COUNTER-MEASURES AGAINST EARTHQUAKE RISKS AROUND THE WORLD

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ABSTRACT

This paper first introduces briefly the disasters resulting from major earthquakes and analyze the risk function by examining its variables. It shows that, for earthquake risk, the future is more hazardous than the present and the past. The paper then offers a comprehensive list of counter-measures against earthquake risk, from the simple ones dealing with the variables to insurance, reinsurance, financial incentive and insurance derivatives. These strategies must be combined and holistically integrated by taking into consideration all relevant factors in order to achieve the maximum level of control over earthquake risk.

KEYWORDS

Exposure, hazard, vulnerability, topography, liquefaction, subsidence, seismic fault, attenuation, mitigation, tsunami, excess of loss, earthquake reserve, equalization reserve, futures, options, swaps, insurance derivatives, OTC, hedge

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And lo! The starry fold reveal
The blazoned truth we hold so dear.
To guard is better than to heal,
The shield is nobler than the spear.

Oliver Wendall Holmes

1. INTRODUCTION

The Great Hannshin Earthquake Disaster occurred on January 17, 1995 with a Richter magnitude of M=7.2. This earthquake affected an extensive area containing three major Japanese cities of Kobe, Osaka and Kyoto and their surrounding satellite cities. The area is an industrial, commercial, trading and cultural center of Western Japan with a population of 15 million people. Although this was not a very large earthquake by its size, the urban disaster caused by it was extensive and devastating. In terms of total economic loss, the Great Hannshin Earthquake is unquestionably the most costly natural disaster in human history. As of now, the total loss has exceeded US$240 billion.

The huge loss in excess of US$240 billion is mind-boggling. It includes the losses from property and casualty damage, deaths and disabilities and the resulting disruption to the domestic and global economy. In other words, the enormous loss is due to this affected area's tremendously large exposure to earthquake risk. As countries continue their fast pace toward industrialization, their infrastructure will fastly become more modern, numerous, complex and costly. This includes all residential, commercial and industrial buildings and facilities, roads, bridges, railways, airports, hospitals, powerplants, pipelines, all sorts of communication systems etc. Moreover, a large amount of daily business transactions together with a booming economy continuing in many countries will make business interruption potentially the largest loss item in a major earthquake.

It is then understandable that with every passing day, earthquake risk is fastly increasing in many countries generally and Asia particularly. Asia's economic miracle has further led to a significant increase in the level and concentration of population and economic values exposed to earthquake disasters. This rapid growth in exposure has contributed to a dramatic increase in the economic cost of disasters over the last few decades.

In this paper, we will first use two recent major earthquakes to show the wide variety of damage and damage-producing mechanisms that need to be understood. We will then examine the earthquake risk more closely by looking into each variable that contributes to the risk. It will then be shown that the future will certainly be more hazardous than the present and the past. The main part of the paper will be devoted to managing earthquake risk in a comprehensive way which will then be followed by a conclusion.

2. TWO RECENT MAJOR EARTHQUAKES IN ASIA

2.1 The Baguio Earthquake, Luzon, The Philippines

The Baguio earthquake occurred on July 16, 1990 with a Richter magnitude of M = 7.7. Lateral displacement along the Philippine Fault was up to 6.2 m with a rupture length of more than 100km. Earhtquakes of this size represent about a one in ten years event in the Philippines where earthquakes greater than M=7 occur almost once a year.

This earthquake caused damage across an area of more than 20,000 square km, killed more than 1,700 people and seriously injured more than 3,500 people. Many of those killed, probably at least one half, died in landslides. More than 4,000 residential, commercial and public buildings were damaged beyond repair.

Many multi-story, concrete-framed buildings, and other unreinforced masonry buildings collapsed, mainly due to groundshaking. Soft ground floors were a common problem but steel-framed and wood-framed buildings performed well. Underneath some buildings, foundation designs were inappropriate for soft soils and settlement of earth fills also led to building collapse. Expectedly, building contents were also damaged; suspended ceiling, light fitting and ventilation ducts fell and unanchored interior components in industrial buildings slid across floors and pulled out piping and electrical conduits.

