

# **Fiscal Reform and Improved Earthquake Insurance Claims-paying Capacity:**

## **Can the Two Coexist?**

**—Attempting to reconcile heightened earthquake risk with sound fiscal policy—**

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# **Fiscal Reform and Improved Earthquake Insurance Claims-paying Capacity: Can the Two Coexist?**

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## **Abstract**

From the standpoint of reconciling heightened earthquake risk with sound fiscal policy, this paper performs a simplified simulation analysis of obtainable risk reduction in proportion to reinsurance premiums to explore the potential for improving the claims-paying capacity of Japan's earthquake insurance program by using reinsurance, which is currently considered the least expensive method for improving risk transfer/claims-paying capacity.

We divided the roughly 5 trillion yen of risk that is currently retained by Japan's earthquake insurance program into 21 layers, starting with four successive layers in the 200 billion yen to 1 trillion yen group and ending with four successive layers in the 4.2 to 5 trillion yen group. We then compared the price of risk (reinsurance premiums necessary for reducing one unit of risk) for the different layers. Our analysis indicated that the four layers in the 1.4 to 2.2 trillion yen group could be reinsured for the lowest price per unit risk. Hence, if these successive four layers were ceded, the reinsurance premiums to be paid under the base case would be 42.5 billion yen (a 5.31% reinsurance premium rate is applied for ceding 800 billion yen risk), thereby making possible risk reduction on the order of 698.5 billion (99% Tail VaR).

**Keywords:** Government Special Account reform, earthquake insurance program, claims-paying capacity, reinsurance, price of risk, Tail VaR

**JEL codes:** H60, H61, H63

## 1. Introduction

From the standpoint of reconciling heightened earthquake risk with fiscal administration, this paper explores ways to increase the claims-paying capacity of Japan's earthquake insurance program.<sup>1</sup>

Originally established in 1966, the earthquake insurance system in Japan has been in place for over 40 years as a "public-private partnership," and has received high marks both domestically and internationally. However, in view of recent concerns about another major earthquake, including one that could occur with an epicenter in the Tokyo Metropolitan Area, excessive population concentration in Tokyo, the increased number of earthquake insurance policyholders and the attendant increase in PML (probability of maximum loss), and Special Account reform, the purpose and methods of the system now require a thorough re-examination.

At the same time, with developments in "financial engineering," the two fields of traditional finance and insurance are effectively merging on a global scale. Numerous examples include the securitization of earthquake risk, integrated management of insurance risk, and financial risk. Analyses, though not related to earthquake risk, are being performed by McNeil (1997) on the catastrophic fires in Denmark, and by Rootzen and Tajvidi (1997) on wind hazard insurance in Sweden. For some overseas public natural disaster insurance programs, development of these new financial technologies has made it possible to finance claims-paying capacity using new methods.

Under such circumstances, improving the claims-paying capacity of the earthquake insurance program has the potential to provide a solution to the conundrum of reconciling heightened earthquake risk with sound fiscal administration. All systems are constructed to achieve a principle or goal in a given environment. If changes have occurred in the environment, even though the principles and goals may remain the same, it's natural that systemic reform may be required.

Therefore, in this paper, we will clarify issues concerning the claims-paying capacity of the existing earthquake insurance program, and, at the same time, perform a simplified simulation analysis to demonstrate the degree of risk reduction that might be achievable in proportion to reinsurance premiums. As an example we will use reinsurance, which is currently considered the least expensive measure for improving risk transfer/claims-paying capacity, to explore the possibility of improving the claims-paying capacity of the earthquake insurance program.

Let us first summarize the results of our analysis as follows. We divided the roughly 5 trillion

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<sup>1</sup> This paper chiefly discusses the improvement in claims-paying capacity of earthquake insurance program from the aspect of risk financing. With regard to risk control-based discussion, refer to paper by Hiraizumi, Oguro, Mori and Nakakarumai (2006), etc.

yen of risk retained by the current earthquake insurance program into 21 layers, starting with four successive layers in the 200 billion yen to 1 trillion yen group and ending with four successive layers in the 4.2 to 5 trillion yen group, and compared the price of risk (reinsurance premiums necessary for reducing one unit of risk) for the different layers. Our analysis indicated that the four layers in the 1.4 to 2.2 trillion yen group could be reinsured for the lowest price of risk. Hence, if these successive four layers were ceded, the reinsurance premiums to be paid under the basic case would be 42.5 billion yen (a 5.31% reinsurance premium rate is applied for ceding 800 billion yen risk), thereby making possible risk reduction on the order of 698.5 billion yen risk reduction (99% Tail VaR).

This paper is composed of the following sections: Section 2 provides an overview of the claims-paying capacity of overseas public natural disaster insurance programs and discusses issues concerning the claims-paying capacity of Japan's existing earthquake insurance program; Section 3 shows a simulation of how much risk can be reduced by paying what amount of reinsurance premiums, by using as an example, reinsurance, which is currently considered the least expensive measure for improving risk transfer/claims-paying capacity, and briefly looks at the results; and finally, Section 4 provides the conclusion and raises future issues.

## **2. Features of the claims-paying capacity of overseas public natural disaster insurance programs, and the issues faced by Japan's earthquake insurance program**

### **2.1 Overview of Japan's earthquake insurance program**

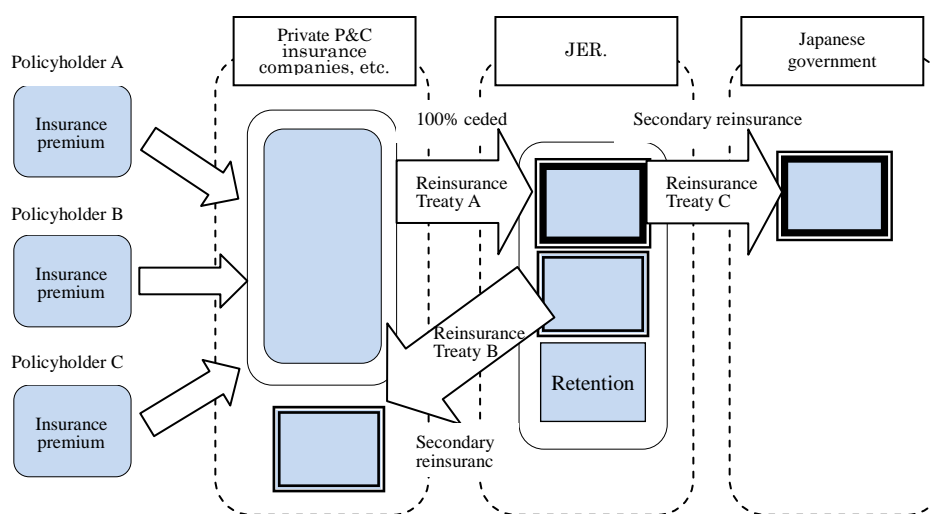
We will first briefly outline Japan's earthquake insurance program before describing features of the claims-paying capacity of some other overseas public natural disaster insurance programs.

