Earthquake Risk and Earthquake Catastrophe Insurance for the People's Republic of China

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Dr. Zifa Wang is managing director of Risk Management Solutions, Inc. and a research professor at the Institute of Engineering Mechanics, China Earthquake Administration.

Mr. Tun Lin is a natural resources economist of the Asian Development Bank.

Dr. George Walker is a senior risk analyst of Aon Benfield Asia Pacific.

Asian Development Bank

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org/

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Acronyms

AAL	average annual loss
CEA	China Earthquake Administration
CIRC	China Insurance Regulatory Commission
DFA	dynamic financial analysis
GDP	gross domestic product
IEM	Institute of Engineering Mechanics
PML	probable maximum loss
PRC	People's Republic of China
SME	small and medium-sized enterprise
TREIF	http://www.treif.org.tw/

Abstract

The year 2008 witnessed the regained interests in earthquake risk management and insurance in the People's Republic of China (PRC) after the Wenchuan earthquake. Locating along the southeastern edge of the Euro-Asian Plate, the PRC has a relatively high seismicity, which is manifested by the frequent occurrence of large and disastrous earthquakes in the country. Buildings and infrastructure in the earthquake-prone regions of the PRC have a relatively low earthquake resistance level. Hence, disastrous earthquakes result not only in large numbers of injuries and fatalities but also in huge economic losses from property damages. While the PRC began testing earthquake programs in the late 1980s, the penetration has been low and the government continues serving as the predominant bearer of earthquake catastrophe risk. The paper discusses historical earthquakes and earthquake risk in the PRC and the recent developments of PRC's earthquake risk reduction efforts. The general principles of earthquake programs are explained and the critical issues of formulating earthquake programs in the PRC are discussed, including lessons from earthquake insurance in other countries and other catastrophe insurance in the PRC, data issues, loss risk modeling issues, financial risk modeling issues, legislative issues, and public awareness issues. The paper concludes with policy suggestions for the Asian Development Bank in the PRC.

1. Historical Earthquakes and Earthquake Risk in the People's Republic of China (PRC)

1.1. Selected Disastrous Earthquakes in the History of the PRC

The PRC has regularly suffered from large and disastrous earthquakes. Historical records document four great earthquakes with over 200,000 human fatalities per event: (i) the 1303 Hongdong earthquake in Shanxi Province, (ii) the 1556 Huaxian earthquake in Shaanxi Province, (iii) the 1920 Haiyuan earthquake in Ningxia Hui Autonomous Region, and (iv) the 1976 Tangshan earthquake [1] in Hebei province. Disastrous earthquakes not only result in a large number of injuries and fatalities but also in huge economic losses. Table 1 shows the estimated top three loss events in the history of the PRC should they have reoccurred in 2004.[2] These are the 1668 Tancheng earthquake in Shandong province, the 1679 Sanhe-Pinggu earthquake near Beijing area, and the 1976 Tangshan earthquake in Hebei province. The projected value in 2008 would be at least 50% higher to account for the rapid economic expansion in the PRC during the last 5 years. The loss amount refers to building loss only. Mean damage ratio is the ratio of the loss amount over the exposure value. The total building loss for the 1668 event is over CNY 1.3 trillion in 2004 value.[3]

Table 1: The Reoccurrence in 2004 of the Top Three Loss Events for Historical Earthquakes
(Losses in CNY million)

Event	Magnitude	Residential Loss	Residential Mean Damage Ratio (%)	Non-residential Loss	Non-residential Mean Damage Ratio (%)
1668	8.25	652	6.20	658	6.40
1679	8.00	335	8.60	466	6.50
1976	7.80	184	5.50	230	3.20

[1] Huixian Liu, ed. The Great Tangshan Earthquake Damage Report, *Seismology Press*, 1986.
[2] Information provided by Risk Management Solutions Inc.
[3] Patricia Grossi. 2007. *The 1679 Sanhe-Pinggu Earthquake – Implications for the Modern-Day Beijing Region*. Risk Management Solutions, Inc. The exchange rate was $1 = CNY 8.28 in 2004.

1.2. Wenchuan Earthquake

The latest earthquake to cause significant damage in the PRC was the Wenchuan earthquake,[4] which occurred on 12 May 2008 in Sichuan province. The earthquake had an extremely high epicenter magnitude of 8 and affected an area of more than 440,000 km^2 with a total population of 45.61 million. The affected areas covered roughly 417 counties in 16 provinces and municipalities, including the provinces of Sichuan, Gansu, and Shaanxi, and the Municipality of Chongqing. According to the State Council Information Office's announcement, the estimated fatality count is 70,000 dead and close to 18,000 missing.

The Wenchuan earthquake happened in an earthquake-prone and densely populated mountain region. There are historical records of eight earthquakes with magnitudes larger than magnitude 7 that have occurred within 200 km of the epicenter of the Wenchuan earthquake. The largest among these events was the 1933 Diexi earthquake in Mao County of Sichuan province which registered magnitude 7.5. Exacerbating the damages caused by these earthquakes were accompanying geological hazards such as landslides, mud-rock flows, and "quake lakes" formed by landslide-induced reservoirs.

Most buildings in regions severely affected by the earthquake had a relatively low seismic resistance level. Wenchuan County, the epicenter of the Wenchuan earthquake, is one of Sichuan's four ethnic minority counties with 27% of the population of Qiangzu descent. Qiangzu people typically build their structures using stone masonry walls or rammed earth, which are materials with characteristically very low seismic resistance. When the M8 earthquake hit the region, many buildings collapsed or were badly damaged.

Official estimates of property losses released by the PRC Government are in excess of CNY845 billion, or roughly $120 billion, making the Wenchuan earthquake the most devastating earthquake in the PRC in terms of direct economic losses. In Sichuan province alone, the loss amounted to about 3% of the province's gross domestic product (GDP).

1.3. Seismicity in the PRC

The PRC is located on the southeastern edge of the Euro-Asian Plate, which is subject to continuous pressures from both the Pacific Ocean Plate and the Indian Ocean Plate. The pressure buildup in the earth's crust is the source of PRC's high seismicity, and this is manifested by the frequent occurrence of large earthquakes in the country. Seismicity in the PRC is not only high but also largely concentrated in certain regions. These seismically active areas, known as seismic regions, are in turn divided into seismic belts. The PRC has 7 seismic regions, 4 seismic subregions, and 20 seismic belts. Seismic subregions and belts are units used in seismicity evaluation.

1.4. Urbanization and Earthquake Risk in the PRC

Over the last 30 years, PRC's economy experienced rapid growth and development with GDP growing at an average rate of 8% annually. With rapid economic expansion comes

[4] China Earthquake Administration, 2008. The direct loss report of the 12 May 2008 Wenchuan earthquake.

urbanization. The urban population increased from less than 20% of PRC's total population in 1979 to more than 43% at the end of 2007. The level of urbanization is expected to reach over 60% by 2020.[5]

Increasing urbanization in the PRC poses many challenges. First, urbanization creates a larger concentration of people, wealth, industry, and activities in large cities. The three largest metropolitan areas of the PRC—i.e., Beijing, Guangzhou, and Shanghai—although occupying only 3% of the nation's land area produce more than 60% of the country's GDP and over 90% of its exports. If a large earthquake were to hit one of these three key metropolitan areas, the consequences would be catastrophic in terms of economic losses. Second, rapid urbanization and strong economic growth have created cities populated with buildings of varying design standards, with newer structures in general having higher earthquake resistance standards. The older buildings in general are much more vulnerable to earthquakes, and are a weak link in PRC's earthquake disaster reduction efforts. Third, vast urbanization has forced construction activities to expand and move onto relatively poor site conditions, which not only increases the cost but also create new weak points within the city. In cities such as Shanghai, Shenzhen, and Tianjin, rehabilitated areas (i.e., man-filled land or soft sites) are used as sites for constructing high-rise buildings. These sites unfortunately are highly susceptible to the impacts of large earthquakes, even those originating at distances hundreds of kilometers away.