Most of serious damage to lifelines occurred in areas of soft soils where ground spreading and liquefaction occurred. In the central business district of Dagupan which was built on loose saturated sand, about 90% of buildings sank 1-2 meters relative to street levels. In Baguio 70% of the water supply system become inoperable because of pipe rupture. In other areas underground pipelines were disrupted by ground settlement. Also, buoyant underground tanks rose toward the surface rupturing pipelines.

At the Port of San Fernando which services Northern Luzon, all 3 piers were damaged by liquefaction. Many bridges were also damaged by liquefaction isolating towns. Numerous small towns were affected by both ground spreading and liquefaction. Furthermore, landslides buried some villages entirely and roads were blocked. Baguio was isolated for 3 days by landslides blocking roads. Near the Digdig Fault there were up to 4 landslides per kilometer of road. In the Dalton Pass area 27km of highway was blocked by 14 major and 82 minor landslides. At Baguio airport a landslide displaced the runway, taxiways and the terminal building.

In the Baguio area several foreign-owned facilities vital to production processes around the world collapsed or had serious business interruptions. These affected not only local operations but also production and schedules of worldwide operations. Also, many of the better hotels in Baguio were seriously damaged. The unfavorable publicity with respect to all these can significantly affect Baguio's future business on a worldwide basis. The total losses in the Baguio earthquake was estimated at US$2 billion.

2.2 The Great Hannshin Earthquake Disaster

This earthquake occurred at 5:46 a.m. of January 17, 1995 with a Richter magnitude of M=7.2. The causative fault extended over 40 km in the south-west to north-east direction near Kobe. The epicenter was located under Akashi Straits which lies between Kobe City and Awaji Island. The area most heavily damaged by this earthquake extends in a belt-shaped zone along the causative fault system. It extends over the entire east-west length of the most densely populated parts of Kobe City and, also, to Ashiya City and Nishinomiya City. Northern part of Awaji Island was also seriously damaged. About three million people in this region were affected by the earthquake.

All told, about 200, 000 buildings, mostly old wooden houses and building constructed under Japan's pre-1981 building code, were collapsed. These building collapses were the major reason for the high death toll of 5,500. More than 200 fires broke out following the earthquake and burned out an area of 100 hectares with 7,500 houses and buildings being destroyed. Transportation systems, especially bridges, highway viaducts and railways, were heavily damaged, some completely collapsed. Kobe port and harbour facilities were so seriously damaged that their functions as Japan's most important liner port were temporarily lost completely. The major cause for the damage was soil liquefaction on reclaimed lands. Disruption to lifeline such as power, water, gas, sewer, telecommunication was so extensive that their restoration periods needed five to ten times as long as those experienced in previous major earthquakes.

3. EARTHQUAKE RISK

We can observe from the two major earthquakes as described in Section 2 above that earthquake risk is a function of four variables: hazard, exposure, location and vulnerability. Different combinations of these variables yield different levels of risk. Since earthquake risk is a function of the interplay of these variables, we will now look into each variable in the following:

3.1 Hazard

There have not been major changes in the level of earthquake hazard on the global basis for at least the past few hundred years. Thus, the level of earthquake hazard has remained roughly constant from year to year on a worldwide basis. However, the distribution of earthquake hazard varies. For example, Japan is located in the circum Pacific earthquake belt and is one of the most earthquake prone countries in the world. In the past, many earthquakes occurred in and around Japanese archipelago and many lives and properties were lost. Because of the constant level of earthquake hazard, each country or society will not be exposed to increasing levels of earthquake risk without considerable growth in its exposure to earthquakes.

3.2 Exposure

Due to massive population growth and urbanization around the world, exposure to earthquake has been increasing at an unprecedented rate. This rate of increase is expected to accelerate even faster because of the continuing growth in economy in general and trade and commerce in particular. Moreover, not only is the population growing rapidly, it is becoming more and more concentrated in the more earthquake-exposed areas.

As the damage due to the Great Hannshin Earthquake exceed US$240 billion, one should be able to appreciate the magnitude of damage that can be caused by a major earthquake occurring in highly developed urban areas. Events of similar impact could occur in a number of places throughout the world, with Tokyo, Jarkarta and other areas of Japan being the most obvious. Studies have shown that total economic losses from a major earthquake in the Tokyo area could reach US$2 trillion.

