

# Catastrophe Risk Management

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## Abstract

*Catastrophe risk is a danger that threatens property and persons, whose realisation can result in human victims and material damage. The choice of this paper's topic is consequence of continuously growing frequency and identity of catastrophe events and need of sustainable models for managing and funding disasters. Developing countries are much more vulnerable to the consequences of catastrophe losses, that threaten sustainable development, especially in the long run and therefore the traditional ex-post model for managing these risks must be changed.*

**Keywords:** catastrophies, risks, insurance, funding

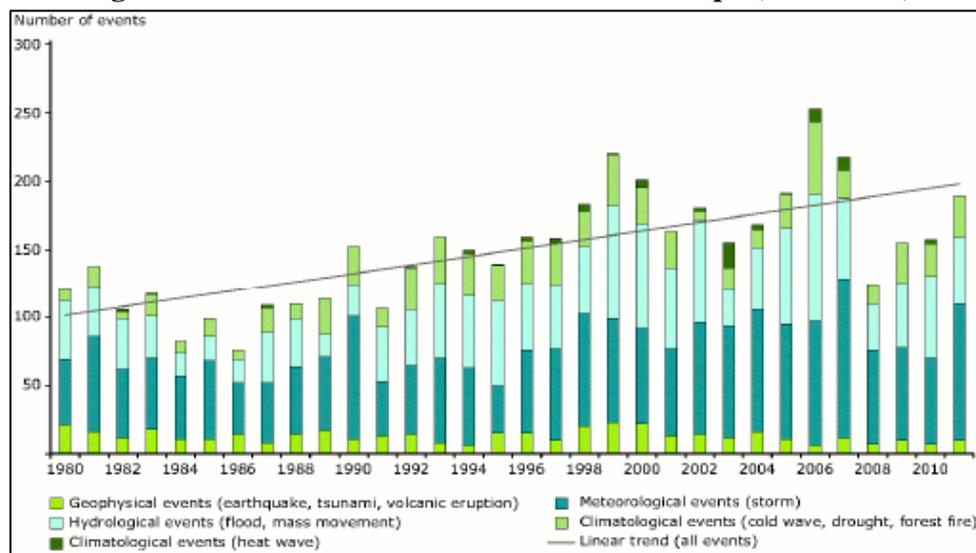
**JEL Nr.:** G22, insurance; insurance companies; actuarial studies

## Introduction-The importance of the topic and research

In last several decades, many natural disasters happened and the number of catastrophe events are rising globally. Increasing population density and the accumulation of the assets values affect that potential consequences of catastrophic events can be greater than ever before. If we want to illustrate dimensions of danger, we can see that average number of natural disasters in Europe was 104 per year in the ninth decade of the 20th century, while in the first decade of the 21th century it soared to 179 (Figure 1). In different parts of the world, international organisations and associations, governments and people are struggling with different types of disasters. In east and south Asia, central and south America, geographical events dominate (earthquakes, tsunami, etc), while in Europe meteorological and hydrological events dominate (storms, floods, mass movements), and frequent types of natural disasters are also other types of climate events (draughts, forest fires, cold waves, etc). Europe has slightly better structure of these events because in some cases it is possible to predict them or to provide prevention activities in order to minimize losses.

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**Figure 1. Number of natural disasters in Europe (1980-2011)**

Source: European Environment Agency, Climate Change, Impact and Vulnerability in Europe 2012 - and Indicator-Based Report, EEA Report 12/2012

Every year, as a result of catastrophe events, large number of people suffer and huge damages of assets happen. Defining the concept of catastrophic risk varies depending on the conditions of taking this risk by reinsurance companies. *Swiss Re* classifies an event as catastrophic by taking three factors: the amount of insured damages, total damage and number of human victims (casualties). According to *Munich Re*, catastrophic events are all natural events that have resulted in over 20 human victims and damage of more than \$50 million.

Risks of catastrophe events include:

- risks of natural disasters (earthquake, storm winds, floods, volcanic eruptions),
- risk of critical infrastructure (transmission systems, the water supply, electricity, complex systems),
- the risk of human factor (terrorism),
- catastrophe environmental risks (climate change, genetic engineering, nuclear power plants).

