Assessment of Capacity and Solvency of Earthquake Insurance Programs for Earthquake-prone Regions and Countries

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SUMMARY:
In several earthquake prone regions and countries, governments play a key role in establishing earthquake insurance programs in order to effectively manage risks, compensate for economic losses from property damage, speed up recovery of disastrous areas and reduce government's financial burden. This paper summarizes earthquake insurance programs in the five major earthquake-prone countries, including three Asia-Pacific countries (Japan, Taiwan, and New Zealand), Turkey and California (U.S.), discussing their history, regulations, insurance schemes and the approximate penetration rates of available policies. Further, in order to assess the performance and solvency capacity of these insurance programs, insured exposures and the resulted losses are estimated for the studied regions and countries. Based on performed studies, the results from the perspective of the operation of earthquake insurance systems in earthquake-prone countries are also discussed.

Keywords: Earthquake insurance, solvency capacity

1. INTRODUCTION

Key insurance parameters of the earthquake insurance programs in five earthquake-prone regions, namely California, Japan, New Zealand, Taiwan and Turkey are first summarized. Furthermore, a study of relative exposure and risk estimates of each earthquake insurance program is presented. Finally the implications for the performance of the insurance programs based on the relative studies and research is discussed.

2. OVERVIEW OF THE FIVE EARTHQUAKE INSRUANCE PROGRAMS

California Earthquake Authority (CEA)

After the 1994 Northridge earthquake, the California Earthquake Authority (CEA), a quasi-state agency, was established to replace the private market for earthquake insurance in California. The law requires insurers that sell residential property insurance in California to also offer earthquake coverage to their policyholders. In offering earthquake coverage, insurance companies can become a CEA participating insurance company and offer the CEA’s residential earthquake policies or they can manage the risk themselves. CEA participating insurers are responsible for almost 80% of California's residential property insurance. By far, CEA is the largest monoline writer of residential earthquake insurance in the United States, with about 820,000 policies in force, an estimated 600 million US dollars (USD) in annual premium revenue. In past years, these policies represent approximately 9-12% take-up rate of residential earthquake coverage across the state. The basic CEA policy covers structural damages to a residential dwelling or mobile home, paying up to 5,000 USD to repair or replace personal possessions and 1,500 USD for additional living expenses while the home is being repaired or rebuilt. For this basic coverage, all claims are subject to a 15% deductible. CEA offers selections of either a 10% or 15% deductible on the dwelling coverage, and CEA’s increased-limit options allow you to increase personal property coverage to as much as 100,000 USD and additional living expenses/loss of use coverage to as much as 25,000 USD (CEA website).

Japan Earthquake Reinsurance (JER)

In Japan, Japan Earthquake Reinsurance Co., Ltd. (JER) was established after the Niigata Earthquake in 1964. Earthquake insurance is arranged as an optional rider to fire insurance which covers buildings for residential use and/or personal property. Earthquake insurance however cannot be purchased separately. The premium rate for earthquake insurance is calculated by the Non-Life Insurance Rating Organization (NLIRO) of Japan. Prefecture level earthquake penetration rates vary from 10-35%.; the national average is 23-24% for the combined building and personal property policies as of 2010 (NLIRO earthquake statistics, 2010). One unique feature in the Japanese earthquake policy is its stepped payments of earthquake claims according to the degree of loss by total, half or partial loss of the policyholder's insured residential building and/or personal property (JER annual report, 2010). The details of earthquake policy payout are summarized in Table.1.

Table 1. Japan earthquake policy payout by degree of loss

Coverage	Degree of loss	Damage ratio	Amount of insurance claim paid
Residential buildings, personal property	Total loss	Building: ≥50%, Content: ≥80%	100% of amount insured
	Half loss	Building: ≥20%, <50% ; Content: ≥30%,<80%	50% of amount insured
	Partial loss	Building: ≥3%, <20% ; Content: ≥10%,<30%	5% of amount insured

New Zealand Earthquake Commission (EQC)