3.3 Location

This refers to the site specific conditions where houses, buildings, facilities or other infrastructure are constructed. As an example, the soil condition and topography impact the level and type of ground motion and acceleration, landslide potential, liquefaction potential and subsidence potential at and around the site.

Compared with other parts of the world, Asia's population density is significantly higher. Since the best real estate in Asia has already been developed, new development typically occurs in less desirable locations from the viewpoint of earthquake risk. For example, building on reclaimed land has become more and more common in Asia but it poses significant risk unless costly engineering work is done to stabilize the soil. This risk was best illustrated by the serious liquefaction and subsidence suffered by the widespread areas of reclaimed land in Kobe during the Great Hannshin Earthquake. Location is expected to play an ever more important role in increasing earthquake risk as developers tend to use those sites that are most exposed to earthquake damage.

3.4 Vulnerability

This refers to how well a building, facility or infrastructure will perform under various levels of earthquake hazard. Although construction science and engineering now enable earthquake-resistant structures to be built, the overall vulnerability of much of the world's infrastructure continues to worsen due to the deteriorating condition of older and vulnerable structures.

This was vividly demonstrated by the pattern of destruction in the Great Hannshin Earthquake in Japan. Two hundred thousands of structures destroyed by the quake were built soon after World War II when proper building materials were not available. This lack of materials, combined with an urgency to reconstruct Kobe led authorities to relax the building code of 1924. These two factors jointly increased the vulnerability of the structures. This kind of situation is expected to recur so long as these older and vulnerable structures are in existence.

There are reasons to believe the vulnerability of infrastructure systems, buildings and facilities will continue to worsen. During periods of rapid population growth and economic boom, speedy development will create residential and commercial buildings and facilities with poor vulnerability. Even for concrete and steel structures, their condition is expected to worsen over time due to aging. As an example, many bridges are corroding due in part to their exposure to salt water. Moreover, new constructions often do not use the most advanced earthquake-resistant engineering due to the associated increase in costs.

3.5 With the level of earthquake hazard being constant, earthquake risk is rising due to increasing exposure, poor selection of locations for new development and the worsening vulnerability of infrastructure. This risk is not limited to physical damage only. Often the impact from a major earthquake on business activities, financial and legal liabilities and long-term social and economic activities is greater than the economic cost of physical damage.

4. THE FUTURE

We have reasons to believe that the future will certainly be more hazardous than the present and the past, at least from the insurers' and reinsurers' point of view, and for at least part of the time.

4.1 As described in Section 3 above, increasing exposure, poor selection of locations for new development and the worsening vulnerability of infrastructure will jointly increase earthquake risk at an unprecedented rate around the world. Since 1900, per capita assets have risen about 10% per decade and this trend is continuing. While this growth has been far from uniform in time and in space, it appears certain that this trend is accelerating especially fast in Asian countries during the last decades of this century. This will accelerate the increase in exposure in Asia.

4.2 The growth in assets has been accompanied by an increase in the complexity of economic activity with investments in highly sophisticated technologies and services. Multinational corporations with a global spread of this kind of complex economic activities will be particularly vulnerable to the consequences of losses at one site affecting their global operations.

4.3 Enormously complicated giant projects involving countries or governments have become more common. Meanwhile, we have all become much more reliant on a worldwide web of highly effective electronic equipments and telecommunication systems. High-tech hazards can stem from the interactions of earthquake with technologically complex facilities. As an example, one should question how well the following effects are understood:

(a) The effects of an earthquake on a nuclear powerplant.

(b) The effects of an earthquake on a modern oil terminal.

4.4 The increasing complexity of modern insured risks suggests that loss of profits lines may become more important. Similarly, contamination problems, environmental damages, long tail product liability and other liability issues are likely to increase.

4.5 Since cities and other areas of risk accumulation are growing rapidly, the insurance density in all these areas must also be rising rapidly. For example, based on Munich Re world map of natural hazards, on the basis of 1985 population estimates, 74% of the 50 largest cities were exposed to hazards. However, when the 50 fastest growing cities were considered, 88% were exposed to the same natural hazards. It seems very likely that the higher the exposure, the higher the insurance density. Although insurance can reduce the devastating financial misfortune from catastrophes, it can also increase the risk of them happening. The higher the insurance density, the greater the increase in this type of risk.