Japan's earthquake insurance system is an integrated public-private system under which the government shares insurance risk-bearing responsibility with private property & casualty (hereafter referred to as "P&C") insurance companies through the mechanism of reinsurance. Unlike commonly available P&C insurance, the government reinsures private P&C insurance companies because of the special features of earthquake disasters—i.e., enormous damage may be incurred in the event of a massive earthquake; the losses caused by a single disaster may substantially exceed a private P&C insurance company's ability to pay claims; and the fact that insurance income and outflows due to such claims need to be considered over an extremely long term in order to smooth

out the risks, which makes it difficult for private insurance companies to operate stably inasmuch as they are focused on (relatively) shorter-term insurance income and outflows.

The earthquake reinsurance system is operated by private P&C insurance companies, the government, and the Japan Earthquake Reinsurance Company, Ltd. (hereafter referred to as “JER”). The latter company was established in accordance with the 1966 Earthquake Insurance Act as the only company in Japan authorized to handle reinsurance for earthquake damage to personal dwellings. JER accepts through reinsurance all earthquake insurance liabilities underwritten by private P&C insurance companies (Reinsurance Treaty A). JER then homogenizes and smooths the liabilities and receives secondary reinsurance coverage from private P&C insurance companies (Reinsurance Treaty B) and from the government (Reinsurance Treaty C) in accordance with their respective maximum limits, and bears the residual liabilities. (See Figure 1)

**Figure 1: Structure of earthquake reinsurance**



Source: Non-Life Insurance Rating Organization of Japan

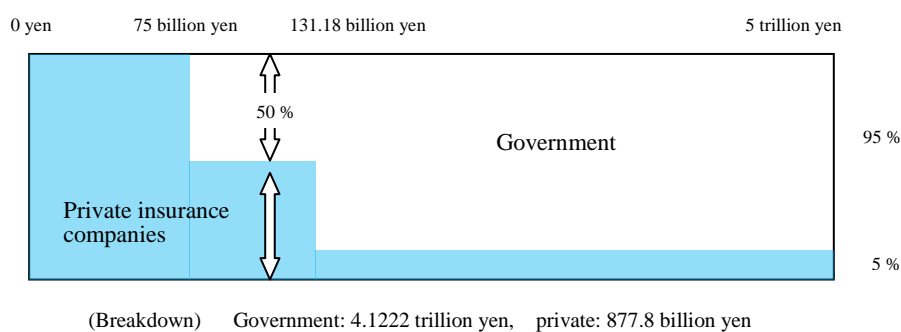
Furthermore, the system stipulates a ceiling for the insurance claim, total payments that should be borne jointly by the public and private sectors. This Insurance Claim Total Payment Limit is currently set at 5 trillion yen (revised as of April 2005) per single earthquake.<sup>2</sup> This payment limit was determined based on an estimation of the total insurance claims payments that would be required in the event of a recurrence of an earthquake equivalent in scale to the Great Kanto

<sup>2</sup> Although the Insurance Claim Total Payment for a single earthquake was stipulated at 5 trillion yen until FY2008, it gradually rose from 5 trillion yen after FY2009 and is stipulated at 7 trillion yen as of April 2015.

Earthquake in 1923. Also, in order for the government and the private insurance companies to secure the payments of insurance claims, the share of burden and the burden amount of the Insurance Claim Total Payment Limit for the each of the public and private sector is stipulated. However, as it is not possible to accurately predict the damage caused by an earthquake, it is stipulated that in case the total amount of insurance claims to be paid due to a single earthquake exceeds the Insurance Claim Total Payment Limit (5 trillion yen), the insurance claims actually reimbursed by the public and private sector, respectively, can be reduced pro rata in accordance with their respective share of that excess amount.

In practice, payments of damage claims up to the first 75 billion yen of the 5 trillion yen shall be borne 100% by the insurance companies, and for amounts paid totaling between 75 billion yen up to 1,311.8 billion yen, insurance companies and the government shall each bear 50% of the payment of insurance claims. Moreover, the government shall bear 95% and insurance companies the remaining 5% of payments for the portion of total claims that exceeds 1,311.8 billion yen, up to 5 trillion yen (co-insurance). Assuming a current total payment amount of 5 trillion yen, the private sector would bear 877.8 billion yen and the government would bear 4 trillion 122.2 billion yen (See Figure 2).

**Figure 2: Insurance claim total payment limit and liability-sharing of by insurance companies and the Japanese government (as of April 2008)**



## 2.2 Features of the claims-paying capacity of overseas public natural disaster insurance programs

Herein, “claims-paying capacity” refers to the amount of funds that can be allocated to the payment of insurance claims, and, in the case of private P&C insurance companies, the capital base or shareholders’ equity in a broad sense (e.g. including liability reserve, provisions, marketable

securities, unrealized land profit, etc.). The public natural disaster insurance programs around the world have secured additional funds to pay insurance claims using methods such as reinsurance and issuance of catastrophe bonds for the portion exceeding this *self-owned* capital base. This is because the damage from a natural disaster is potentially so huge that it threatens sustainability of the company even if it may occur with low frequency, inasmuch as it may well exceed the liability reserve and *self-owned* capital available to cover yearly expected losses. Although there are varied claims-paying sources apart from *self-owned* capital, typical methods include reinsurance, catastrophe bonds, borrowing facilities, and government guarantees.