### Developing opportunities and catastrophe events

Catastrophe risk realization leads to dramatic human casualties, destruction of economic and social infrastructure, as well as to environmental damages. In short term, as result of natural disasters, 100.000 human lives are lost in the world per year and it is estimated that global amount of material losses will overcome USD 300 billion annually by 2050. Further, losses of natural resources (water, forests, biodiversity, etc) are difficult to estimate and generally impacts of disasters are usually underestimated. Short-term results affect long-term consequences for country development, more precisely, on economic and social conditions, which are impaired through escalation of poverty and reducing economic activities. Vulnerability of country to catastrophe risks is determined by a complex, dynamic set of factors,

including economic structure, level of development and prevailing economic and social conditions.

Speaking about damage of catastrophe events in absolute terms, level of damage is greater in developed economies, because of high concentration and accumulation of assets values. In relative terms, in comparison with GDP level, the damage of this events is greater in small and undeveloped countries. Beyond, in economically developed countries, the harmful effects of catastrophe events, are usually compensated through a combination of advanced private financial arrangements and efficient schemes of public revenues, based on powerful taxation systems. In developed economies more than 40% of damages in catastrophe events are insured, in developing countries 10% and in underdeveloped counties 5% of losses are insured. This shows that the insurance market and market mechanisms are not developed in developing and underdeveloped countries. Because of that, the fiskal pressure in this economies is growing in catastrophe events periods. Ability of developing countries to minimize and limit their fiscal exposure and pressure is becoming priority for their sustainable development.

The opportunity costs of the ex-post financing strategy of catastrophe damages in developing countries are relatively high. The resistance of catastrophe risks is increasing with higher level economic development, but also, as we saw before, can contribute to their emerging.

**Table 1. Interdependance of development and catastrophe risks**

	<b>Economic development</b>	<b>Social development</b>
<b>Catastrophe events limit development opportunities</b>	Destruction of fixed assets. Loss of production capacity, market access or material inputs. Damage to transport, communications and energy infrastructure. Erosion of livelihoods, saving and psysical capital.	Destruction of health or education infrastructure and personnel. Death, disablement or migration of key social actors leading to an erasion of social capital.
<b>Development causes catastrophe risks</b>	Unsustainable development practices that create wealth for some at the expense of unsafe working, living conditions for others, degrade the environment.	Development paths generating cultural norms that promote social isolation or political exclusion.
<b>Development reduces catastrophe risks</b>	Access to adequate drinking water. food, waste management and a secure dwelling increases peoples` s resiliency. Trade and technology can reduce poverty. Investing in financial mechanisms and social security can cushion against vulnerability.	Building community cohesion, recognizing excluded individuals or social groups (such as women), and providing opportunities for greater involvement in decision-making enhanced educational and health capacity increases resiliency.

*Source:* United Nation (2004) Reducing disaster Risk: A Challange for Development . New York: United Nations, p. 20.

Losses caused by catastrophe events can be classified into direct losses, indirect losses and secondary effects. When these events cause physical damages to

infrastructure (economic-telecommunication network, railroads, transportation roads, airports, etc. and social-hospital, schools, cultural buildings, etc.), assets, stocks that are direct losses. Fall of productivity, loss of earning, rise of medical expenses and disruption of flows of goods and services are classified into indirect losses. Previously, some kinds of secondary effects are mentioned. That are pressure on fiscal and monetary performances, impact on wealth distribution and on the overall economic and social circumstances.

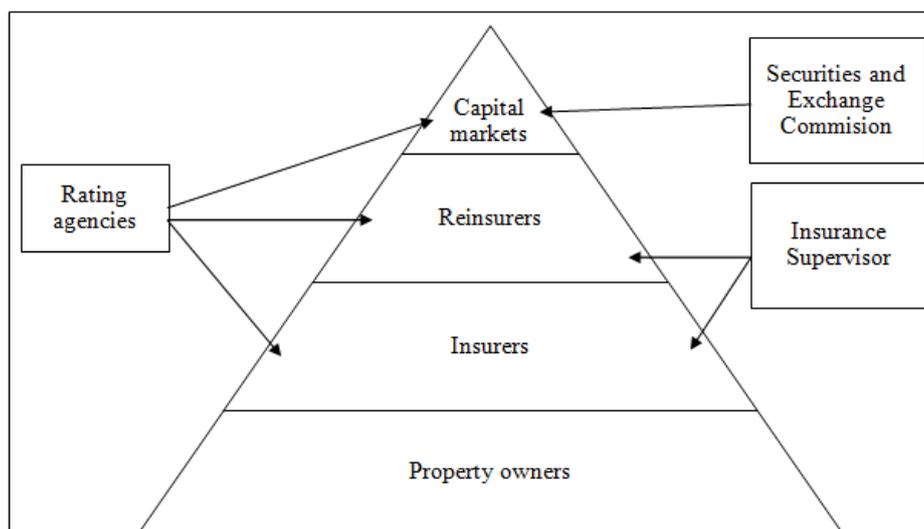
### Natural disasters risk financing models

The increase of catastrophes number and escalation of amount of following losses and costs set problem of sustainable financing of natural disasters consequences as well as financing prevention, as very important. Models of sustainable financing disasters may be divided into public and private, according OECD on the base of theoretical framework and comparative practice worldwide.