4.6 Although the earthquake hazard on a worldwide basis has been quite constant for the past few hundred years, the distribution of the hazard in time and in space as measured by the total of great earthquakes is quite variable. We must expect periods when major earthquakes are relatively common. Moreover, there is evidence of concentrations in time of earthquakes.

The above clearly suggests that earthquake risk in the future will definitely be significantly greater than those at present or in the past. At the very least, the future will certainly be more hazardous than the present and the past and for at least part of the time.

However, the picture may not be all adverse; improved technologies and increased efforts at hazard mitigation, improved building design and construction, enhanced public education and warning systems will all help to redress the balance.

5. EARTHQUAKE RISK MANAGEMENT

Although the earthquake risk around the world has grown in an unprecedented rate, there are many strategies available now which can be used to stabilizing, reducing, controlling, mitigating and managing that risk. In what follows, we will describe each such strategy:

5.1 Identify and assessing the earthquake risk and preparing for it.

This means constructing long records spanning as long a period as possible ------------------ certainly for hundreds of years. The records not only show the occurring time, magnitude, damage and losses but also those quantifiable variables that are potentially related to the occurrence of earthquakes. These include the time elapsed since the last earthquake, tilting of the land surface, fluctuations in the magnetic field, and changes in the electrical resistance of the ground. Armed with the records, steps must be taken to prepare for the events in the future. Both public and private sectors must take part in the process. Preparing for earthquake risk involves educating the exposed population on the following:

(a) why earthquakes occur
(b) how to prepare for an earthquake
(c) how to react when one strikes
(d) how earthquake drills can instill an automatic reaction and
(e) the existence and scope of the potential loss.

This awareness should generate interest in preparing for the hazard, thereby reducing the impact of an earthquake disaster.

5.2 Mitigating earthquake hazard

This requires states (countries or societies) to adopt building and other safety codes for new and substantially modified buildings. Also, the states must certify that local communities have adopted and are enforcing such codes. Each earthquake-prone state or community should be required to develop a mitigation plan that would

(a) verify compliance with codes;
(b) identify and rank earthquake-prone communities;
(c) establish priorities for critical facilities;
(d) identify most cost-effective mitigation techniques;
(e) improve emergency response to disasters;
(f) expedite rebuilding of crucial lifelines;
(g) encourage development of local hazard mitigation plans;
(h) develop standards for staffing, operations and training.

5.3 Improving location selection and reducing exposure

This requires states (countries or societies) to plan their land use and development. By controlling what types of development may be permitted in what kind of locations, land use planning can reduce property damage and save lives in times of earthquake disaster. Just as building and other safety codes, land use planning can be effective if states can enforce it without difficulty. However, it is generally fraught with opportunity costs and politics. On a global basis, it has not worked really well historically in major urban areas where the earthquake risk is highest. Not only have governments had difficulty in drafting laws acceptable to all parties concerned, they have not been able to implement laws and regulations once they are passed by the legislature. Examples abound. To help implement land use planning laws, governments could develop some rating system that rewards communities or developers which take proactive steps to mitigate their earthquake risk with lower earthquake insurance premiums. Note that land use planning improves location selection which in turn reduces exposure to earthquake risk.

5.4 Reducing Vulnerability

Vulnerability is concerned with the susceptibility to damage and loss of the elements at risk such as buildings, facilities, contents and other infrastructure. One of the most obvious ways to reduce vulnerability is to increase the quality of buildings, facilities and infrastructure, not only prospectively but also retroactively. Today's constructure science and technology are capable of building high quality structures that will not collapse but remain functional even in a major earthquake. Using this technology to build earthquake-resistant structures would reduce both casualties and economic losses, both direct and indirect, that are attributable to property damage. However, it is expensive, especially for substantially modifying existing structures retroactively. In general, the older the existing structures, the more costly the modifying work. As was mentioned in the Great Hannshin Earthquake Disaster, the majority of both the property losses and human casualties were due to collapse of or severe damage to older structures.

There are reasons why most people and developers do not use modern technology to build earthquake-resistant structures even in earthquake-prone areas:

(a) The added cost can be substantial

(b) The benefit of building such structures is unknown

(c) Earthquake occurs infrequently, especially the major ones, and its prediction is not a precise science.