In other words, in Japan the claims-paying capacity of the earthquake insurance program is supported by private P&C insurance companies, JER, and the government's Earthquake Reinsurance Special Account. But if we look at the claims-paying capacity of the overseas public natural disaster insurance programs, we see that they take advantage of a wider variety of methods, including coverage by reinsurance and/or secondary reinsurance, issuance of catastrophe bonds, allocation to private general insurance companies, additional collection of insurance premiums from policyholders, government guarantees, etc.

Table 1 presents an overview of the claims-paying capacity of the public natural disaster insurance programs targeted at earthquake risks in the state of California, USA; New Zealand, Turkey and Taiwan, federal flood insurance, and the state of Florida's hurricane (re)insurance.

**Table 1: Claims-paying capacity of overseas public natural disaster insurance programs<sup>3</sup>**

Program name	Total claims-paying capacity	Breakdown of claims-paying capacity
California Earthquake Authority	10.2 billion US\$ (a. through c.)	a. CE Capital b. Reinsurance c. Revenue Bonds Participating Insurer Assessments
Earthquake Commission	5.42 billion NZ\$ (a. through d.)	a. EQC fund b. EQC fund + reinsurance c. Reinsurance d. EQC fund e. Government guarantee
Turkish Catastrophe Insurance Pool	1 billion US\$ (a. through f.)	a. TCIP's surplus fund b. World Bank c. Reinsurance 1st layer d. Reinsurance 2nd layer e. Reinsurance 3rd layer

<sup>3</sup> Regarding the details of the total claims-paying capacity, see Phillips Lewis (2006), Earthquake Commission (2006), Gurenko Eugene N (2005); Guy Carpenter (2006a), American Institutes for Research et al. (2005); and Florida Hurricane Catastrophe Fund (2007).

		f. World Bank g. Government
Taiwan Residential Earthquake Insurance Pool	60 billion NT\$ (a. through e.)	a. Private P&C insurance companies b. TREIP fund c. Reinsurance, catastrophe bonds d. TREIP fund e. Government
National Flood Insurance Program	30.425 billion US\$ (b.)	a. NFIP Surplus (Turned into deficit since Hurricane Katrina.) b. Has the authority to borrow from the Department of Treasury (expanded to 30.425 18.5 billion US\$ in January 6, 2013.
Citizens Property Insurance + Florida Hurricane Catastrophe Fund	17.25 billion US\$ (b.)  + 17 billion US\$ (c.)	a. Citizens' Surplus b. Reinsurance by FHCF + Industry Co-Payments c. Pre-Event Bonds + Industry Co-Payments d. Post-Event Bonding + Industry Co-Payments e. Remaining Surplus of Citizens
Japan's earthquake insurance program	7 trillion JPY	a. Private P&C insurance companies b. Government (Earthquake Reinsurance Special Account) + private P&C insurance companies

Source: Prepared by authors of this paper.

We can see from this table that the claims-paying capacity of the overseas public disaster insurance programs are characterized by their efforts to transfer disaster risk as much as possible to other parties rather than retaining it all within their countries. Although the methods of risk transfer vary, by and large, after their liability reserve has been fully paid out, the programs have access to “*own capital*” for the lower layer, reinsurance and catastrophe bonds for the middle layer, and government (public funds) for the upper layer. In other words, they have designed role-sharing systems by which they manage high frequency and small damage risk with private capital bases, low frequency but bigger damage risk with reinsurance, and exceptionally rare but major damage risk with government commitments. This design helps them respond to relatively large-scale disaster while at the same time controlling reinsurance premiums.

The features of the claims-paying capacity of overseas public natural disaster insurance programs can be summarized by the following three points:

- a. Reinsurance is being used with the exception of the National Flood Insurance Program and Japan's earthquake insurance program.
- b. Reinsurance is being used for the middle layer (shaded parts in the table).
- c. Governments manage the upper layer and serve as the insurer of last resort.



### **2.3 The challenge of the claims-paying capacity of the Earthquake Reinsurance Special Account**

Japan's earthquake insurance system (or the Earthquake Reinsurance Special Account) currently retains all the risk within the system (or within the Special Account). However in view of the design of overseas public natural disaster insurance programs, there seems to be ample room to take advantage of transfer mechanisms such as reinsurance and improving claims-paying capacity. There are three keys to addressing this issue.

#### **(1) The current system retains all risk**

Insurance is a mechanism under which a policyholder, who wishes to reduce economic uncertainty, transfers risk to an insurer, while the insurer distributes the risk by way of risk pooling, premium rate setting and product design by leveraging the law of large numbers (end result will be close to the average) and central limit theorem (end result will be close to the normal distribution). In other words, it is a mechanism under which the risk is transferred from one economic entity to another entity (e.g. from policyholder to insurer to reinsurer) who can more efficiently manage and process the risk. The primary yardstick for when to retain or transfer (or insure) risk is as follows: "retain reasonably predictable risk and transfer potentially large and destructive risk." Natural disasters such as earthquakes, which occur with low frequency but cause major damage, are a prime candidate for risk transfer.

By contrast, under Japan's current earthquake insurance system, all earthquake risks, including even such risks that might as well be transferred, are retained and not transferred outside of Japan. It is true that, unlike commercial enterprises, there is no way that the Earthquake Reinsurance Special Account will default on its obligations, because if it were in danger of defaulting, there would be transfers from the general account. However, as a special account, it should maintain its financial independence to the full extent that is feasible. It goes without saying it would be desirable that it did not rely on transfers from the general account at all.

The system advocates balancing revenue and expenditure over a 500-year span. It assumes as a general principle that even if within a certain period it may temporarily be obliged to rely on transfers from the general account, it should be able to repay that borrowing at some later stage, and thereby maintain its self-containment (financial independence) as a Special Account.

However, setting aside theoretical discussion, a period of 500 years is hardly a practical time frame to use for realistic planning purposes. If 1966, the launch year of the earthquake insurance system, is designated as the first year, 500 years from that time would be 2466. If so, it is highly likely that if a large-scale earthquake disaster occurs, the self-containment of the Earthquake Reinsurance Special Account would be damaged over a considerably long period of time as long as borrowing from the general account remains on the balance sheet.