2. Recent Development of PRC's Earthquake Disaster Reduction Efforts

2.1. Earthquake Research

Earthquake research gained importance in the PRC in the early 20th century after the occurrence of a few major earthquakes, including the Haiyuan earthquake in 1920. Site investigation of these earthquakes was carried out by Wong Wenpin and others in 1918–1920, resulting in influential research on the relationship between geological structure and seismicity. Their research led to the first zoning of seismicity for PRC's eastern region. The earthquake research programs were greatly improved after a series of destructive earthquakes were experienced in the 1960s and the establishment of the State Seismological Bureau (SSB) in 1971. With the SSB leading the efforts in the country, PRC's earthquake research programs expanded into many specialty areas.

The recent completion of a CNY2.7 billion (about $4 billion) national digital network for earthquake observation provides a unique platform for earthquake research. Current expansion of experimental facilities in earthquake engineering is equipping researchers with state-of-the-art testing facilities for earthquake damage research. Researchers should also benefit from PRC's rapid economic growth in terms of access to funding for key research activities, particularly for future earthquake disaster reduction efforts. Extensive international collaboration and exchange programs on earthquake research have been formed with over 50 countries and/or regions.

[5] Information provided by Professor Liangyong Zha, Tsinghua University.

2.2. Earthquake Design Code and Practice

In 1959, under the leadership of Huixian Liu, Director of the Institute of Engineering Mechanics (IEM) of the China Earthquake Administration, the first design code for buildings in PRC's seismic regions (Code 59) was completed. This was based on the 1955 seismic design code of the former Soviet Union. Within years after Code 59 was developed, Prof. Liu organized the drafting of a seismic design code based on PRC's actual situation. The draft code, known as Code 64, was completed in 1964. The PRC was hit by a series of destructive earthquakes in 1966–1976, including the Xingtai earthquake in 1966, Tonghai earthquake in 1970, Haicheng earthquake in 1975, and Tangshan earthquake in 1976. Post-earthquake investigations produced a vast amount of new information on earthquake damages to buildings and engineering structures. This data helped identify the drawbacks in the seismic design. By 1970, the IEM and other institutes started revising Code 64, the results of which were reflected in the 1974 Code for Design of Industrial and Civil Buildings (Code 74). The Tangshan earthquake in 1976 provided more information which helped revise Code 74, resulting in the issuance in 1978 of Code 78. Code 78 stipulated the basic intensity as the level of seismic resistance. In 1982, another round of revision to the seismic design code of buildings was initiated on Code 78, resulting in the issuance of Code 89 in 1989. Code 89 introduced a new principle for seismic design in the PRC, which is "no damage under small earthquakes, repairable damage after moderate earthquakes, and no collapse under strong earthquakes."

From the 1990s onwards, several damaging earthquakes occurred worldwide, such as the Kobe earthquake (Japan) in 1995, Lijiang earthquake (PRC) in 1996, Jiji earthquake (Taipei,China) in 1999, Izmite earthquake (Turkey) in 1999, Bhuj earthquake (India) in 2001, and Bam earthquake (Iran) in 2003. Additional data on damage characteristics gathered from these earthquakes prompted revision of Code 89. The rapid increase of urbanization also triggered the proliferation of new types of building structures, including high-rise buildings which were not included in Code 89. Revision of Code 89 started in 1997 and was completed in 2001 (Code 2001).[6]

Following the disastrous 2008 Wenchuan earthquake, further revisions of earthquake design code are being considered. A new code, expected to come out around 2010, should underscore the importance of public facilities, such as schools and hospitals, and the need for urgent rehabilitation of earthquake-stricken areas, such those in Sichuan and Gansu provinces.

2.3. Prediction of and Emergency Response to Earthquakes

In 1998, the Law on Protection against and Mitigating Earthquake Disasters was approved. Moreover, the State Council issued four regulations which included earthquake emergency response, earthquake prediction management, earthquake safety evaluation, and earthquake monitoring. All regional governments, which are composed of provinces, autonomous regions, and municipalities, subsequently issued their own version of the earthquake disaster reduction regulations that correspond to the national ones earlier issued by the State Council. Furthermore, there are currently 10 national standards and 38 industry-specific standards for earthquake disaster reduction. A basic legal framework has been put in place, which consists of national laws, national administrative regulations, regional regulations and guidelines, and ministry-specific guidelines.

[6] GB50011-2001, Seismic Design Code of Buildings. *Architecture Industry Press of China*. Beijing. 2001.

To enforce PRC's earthquake disaster reduction programs and regulations, efforts have been taken in areas of earthquake prediction, monitoring, prevention, and emergency responses. The PRC has built a national network for earthquake observation which not only covers the whole country but also includes seismic, precursory, and strong motion observation systems. There are currently 900 fixed stations for seismic observation, ensuring the detection and monitoring of any earthquake with a magnitude greater than 3 in over 90% of the PRC. The network also has the capacity to monitor earthquakes with a magnitude as low as 1 in selected key areas. There are 1,160 stations for strong motion observation and over 800 precursory monitoring stations that can observe gravity, the earth's magnetic field, crustal deformation, the earth's electric field, and underground fluid. The completion of this advanced modern earthquake observation network provides a solid basis to carry out research and its application of earthquake prediction and to accumulate rich and large volumes of observation data sets for future earthquake research.

To increase the earthquake resistance of its engineered structures, the PRC has compiled a national zoning map for strong ground motion and been promoting the use of latest seismic design code for buildings. For projects which have the potential for serious consequences should they fail in an earthquake, and for structures which have a profound impact on the lives of citizens and the nation's interest, a site-specific earthquake safety evaluation is required to be carried out to verify the project's earthquake design. In the rural areas, an important large-scale project called Earthquake Safety for Rural Residences has been implemented in recent years. The project has increased the earthquake resistance capacity of buildings in the countryside. For example, when an earthquake with a magnitude of 6.2 occurred in Kashi of Xinjiang Uygur Autonomous Region in February 2005, rural residential houses which had been constructed with earthquake-resistant techniques essentially bore no damages. Also, during the Wenchuan earthquake in May 2008, as duly observed, many newly constructed earthquake-resistant rural residential houses endured the strong earthquake ground motion intensities, thereby greatly reducing the number of casualties in the affected region.

In terms of emergency response, the National Preparatory Plans for Earthquake Emergency Response have been drafted based on the National Guidelines on Emergency Response Management for Destructive Earthquakes. The relevant ministries under the State Council and the various levels of regional governments have completed their preparatory plans for earthquake emergency response. The steering and executive organizations for earthquake emergency response have been set up at the central level as well as in all the provinces, autonomous regions, and municipalities. The development of professional search and rescue teams has been fast in the PRC. Currently, a PRC national search and rescue team and 26 provincial search and rescue teams have been formed with total membership of 3,000. PRC teams for earthquake emergency response have been engaged in Algeria, Indonesia, Iran, and Pakistan for search and rescue operations after disastrous earthquakes in those countries. In 2008, the construction of a national training center for earthquake emergency search and rescue was completed.