Therefore, this structural approach to reduce vulnerability should be imbedded in the law governing construction within the states (countries or societies). In other words, this approach relies heavily on changes in the content and enforcement of states' building and other safety codes. These codes are rules and regulations adopted by states to govern construction within the states. They contain specifications as to the materials and techniques used in construction and guidelines for engineering design. Since they are generally the products of compromise among groups with conflicting interests, they represent the minimum standards of construction. However, they can play an important role in reducing the vulnerability of structures by establishing a standard for construction that can be improved over time. With good building and other safety codes in place and right incentives, construction techniques can be effective in improving existing buildings so that structures will not collapse or suffer serious damages. Although structural approach to new development has significant long-term benefits, the sheer number of existing structures indicates that strengthening or modifying existing structures is the most important step to be taken in preparing for an earthquake.

5.5 Disaster planning and management

Just as earthquake education, disaster planning and management can reduce the number of casualties and the amount of economic losses caused by a disaster. All organizations such as governments, agencies and other relief organizations, fire departments, utilities companies (power, gas, electric, telephone and water companies), hospitals and other critical care facilities must have plans in place and practise different scenarios periodically in order to be effective in improving rescue and recovery operations. As an example, in the Great Hannshin Earthquake, Kansai Electric Power Co demonstrated the effectiveness of such planning and management through its speedy restoration of electricity to the disaster area. Even though the damage in the disaster area is enormous, Kansai Electric was able to restore power to the main streets within 24 hours and then essentially restore it throughout the whole city within one week after the earthquake. This rapid response was made possible by the company's disaster response planning, training and management.

An effective earthquake planning and management program should take into account the following:

(a) A survey of the area's infrastructure with emphasis on its vulnerability to earthquakes,
(b) A comprehensive estimation of the consequences of potential earthquakes in the area,
(c) An effective utilization of the capacity of all the people who may be involved in an earthquake,
(d) A set of specific and realistic recommendations for reducing the area earthquake risk,
(e) An active participation of people who make the recommendations, in executing them,
(f) A framework of a comprehensive program to manage the area's earthquake risk.

5.6 A free market approach to determine earthquake insurance premium

As described in Section 3 above, earthquake risk is a function of four variables: hazard, exposure, location and vulnerability. Today's technology has made it possible to develop a software package which can calculate earthquake risk for a specific location. As an example, the commercial software package Insurance/Investment Risk Assessment System (IRAS) can perform location-specific analysis based on the above four variables. For the earthquake hazard, IRAS performs its calculations on the basis of geoscientists' understanding of the location of seismic faults, the attenuation of seismic energy through different materials and the translation of that energy into ground shaking intensity and collateral hazards such as landslide, liquefaction and fire. The resulting hazard is then combined with exposure data on the inventory of structures, soil conditions and topography in the given location. Finally, IRAS uses vulnerability relationships to translate the above data into an estimate of financial loss to a given structure, calculated as a function of ground shaking intensity and adjusted according to location specific data.

Commercially available software packages can be used by insurance companies to perform location-specific analysis of earthquake risks and price earthquake insurance policies according to their individual level of risk. Thus insurance premium is truly a function of risk; the higher the risk, the higher the premium. If implemented, such rational pricing mechanisms could influence people and organizations to build better designed and better quality structures in areas with lower earthquake risk. Based on such an equitable pricing system that reflects different levels of risk, insurance companies can also impress upon architects and construction engineers the relative seismic performance of different types of designs and structures. Through the equitable insurance pricing mechanisms, insurance companies can further influence people and organizations to demand that architects and engineers build structures that can be insured at lower cost. Similarly, developers can be so influenced that they will use better locations since premiums are allowed to reflect different levels of risk associated with different locations.

5.7 National earthquake insurance program

A national earthquake insurance program can be designed to provide insurance against physical damage to property resulting from earthquake. The premium rates should be required to be actuarially sound and shall be based on the following factors:

(a) Known hazard, including frequency and severity, in each geographical area;
(b) Risk of damage from an earthquake;
(c) Value and age of insured property;
(d) Construction and architectural type of structure;
(e) Hazard mitigation measures utilized; and
(f) Any other relevant criteria affecting insurance premium.