## **(2) Burden on non-policyholders is not taken into account**

Under the current methods of retaining all earthquake risk within the system, when the payment of insurance claims to earthquake insurance policyholders exceeds approx. 2 trillion yen,<sup>4</sup> the reserve that has been accumulated in the past 40 years since the launch of the system in the Special Account runs out, and necessitates transfer from the general account. Incidentally, an earthquake disaster exceeding this level occurs once in 88 years according to the risk model used for simulation in Section 3. Furthermore, in consideration of the current approximately 50 billion yen annual provision for liability reserve (the amount roughly equal to the total revenue of the government's Earthquake Reinsurance Special Account from insurance premium), it would require approximately 60 years for the Special Account to increase its liability reserve to the level of 4 trillion yen, even if insurance claims payments after a large-scale earthquake are made. Most importantly, however, transfer from the general account would mean forcing non-policyholders of earthquake insurance to also bear a burden, even though they would have received no benefit.

It is fundamental that the earthquake insurance program is maintained and operated under the Special Account in order to clarify the relation between benefits and burdens, and revenue and expenditure of the operation by separating accounting for insurance policyholders from other accounts. It is extremely important that under the operation of this system, the policyholders who pay insurance premiums in exchange for risk transfer are differentiated from non-policyholders, and therefore creation of a special account is considered essential. Therefore, a transfer from the general account intended to pay out insurance claims in excess of the liability reserve must be avoided at the outset, through system design, product design, premium setting, and other means.

As a matter of logic, if one places a burden on non-policyholders, they will naturally demand a benefit, and the earthquake insurance will no longer be insurance for the policyholders but will

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<sup>4</sup> It equals the sum of the balance of the contingency reserve of the private general insurance companies (806.1 billion yen) and the balance of the liability reserve of the Earthquake Reinsurance Special Account (1012.3 billion yen, as of March 31, 2006). To be more precise, it is approx. 1.8 trillion yen.

become a mechanism for revenue transfer that does not take into account the beneficiary's qualification. Therefore, a "risk transfer" that helps reduce the burden on non-policyholders as much as possible is necessary to maintain the integrity of the system. If the insurance as a system were to fail and turn into a revenue transfer mechanism, it would undermine the non-policyholders' proper attitude toward risk. Furthermore, it could also have a negative impact on the overall countermeasures against earthquake disaster, including risk reduction initiatives, irrespective of the earthquake insurance system. For instance, following the 1999 Izmit Earthquake, with an aim to have another look at all the systems with earthquake risk, the government of Turkey launched a new earthquake insurance system (TCIP) that offers compulsory earthquake insurance in collaboration with the World Bank. However, since TCIP provided generous compensation for the disaster victims of the Afyon Earthquake in 2002 and the Bingöl Earthquake in 2003 without drawing a line between policyholders of the compulsory insurance and non-policyholders, the non-policyholders' proper attitude toward risk was lost thus, creating a classic case of moral hazard.

If a large-scale earthquake exceeding the liability reserve of the Earthquake Reinsurance Special Account should occur in Japan, the insurance premium burden on policyholders is likely to increase. However, if this additional burden cannot be covered solely by increasing the insurance premium burden, the government will be forced to transfer funds from the general account by way of issuing government bonds. The common explanation is that unlike geological distribution (reinsurance) of earthquake risk adopted by other countries, Japan's system is intended to distribute earthquake risk by smoothing over time. However, the issuance of government bonds could, in turn, increase the burden on non-policyholders as well. Transfer from the general account should be considered solely as a last-resort measure to maintain the viability of the insurance system. Would it be possible to forthrightly justify transfer from the general account by maintaining that it is intended to distribute risk in terms of time? Probably not. It is true that the net premium rates of the earthquake insurance program are calculated based on the damage data of about 400 earthquake events in the past 500 years or so. However, that does not necessarily mean that the risk is sufficiently distributed in reality.

Moreover, it should be noted that the transfer from the general account can, depending on the time of maturity of the corresponding government bonds, invite the moral hazard issue of postponing the burden to the next generation and beyond. If the risk is more effectively distributed time-wise, and the time of maturity is set over a long period of time, the burden may be postponed

further, and the burden on the current generation will be reduced. It is quite natural that the generations still working at the time of the earthquake event are tempted to ease the burden on their own generations by postponing it as much as possible over a longer period of time. However, the later generations will have to face earthquake risk during their own lives. In short, risk distribution in terms of time, based on possible transfer from the general account, has the additional issue of postponing the burden to the next generation and beyond.

### **(3) A trade-off relation between the earthquake insurance portfolio risk and risk transfer cost**

Although many have pointed out the high cost of reinsurance, which is the most prevailing and convenient transfer method, premiums have actually been settling down to a theoretically reasonable level through the development and spread of alternative risk transfer methods benefiting from advances in various financial technologies. The reinsurance premium rate is the sum of yearly expected losses (or net insurance premium rate), sales and general administrative expenses, capital cost and profit, or the sum of yearly expected loss and risk load. And the risk load is the sum of sales and general administrative expenses, capital cost and profit, or the value obtained by multiplying the standard deviation of the yearly expected loss (or net insurance premium rate) by a constant that varies by reinsurance company.<sup>5</sup>

This reinsurance premium is, so to speak, a “theoretical” value, and it can differ from actual reinsurance premiums to a great extent, which vary depending on supply and demand in particular, due to the insurance underwriting cycle. As an example, the reinsurance underwriting cycle for natural disasters in the US is shown in Figure 3. The “insurance underwriting cycle” in general refers to the contraction and expansion cycle of the reinsurance market that usually involves the following stages: 1) the reinsurance companies’ capital is impaired due to huge insurance payouts for damages from a large-scale natural disaster, or, the reinsurance companies exit the market, and cost of (scarce) capital increases, which means that the reinsurance premium rate soars (hardening of the market); 2) attracted to the appreciating reinsurance premium rate, new capital flows into the reinsurance industry, the capital becomes abundant partly because of the new entrants, and the reinsurance premium rate begins to settle; but then 3) capital inflows continue to an excessive level, and reinsurance premium dumping begins (softening of the market), thereby significantly impairing capital in the event of the occurrence of a disaster, thereby obliging reinsurance companies to