2.4. Earthquake Insurance Programs in the PRC

Unlike a number of countries where earthquake insurance has been available since early in the 20th century, earthquake insurance only started to be made available in the

PRC in the late 1980s. The premium rate was often of the order of 1/10,000 of the insured value, even in areas of high seismicity. After learning the effects of the 1994 Northridge earthquake on the US insurance industry,[7] insurance companies in the PRC scaled back on their coverage of earthquake damages.

In late 2003, the China Earthquake Administration, with the support of the China Insurance Regulatory Commission (CIRC) and a number of other government ministries, pushed for a national earthquake insurance pool. Although the proposal passed through the State Council, it did not successfully win the endorsement of all relevant agencies because of lack of funding. At the same time, insurance companies started earthquake insurance programs in selected areas. It was usually offered as an option with fire insurance but with a rate still in the order of 1/10,000 of the insured value, much lower than estimates of the average annual loss ratio caused by earthquakes in major urban areas such as Beijing where it has been estimated to be in the order of 1/1,000 of the building values.[8]

Although a number of insurance companies offer earthquake insurance coverage in the PRC, the overall penetration rate of earthquake insurance is very low. The nationwide average is around 3%, compared with over 20% in Turkey, over 50% in Japan in recent years for buildings with mortgages, and over 90% of privately owned buildings in New Zealand and Australia. During the recent Wenchuan earthquake, the total payout made by the insurance industry reached around CNY1 billion (about $147 million) by the end of August 2008. The CIRC website reports that this amount is equivalent to much less than 1% of the total amount of losses. In the western and southwestern part of the PRC, where seismicity is high and the local economy is not well developed, there is essentially no earthquake insurance coverage. The low penetration rate not only creates disruptions for the government after a major earthquake but also, in some cases, delays the reconstruction efforts.

The 2008 Wenchuan earthquake had at least two significant impacts on the insurance industry. One is a growing awareness of earthquake insurance programs and their importance in mitigating the impact of earthquakes on individuals and communities. The other is the realization of the magnitude of risks insurance companies are taking in their policies, which appears to have led to a trend of delisting earthquakes from the insurance coverage policies, with earthquake being excluded from hazard insurance programs in the coastal areas which cover typhoon, flood, and accident loss.

3. General Principles of Earthquake Insurance

3.1. Role of Earthquake Insurance

As a result of the low penetration of earthquake insurance in the PRC, the government serves as the primary bearer of financial risk from earthquake catastrophes. After every destructive earthquake occurrence, the government has to expeditiously search for essential funding for emergency responses and reconstruction and recovery efforts. The

[7] The Northridge earthquake caused an estimated $20 billion in damage, making it one of the costliest natural disasters in US history. See http://nisee.berkeley.edu/northridge/. 2005.

[8] Information provided by Risk Management Solutions Inc.

delays associated with this and inevitable frustrations of dealing with hastily prepared bureaucratic procedures also lead to much personal distress.

Funding the recovery from disasters through government and charity relief measures organized after an event is an example of post-disaster funding of catastrophe financial losses, where the funds have to be found by government and collected by charities after the event. In the case of government funding in developing economies, this can often lead to governments having to seek loans from international agencies, such as the Asian Development Bank (ADB) and the World Bank, imposing additional strains on government finances and ultimately the taxpayers in paying for the disaster losses.

Normal commercial insurance is an example of pre-disaster funding since the funding of the losses has been paid for in advance. Insurance plays a significant role in reducing the financial impact of disasters, and enhancing the sustainability of communities affected by them through the provision of assured funding for the recovery phase.[9] Because the arrangements are made before the event, when an event occurs the system for providing the funds through claims on insurance policies can be quickly put in place and the payments made, facilitating the speed of recovery and significantly reducing the financial stress on the owners of the insured property. Furthermore claims are usually accompanied by a high level of accountability through the use of specially trained loss adjusters, leading to a greater control of losses.

In addition to its primary role of funding recovery after disasters, insurance also increases economic efficiency in relation to disaster management by reducing individual exposure to catastrophe through the transfer of risk that is inherent in the insurance process, the accumulation of capital resources which are made possible by the pre-disaster funding in the form of premiums, and the establishment of the true market price of the catastrophe risks. The commodity traded by insurance companies is risk, and unless it is priced properly, a company runs the risk of either becoming insolvent by underpricing or uncompetitive by overpricing. To achieve this the insurance industry has over the past 20–30 years developed sophisticated models for assessing catastrophe loss risk and managing this risk by appropriate premiums, capital resources, and risk financing structures to ensure they can offer a competitive product and maintain an acceptable low risk of insolvency. The resulting premium rates will be the market cost of transferring the risk in a sustainable manner.

Unless constrained by government regulation, insurance companies will generally seek to charge each policyholder a premium close to the market value of the risk being transferred. Since the market value will reflect the vulnerability of the particular property to the hazard causing the loss risk, this then acts as an incentive to mitigation, since the lower the vulnerability the lower the premium which will be charged. In some cases insurance companies may even make achieving a specified level of mitigation a condition of insurance. Consequently insurance can play a significant role in mitigating the overall loss from disasters, even though it is not its primary purpose. In relation to building fires, the insurance industry has played a major role historically through its mitigation incentives with many fire regulations in building codes having their origin in insurance.

Although in many relatively wealthy countries catastrophe insurance is based on indemnity and pays almost the total cost of repair or reconstruction of buildings plus

[9] Walker, G., T. Lin, and Y. Kobayashi. 2009. Is Flood Insurance Feasible? – Experiences from the People's Republic of China, *ADB Sustainability Working Paper Series*, No.5. April.

replacement of damaged contents, these are not necessary conditions. The prime purpose of catastrophe insurance in a development context is the sustainability of communities in the event of disasters. The risks from major catastrophic events are usually low in terms of individual priorities with the health, vehicle accidents, and employment generally being very much greater risks to their well-being. But at the community level, catastrophic risks are major risks. This is why most catastrophe insurance schemes have a relatively high level of compulsion, and why most of the pressure for catastrophe insurance is community based rather than individual based. It also follows that full reimbursement of replacement and reconstruction costs is less important than providing sufficient funds to enable the affected community to get back on its feet as quickly as possible.

Earthquake insurance also spreads the concentration of risks among the different domains of time, space, and type of perils. First, an earthquake is a natural catastrophe with low occurrence probability but with severe consequences when it does happen. An earthquake insurance program can be an effective mechanism for accumulating funds in preparation for future earthquake disasters, thereby diversifying risks within the time domain. Second, destructive earthquakes rarely occur again in the same area within a short time. Earthquake insurance programs enable the use of premiums accumulated from other areas to help cover the loss and damages in the affected area. This is what we refer to as diversification of risks within the space domain. Lastly, it is also possible to combine the risks from different perils, such as earthquakes, typhoons, floods, and droughts, since these natural disasters rarely happen at the same time and in the same region. This is the diversification of risks among different types of perils. Additionally, the risks can be diversified among the international capital markets to further reduce the direct impacts of catastrophic earthquake events on individual property owners.

3.2. Characteristics of Catastrophe Insurance

Earthquake insurance is part of a general class of insurance known as catastrophe insurance. The major characteristic feature of catastrophe insurance is that all the losses in the area affected by the catastrophic event are highly correlated with each other. This violates a basic principle of ordinary insurance, which is based on combining a large number of independent risks of similar magnitude—which is what is meant by diversification of risks. To diversify catastrophe insurance risks, the overall event insurance risks have to be combined with a significant number of independent event risks of similar magnitude. This is generally achieved by a combination of accumulation of funds to combine independent events over time, reinsurance which combines independent events in terms of location and type of peril, and in some cases combination with independent capital market risks through facilities such as catastrophe bonds.