Rates may be structured as an incentive to loss mitigation. For example, lower rates may be charged for property that meets building standards or for buildings constructed far away from seismic faults. The insurance coverage must include damage to the covered property, debris removal, additional living expenses and ordinance and law compliance such as the cost for the rebuilt property to comply with local law and codes. Insurance benefits are payable only if the losses are caused by:

(a) An earthquake or fire proximately caused by an earthquake;
(b) A tsunami associated with an earthquake

Insurance companies participating in this program are required to include this coverage in policies for residential property owners in eligible geographical areas. Insurers may opt out of this program. However, they must notify their insureds of this fact. It may be stipulated that no mortgage loan secured by residential property located in an earthquake-prone area may be made, increased or extended unless insured by a participating insurer.

Under the national earthquake insurance program, a fund is set up to pay losses and mitigation costs. The fund consists of premiums, amounts borrowed and interest income and can be used to pay losses, loss adjustment expenses, participating insurer overhead, operating expenses of the program and principal and interest on amounts borrowed. Participating insurers pay premiums to the fund which reimburses insurers for covered losses paid. Premiums collected by the fund are not subject to any tax except premium taxes. The obligation of the fund are backed by the full faith and credit of the national government.

5.8 National earthquake reinsurance program

A national earthquake reinsurance program can be designed to provide an excess of loss reinsurance coverage for private insurers, private reinsurers that reinsure private insurers which participate in the national earthquake insurance program. The program could cover, say, 95% of the losses of participating insurers arising from one or more catastrophes within a 12-month period when some loss situation occurs. Examples of such a situation: (a) the insured losses exceed, say, 15% of consolidated industry surplus, (b) the participating insurer incurs losses of, say, 15% or more of its surplus.

When an earthquake occurs in a limited geographical area with relatively few insurers, the reinsurance fund may be allowed to respond in such a case. As an example, a participating insurer may recover 95% of its losses above 20% of its surplus but in no event more than 200% of its pre-earthquake surplus. The response of the reinsurance fund may also be stated in terms of amount. For example, the fund will pay 95% of the losses from catastrophes within 12 months when the total losses exceed the lesser of $500 million or ten times the volume in that area for earthquake business.

Eligible losses include loss adjustment expenses, assessments, surcharges or other liabilities. Items which are generally allowed to be subtracted from eligible losses are collectible reinsurance recoveries and an appropriate percentage of any uncollectible reinsurance.

The reinsurance premium rates should be required to be actuarially sound and should include a consideration of the following factors:

(a) Premium volume in earthquake-prone areas;
(b) Proportion of total expected payments by geographic area for each ceding company;
(c) Private reinsurance capacity;
(d) Need to pay back Reinsurance Fund for borrowed assets;
(e) Ratio of net written premium to policyholder surplus for each ceding company; and
(f) The specific amount and nature of the true risk for each ceding insurer for the various coverages it writes.

Just as the fund set up under national earthquake insurance program, a reinsurance fund is created under national earthquake reinsurance program. One difference between these two funds could be that premiums collected for the reinsurance fund are not subject to premium taxes.

5.9 Maximizing insurance industry capacity for coverage of earthquakes.

There are several steps that can be taken to maximize insurance capacity available to cover earthquake risk:

(a) Enhance the current distribution of earthquake risk

  (1) by increasing participation in the risk for those insureds in the most earthquake-prone locations through larger deductibles, greater coinsurance and higher premiums;

(2) by expanding the spread of risk to include enhanced sharing in the ultimate costs by those insureds located in earthquake-prone areas but not yet affected by the earthquakes;

(3) by ensuring that all insurers providing earthquake coverage are bearing a reasonable share of the risk for their own net account; and

(4) by continuing to improve the relation of premium to exposure for reinsurers willing to assume the earthquake risks.

(b) Develop better information about the nature, location, extent and loss potential of risks exposed to earthquake through improved cooperation between insureds, reinsureds and their reinsurers and through commitment of resources necessary to capture the relevant data;

(c) Encourage government and legislators to reevaluate, upgrade and enforce compliance to building codes and construction standards which include considerations for minimizing structural damage due to earthquakes; and

(d) Expand the initiatives, by means of joint efforts of industry and government, if necessary, to contain the growth of aggregate exposures in earthquake-prone areas already saturated with risk.