The New Zealand Earthquake Commission (EQC) has its origin in an insurance pool set up in 1941 to address war damages. It later was expanded to earthquake damages and in 1993 became the Earthquake Commission. Nowadays, EQC is the country's insurer for earthquakes and other natural disasters. The EQC insurance scheme is compulsory for residential property owners, and it insures about 90% of New Zealand homes (Earthquake Commission Annual Report, 2009-2010). Coverage is for physical damage against earthquake, natural landslip, volcanic eruption, hydrothermal activity, tsunami; in the case of residential land, a storm or flood; or fire caused by any of these (EQC, website). Although there is a maximum sum insured (100,000 New Zealand dollars (NZD) on each dwelling and 20,000 NZD on contents, on a first loss basis), over 95% of all damages to homes will be met by EQC. The legislation controlling EQC contains a government guarantee that all the obligations of EQC will be met. This is a necessity for a compulsory scheme and it provides EQC with the best financial security available. EQC is not set in a competitive environment, and the legislation believes that setting aside financial reserves and preparing to help a community to recover from a disaster do not fit an environment driven by market forces. (David Middleton)

Taiwan Residential Earthquake Insurance Fund (TREIF)

In the aftermath of the 1999 Chi-Chi Earthquake (magnitude 7.6), Taiwan Residential Earthquake Insurance Fund (TREIF) was created by the Taiwan Ministry of Finance to facilitate a risk sharing mechanism between private insurance companies and the government covering insured residential earthquake losses. TREIF collects premium for the earthquake risk from the insurance companies and redistributes the premium to the various risk sharing entities (including itself). If losses occur, TREIF collects the appropriate funds from the risk sharing entities and reimburses the direct insurers for their payments to the policyholders. As of December 31, 2011, there were 2,390,202 policies in-force, representing an approximate take-up rate of 30% (based on a total of 8,166,245 households in Taiwan), largely increased from 6% in 2002. The annual flat premium is 1,350 New Taiwanese dollars (TWD) based on a limited insured amount of 1.5 million TWD. Additional coverage of 200,000 TWD per dwelling will be provided for additional living expense in the event of total loss (damage ratio of the structure >50%) of the insured dwelling (TREIF website).

Turkish Catastrophe Insurance Pool (TCIP)

In Turkey, Turkish Catastrophe Insurance Pool (TCIP) was created to offer earthquake insurance, which was made compulsory to all residential buildings that fall within municipal boundaries since 2000. As the compulsory scheme covers only residential buildings, industrial and commercial risks as well as residential buildings in small villages (with no established municipality) can be insured on a voluntary basis. The number of insurance policies reached 3,435,861 insured dwellings as of 2009. This number represented approximately 26 % of total dwellings that fall within the compulsory scheme. The penetration rate varies across different regions in Turkey, with highest penetration rates observed in the Central Anatolia region (34%), the Marmara region (32%), and the Aegean region (26%). (Turkish Catastrophe Insurance Pool Compulsory Earthquake Insurance Annual Report, 2009) Premium rates are actuarially sound, not subsidized, and vary with construction type and property location. As of January 2012 the maximum sum insured amount granted by TCIP policies in all structure types is determined as 150,000 Turkish Lira (TRY) (TCIP website).

3. ESTIMATION OF INSURED EXPOSURES AND LOSSES OF THE PROGRAMS

The basic components of loss estimation for a given country are the probabilistic earthquake hazard, the regional building inventory and the building vulnerability functions associated with typical construction types in the region as well as the estimation of replacement cost values for different damage levels. In this section, the general methodology for estimation of the insured property exposures of each country's insurance program will be discussed first. Then the stochastic loss analysis for each program's exposed values using RMS proprietary earthquake models is performed followed by a discussion on the implications of the resulted loss metrics in each of the insurance programs. Since the focus of this paper is the discussion on the comparisons of each regional earthquake insurance program and due to the limitation of space, the detailed scientific and engineering information of key components in the earthquake model (i.e. earthquake hazard, vulnerability, and financial modelling) will not be described here.

3.1 Estimate economic and insured exposures of each regional insurance program

The general methodology of estimating insured exposures for a given geography and lines of business follows the simplified formula below:

$$Exp = B * C * P \tag{3.1}$$

where *B*, the total building stock, and *C*, the unit cost can be calculated based on the census and construction statistics in the given country. Multiplying building stock by unit cost, the economic building exposures can be determined at any administrative level depending on the availability and coverage of the data sources. *P* represents the penetration rate of the earthquake insurance program, which is the ratio that quantifies the percentage of properties that buy earthquake insurance. The insurance assumptions such as limits and deductibles are also applied to the modelled insured exposures based on the policy information available in each of the programs' official website (summary can be found in the previous section).