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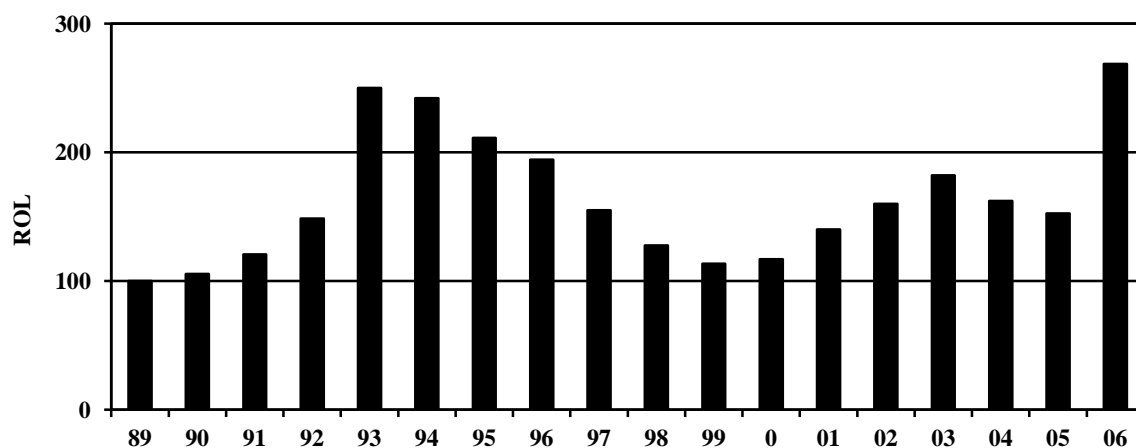
<sup>5</sup> For details, see Peter Zimmerli (2003) and Rodney Kreps (1998).

undertake reinsurance at premium rates that force some of them to exit the market.

Recently, after Hurricane Katrina hit the southern US in August 2005, resulting in the largest-ever insurance claim payment of 38 billion dollars, the insurance underwriting cycle that makes the reinsurance premium rate volatile had a major negative impact on the reinsurance premium rates in the US, boosting them to 76.2% for contracts being renewed in the 4<sup>th</sup> quarter of 2005.<sup>6</sup> As a result, the issuance of catastrophe bonds reached 4.69 billion dollars (8.48 billion dollars on the outstanding issue basis, which was over twice as much as the previous record amount of 1.99 billion dollars in 2005.<sup>7</sup> The transfer methods (ART or alternative risk transfer) represented by catastrophe bonds other than reinsurance programs have become diverse with time. At the same time, supported by a broadened investor base such as hedge funds, CAT (catastrophe) investment funds, and others, these methods have also come to complement reinsurance if not replace it. It is expected that further expansion of the market will complement the currently about 124 billion dollar-scale reinsurance market for natural disasters (2006 data) and contribute to its stabilization.<sup>8</sup>

As discussed above, as ART including catastrophe bonds define the upper limit of reinsurance premium rate, it has become increasingly difficult for reinsurance companies to present exorbitant premium rates that deviate from prevailing market rates.

**Figure 3: Undertaking cycle of reinsurance for natural disasters in the US**



Source: Guy Carpenter & Company, Inc.

<sup>6</sup> See Guy Carpenter (2006b).

<sup>7</sup> See Guy Carpenter (2007).

<sup>8</sup> Rainer Helfenstein and Dr. Thomas Holzheu (2006)—“Securitization—New Opportunities for Insurers and Investors,” sigma No. 7/2006, Swiss Reinsurance Company.

### 3. Analysis of a specific proposal for improving claims-paying capacity

Based on the discussion so far, in this Section, we would like to propose specific measures for improving the claims-paying capacity of Japan's earthquake insurance program with the use of reinsurance.

To this end, on the basis of the earthquake insurance ownership status as of the end of FY2005 (Non-Life Insurance Rating Organization of Japan), etc., we will conduct a simulation and verify the possibility of improvement with the purpose of clarifying which layer should be ceded in order to achieve maximum risk reduction with minimum reinsurance premiums.<sup>9</sup>

We set the reinsurance premiums as a theoretical value by abstracting the demand-supply factors of each year and adopt the average value obtained by equation (1) and (2) below.

#### (1) Pure premium rate + risk load

The risk load consists of one of the following: (a) cost + profit + capital cost, (b) cost + profit, or (c) standard deviation of the pure premium rate  $\times \alpha$  (a constant ratio decided on by each reinsurance company, which varies depending on the claims paid, ROE, stock price, etc. of the preceding year).

#### (2) Investment Equivalent Reinsurance Pricing

This is a practical reinsurance underwriting standard for reinsurance companies advocated by Kreps (1998) (1999). Although this is a simplified version of several models, it can be intuitively expressed as “**(capital  $\times$  cost of capital + expected loss in claims + SG&A\_cost – return on portfolio investment)  $\div$  capital.**” It can also be explained as follows. If a reinsurance company obtains capital from shareholders at the cost of capital (ROE), underwrites reinsurance (equivalent to the amount of capital) secured by capital, and invests the amount in risk-free bonds, the average cost will roughly be “capital  $\times$  cost of capital + expected loss + SG&A cost – return on risk-free bond investment.” The ratio of the average cost to its own capital is equal to the average loss rate in case the relevant reinsurance company does not demand reinsurance premiums. In short, if this reinsurance company underwrites reinsurance risk-neutrally and with zero profit, it would need to demand this reinsurance premium rate. That is to say that this reinsurance premium rate corresponds to the break-even point for such a hypothetical reinsurance company.

As a base case, “advisory pure premium rate + standard deviation of advisory pure premium

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<sup>9</sup> We enlisted the cooperation of Guy Carpenter, the world's largest reinsurance broker (arranging optimal reinsurance capacity for their clients, general insurance companies) in the world's largest catastrophe (CAT) field as this simulation required detailed earthquake data, etc.

rate  $\times \alpha$ ” that is most commonly used in the reinsurance industry is adopted for equation (1) by choosing  $\alpha = 33\%$ . As for equation (2), we chose cost of capital (ROE) = 10% and SG&A cost rate = 13%.