#### *Models of sustainable financing catastrophe events by private sector*

In this model of financing is several stakeholders who have role in catastrophe risk management (Figure 2).

**Figure 2. Key private sector stakeholders in catastrophe risk management process**



*Source:* Gross, P. Kunreuther, H. (2006). Catastrophe modeling: A new Approach to Managing Risk. Boston: Springer, p. 8.

In this Figure, stakeholders of catastrophe events insurance are shown and on the bottom of the pyramid are property owners. Their assets are threatened by natural disasters and they are faced with potential losses. Catastrophe risks that threaten property owners can be transferred to insurers, who further may transfer these risks to reinsurers. In recent years, capital market, which is on the top, provides financial

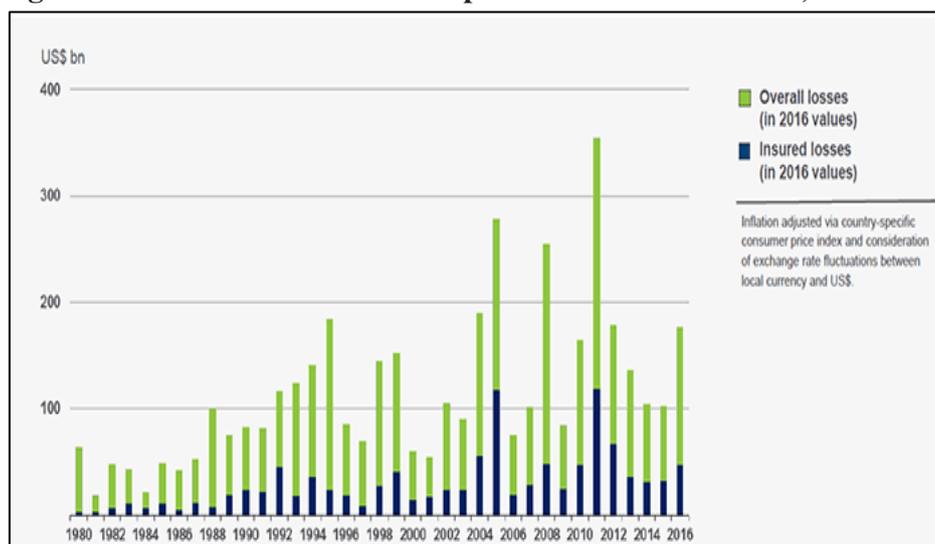
protection of insurers and reinsurers. Mechanism of that protection is being transferred through alternative risk techniques (ART), in the form of catastrophe bonds (cat bonds) and derivatives associated with catastrophe events.

Property owners have several management strategies to avoid or to reduce losses. Risk control means measures of prevention and reduction (using high quality materials in construction, strict regulation, etc.). Another one is to transfer risk to insurance companies, through purchase insurance policies. Individual preferences impact on choice of strategy, but, as a rule, the owners of commercial buildings take on a more active role in catastrophe risk management, compared to homeowners, who usually underestimate such risks.

The important question, for sustainable development of the economies, is market-based insurance models of natural disasters, because countries with higher contribution of private sector to manage their risks are less exposed to fiscal stresses. Therewith, the United Nations Convention on climate change (1992) and the Kyoto protocol point to the (re)insurance sector as momentous for managing their risks. Other protocols and agreements that deal with this topic (e.g. Hyogo Framework for Action 2005-2015) on international level indicate the importance for sustainable development of transferring risks to (re)insurance companies and promoting activities to strengthen resilience of societies to catastrophe events.

Amount of overall losses as well as insured losses have risen according to the global data (<http://www.iii.org/fact-statistic/catastrophes-global>) since 1980. Growth of losses is more expressed than growth of insured losses amount and the uptake rate of natural disaster insurance is still low - around 10% of policyholders tend to buy supplementary insurance against natural disaster risks (OECD 2003).

