurance market. Additional benefits of such tools for developing countries include:

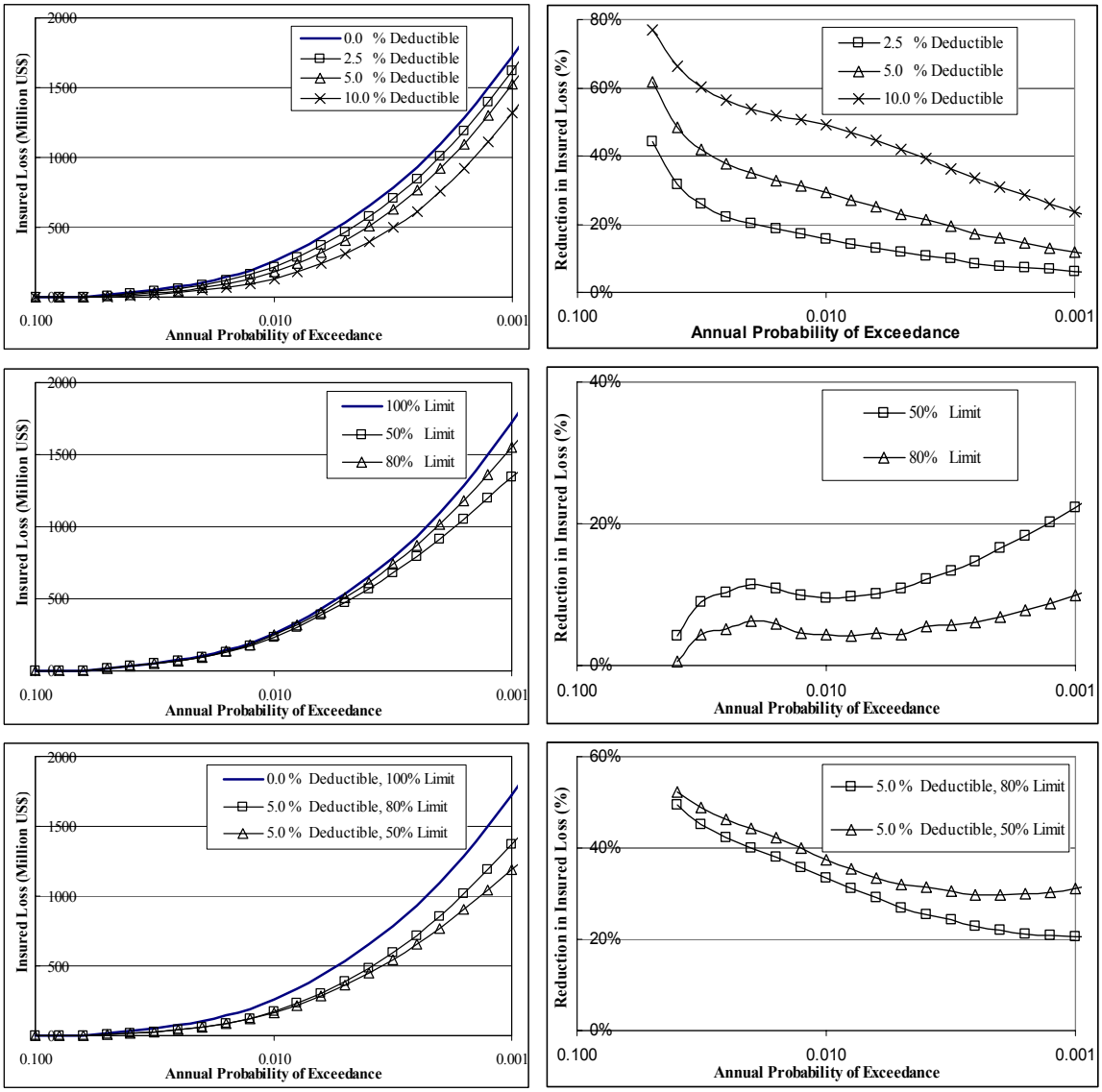
- Actuarial studies to determine rates for catastrophe insurance
- Preparation of policy terms and conditions based on risk pricing as well as regional affordability and risk attitude
- To develop a risk-based underwriting and pricing system which provide supports for changes in land use planning, help mitigation and building retrofit programs and improve building construction practices
- To increase the healthy penetration of insurance market, taking into account risk-based premium derived from proper risk assessment exercise
- To investigate available alternative risk transfer solutions
- To bring specialized expertise in catastrophe risk management to the domestic insurance sector and assist the industry to build a well-capitalized professionally managed specialized insurance market
- To increase national awareness and education on the risk of natural disasters
- To review of the existing legislation and preparation of the catastrophe insurance law
- Vulnerability assessments of the housing stock and lifelines

6 PILOT STUDY

As an example, application of catastrophe risk model for residential buildings in one of the city district in Tehran, as conducted by Zolfaghari (2008) is presented here. Despite high potential natural catastrophe exposure, the penetration of property insurance in Iran is relatively low. Among many factors contributing to low insurance penetration are lack of proper risk assessment measures towards effective risk pricing and also low affordability for the general public to pay for adequate premium, given the level of hazard and vulnerability of existing building stock.