The pricing of catastrophe insurance is a function of the average annual insurance loss to an insured building, the rarity of a major event loss to which it would contribute, and the number of possible independent catastrophic insured event losses of similar maximum magnitude with which it can be combined. Together with administrative costs the latter two components provide a multiplying factor to the average annual loss that has to be applied to get the premium. The rarer the event and the larger the magnitude, the greater is the multiplying factor. Earthquakes, being relatively rare events in any particular region, generally produce multiplying factors of the order of about two for relatively small magnitude events but can be very much higher for events of large

magnitude for which there is limited scope for diversification with events of similar potential loss magnitude, such as a major earthquake in California, which makes earthquake insurance in California several times the estimated average annual loss and consequently very expensive. Using the capital markets tends to be more expensive than normal reinsurance when the multiplying factors are low; but when they get large, diversifying into the capital markets can become very worthwhile and even necessary. One consequence of this for the PRC is that while the multiplying factor at this stage will be at the low end—i.e., probably of the order of 2—making capital market solutions unnecessary, as the penetration and insured values increase the multiplying factor will increase making them more viable.

Another characteristic of catastrophe insurance is that it does not need to be based on indemnity. Indemnifying the losses is a basic objective of traditional property insurance because that is what policyholders want in relation to normal fire, theft, and thunderstorm cover, which are viewed as relatively common occurrences in the community. However, the relatively low penetration of catastrophe insurance where it is voluntary for rare events like a major earthquake suggests there is not the same demand for indemnity of losses. This opens the door to parametric insurance which under some circumstances can be a better approach to catastrophe insurance.

3.3. Requirements of a Earthquake Insurance Scheme

To be effective in mitigating disaster, the provision of residential earthquake insurance should meet the following criteria:

- Provide adequate funds for the reconstruction and repair of damaged buildings, restoration of contents, and temporary accommodation if the building is made uninhabitable
- Be affordable by most property owners
- Be sustainable over a long period
- Have an efficient administrative system including response to claims
- Be free of moral hazard
- Be linked with mitigation activities
- Have high penetration
- Be politically acceptable
- Be culturally acceptable

Affordability is critical to achieving high levels of penetration of earthquake insurance. This may mean limiting the policy conditions to make the insured risk fit the affordable premium. Affordability on its own, however, is not the issue. Willingness to pay is also very important and, as explained previously, catastrophe insurance is usually well down on individual priorities when it comes to spending limited funds. It is exacerbated in some Asian societies where there is cultural resistance to insuring against catastrophic events. This produces a political problem as regards enforcing compulsory schemes for which the premium not only needs to be affordable but also politically acceptable.

Sustainability is one of the more difficult, but very important, criteria to meet if a scheme is not to become insolvent in the first big event which it experiences. The temptation is to charge lower premiums than are actuarially required for sustainability in

the long term. In recent years the development of dynamic financial analysis (DFA) tools which can model in a probabilistic manner the future performance of schemes based on the output of catastrophe loss risk models has made design for sustainability a much more rational process than in the past. Such an analysis needs to look at the long-term performance given a purely random occurrence of events, as well as include a stress test by simulating the long-term performance if a major event occurs in the immediate future. The consequences of developing systems in which the long-term sustainability has not been adequately assessed can be seen in some of the current problems facing State hurricane insurance schemes in Texas and Florida in the US. Design for sustainability usually involves finding a balance between premiums, policy conditions, the levels of pre-disaster protection to be provided by reinsurance and catastrophe bonds, the accumulation of funds, and the level of post-disaster protection to be provided by government guarantees.

Moral hazard can be a significant problem in both developed and developing countries. One major argument for using a parametric approach to catastrophe insurance is the reduction of risk from moral hazard that can occur with indemnity insurance. Partial damage is generally much more common than total loss, and much of it is reflected in cracking. But many things can cause cracks in buildings, earthquakes being only one of them. After an earthquake all cracks are viewed as having resulted from the earthquake, which can lead to major disputes about the cause and level of the repairs required. Another form of moral hazard risk can occur if the size of the accumulated fund gets very large and tempts politicians and others to use it for other purposes.

Linking catastrophe insurance with mitigation is also essential if the scheme is to be both affordable and provide a reasonable level of financial relief. By and large, providing incentives for mitigation is more difficult when there is a degree of compulsion, especially if premiums are not individually risk rated. In this case mitigation needs to be the subject of a reasonable degree of compulsion, which in developed countries is achieved by the rigorous imposition of building codes incorporating a high level of hazard mitigation within them. This still leaves the problem of older buildings built to substandard codes, a problem that is being increasingly solved in developed countries by the imposition of building inspections for earthquake risk and requirements for retrofitting those that do not meet the specified minimum levels of earthquake resistance.

The administration of catastrophe insurance requires a different approach than normal insurance. It needs a system which, most of the time, is only concerned with the collection of premiums and managing the reinsurance and investment of accumulated funds but when a major event occurs is equipped to handle a huge demand for claims-handling services with a high level of probity to minimize the moral hazard risk which can arise in such situations. Getting the administrative system right is just as important as getting the technical-based aspects right if a system is to cope when the big event for which it is primarily intended occurs.

3.4. Types of Schemes

Almost all earthquake insurance around the world is purchased through normal insurance companies, usually in association with the purchase of fire insurance for the insured property. But there the similarity ends, with large differences existing in the way

earthquake insurance is provided. These differences can significantly impact public policy outcomes in relation to the management of earthquake risk.

In some countries there is no government involvement and the entire earthquake risk, together with the risks from other hazards, is carried by the commercial insurance and reinsurance industry. Countries where this approach is common are usually those where the earthquake risk is perceived as relatively low, such as Australia.

Where governments are involved, the nature of the involvement can range from schemes which are wholly owned and managed by governments with the role of commercial insurance companies only to collect the premiums to schemes which are dependent on private–public partnerships between the government and insurance companies.

3.4.1. Wholly Government-Owned Schemes

Examples of wholly government-owned schemes are two of the oldest specific disaster insurance schemes, the Spanish comprehensive disaster insurance scheme managed by the Consorcio de Compensacion de Seguros,[10] and the residential earthquake insurance managed by the New Zealand Earthquake Commission,[11] both of which are over 60 years old. In both cases they are managed as government business enterprises and expected to be sustainable with the assistance of government guarantees for very extreme events. Because the Spanish system is very comprehensive in terms of both the types of property covered and types of hazards covered, it has a significant level of self-diversification and relies on government guarantees diversifying the event risks over time for financial protection without resorting to reinsurance. This reduces the premiums which are risk rated. Mitigation appears to be primarily achieved by the imposition of regulations on building standards and land use. The New Zealand scheme is much more limited, covering only residential buildings, providing first loss cover up to a fixed limit for buildings and contents separately, independent of their actual value, and for a fixed premium rate which is the same for all property irrespective of its individual earthquake loss risk. In New Zealand diversification has been achieved by accumulating a large fund over time, largely as a result of the government fully guaranteeing the system during its first 40 years during which no reinsurance was purchased, and having the good fortune to have not had to respond to a major event since its inception. Both schemes are compulsory for property insured for fire.