Figure 1 shows the validation performed for the modeled economic residential exposure per capita against the GDP per capita for each regional program. The trend line indicates that in general the higher the national wealth is, the higher the economic exposures per capita would be, which agrees with the common observation that property values are positively correlated to the economy and wealth standards in a given region.

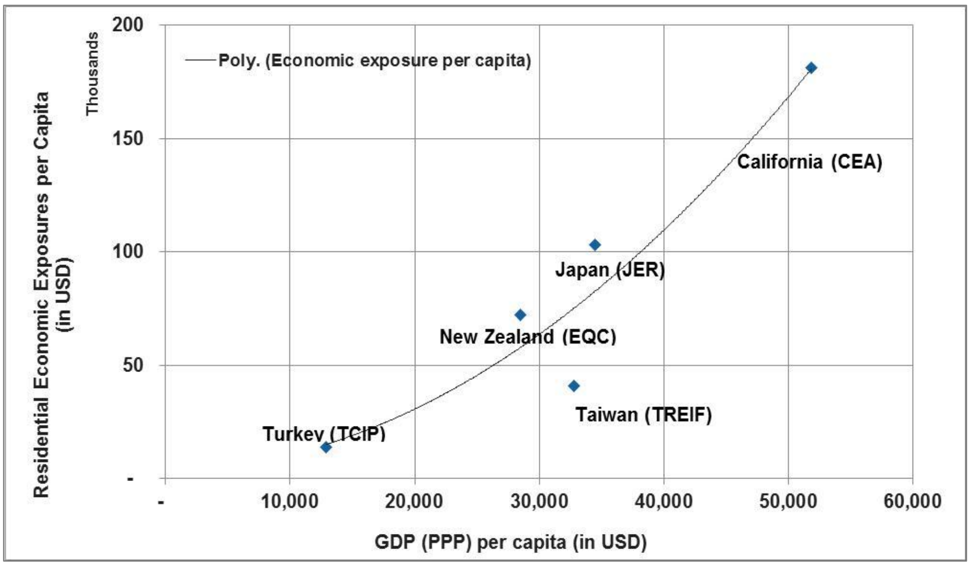
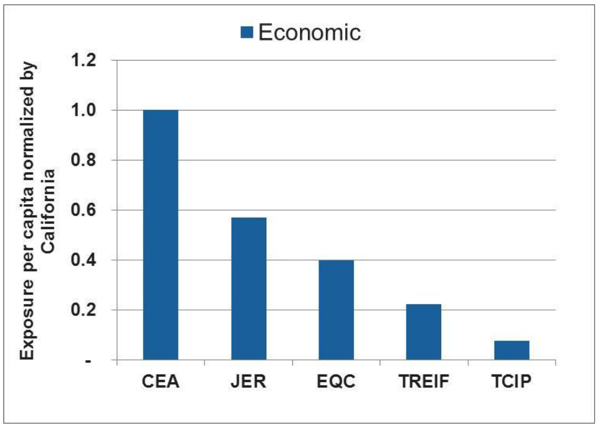


Figure 1. Correlation of residential economic exposure per capita and GDP (PPP) per capita

Figure 2 and Figure 3 compare the modeled economic and insured residential exposures (in USD) per capita per program relative to California. While the CEA has the highest economic exposure per capita among the five programs, its low penetration rate results in relatively same level of insured exposure per capita comparing to JER and TREIF (in economic perspective, JER and TREIF exposures per capita only account for 57% and 23% of CEA's exposure per capita, while in the insured perspective the relativity increases to be about 72% relative to CEA, implying the higher penetration rates in the JER and TREIF programs). Due to the mandatory regulation of earthquake insurance in New Zealand (estimated to be about 90% penetration rate), the EQC has the highest insured exposed risks per capita among all of the five programs. Its high penetration rate results in approximately five times the insured exposure per capita against CEA. While TCIP is also a compulsory insurance for all residential buildings, it has much lower penetration rate as compare to EQC, due to its relatively strict regulation of the insurable properties which only covers legitimate residential buildings that fall into the municipal boundaries.