With regard to a measure of risk reduction, 99% tail VaR was used as the indicator to find out how much risk has been reduced compared with the case where all earthquake risk is retained (no cession). Incidentally, 99% tail VaR is the average value of loss likely to occur with a frequency of once in one hundred years, and it is set at approximately 2.5 trillion yen under present circumstances (all risk retained, no cession).

Other conditions of the simulation are as described below:

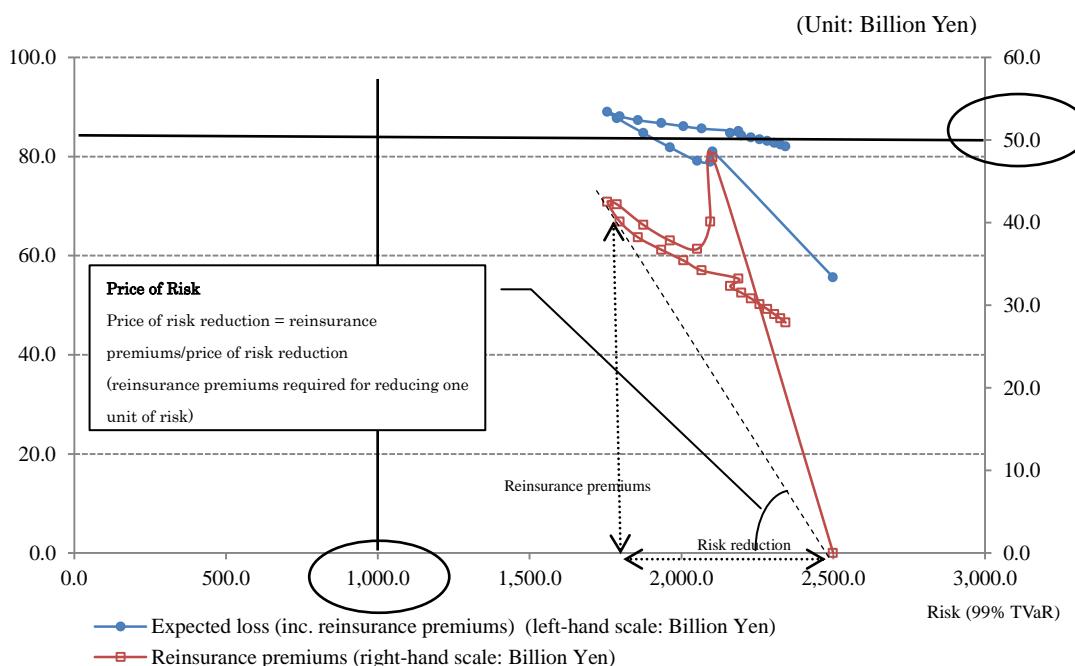
- a. The upper limit of reinsurance premium is 50 billion yen, which is equivalent to the reinsurance premium income of the Special Account (return from investing policy reserve is put in a lockbox.)
- b. The ceiling on ceded insurance is 1 trillion yen.
- c. There are a total of 24 layers starting from 200 billion yen (set at this level for purposes of simplification, although technically it should be set at 75 billion yen, at which point payment from the Special Account starts) up to 5 trillion yen at a 200 billion yen intervals.
- d. Although there are 10,626 combinations in arbitrarily choosing 4 layers from 24 layers, for simplification, we conduct simulation on 21 patterns under which four successive layers are ceded.

Based on the above settings, we conducted 500,000 consecutive simulations on 21 patterns under which 4 layers out of the 24 layers are ceded at the same time, using the Monte Carlo method that takes into account the event probability of each earthquake, etc. The results are shown in Figure 4. (See Appendix for an outline of the simulation model.)

The left vertical axis indicates the expected loss including reinsurance premiums; the right vertical axis indicates reinsurance premiums; and the horizontal axis indicates 99% tail VaR as the risk indicator, showing the amount of loss incurred with a frequency of once in one hundred years. This figure presents two different plotted points: those showing the relationship between the expected loss and risk, and the others showing the relationship between the reinsurance premiums and risk. The former (blue plotted points) represents the expected loss and the risk (99% tail VaR) that the Special Account would incur in the case of ceding 800 billion yen risk (ceding four adjoining layers of 200 billion yen in succession). For instance, prior to cession, the Special

Account retained slightly below 60 billion yen expected loss and 2 trillion 500 billion yen risk. If this risk is ceded, one blue plotted point of the former moves to other blue point clockwise and one red plotted point of the latter moves to other red point counterclockwise. It is clear from this figure that it is possible to reduce the risk to about 1 trillion 700 billion yen at a maximum, in which case, however, the expected loss will increase due to payment of reinsurance premiums.

**Figure 4: Reinsurance premiums of the Earthquake Reinsurance Special Account vs 99% tail VaR**



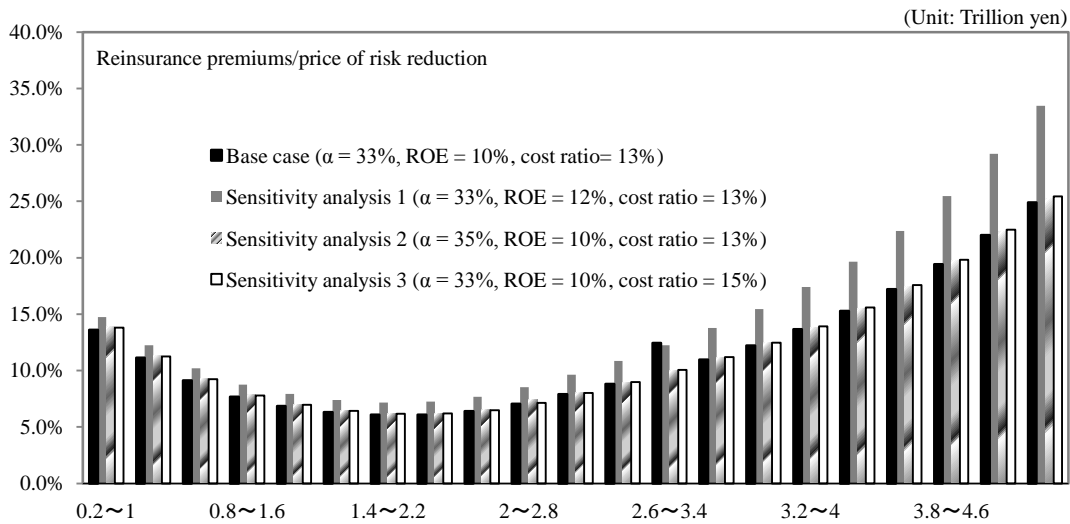
Source: Prepared by authors of this paper.