A more recent compulsory wholly government scheme is the Turkish Catastrophe Insurance Pool (TCIP).[12] In the Turkish scheme the premiums are individually risk based and first loss cover is provided to fixed uniform limit with a relatively small deductible as in New Zealand. Unlike most other schemes, the TCIP is independent of fire insurance. It is funded by a combination of accumulated funds, commercial reinsurance, and a contingent loan facility provided by the World Bank.

Voluntary schemes wholly owned and managed by government are those managed by the California Earthquake Authority[13] and the government residential earthquake

[10] See www.consorseguros.es

[11] See www.eqc.govt.nz

[12] Gurenko, E.N., R.R. Lester, and O. Mahul. 2007, *Earthquake Insurance in Turkey: History of the Turkish Catastrophe Insurance Pool.* World Bank.

[13] See www.earthquakeauthority.com

scheme in Japan.[14] A significant aspect of these schemes is the limited cover provided. In the Californian system this achieved by high deductibles, and in the Japanese scheme, by specified amounts based on a different defined levels of damage. The Japanese scheme is primarily covered by accumulated funds and government guarantee plus reinsurance from a government-owned earthquake reinsurance company. The Californian system is covered by a combination of accumulated funds, commercial reinsurance, post-event assessments to be levied on commercial insurance companies operating in California, and a line of credit, which is another form of post-event funding. The use of post-event levies on insurance companies is also a feature of government-based hurricane insurance systems in the US. It creates a liability for insurance companies for which they do not receive premiums, but is a condition of the company providing general property insurance in the relevant state.

In France government involvement is through the wholly government-owned Caisse Centrale de Reassurance[15] which provides catastrophe reinsurance to French insurance companies by a combination of accumulated funds and government guarantee. The provision of catastrophe insurance by insurance companies is compulsory but because the reinsurance scheme is not itself reinsured, the reinsurance premiums charged by the scheme are lower than those charged by commercial reinsurers reducing the premiums charged to individual property owners.

3.4.2. Joint Government Insurance Industry Schemes

A number of earthquake insurance schemes in which governments are a significant participant are ones in which the local insurance industry is also a significant participant. Two recently created schemes in the Asian region which are examples of this approach are Taipei,China's earthquake insurance fund (TREIF)[16] and the Indonesian earthquake pool known as MaiPark.[17] TREIF is compulsory when a property is insured for fire and has a uniform fixed premium associated with a uniform fixed amount which can be claimed only if property is declared a total loss. MaiPark is essentially an earthquake insurance pool created and operated in accordance with government legislation, but owned by the insurance companies. Earthquake insurance is offered on a voluntary basis by insurance companies and a proportion of all premiums and risk is transferred to the pool which establishes the risk-based system of premiums to be charged for earthquake cover. Its purpose is primarily to ensure actuarially sound premiums are charged for earthquake cover. MaiPark is funded by a combination of accumulated funds, assessments on participating insurance companies, and commercial reinsurance.

In Norway catastrophe cover is compulsory with fire insurance, with most catastrophe insurance risk covered by a separate catastrophe pool managed by the insurance industry which is fully reinsured commercially and which sets premiums based on the cost of the reinsurance.

[14] 2005. *Creating a Technical Foundation for Earthquake Insurance in China. Risk Management Solutions*. Available: www.rms.com/publications

[15] See www.ccr.fr

[16] See www.treif.org.tw

[17] See www.maipark.com

3.5. Lessons from International Experience

The most obvious lesson from studying other schemes is that the best solution for the PRC will unlikely be a clone of an existing scheme in another country. Almost all present national approaches to catastrophe insurance are different, and the more government is involved in them, the more different they are from one another. The reason for this appears to be that catastrophe insurance is primarily concerned with meeting a community need, as opposed to an individual need, and consequently local economic, social, and political factors play a major role in developing an acceptable and sustainable system. The value from studying other systems is the knowledge that can be learned about the wide diversity of approaches that are possible.

There are also lessons to be learned about the relative effectiveness of different approaches. In terms of penetration of earthquake insurance, the highest levels of penetration tend to be in countries where the penetration of ordinary fire insurance is high and the earthquake risk is perceived to be relatively low resulting in earthquake being a standard inclusion in most fire insurance policies. The wealthier European countries appear to be in this situation, along with Australia where in excess of 90% of all privately owned industrial, commercial, and residential buildings are probably fully covered for earthquake damage on a replacement basis. One country where earthquake is a significant risk and the penetration is of similar level is New Zealand. Primarily because of the high penetration of fire insurance, earthquake insurance under the government scheme is compulsory for all fire policies relating to residential property. Also earthquake is traditionally regarded as a standard inclusion in commercial and industrial fire policies as a result of these being included in the compulsory government scheme for the initial 50 years of the scheme.

In Taipei,China, the current penetration is about 25% and increasing every year. Although compulsory with fire insurance, fire insurance tends to be purchased only as a condition of mortgages which cover only about 50% of residential properties. Before its introduction, the premiums were paid up-front as part of the loan to cover the whole period of the loan which was typically 15 years and the scheme has only been applied to new mortgages taken out since its inception. In Turkey, although the scheme is nominally compulsory for all residential property, the penetration has been estimated to be only about 20%—probably because there are no penalties for noncompliance. In California, despite a high penetration of fire insurance, the penetration of earthquake insurance at the residential level has been estimated at only 12%, primarily because it is voluntary and the cover is perceived as insufficient relative to the high premiums. In Japan the penetration is relatively high for those involved in cooperatives, but relatively low among those not involved in these organizations who form the majority—partly for similar reasons to California and also probably for cultural reasons as well.

This suggests that without a considerable degree of compulsion which is enforced, achieving a high level of penetration is difficult. Even then a high penetration of fire insurance is also needed, unless the insurance is handled separately from normal insurance.

Another lesson is that if premiums are likely to be high relative to affordability when determined in accordance with the normal commercial indemnity approach to insurance using commercial insurance, then some trade-offs may have to be made. Limitations on policy conditions, possibly in conjunction with parametric insurance, can be applied. These, however, will mean that individual policyholders will only be partially covered if they sustain losses. Alternatively, a combination of pre- and post-event funding of the

risk can be explored, with the government assuming a significant portion of the risk through guarantees or the use of contingent debt facilities, which may mean levies or tax increases to fund these losses after a major event occurs. This retained liability has to be compared with the liability assumed if no scheme is developed and the penetration of earthquake insurance is very low.

4. Critical Issues of Formulating Earthquake Insurance Programs in the PRC

4.1. PRC Experience in Catastrophe Insurance

Although the PRC has limited experience of providing earthquake insurance, mainly as a voluntary additional cover provided by insurance companies to their fire policies for commercial and industrial properties, it has significantly more experience in other forms of catastrophe insurance. This has highlighted some unique characteristics regarding insurance operations in the PRC which will be important to recognize in developing earthquake insurance in the country.

A number of separate pilot studies of government-based flood insurance schemes have been undertaken since 1992 as described in a previous working paper[18] which appear to have set a pattern for developing government-based schemes.

A national scheme of agricultural insurance was initiated in 2007 with the establishment of a number of pilot schemes. A major component of the proposed cover is insurance against weather-related catastrophic events in association with a considerable level of government subsidization. A feature of these pilot studies was that although initiated nationally, they required collaboration, including a preparedness to share the subsidization costs, by the participating governments at both the provinces and counties. Furthermore considerable flexibility was given to individual provincial governments in the development of the pilot projects, which allowed different schemes being developed and tested. Another feature of the scheme was that the insurance scheme was envisaged to be operated by insurance companies who would be the primary carriers of the risk, and then include it in their normal reinsurance arrangements. Government was involved in subsidizing the premiums, which would need to be actuarially sustainable and agreed on by the participating insurance companies, and in providing the associated legislation.