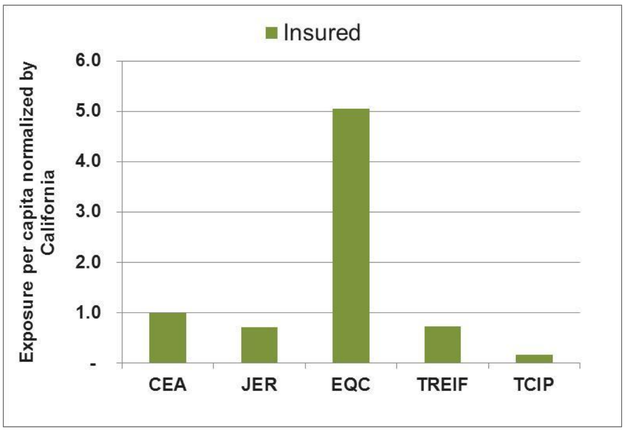


Figure 2. and Figure 3. Comparisons of residential economic and insured exposure per capita relative to CEA

(Note: In the Figure 1, Figure 2 and Figure 3, exposure values presented have all been trended to 2010 using demographic and economic statistics from census. For the comparison across countries, the exposure values of each program have also been converted to USD dollars using currency conversion rates as of January 2011).

3.2 Modeled regional loss metrics

Average annual losses (AAL) are the expected values of an exceedance probability loss distribution. It can be considered as the product of the loss for a given event with its probability, summing over all events in the stochastic sets. Loss cost, which is normalizing the AAL by exposure values, can be used for the comparisons of relative risks, since it excludes potential differences in how the building stock values and the penetration rates are modeled. AAL is also used as the basis to determine the insurance premium rate. The basic rate of insurance premiums consists of a risk premium rate applicable to the future payment of insurance claims and a loading premium rate applicable to non-life insurance company expenses, profits and agency commissions. Table 2 summarizes the ratios of annual written premiums to the modeled AAL per regional program. This comparison is one of the validations performed to verify whether the modeled exposures as well as the applied penetration rates are assumed reasonably. In general, it is expected that the annual written premiums would be closer and larger than the AALs as there would be additional loading premium rates charged per policy for covering the expenses, commissions and other overhead from the insurance companies.

Table 2. Ratio of annual written premiums to the modelled AAL per regional insurance program

Program name	Ratio of annual written premiums to AAL
CEA	2-3
JER*	Close to 1
EQC	Close to 1
TREIF	More than 1
TCIP	Close to 1

*Note the JER here represents the overall residential insured losses without considering the sharing layers with government and primary insurers

Figure 4 provides an alternative view of the impact of relative risks on the priced premiums per policy. As expected, the higher relative risks in the given region, the higher the average premium policy is priced. Unlike the other four insurance programs, CEA's premiums have been priced higher than its risk premiums. The main reason for higher premium is because of the CEA's heavy reliance on the reinsurance industry to ensure its claim paying capacity. As indicated in one of the CEA reports, even as CEA capital has grown in the past, nearly one-third of CEA's claim-paying capacity (which today totals 9.5 billion USD) is provided through reinsurance (CEA, 2010).