In this study, the residential building stock for District 3 in the north-eastern part of Tehran, as a pilot region, are modelled against probabilistic earthquakes in order to assess potential economic losses. The main objective for this exercise is to show how computer loss modelling can help in the optimal design of property insurance contracts for cities such as Tehran, where people cannot afford the full risk-based insurance premium. It demonstrates how residential insurance contracts can be designed to better facilitate the degree of risk sharing between households and insurance companies by using policy conditions such as risk deductibles and limits. To illustrate such concepts, the effects of risk deductibles and limits on insured losses for residential buildings in the study area are investigated. Figures (2a) and Table (1) show the effect of various policy deductible on probabilistic seismic losses for this area. The deductible values used in this study show percentages of total insured value (building replacement values). The reduction in the insurer's liability at different return periods are also shown in Figure (2b). As expected, high probable losses are more influenced by deductibles, while low probable losses are less sensitive to deductible values. The insurance deductible in fact filters out small but frequent losses from the insurer's liability as shown in Figures (2a and 2b). This is due to the fact that low-level seismic ground motions are more frequent and as a result minor damages to properties can be absorbed by deductibles and are therefore retained by policyholders.

Zolfaghari (2008) also showed that similar loss reduction can be achieved by capping insured losses at a certain level using policy limit. Figures (2a and 2b) also show loss sensitivity to various insurance limits. The effect of a policy limit on the loss curve, as one can imagine, is opposite to that of a deductible. Losses with low probability are less sensitive to the insurance limit. The effects of insurance limits are most pronounced for the earthquakes of low probability / high severity. Such events have the capacity to damage buildings beyond the specified limit. The design of affordable insurance products sometime requires the use of both deductibles and limits. Figures (2a and 2b) also show the combined effects of deductibles and limits on the probabilistic losses for this area.



a b

Figure 2 Effect of policy deductibles and limit on insured losses for residential buildings in Tehran District 3 a) Probabilistic loss curves b) Loss reduction ratios induced by policy deductible and limit (Zolfaghari, 2008)

Policy Conditions		Probabilistic Seismic Loss Ratio					
Deductible (%)	Limit (%)	AML	50 years	100 years	250 years	500 years	1000 years
0.0	100	0.23%	2.11%	5.19%	13.05%	22.02%	34.76%
2.5	100	0.20%	1.68%	4.39%	11.65%	20.31%	32.59%
5.0	100	0.18%	1.37%	3.68%	10.28%	18.49%	30.66%
10.0	100	0.14%	0.97%	2.65%	7.93%	15.24%	26.60%
0.0	50	0.19%	1.86%	4.70%	11.47%	18.39%	27.00%
0.0	80	0.21%	1.97%	4.97%	12.33%	20.50%	31.30%
5.0	50	0.14%	1.17%	3.25%	8.97%	15.48%	23.95%
5.0	80	0.16%	1.26%	3.46%	9.71%	17.21%	27.61%

Table 1 Probabilistic loss ratios by policy condition, for residential buildings in District -3 in Tehran (Zolfaghari, 2008)

Catastrophe loss assessment tools, in addition to probabilistic loss curves, provide annual mean losses (AML) mostly used by insurers to estimate their premium. AML is representative of the long-term annualized expected losses that insurance company may suffer and therefore, on top of which other costs (surcharges, profits and uncertainties) are loaded to arrive at an insurance premium. The effects of policy deductibles and limits on insured losses are not specific to the PML's only but are also observed in the annual mean losses (AML) (Table 1). Therefore, the proper application of computer loss models can enable insurer to optimize its insurance products to meet its widespread market demand and also to manage its capacity while still providing affordable products to customers.

7 CONCLUSIONS

The adverse economic effects of natural hazards on developing countries are far more significant than with developed countries. This is mainly due to limited financial resources available to developing countries and the lack of proper risk management strategies and programmes. Dealing with natural hazard makes several challenging issues for governments in these countries. Managing and sharing the limited financial resources between risk mitigation measures and pooling for post-disaster recovery plans remains a key challenge. Despite rapid urbanization and the high concentration of exposures in hazard prone areas, the penetration of property insurance products in developing countries is quite limited. This is mostly due to undeveloped state of the domestic insurance markets and the lack of appreciation of the extent of accumulated risk which result in their inability to transfer risk to international reinsurance markets. This paper has attempted to highlight how catastrophe risk assessment tools, used together with reliable building inventories and scientific knowledge, can help the insurance industry to design affordable yet manageable catastrophe insurance products. The development and application of such tools open up the possibility of the creation of a robust property insurance framework – one that allows for the improved risk sharing between households, national or regional insurers, and international reinsurers.

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