It is understood that a national life and health microinsurance scheme for rural families is being developed along similar lines with pilot projects due to begin in a number of provinces in July 2009. This scheme will cover some catastrophic losses but exclude earthquakes at this stage.

If a national earthquake insurance scheme is to be developed, it could learn from experiences of existing catastrophe insurance for other natural disasters in the country and would probably be initiated with pilot projects with four general objectives:[19] (i) reduce the financial vulnerability of homeowners and small and medium-sized

[18] Walker, G., T. Lin, and Y. Kobayashi. 2009. Is Flood Insurance Feasible?—Experiences from the People's Republic of China, *ADB Sustainability Working Paper Series*, No. 5, April.

[19] World Bank. 2009. *Catastrophe Insurance Policy for China*.

enterprises (SMEs) to natural disasters, (ii) encourage homeowners and SMEs to engage in proactive disaster risk management, (iii) reduce government fiscal risk exposure to natural disasters, and (iv) provide local governments immediate post-disaster fiscal support.

4.2. Initial Issues for Resolution

If the PRC is to embark on a major program of earthquake insurance, a number of questions need to be initially resolved.

1. What is the intended coverage of the scheme? Is it just residential buildings, all privately owned buildings, buildings only, or both buildings and contents, etc.? One possible approach is to differentiate between residential and small home-based commercial businesses as one group with the insurance provided through a government-based scheme, and larger commercial and industrial property and businesses as another group with the insurance provided as part of normal commercial fire insurance and backed by an industry pool similar to MaiPark in Indonesia.
2. If it is to be a government-based scheme, what will be the role of government? Will it be undertaken by a government business enterprise similar to the New Zealand scheme, or will it follow the more established pattern in the PRC of insurance companies providing the insurance in association with their normal operations, with the premiums being subsidized by government and government providing the legislative framework and overall supervision of the scheme?
3. Will it be voluntary or compulsory? If it is to be compulsory, in what way will it be compulsory, and how will it be enforced?
4. What will be the form of the claim structure? Will claims be based on full replacement value of property, the indemnity value of property, a fixed amount subject to exceedance of a defined parametric value? Will claims be limited by significant deductibles, and/or an upper limit?
5. What will be the form of the premium structure? Will there be fixed premiums or fixed premium rates, varying only at the provincial level, or will premiums be variable based on individual building risk? If a compulsory government scheme is envisaged, what will be the maximum premiums that can be levied on individual property owners?
6. If premiums are to be subsidized from government funds, what level of subsidization can be expected, and what conditions in terms of eligibility can be expected to be imposed?
7. How are the financial risks to the scheme arising for the insured earthquake risk to be managed? Will it be wholly by reinsurance of one form or another without any major accumulation of funds as in Norway, or by government guaranteeing the scheme while a significant fund is allowed to accumulate as was done in New Zealand, or by a combination of both as is being done in Taipei,China, or by the government providing reinsurance backed by its own consolidated funds similar to what happens in France?
8. If it is to be managed by a separate government business enterprise, who will collect the premiums and manage the processing of claims?
9. What will be the relationship between the scheme and mitigation? Poorly planned schemes can become a disincentive to mitigation by providing the same level of cover at the same price for buildings which have poor

earthquake resistance as those with a high level of earthquake resistance. The PRC is undergoing rapid urban development. It will only be feasible to provide a high level of earthquake insurance in many urban areas if buildings have a high level of earthquake resistance. Without the insurance, the PRC could face a crippling economic blow from a major earthquake in these areas.

These issues are not technical but until they are resolved, much of the detailed technical analysis required to ensure the sustainability of a proposed scheme cannot be undertaken. Depending on the answers to these questions, the design of the earthquake insurance program can vary significantly. Box 1 illustrates one example of insurance and reinsurance policy structure.[20]

[20] The example is constructed for illustration only. It is based on preliminary research by the authors and the World Bank.

Box 1: An Example of Policy Structures for an Earthquake Insurance Program

A two-tiered flexible earthquake insurance program can be used to account for the differences in seismicity, economic development, and earthquake resistance among different regions of the PRC. The insurance program is a combination of both mandatory and voluntary policies. For both coverage policies, the pricing and payment schemes need to be based on the results of vigorous risk modeling.

The basic insurance coverage is mandatory to all registered homeowners and small and medium-sized enterprises, offered in the provinces with every province determining its respective policy based on its distinct regional characteristics and local economic conditions. The minimum payment limit is set to no less than CNY20,000 (about $2,900), which is an amount needed in most rural areas for constructing the basic residence of a four-member household. Besides a flat minimum cover (e.g., CNY20,000), an alternative is to base the insured limit on median property values in each province (or a similar formula). Under the basic coverage, the governments share a high percentage of risks (e.g., 80% or more) to limit the risk exposure of the private insurers and to make the coverage affordable to most citizens. The sharing of risk between local and central governments can vary across provinces depending on the distinctive needs, characteristics, and circumstance of each province.

In addition to the basic earthquake insurance coverage, extended coverage is optional to the relatively affluent citizens and to urban areas where the reconstruction costs are higher than the basic mandatory coverage. The optional earthquake insurance program can be executed at city or county level. Its limits and deductibles can vary from one city to another. The governments' sharing of risk under optional coverage can be significantly less, allowing the private insurers to cover and underwrite a greater share of risk.

Both basic (mandatory) and extended (optional) insurance are backed up by the international reinsurance, i.e., the capital market in terms of earthquake catastrophe bonds, and the government. For the basic earthquake insurance, reinsurance can be purchased at the national level; whereas reinsurance for the optional coverage can be purchased at the provincial level with central government backup. Annual reviews should be performed on the insurance pool to make sure an adequate amount of reinsurance considers the level of reserved fund as well as the degree of exposure and seismicity.

In terms of claims settlement, property damages after the earthquake will be adjusted by participating insurance companies. To ensure consistency in loss assessments, adjusters should receive special training. The key elements of government participation include introduction of special catastrophe insurance legislation, enforcement of the basic (compulsory) coverage, and provision of a backstop contingent capital facility to the program.

4.3. Data Issues

High quality data are essential for the development and maintenance of a sound earthquake insurance system. Key data sets for earthquake insurance programs include, but are not limited to, the following: (i) hazard data, including the seismic sources, historical activities, earthquake catalogues, ground motion attenuation, and the local soil conditions; (ii) vulnerability and exposure data, including inventory information, economic

exposure, and exposure classification; and (iii) historical loss information. Using the above information, the average annual loss and loss exceedance frequency tables, which underpin the dynamic financial analysis (DFA) modeling used in the sustainability analysis and earthquake insurance pricing, can then be estimated.

A data standard for exposure reporting of catastrophe insurance is currently being developed in the PRC. This should facilitate the generation of the detailed location dependent data essential for modeling earthquake insurance loss risk. Once this data standard is adopted and implemented, a compulsory reporting of exposure at regular intervals will be required to ensure that the China Insurance Regulatory Commission (CIRC), earthquake insurance administrators, and other relevant organizations get access to data for monitoring the risk accumulation and concentration and for managing the changing risks to the earthquake insurance scheme.