**Figure 3. World Natural Catastrophes Overall And Losses, 1980–2016**



*Source:* Insurance Information Institute, Catastrophies Global (available at <http://www.iii.org/fact-statistic/catastrophes-global>)

There are several different insurance regimes worldwide. Insurance uptake rate is the lowest in countries with voluntary regimes and rates are between 5% and 10% in Austria, Germany, Italy, the Netherlands. Some countries have bundled system, that

covering disaster risk and different kinds of risk in a package. As a rule, in that countries, the uptake rate is higher, from 35% in Japan to 95% in Israel and UK (OECD 2003). It is interesting that USA have more aggressive government intervention with National Flood Insurance Program, providing basic coverage for residential and commercial zones, on the areas often affected by floods. This almost doubled the uptake rate of flood insurance.

In some countries disaster risks` insurance is obligation and they have mandatory flood and storm insurance system (Poland, France, Iceland, Norway, Spain, Switzerland).

Theoretical approach to insurance lead to basic model, which describes and determines factors of insurance demand. Model distinguish separate demand factors:

- probabilities of losses,
- premium-price of insurance,
- amount of wealth,
- value of asset exposed to risk,
- individual`s utility function and risk aversion.

Individuals faced with benefits (insured risk and compensation) and costs (premium) choose to purchase or not insurance policy. Companies` demand depends of same factors as in case of individuals, except of utility function.

Economic efficiency depends of insured amount of losses caused by disasters and important questions for governments and legal entities are eliminating the moral hazard behavior stimuli and to eliminate and to reducing adverse selection problem. Sometimes state investments for lowering disaster risks, can create impression of security, reducing private insurance uptake rate, despite positive effects on infrastructure and preventing catastrophe events. Also, post-disaster assistance creates moral hazard and discourages the development of private insurance against catastrophe events.

Speaking about demand, we can add, that empirical studies shows that amount of wealht/income is positively related with demand for premium, while the price of insurance is negatively related to demand, although the elasticity is relatively low. Besides that, people tend to underrate the probability of occurrence of disasters.

On the supply side, insurers are faced with many limitations and problems that took place in modern, global world. Scarcity of adequate statistical base increase information costs and cause adverse selection problem, inability of reliable catastrophe modeling affect on appropriate product designing. Further, we can segregate other limitations and problems:

- increasing frequency of losses-percentage of world population that live in areas exposed to disaster risks is growing,
- rapidly developing world affect growing assets value as growing concentration of modern buildings located in exposed areas,
- climate changes increase a number of natural disasters, especially floods in winter and sping and draughts and wildfires in summer.

Insurance companies react on these trends and take actions towards international reinsurance operations as well to pooling arrangements, but some of them also follow more conservative policy which implies significant increase of premiums and reduction in coverage.

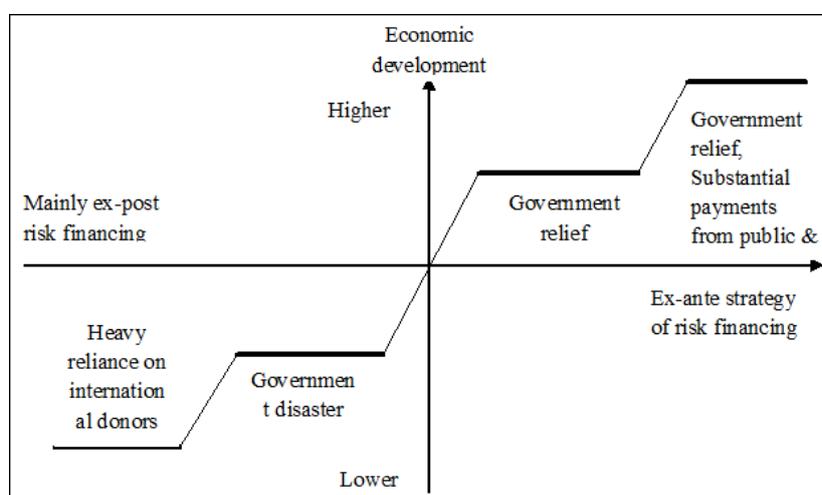
Withal, surely, progressive insurance strategy is linked with financial instruments which are connected to catastrophe events, capital markets and reinsurers. A category of such instruments are catastrophe bonds, for which disaster realization causes the principal's payment of interest to the investor.