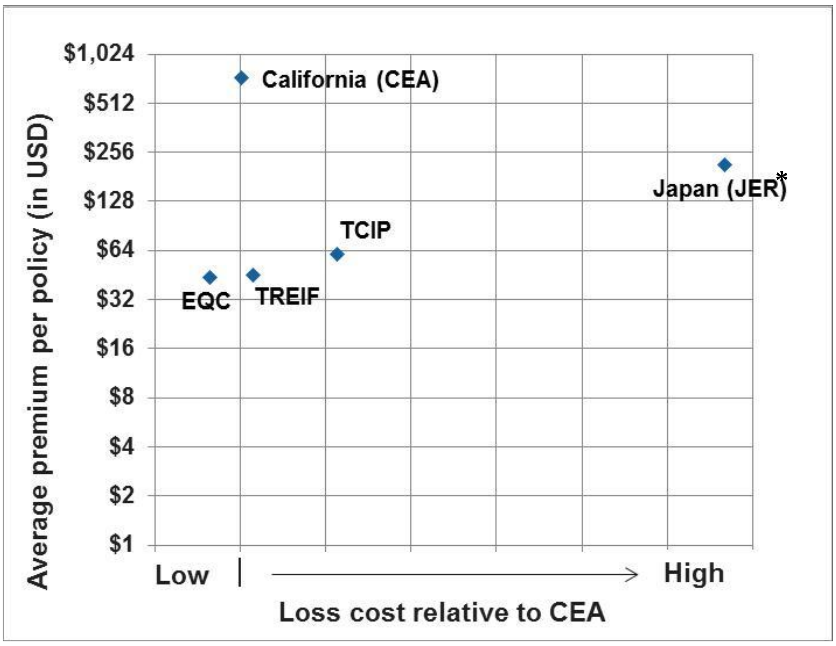


Figure 4. Loss cost relative to CEA and average annual premium per policy

4. INSURANCE PROGRAM CLAIM PAYING CAPACITY

The concept of solvency can be materialized in the form of the amount of accumulative claims losses that insurers are capable to pay when a catastrophe event happens. Such paying capacity can be a fixed amount, with the absorbed return period event losses considered. Table 3 summarizes the claim paying capacity of each insurance program and their managed absorbed losses given the required event return period. Because of the huge amount of possible payable claims, a thorough risk sharing mechanism needs to be considered. The detailed financing structure per regional insurance program is discussed subsequently.

Table 3. Claim paying capacity of each of insurance programs and the managed absorbed return period event

Program name	Claim-paying capacity	Managed absorb return period estimated by insurance programs
CEA	9.5 billion USD	526 year
JER	5.5 trillion JPY	250 year
EQC	8.4 billion NZD	1000 year
TREIF	70 billion TWD	400 year
TCIP	3.5 billion TRY	350 year

The metric used to determine the CEA's maximum claim-paying capacity is, "the capacity that provides a 99.9% probability that the CEA financial structure will have sufficient claim-paying capacity to pay all claims that might arise from an earthquake, or series of earthquakes, during a one-year period" (CEA, 2005). This translates into a 1- in-1000 year loss event. At the end of 2011, CEA claim-paying capacity was 9.5 billion USD, well over the 1-in-526-year level required of the CEA (CEA, 2011). The CEA's current claim-paying capacity is supported primarily by CEA capital, reinsurance and participating primary insurers. The risk transfer mechanism is constructed of four layers as follows:

- Layer 1: 3.75 billion USD, undertaken by the CEA capital.
- Layer 2: 2.85 billion USD, undertaken by the reinsurance
- Layer 3: 0.30 billion USD, undertaken by the revenue bonds
- Layer 4: 2.6 billion USD, undertaken by the participating insurer assessments

The JER assumes residential earthquake exposures from domestic insurers, and provides up to 5.5 trillion JPY (66.9 billion USD) in claims-paying capacity, managed to absorb the reoccurrence of the 1923 Great Kanto earthquake (1-in-250 year) (OCED, 2004). Losses above 115 billion JPY (1.4 billion USD) are shared with domestic insurers and the Japanese government at various levels of co-participation as loss levels increase beyond the JER's first layer retention. Figure 5 is the JER's complex reinsurance scheme, showing how JER, non-life insurance companies and the government share insurance liabilities, and the way each handles the shared liabilities (JER annual report, 2010).