In addition to the detailed exposure report, a regular risk analysis report is also needed to ensure that the CIRC and the government are aware of the risks involved in the earthquake insurance program. The analysis should include exposure concentration, changes in total exposure, average annual loss, probable maximum loss, and other parameters. This risk report can serve two purposes: (i) for decision makers to better understand the total risk involved for sound decision making, and (ii) for the government and the insurance/reinsurance companies to better plan and prepare for future disastrous earthquakes.

4.4. Loss Risk Modeling Issues

Loss risk modeling is very important in determining the risks from earthquake catastrophe. Earthquake loss risk modeling[21] is an approach that combines engineering and scientific approaches, rather than a simple traditional statistical approach based on past records. Early versions of loss risk assessment in the PRC were often conducted at the macro level by using information on basic seismicity and the effect on GDP to roughly estimate the earthquake risk. The problem of this approach was its lack of detail and accuracy to calculate the pricing of earthquake insurance and reinsurance.

In recent years, commercial versions of risk modeling packages have been made available. Risk Management Solutions Inc. has released a risk modeling package in collaboration with the Institute of Engineering Mechanics (IEM) of the China Earthquake Administration (CEA), the government research arm on earthquake engineering. Applied Insurance Research has also released one. Commercial packages like these are being used by large international insurance and reinsurance companies to estimate the earthquake risk in the PRC. The availability of these models is expected to greatly help the development of earthquake insurance in the PRC.

Risk modeling has two fundamental components: (i) themethodology used and (ii) the key metrics, such as the average annual loss (AAL) and a table or chart indicating the estimated frequency of exceedance of different levels of loss. There are three key elements of an earthquake risk model: (i) how to define the hazard, (ii) how to derive the vulnerability, and (ii) how to describe the inventory and exposure. For the development and maintenance of a sustainable system of earthquake insurance, a wholly probabilistic approach is needed for simulating the earthquake loss risk. The uncertainty of modeling

[21] Grossi, P., W. Dong, A. Boissonnade. 2008. Evolution of Earthquake Risk Modeling. Proceedings of the 14th World Conference on Earthquake Engineering, October 2008, Beijing, China.

should also be fully addressed and considered in the modeling process. The development of a standard by which to judge the reliability of models would enhance their use in the PRC.

AAL stands for average annual loss, which is one of the key parameters in pricing insurance. The average premium rates which would need to be charged will be a multiple of these, the multiple depending on the probable maximum total insured loss from all credible earthquake events in the locality. Using the Risk Management Solution model, the estimated loss ratios for residential houses, where the loss ratio is defined as the AAL divided by the exposure value, vary across different locations of the country. This indicates the large differences in premium rates that could be expected across the country if premiums are based on local risk.

PML stands for probable maximum loss, which is the loss amount for an anticipated worst case scenario. In general insurance and reinsurance companies base PMLs on a specified risk of annual exceedance, which will be related to their accepted maximum risk of insolvency. In Australia because of regulations on insolvency, most companies adopt an annual probability of exceedance of 1/250 as the basis for their PML. In some countries, a probability of 1/500 is commonly used for earthquake risk. The PML is then used to define the upper limit of the risk to an individual insurance company program, while the estimated sum of all PMLs for a particular region is the maximum event insured loss on which the multiple of the AAL for premium pricing is based. As a general rule, the maximum event loss from all PMLs for a region should be greater than the estimated insured loss if known past events were to reoccur at present.

4.5. Financial Risk Analysis Models

DFA modeling is essential to the development and maintenance of actuarial sustainable earthquake insurance schemes, including the determination of appropriate premium levels, and the design of appropriate financial protection structures including reinsurance.

Generic DFA models are available but they are not as well developed commercially as the loss risk models. For actual use they need a significant amount of customization to the actual insurance system, and for the design of catastrophe insurance schemes they are normally purpose built by actuaries. This expertise is now widely available in the reinsurance broking industry in general, but it may be limited in the PRC outside of universities with strong insurance departments.

Ascertaining the level of expertise in DFA modeling and its application to the design and maintenance of catastrophe insurance schemes, and addressing the need for more expertise if required may be a necessary early step in developing a national earthquake insurance program.

4.6. Legal Issues

Before the Wenchuan earthquake, specific legal support for a national earthquake insurance program was absent. Without such legal framework, it is difficult to set up a national system of earthquake insurance. Based on experiences and lessons learned from around the world, an effective earthquake program should be compulsory (or partially compulsory) in nature and should have strong financial support mechanism.

Only through a sufficient legal support system can the earthquake insurance program be mandated as compulsory and the needed financing machinery set up to effectively support a PRC earthquake insurance pool.

The best approach to address this issue is through national laws. There are two types of national laws, namely, basic laws and specific laws.

1. **Basic Laws.** The basic laws supporting PRC's earthquake insurance programs are: (i) the basic law on Protection against and Mitigating Earthquake Disasters, and (ii) the basic law on general insurance programs in the PRC. Changes will need to be made to these laws to accommodate the need for an earthquake insurance program in the PRC. The Law of the People's Republic of China on Protection against and Mitigating Earthquake Disasters was initially approved in 1997 by the China People's Congress for overall earthquake disaster efforts at the national level. There was a clause in the 1997 law about earthquake insurance, which encouraged commercial insurance companies to start the program in the PRC without further support from the government. Revisions of the law started a couple of years ago and accelerated after the Wenchuan earthquake. A minor section was added specifically for earthquake insurance, requiring the government to start earthquake insurance programs in the PRC with financial support. The revision was passed at the end of 2008 by the Standing Committee of the China People's Congress. In the Law of the People's Republic of China on Insurance, no direct reference to an earthquake insurance program is currently made. Inclusion in the law of specific provisions for the legal support of earthquake insurance programs, including its administration, coverage, and financial assistance, would greatly facilitate the development of future legal framework and the specific details of PRC's earthquake insurance programs.

2. **Earthquake Insurance Law.** During the annual meeting of China People's Congress in March 2009, a number of national delegates proposed that a specific national law on catastrophe insurance be developed, with earthquake insurance being given first priority. The proposed law would be expected to cover most issues discussed in Section 4.2 including the scheme's administration and management, the form and level of government support, the role of other stakeholders, and its coverage.

4.7. Public Awareness

There is no widespread promotion and information campaign of earthquake insurance in the country. The impact of the disaster seems to fade easily in the minds of the people, thus the need for property protection was never perceived as indispensable. This partially explains the low insurance penetration rate in the country. The absence of demand can be correlated to the lack of awareness of the public on the benefits and extent of an earthquake insurance coverage. A more aggressive approach on the promotion of earthquake insurance to the population is necessary for PRC's earthquake insurance program to be effective.

Education and training programs are important in raising the public awareness of earthquake disasters, disseminating necessary information to the general public, and helping inform decision makers. Countries like Japan have had a number of very

effective education programs. The PRC has also started to realize the importance of education and training in promoting its earthquake reduction efforts. Special focus should be placed on the following:

1. **Education centers in technology museums.** Several technology museums have already been constructed in many places in the PRC. Building earthquake education centers in these museums is relatively easy and inexpensive. These centers are great venues for public sharing of information on earthquake disaster and earthquake insurance programs.
2. **Education program in classrooms.** Schools are the best place for education on earthquake disaster reduction. Students not only absorb the knowledge quickly but they also learn it early and can benefit from it all their lives. At the same time, they can also pass on their knowledge to other members of their family. The best education programs on earthquake disaster reduction are undoubtedly the ones given in the classrooms.
3. **Graduate degree programs in risk management.** Earthquake insurance and earthquake disaster reduction are very complicated subjects, and special knowledge is required to properly address its risk management needs. It is important that graduate programs on earthquake risk management be available to facilitate the preparation of better and more effective programs in the future.
4. **Regular media coverage on disaster reduction and risk management.** Media coverage is important in raising public awareness about the importance of earthquake disaster reduction. Regular TV and other broadcast programs and/or print (newspaper) and online (internet) media coverage will have profound influence in providing the public with relevant information.
5. **Proposal on Disaster Reduction Day.** To commemorate the tragedy caused by the 12 May 2008 Wenchuan earthquake, a national day dedicated especially for earthquake disaster reduction efforts is proposed on its anniversary date. Various activities can be designed for this day to remind people of the impact of earthquake disasters and the importance of earthquake reduction efforts.