5.10 Making earthquake reserves tax deductible

If pre-funded earthquake reserves are qualified for tax deductibility, insurers will be more prudent in managing their earthquake reserves. On the other hand, earthquake reserves need to be tax deductible to help mitigate the adverse impact on financial statement due to the establishment of such reserves. Many European countries, including Germany, France and Netherlands, have special tax rules governing catastrophe reserves generally called equalization reserves in their tax codes. These rules provide for a tax deduction on the establishment of the reserves and taxable income when the reserves are drawn down.

Although there are differences among these countries, these rules all function to smooth the profits that emerge from the affected lines of business. Catastrophe reserves are established in profitable years to be drawn down in those years when there is an underwriting loss due to a catastrophe. While there is no uniformity as to the lines of business which may be qualified for equalization reserves, qualified classes of business generally include the more volatile and unpredictable lines. As an example, in France, equalization reserves may be set up for hazards such as hail, nuclear and pollution.

Other countries could conceivably be patterned after the European models, allowing for a tax deduction when the reserves are established and taxable income when the reserves are drawn down in later years to help mitigate an underwriting loss due to a catastrophe. In designing such a model, one should probably take into account the following factors and points:

(a) Determination of a threshold level permitting insurers to establish and tax-deduct earthquake reserves for their net retained liabilities, including a percentage of losses that exceed their own earthquake covers;

(b) A capping mechanism to prevent insurers from artificially overstating their earthquake reserves to obtain a tax deduction;

(c) The model would presumably expand the definition of an insurer's tax deductible reserves within the context of each country's insurance company tax law. Non-insurance companies are not allowed currently to deduct reserves for future events and this should not change under the model; and

(d) The model would not change the basic requirements that reserves must meet first in order to further qualify for a tax deduction. These are actual risk transfer, risk shifting and risk distribution. Non-insurance companies' self-insurance reserves clearly cannot meet these requirements whether considering contingency reserves for catastrophes or any other reserve for the normal risks of business losses.

5.11 Using insurance derivatives to hedge earthquake risks

In recent years, derivative securities such as futures, options, swaps and other synthetic products resulting from some combinations of these and other derivatives have grown explosively worldwide. Even conservative insurance companies use derivatives to hedge the risks in their investment portfolios The new products called insurance derivatives are the results of applying derivative securities to manage insurance risks. Enthusiasts for insurance derivatives believe that a robust market in them could at least help increase the capacity of the reinsurance market.

Currently, the only exchange listing insurance derivatives is the Chicago Board of Trade (CBOT). After spotting the vacuum in the property-catastrophe market after Hurricane Andrew, it launched a catastrophe futures contract in December, 1992, followed by options on the futures the following summer. The futures' price is based on a quarterly loss-ratio index which is calculated by dividing the total losses from catastrophes for a quarterly period reported by 26 American insurers by a premium figure that is fixed in advance. The ratio is multiplied by $25,000 to arrive at the contract price. The loss or gain on the contract is the difference between its price at the beginning of a quarter and at the end of it. The higher the losses incurred in a given period, the higher the price of the future. However, the sellers of futures contracts have limited liability because the maximum payout on a futures contract is capped at $50,000.

To refine the system, the CBOT has created three regional indices ------ eastern, mid-western and western ------------ as well as a national one. These reflect the different risks that companies face in each area: hurricanes in the east, tornadoes and floods in the mid-west and earthquakes in the west. In spite of this ingenuity, trading in the futures in CBOT has been slow. But turnover in catastrophe options has been growing steadily. This is because options buyers can isolate particular layers of catastrophe risk by using a certain combination of options. This mimics a standard reinsurance contract, which also works on the basis of layers: one reinsurer might agree to cover the first $10 million of any losses in excess of $50 million, another will cover the next $10 million, and so on.

In addition to exchange-traded insurance derivatives, there are those which are privately negotiated or so called over-the-counter (OTC). It is estimated that OTC business is about 20 times as large as that traded in the CBOT. The attraction of OTC contracts is that they do not have to be pegged to the CBOT's own index, but can be specially designed to reflect an insurer's spread of risks.