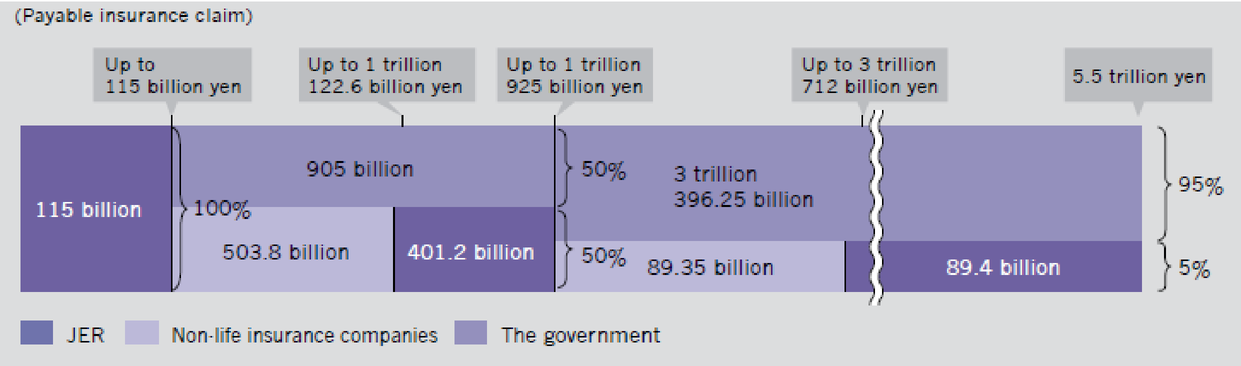


Figure 5. JER reinsurance liability sharing mechanism (JER annual report, 2010)

In New Zealand, the fund responsible for paying claims is funded both by the compulsory EQC levy assessed on the purchase of fire insurance for residential properties and investment income. EQC has an unlimited federal guarantee, which is the key to reducing the cost of providing insurance to the people. The EQC currently has the capability to cover a 1‑in‑1000 year event with an estimated value of up to 8.4 billion NZD before having to call on the federal guarantee (EQC Annual Report, 2009-2010). EQC is independent of the insurance market and any other commercial enterprise. The legislation controlling EQC contains a government guarantee that all the obligations of EQC will be met. This is a necessity for a compulsory scheme and it provides EQC with the best financial security available (David Middleton).

In Taiwan, the Ministry of Finance determined that the earthquake scheme would have a cap of 50 billion TWD which showed 1‑in‑400 year return period at the first stage of the implementation. Following the increased take-up rate and accumulated risk, the limit of the scheme was increased to 70 billion TWD as of 1st January, 2011 (TREIF website). The risk transfer structure of the 70 billion TWD is supported by two tiers as follows:

- Tier 1: 3 billion TWD, undertaken by the Co-insurance Pool
- Tier 2: 67 billion TWD, undertaken by the TREIF and transferred to various risk takers. Under Tier 2, handling of risk assumed by:

  1) Under 17 billion TWD, assumed by the TREIF
  2) Over 17 billion to 37 billion TWD, assumed by the domestic/overseas reinsurance markets or capital markets
  3) Over 37 billion to 53 billion TWD, assumed by the TREIF
  4) Over 53 billion to 67 billion TWD, assumed by the government

The catastrophe risk financing strategy of the TCIP relies on both risk retention and reinsurance. The TCIP's risk financing strategy optimizes the relationship among premium levels, policy coverage, and creditworthiness. The TCIP covers losses that would exceed the overall claims paying capacity approximately 3.2billion TRY of the TCIP, which is currently sufficient to withstand a 1-in-350 year earthquake (GFDRR). The TCIP retains the first 378 million TRY of losses through its reserves and transfers more than 90% of the excess losses to the international reinsurance markets (TCIP Annual Report, 2009)

5. IMPLICATIONS FOR THE PERFORMANCE OF THE FIVE INSURANCE PROGRAMS

In order to compare the performance of the five insurance programs, key distinguishing features of each program based on the above research and studies is summarized in Table 4.

Table 4. Relative metrics of five insurance programs

Program name	Relative loss cost	Penetration rates	Property coverage limit	Average premium	Paying capacity in terms of absorbed return period
CEA	Medium	Low	Medium	High	High
JER	High	Low	Medium- High	Medium	Medium - Low
EQC	Medium	High	High	Low	High
TREIF	Medium- High	Medium	Low	Low	Medium - High
TCIP	Medium	Medium	High	Low	Medium - Low

As we review these different programs, we can measure their performances by simply considering the following three questions:

- Does it maximize the number of exposed dwellings to be covered by the insurance
- Does it provide affordable policies and adequate coverage to the homeowners
- Does it cover as much as possible of the economic losses caused by earthquakes

In the Table 4, we can observe that CEA's high premium rate has resulted in the very low penetration rate in the California, limiting the insurance protection for the homeowners exposed to earthquake risks. The high premium rates are mainly attributed to CEA's high reliance on expensive reinsurance.