5. Policy Implications for ADB in the PRC

In the wake of the Wenchuan earthquake, ADB provided the PRC a technical assistance of $1 million[22] in May 2008 to assess the earthquake damage and reconstruction needs for Sichuan. Following a few policy notes to advise the PRC government on dealing with transition from disaster response to recovery[23] as well as on lessons of international

[22] ADB, 2008. Technical Assistance to the People's Republic of China for Providing Emergency Response to Sichuan Earthquake (TA 7081) .

[23] ADB. 2008. Observations and Suggestions on Recommendations for Dealing with Transition from Disaster Response to Recovery.

experiences on earthquake insurance,[24] a $650,000 grant[25] was provided to the PRC to help improve its disaster risk management system. The funds will be used to conduct a full review of the current system and to help the PRC develop a risk management strategy that is coordinated, effective, and more inclusive of the civil society and the private sector. It is the first time that ADB is providing technical assistance to support the development of public–private partnerships in disaster management. Moreover, in February 2009, ADB approved a $400 million emergency assistance loan[26] to rebuild roads and schools that were demolished or badly damaged. It was the first loan to the PRC under ADB's disaster and emergency assistance policy, and is designed to ensure that authorities on the ground can move swiftly with rebuilding work. The loan will be used to rehabilitate and reconstruct over 350 roads and bridges, along with 12 schools, in the worst-hit counties of Sichuan and Shaanxi provinces.

ADB has rich experiences in providing assistance in disaster mitigation, response, and recovery in the Asia and Pacific region through its technical assistance and lending projects. ADB approved its Disaster and Emergency Assistance Policy in 2004.[27] The underlying principles of the policy include adopting a systematic approach to disaster management; mainstreaming disaster risk management as an integral part of development; strengthening partnerships among development and specialized organizations; and improving organizational arrangements within ADB for planning, implementing, and communicating effectively on disaster and emergency-related assistance. In accordance to the policy, ADB is conducting a regional study on the catastrophic insurance,[28,29] which will provide valuable lessons for the PRC. Several general directions that ADB can take to help the PRC in its design and implementation of earthquake insurance include

1. **Assess country risk and project risk for ADB operations in the PRC**. ADB could mainstream risk management considerations into ADB's country partnership strategy with the PRC to better assess risk profile of the PRC and identify appropriate response measures. At the individual investment project level, ADB may conduct an internal assessment of its own portfolio in the PRC, as a demonstration of proactive risk management, to account for the catastrophe risk exposure of ADB's project loan or guarantees.
2. **Encourage the PRC to incorporate disaster management into development planning and project approval.** This will help build a disaster-resistant economy, limit disaster losses, and make the insurance scheme sustainable in the long term. The Sichuan earthquake should prompt the PRC to review risk management practices in its development planning and project approval. The current National Plan for Comprehensive Disaster Reduction

[24] ADB. 2008. Observations and Suggestions on Earthquake Insurance: Lessons from International Experience and Key Issues for Developing Earthquake Insurance in the People's Republic of China

[25] ADB. 2009. Technical Assistance to the People's Republic of China for Promoting A More Inclusive And Effective Disaster Risk Management System (TA 7203).

[26] ADB. 2009. Loan to the People's Republic of China for Emergency Assistance for Wenchuan Earthquake Reconstruction (Loan 2508).

[27] ADB. 2004. Disaster and Emergency Assistance Policy. Manila. An action plan was developed in 2008 and the Asia Pacific Disaster Response Fund (APDRF) was established in 2009.

[28] ADB. 2005. Regional Technical Assistance for Development of Catastrophe Risk Insurance Mechanisms.

[29] ADB. 2008. Small Scale Technical Assistance for Natural Catastrophe Risk Insurance Mechanisms for the Asia and Pacific Region.

requires “integrating disaster reduction into the national overall planning of economic and social development”. At the project level, a much stricter assessment of a project’s vulnerability to earthquake, as well as other catastrophe, is also needed, including compliance with building codes.

3. **Facilitate stakeholders' dialogue and foster public–private partnership to form a common view on earthquake insurance.** To design and implement an effective earthquake insurance program, different government agencies, including Legislative Office of State Councils, CIRC, China Earthquake Administration, National Development and Reform Commission, Ministry of Finance, Ministry of Civil Affairs, Ministry of Housing and Urban-Rural Development, and provincial and local governments, have to collaborate with one another. Moreover, a partnership has to be established between these government agencies and the private sector, including commercial insurance companies and the civil society. ADB may facilitate the dialogue and foster the partnership among these agencies and the private sector through roundtable discussion(s) and workshop(s) to discuss the need, feasibility, and implications of establishing a national earthquake insurance program.
4. **Support data collection and dissemination**. ADB may support the collection, generation, and dissemination of hazard and exposure data sets to determine the vulnerability of PRC populations and infrastructure by region, by province, and by sector. Developing, synchronizing, and sharing risk information across government agencies, commercial insurers, and the general public are vital for the design and implementation of catastrophe insurance. Institutional capabilities to collect and develop risk information at the local level are lagging and should be strengthened. As indicated in the current National Plan for Comprehensive Disaster Reduction, the PRC needs to map comprehensive disaster risks and survey disaster reduction capabilities. This requires a concerted effort across different government agencies to synchronize risk information.
5. **Support insurance design.** ADB may provide technical assistance for designing earthquake insurance in the PRC, using a participatory approach and covering legal and regulatory systems, data collection and management, risk modeling, insurance/reinsurance policies, and awareness and education campaigns.
6. **Finance insurance**: ADB may explore different ways to help the PRC in financing its earthquake insurance program. The possibilities could include (i) providing lending to support pilot earthquake insurance scheme(s) either nationwide or in certain region(s) or province(s), (ii) sponsoring or guaranteeing a catastrophe bond issue by the PRC, (iii) directly providing earthquake catastrophe risk protection to ADB project loans, and (iv) supporting PRC projects to avail earthquake insurance offered either within or outside the country.
7. **Enhance public awareness and institutional capacity.** ADB may support information campaigns to introduce to the public the benefits and extent of an earthquake insurance coverage. ADB may also enhance the country institutional capacity to effectively implement and improve its earthquake

insurance through supporting training and education programs for the earthquake professionals.

Earthquake Risk and Earthquake Catastrophe Insurance for the People's Republic of China

This paper discusses historical earthquakes and earthquake risk in the People's Republic of China (PRC) and the recent developments of its earthquake risk reduction efforts. The general principles of earthquake programs are explained and the critical issues of formulating earthquake programs in the PRC are discussed, including lessons from earthquake insurance in other countries and other catastrophe insurance in the PRC, data issues, loss risk modeling issues, financial risk modeling issues, legislative issues, and public awareness issues. The paper concludes with policy suggestions for the Asian Development Bank in the PRC.

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