### Models of sustainable financing catastrophe events by public sector

Ex-ante activities, by providing funds in case of disaster and ex-post activities, by providing funds after catastrophic events, are used in the model of public financing catastrophe events which consists of allocation of tax revenues. Governments take quick actions to respond on consequences of disasters in the short term, take recovery activities in mid-term and can also take activities that are based on re-construction operations in the long run.

In Figure 4, bellow, is shown that public financing model as well as catastrophe risk state management is linked and related to achieved level of economic development.

**Figure 4. The role of government in catastrophe risk management as function of achieved level of economic development**



*Source:* Michel-Kerjan, E., Zelenko, I., Cardenas, V., Turgel, D. (2011). Catastrophe Financing for Governments: Learning from the 2009-2012. MultiCat Program in Mexico, OECD Working Papers on Finance, Insurance and Private Pensions, No. 9, Paris: OECD Publishing, p. 7.

Less developed countries, on the bottom of economic development scale, are dependent of international donors which are mostly international institutions. Characteristic of their public financing model is expressive ex-post financing, which means that governments take actions after catastrophe events. Funds, collected from donors are allocated by the government.

As a rule, more developed countries choose ex-ante strategy, before disasters, to reduce probability of catastrophe events and prepare action plans in case of disaster. Even in most developed countries, when with economic development grows role of private sector in catastrophe events insurance, important role plays state in catastrophe risk management.

Previously, supply side imperfections of the private insurance market are listed and they justify the intervention by state in catastrophe risk management. Governments can apply several mechanisms, mostly ex-ante, to provide financing consequences of catastrophe events (OECD 2013):

- Government reserves - two different approaches is being applied. First, in which, reserves are located in national budgets annually, and in next year reserves of previous year are replaced. Second, in which amount of unspent reserves of current year is being transfer to budget reserves for catastrophe events management of next year, thus forming growing reserves for forthcoming losses.
- Contingent credit arrangements - governments have arrangements usually with financial institutions, that country can pull low interest resources in case of natural disasters.
- Catastrophe-linked bonds - allowing for issuance of bonds by the insurance companies, which are sold to investors at fixed return. In case of disasters, principal is witten-off, so the sponsor pays only the interest.

In compared practice worldwide, government influence on insurance market can be in three ways. State can be a direct insurer, also government can provide secondary support to private insurers by reinsuring, or take a indirect role in insurance sector defining rules and regulations to ensure the functioning of the private insurance market without direct government support.

Role of direct insuring by state means that this modality is organized and funded by the government and also, that is not based on basic principles of insurance. This modality covering a wide segment of the population, but it is not financial sustainable because a lack of basic principles of insurance, reflected in no premium rate differentiation, which cause problem of moral hazard. Also, direct premium subvention by government, can cause adverse selection problem, putting into privileged position high-risk policyholders. Further, this problem can be solved by establishing obligatory premium for insurance of natural disasters. A defect of obligatory premium is discouraging insured population to take preventive actions to reduce probability of catastrophe risk or to take activities which reduce harmful consequences of natural disasters.

Speaking about the government role in private insurance sector, it is important to say, that modality of catastrophe risk management by state with reinsurance role in market has advantage in combining government's ability to provide a broad scope of insurance coverage with private market ability to effectively apply insurance principles.

In today, global economy, with no-borders, political circumstances indicate partnerships among countries even from different continents, especially from same region of a continent. That effect of globalization gives small, open economies in same region, which are faced with natural disasters to make agreements among them, to share mutual risk of catastrophe events. Limited access to international financial markets is the reason more for small countries to make this arrangements and establish mutual funds, statistical database and know-how on relevant methodologies for comprehension of catastrophe risk.

### **Modern and innovative catastrophe risk insurance mechanisms**

Need for new, innovative risk financing modalities, appear because of rapid increase number and amount of catastrophe events losses. These tools are mostly market-based, but governments have important role in regulation.