Next, the latter red plotted points in Figure 4 represent the relationship between the reinsurance premiums paid out by the Special Account and the subsequent risk in the case of ceding 800 billion yen risk (ceding four adjoining layers of 200 billion yen in succession). What is significant here is the relationship between the upper limit of reinsurance premiums and the Earthquake Reinsurance Special Account's reserve. With approximately 50 billion yen annual reinsurance premiums income, the Special Account is able to pay out only for the area below the horizontal bold line. In this case, all of the latter red plotted points are located in this area. On the other hand, the Special Account's own capital is about 1 trillion yen, which is shown as the vertical bold line. The closer the risk is to this line, the better. Now, which layer should best be ceded can be judged by the latter plotted



points that represent the relationship between the reinsurance premiums and risk. The point prior to the cession is plotted on the vertical line, indicating zero reinsurance premiums and 2 trillion 500 billion yen risk. If straight lines are drawn to connect this point with the respective latter plotted points that show the relationship between reinsurance premiums and risk, the vertical width shows the reinsurance premiums, and the horizontal width shows the price of risk reduction. If we call reinsurance premiums necessary for reducing one unit of risk “price of risk reduction,” it equals the slope of these straight lines. This is usually called “price of risk.” Let us now move on to study the criteria for judging which layers to be ceded by leveraging this price of risk.

**Figure 5: Price of risk estimation results**



Ceded layer	0.2~1	0.4~1.2	0.6~1.4	0.8~1.6	1~1.8	1.2~2	1.4~2.2	1.6~2.4	1.8~2.6	2~2.8	2.2~3
Base case	13.60%	11.14%	9.13%	7.68%	6.84%	6.33%	6.08%	6.10%	6.39%	7.05%	7.90%
Sensitivity analysis 1	14.74%	12.23%	10.20%	8.77%	7.92%	7.39%	7.17%	7.25%	7.68%	8.53%	9.64%
Sensitivity analysis 2	13.92%	11.36%	9.32%	7.86%	6.99%	6.45%	6.20%	6.21%	6.51%	7.43%	8.02%
Sensitivity analysis 3	13.80%	11.27%	9.24%	7.79%	6.96%	6.42%	6.18%	6.19%	6.50%	7.15%	8.02%
Ceded layer	2.4~3.2	2.6~3.4	2.8~3.6	3~3.8	3.2~4	3.4~4.2	3.6~4.4	3.8~4.6	4~4.8	4.2~5	
Base case	8.81%	12.44%	10.98%	12.23%	13.65%	15.29%	17.22%	19.41%	22.00%	24.89%	
Sensitivity analysis 1	10.87%	12.25%	13.76%	15.45%	17.40%	19.66%	22.36%	25.48%	29.20%	33.46%	
Sensitivity analysis 2	8.98%	10.02%	11.17%	12.44%	13.85%	15.52%	17.49%	19.73%	22.28%	25.22%	
Sensitivity analysis 3	8.98%	10.05%	11.20%	12.49%	13.90%	15.59%	17.56%	19.81%	22.47%	25.45%	

Source: Prepared by authors of this paper.

The price of risk can be obtained by dividing reinsurance premiums by the price of risk reduction.

The basic case in Figure 5 shows the price of risk calculated by four successive layers. A comparison of the 21 sets of layers, starting with the four successive layers in the 0.2 to 1 trillion yen group and ending with the four successive layers in the 4.2 to 5 trillion yen group, shows that the four layers in the 1.4 to 2.2 trillion yen group achieved the lowest price of risk. These four layers in the 1.4 to 2.2 trillion yen group are positioned in the middle of the layers ranging from 0.2 to 5 trillion yen. This result coincides with the fact that the overseas public natural disaster insurance programs utilize reinsurance for the middle layers, as shown in Table 1.

The following is our intuitive reason why this layer achieves the lowest price of risk. First, although the earthquake damage is small in the lower layers from 0.2 to 1.0 trillion yen, etc., the price of risk goes up because of the higher event probability. On the other hand, although the earthquake event probability of upper layers from 4.2 to 5.0 trillion yen, etc. is lower, the price of risk is higher due to greater damage. This leads us to conclude that the 1.4 to 2.2 trillion yen layer, positioned in the middle of the layers, can be insured for the lowest price of risk. If these successive four layers were ceded, the reinsurance premiums to be paid would be 42.5 billion yen, and considering the 5.31% reinsurance premium rate for ceding 800 billion yen risk, a 698.5 billion yen risk reduction (99% Tail VaR) would be achieved.

Figure 5 also shows sensitivity analyses of the base case. More specifically,  $\alpha$  of “standard deviation  $\times \alpha$ ” of equation (1) and ROE and cost rate of equation (2) were changed by +2% to come up with estimation results shown as sensitivity analysis 1 through 3. It is also clear from these estimation results that the 1.4 to 2.2 trillion yen layer achieves the lowest price of risk.

For instance, in ceding 1.4 to 2.2 trillion yen layer, if the reinsurance premiums is covered by increase in insurance premiums and not by reinsurance premium income of the Special Account (approximately 50 billion yen), the new insurance is estimated to be approximately 1.6 times more expensive than the current insurance premiums (89 billion yen  $\div$  55.6 billion yen).<sup>10</sup> This is because while the values obtained by dividing the expected loss (including reinsurance premiums), as shown in Figure 5, by the total insurance payment mostly equal to the advisory pure premium rate, if no layers are ceded, the expected loss is estimated to be 55.6 billion yen; if the four layers of 1.4 to 2.2 trillion yen are ceded, the expected loss is estimated to be 89 billion yen.