Although CEA's high paying capacity have allowed CEA to withstand events of 1-in-526 year return period, the payments would only cover for those who can afford it. Moreover, a report indicates that CEA's total capacity today withstand events of extremely unlikely probability, considered to exceed in a combination of the 1994 Northridge and the 1906 San Francisco earthquake (CEA, 2010).

Unlike CEA's high premium which discouraging the purchase of earthquake insurance, JER's low penetration rates could be attributed to following reasons (AXCO, Japan non-life insurance market report, 2010):

- Banks do not insist on earthquake insurance as a condition of a house purchase loan
- A significant portion of residential fire insurances is written by Japanese co-operative insurers, which provides low premiums fire policies to their members and automatically cover partial earthquake coverage
- Japanese houses tend to be simply furnished and contents values are low compared to western households

JER, Non-life insurers and government share the liability risk, with the government's share growing as the scale of losses grows. JER and non-life insurance companies save the risk premium of insurance premiums paid by policyholders as risk reserves for the possible payment of earthquake claims while the government saves government reserves in the earthquake insurance special account under law. JER is managed to have a claim-paying capacity which can withstand the reoccurrence of the 1923 Great Kanto earthquake. Current JER's capability is solvent to cover the losses from the March 11, 2011 Great Tohoku earthquake (claims estimated to be 1.12 trillion JPY as of 2012 by JER). It should be noted, however, that it is not to have been tested by a catastrophic earthquake occurred in the great Tokyo region. The program's current capacity is comprised of 11 % shares from each of JER and primary insurers and rest of 78% shares from the government (JER annual report, 2010).

EQC provides the best example in the developed country's residential earthquake insurance programs. Its compulsory insurance has high penetration rates, a high level of coverage and result in a high claim-paying capacity with affordable premiums to the homeowners. EQC is considered a government body, and operates under an act of New Zealand Parliament. EQC's role can be broadly seen as a market-enhancing entity. It provides a range of education, research, facilitation and capacity-building initiatives that supports effective mitigation measures, healthy private insurance markets and New Zealand's resilience and recovery in the event of natural disasters (EQC, 2011).

While TREIF has a slightly higher earthquake penetration rate than CEA and JER, its maximum amount of payment per structure is lowest among the five (only approximate 40,000 USD) and is barely sufficient to only rebuild a basic dwelling in the rural areas. The TREIF policy conditions and premiums were based on the results of earthquake catastrophe models, but premiums are not adjusted according to modelled outputs. TREIF instead charges a uniform fixed premium as a levy for each fire dwelling policy. Premiums were fixed by the government for political and social acceptance and policy conditions were then adjusted to ensure that the scheme was financially sound (RMS, 2005). In additional to its small coverage, the policy can only be claimed if the damaged dwelling is declared as total loss (damage ratio > 50%).

Although the TCIP scheme is intended to be compulsory, it has only a penetration of approximately 26% nationally. While the TCIP has successfully expended coverage into areas that previously had almost no earthquake insurance coverage, it still faces challenges in implementing a compulsory insurance scheme nationwide. Many buildings exist outside government planning municipality boundaries or are not captured in government building regulation statistics. While the raise of penetration rates is considered a great success by the government, its pool claim paying capacity is estimated to likely fall short of meeting the incurring losses in the events of an M7+ earthquake near Istanbul. Durukal *et al* (Durukal, 2008) estimated that assuming 30% insurance penetration and 75% return rate the total claims faced by TCIP will be about three times the current capacity of payment.

6. CONCLUSIONS

In summary, the goals of the earthquake residential insurance program are to maximize the coverage of residential properties, increase the penetration rates and covered amount of rebuilding values, provide affordable premiums to the homeowners, and accumulate sufficient premiums as reserves to enable a financially sound insurance fund.

This study indicates that an increase of penetration rate is the first step to the success in the performance of the insurance pools. Moreover, an expanded coverage of exposures, adequate policy conditions and premium rates based on the catastrophe modelling results are the essential to the risk management and operation of insurance programs. Finally, a thorough risk transferring mechanism is needed to ensure the solvency and paying capacity of the funds.

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