The most widespread innovative mechanisms are (OECD 2002, OECD 2013):

- Parametric index-based weather insurance - traditional insurance mechanisms are related to time lag (from moment of disaster to moment of coverage payment) which includes insured's request for covering, damage evaluation by insurer, long procedure, etc. Consequently, this mechanism is created to improve that defect and reduce time for covering damage by insurer. The insured amount is being paid out once the agreed weather-index deviates from historical average, independent of actual losses. Using a satellite for monitoring current weather situation and collecting data in real time suppose to improve efficiency of this tool.
- Using lending institutions as risk aggregators - the index-based insurance scheme is created, serving as a hedge for credit portfolios. Index-weather values are developed for separate regions worldwide. Values are benchmark for every part of the world and they indicate payment of damage. Compensations are pre-defined as fixed percentage of value of insurance companies' portfolio.
- Insurance-linked securities - The securities values depend of current losses triggered by catastrophe events. Financing low-probability, low-frequency, high-severity disaster losses is their mostly usage.
- Public-private insurance programs - the last but not the least, these programs have important role and contribute to sustainable development of countries. Previously, it is written that combining public and private sectors can give very good results. In these programs, special private entities collect premiums and pay insured amounts for catastrophe events. Further, programs can be linked to the "bundled system" creating combination of non-life insurance (e.g. fire insurance), and disaster insurance (e.g. floods). Expectations, relations and responsibilities have to be clearly defined among participants, in order to avoid "free rider" problem.

Reasons why these mechanisms are important for sustainable financing catastrophe risk and thereby sustainable development are:

- reducing and avoidance future fiscal expenditures for recovery and reconstruction destroyed objects,
- contribution to development of a competitive private insurance market for catastrophe events causing reducing of transaction costs and increasing level of risk diversification,
- reducing moral hazard stimuli,
- creating new business opportunities for "pure" private insurance entities and companies,
- increasing operational efficiency, changing strategic focus of catastrophe risk management through redistribution of responsibilities from the government to private sector.

### **Conclusion**

Recent costly losses in regions which are considered risk-free highlighted the limited understanding of natural disasters by the risk-holder and difficulties in determining the appropriate pricing and monitoring of operations and growth without adequate tools for modeling risk. Indeed, the lack of appropriate risk models suggest that some (re)insurers can not possess adequate scales for the assessment of the risks and nature of losses that might occur in certain territories.

The biggest challenges that companies face are understanding the risks and carefully monitoring the growth of risk exposure when the demand for insurance increases, especially in emerging markets. In addition, companies must recognize the unique characteristics that define each nation. Market entry strategies will vary from country to country, and access to these areas should not be based on one general or common strategy. Therefore, the importance of a better understanding of the risks of natural disasters by the risk takers and overcoming the limitations of the models are key factors to ensure profitable growth.

Risk models are crucial for risk assessment. However, every decision based on a such model should always be made with the knowledge that risk models have numerous "blind spots". Secondary causers of losses were not considered as significant in models of earthquakes, but they have contributed significantly to the total losses. Subsequent earthquakes, tsunamis, landslides and floods are some of these secondary causers of losses. They are "blind spots" in the current models, although their potential impact on the assessment of the risks of earthquakes are significant. Insurance for industry should be considered too, as well as business interruption coverage, which compensates the company for the loss of profit due to damage to production facilities.

Correct decision-making and lack of awareness of these models is a key success factor for risk-taking and risk management. A good and experienced risk management, catastrophe models and robust reinsurance protection can help insurers to manage risk. However, these tools and techniques need to be improved and

extended so that insurers can inform risk management and reinsurance decisions in each new region and identify the hidden potential loss exposure in their portfolios. If we take into account all these catastrophic losses, which covered mainly the international reinsurance companies, we conclude that reinsurance coverage remains the most effective method to protect insurance companies from unexpected catastrophic losses.

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Insurers will have to boost capital adequacy to cover the same level of exposure to catastrophes, which will probably lead to an increase in demand for reinsurance protection. The catastrophe events in the last three years have shown that the insurance industry can operate efficiently and in the most extreme circumstances, and to play a key role in financing post-catastrophic recovery. Moreover, insurance is able to provide coverage, despite the great economic crisis, even while continuously providing coverage for many other dangers.

For economic sustainability of the insurance industry in the long term, the insurance cover need to be able to realistically reflect all the risks involved in it. If history serves as a guide, the insurance industry has a tendency to learn from painful experience after the financial events that cost them dearly. In the future, only by implementing proactive neglected samples of losses, will ensure in advance that expenses of risks be real estimated. Competitive and accessible (open) insurance market, which reflects the true risk, is crucial to maintain continuous coverage. The risk must be spread across a greater number of individuals and business owners, in order to make premium affordable. This will only be possible if awareness about the risk be raised. Only then, the insurance industry will be able to continue to play a key role in reducing risk and financing postcatastrophic recovery.