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<sup>10</sup> The basis for 1.6 times: the risk premiums contained in the current insurance premiums calculated by the Non-Life Insurance Rating Organization of Japan based on the “advisory pure premium rate (expected loss, etc.) + SG&A cost,” under the principle of “no profit, no loss,” is smaller than the risk load, etc. that we used in calculating reinsurance premiums in this paper. If a similar level of risk premiums is added to the current insurance premiums, the “value of 1.6 times more expensive” could be much cheaper.

#### 4. Summary and future agenda

As discussed above, from the standpoint of reconciling heightened earthquake risk with sound fiscal administration, we performed a simplified simulation analysis of risk reduction in proportion to reinsurance premiums to explore the potential for improving the claims-paying capacity of Japan's earthquake insurance program by using reinsurance, which is currently considered the least expensive method for improving risk transfer/claims-paying capacity.

We divided roughly 5 trillion yen risk retained by the current earthquake insurance program into 21 sets of layers, starting with four successive layers in the 200 billion yen to 1 trillion yen group and ending with four successive layers in the 4.2 to 5 trillion yen group, and compared the price of risk (reinsurance premiums necessary for reducing one unit of risk) for the different layers.

Our analysis indicated that the four layers in the 1.4 to 2.2 trillion yen group could be reinsured for the lowest price per unit risk. Hence, if these successive four layers were ceded, the reinsurance premiums to be paid under the basic case would be 42.5 billion yen (a 5.31% reinsurance premium rate is applied for ceding 800 billion yen risk), thereby making possible risk reduction on the order of 698.5 billion (99% Tail VaR). Hence, it is clear that there is a good chance that the claims-paying capacity of the current earthquake insurance program can be improved.

Secondly, let us refer to several future policy agenda items that are suggested by this analysis, from the standpoint of improving the claims-paying capacity of the earthquake insurance program.

The first policy agenda item would be to refine the simulation methodology presented in this paper. We consider it necessary to refine the following aspects of our simulation that we were unable to cope with due to limited resources and time constraints:

- a. **Upper limit of reinsurance premiums:** This was set at 50 billion yen for our simulation. We should perform another simulation by changing the values, ranging from 10 billion yen to 40 billion yen. .
- b. **Cession of non-successive layers:** We ceded four successive layers under our simulation. We should seek four layers that would realize maximum risk reduction at a minimum reinsurance premium.
- c. **Estimation of an optimal total ceded amount:** Although we set it at 1 trillion yen under our simulation based on interviews with scholars, up to 3 trillion yen is also considered theoretically possible depending on the price.

**d. Adoption of reinsurance premiums by taking into account supply and demand factors:**

We abstracted the demand-supply factors for reinsurance under our simulation. What would happen if we modeled price fluctuation and took demand-supply factors into account?

The second policy agenda item would be to undertake an analysis to compare against other risk transfer methods. Due to limitations regarding models and analysis, in this paper we discussed risk reduction possibilities focusing entirely on cession. However, comparative analysis with other risk transfer methods such as catastrophe bonds would be highly desirable. We would like to undertake comparative analyses in the future.

The third agenda item would be the efficiency indicator used to measure the selection of an optimal cession layer. In this paper, we used “price of risk,” obtained by dividing reinsurance premiums by the price of risk reduction, as the indicator for our analysis. However, it is important to use a variety of indicators to the extent possible, to carry forward the analysis. We would like to include this in our future agenda.

As well, currently a legal framework that allows cession is not in place. In order to adopt cession methods, amendment of the law will be required. Needless to say, if we decide to study cession in a factual and rigorous manner, public understanding must be gained concerning the reduction of risk (99% tail VaR) associated with cession and its associated cost burden (reinsurance premiums).

At any rate, following its establishment in 1966, the earthquake insurance system in Japan has continued for over 40 years as a “public-private partnership,” and has received high marks both within Japan and internationally. However, in view of recent concerns about another a major earthquake, including one that could occur with an epicenter in the Tokyo Metropolitan Area, excessive population concentration in Tokyo, the increased number of earthquake insurance policyholders and the attendant increase in PML (probability of maximum loss), and Special Account reform, the purpose and methods of the system now require a thorough re-examination.

Amid calls for reconciling heightened earthquake risk with sound fiscal policy, we hope that this paper will serve as a starting point for designing a more efficient earthquake insurance system.

## Appendix: Outline of the Simulation Model

In building the simulation model described in this paper, we estimated the expected loss (including reinsurance premiums), reinsurance premiums, and risk (99% TVaR) using the following steps:

- (1) Obtain an event curve of earthquakes in Japan. An event curve is a curved line that expresses the risk of the target of the analysis, with the horizontal axis indicating the expected loss and the vertical axis indicating the annual exceedance probability. For this model, we used an event curve that mostly matched the one for which the government projects a 5 trillion yen earthquake insurance payment in anticipation of the recurrence of an earthquake comparable to the Great Kanto Earthquake in 1923. More specifically, we holistically took into account and used the event curves estimated by several specialized organizations such as OYO RMS Corporation.
- (2) Next, set parameters that are used as premises for estimating reinsurance premiums such as 1)  $\alpha$  of the risk load (standard deviation of advisory pure premium rate  $\times \alpha$ ), which is commonly used by reinsurance industry, and 2) ROE and cost rate of Kreps (1999) Investment Equivalent Reinsurance Pricing.
- (3) Choose the layers to be ceded. Then, based on the event curve described in (1) above and in accordance with the Monte Carlo simulation method, estimate the advisory pure premium rate for the layers to be ceded and Kreps (1999) Investment Equivalent Reinsurance Pricing so as to estimate the reinsurance premiums.
- (4) Finally, estimate the expected loss and the risk retained (99% TVaR) by the remaining layers of the earthquake insurance (excluding the layers ceded) in accordance with the Monte Carlo simulation method.

As for the supporting theories of (3) and (4), see Kreps (2009) "Theory and Practice of Timeline Simulation" *Variance Casualty Actuarial Society – Arlington, Virginia* 2009: Spring, Volume 03, Issue 01, pp. 62-95.

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