America's insurance regulators have given insurance derivatives a boost when they announced a national risk-based capital scheme for the non-life insurance industry, which has come into effect in 1995. The new rules require insurers and reinsurers to set capital aside against, among other things, credit risk and underwriting risk. A similar set of rules imposed on the banking industry several years ago led banks to use interest rate and other derivatives more extensively to manage their risks. It is being speculated that history will repeat itself with insurance. So far in the USA only three states -------------- Illinois, New York and California -------------------- have amended their laws to allow insurers to use insurance derivatives.

If insurance derivatives do take off, in a few years they could provide an important new source of capital. Insurers and reinsurers will then be able to write more business, knowing that it can be hedged swiftly, efficiently and cheaply. There are already signs that insurance derivativess could help solve the issue of uninsurable risks. Along this line, one should expect that the insurance derivatives markets will be able to allow one insurer to trade its earthquake risks for another insurer's hurricane ones, or to cover itself against the risk of environmental disasters, at least in the near future.

Since ordinary derivative securities have been growing enormously, it is conceivable that many countries could follow America's model and use insurance derivatives to hedge their earthquake risk through both exchange-traded and OTC approaches. The first step to be taken in this direction is to amend each country's existing insurance law so as to allow insurers to use insurance derivatives.

5.12 In the above, we have described a number of earthquake risk managing strategies. Some of them have been put to use and proven to be highly effective while others are quite new and have not been fully tested yet. For examples, strategies such as identifying and assessing the earthquake risk and preparing for it, mitigating earthquake hazard, improving location selection and reducing exposure, reducing vulnerability and disaster planning have all been used and proven highly successful. This is particularly true in California where the most progress has been made with these strategies in minimizing earthquake risk. Most well-known cases are Anheuser-Busch's brewery in the San Fernando Valley region of Los Angeles, The Gap Clothing Stores of San Bruno-California, Carter Hawley Hale department stores in Southern California, and Intel's headquarters in Santa Clara. Other strategies such as using insurance derivatives and pricing earthquake insurance premium via a free market approach are quite new. The theoretical bases for these strategies are sound and innovative and in time they should prove to be highly effective.

All the strategies as described above need the best cooperation among governments, insurers, reinsurers and insureds. If government can create a more sensible framework for the insurance industry to operate in, if insurers and reinsurers can show some more imagination and if their customers are given suitable incentives to reduce their own risks, each country should be able to cope with most earthquakes without difficulty.

Take the framework first. If insurers are to assume big risks, they need to be allowed to charge premiums that are commensurate with them. Yet in some countries, regulations often prevent them from doing so. Existing tax rules in many countries also make it expensive for insurers to set aside catatrosphe reserves against unforeseen disasters. If natural catastrophes are to remain insurable risks, that must change.

Insurers and reinsurers should also do more to help themselves. For example, they need to develop new policies that spread risk by, say, covering all natural hazards, rather than single ones such as earthquakes or hurricanes. And they need to develop the know-how to profit from insurance derivatives and other innovative risk-management techniques.

The insurance industry and governments need to work together to educate consumers on how to reduce risks and give them sufficient incentives to do so. This means increasing the weighting of the premiums they charge to reflect, say, the riskiness of particular regions, poor disaster planning, inadequate emergency procedures, and non-compliance with building codes, and to reward good risk-management with lower rates.

6. CONCLUSIONS

Earthquake risk has been increasing on a daily basis in the world generally and in Asia particularly. We have shown that, for earthquake risk, the future is more hazardous than the present and the past. There are a great variety of strategies for mitigating earthquake risk. These strategies must be combined and integrated to achieve the maximum level of control over earthquake risk. Each country must take a holistic view of the earthquake problem, rationally evaluate its options for different combinations of strategies and make explicit the trade-offs necessary to develop a cohesive approach toward earthquake risk. These steps must be taken by each country individually since different economic, political, social, legal and cultural circumstances of each country will dictate different trade-offs. Furthermore, each country needs to balance its economic, political, social, legal and technological constraints in determining how best to manage its earthquake risk. A holistically integrated strategy developed by taking all these into consideration will prove to be the best approach to managing earthquake risk around the world.