# How Does an Urban Disaster Differ from a Rural Disaster?

## A comparison of household level impacts of Kobe and Chuetsu earthquakes and its implications for reconstruction after the Great East Japan earthquake

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# 1. Introduction

Urbanization is a developing Asian phenomenon with the world's highest urban growth rate of 2.6 percent. Rapid urbanization has facilitated high economic growth in the region by agglomeration economies. Yet, geographical concentration of population and activities has been associated with growing problems of environmental problems and increased vulnerability against urban disasters due to natural hazards such as floods, earthquakes, and epidemics. Figure 1 shows the number of natural disasters registered in EM-DAT: the OFDA/CRED International Disaster Database for 1960-2006. We can see the apparent increasing trend of natural disasters, especially of hydro-meteorological disasters. A closer look at the data for 1995-2004 by type of triggering hazards reveals that floods are the most commonly occurring

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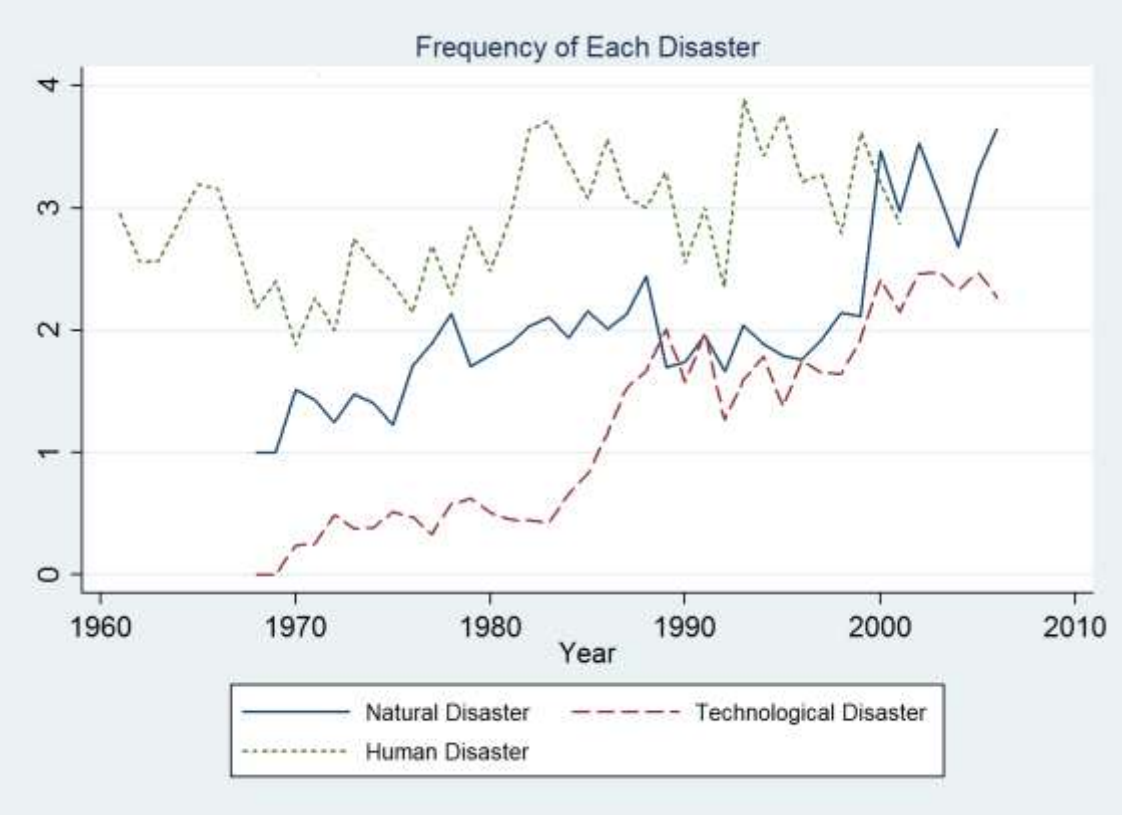
natural disaster, followed by droughts and related disasters, epidemics, and earthquakes and tsunamis. While natural disasters do not select specific economies (Kahn, 2005), spatially-concentrated urban areas are facing ever increasing vulnerabilities against disasters. While these potential urban disasters are arising in developing countries, it would be important to examine and learn from experiences of developed countries in coping with such urban disasters. This paper aims at taking such a task by examining implications from Japanese earthquakes in urban and rural areas and by identifying the need for an efficient financing insurance for disaster reconstruction activities.

**Figure 1**




Data sources) Natural disasters: EM-DAT: The OFDA/CRED International Disaster Database www.em-dat.net; Wars: Correlates of War, 2010, COW Militarized Interstate Disputes, v.3.10, http://www.correlatesofwar.org/; and economic crisis: Reinhart and Rogoff (2010).

Japan is vulnerable to a wide variety of natural disasters such as earthquakes, tsunamis, volcanic eruptions, typhoons, floods, landslides, and avalanches. Of these natural disasters, earthquakes are the most serious and frequently occurring. The continuous earthquake activity is due to the country's location on a subduction zone, where four of the more than ten tectonic plates covering the globe are crushed against each other. Indeed, of the 912 earthquakes with magnitude of 6.0 or greater that occurred in the world between 1996 and 2005, 190 occurred around Japan (Cabinet Office 2007). This means that more than 20 percent of the world's large earthquakes have occurred around Japan.

Throughout the history of Japan, earthquakes have regularly hit the country: a total of 248 large earthquakes have occurred in Japan in the 1,300 years since the Hakuho earthquakes of 684—the oldest Japanese earthquakes to have been recorded in written form. Moreover, in the Nankai and Tokai areas, earthquakes occur regularly every 100 to 200 years (Figure 2), winning the name "the twin earthquake" (Hayashi 2003).[2] In terms of human losses, the worst earthquake in the country's history was the Great Kanto earthquake of September 1, 1923, which had a magnitude of 7.9. Large parts of Tokyo and Kanagawa were destroyed, several hundred thousand homes and buildings were in ruins, and more than 140,000 people were killed or went missing. The fires that followed the quake spread rapidly as many houses and other buildings were made of wood. In Tokyo, 477,128 houses, or 70 percent of the total, burnt down, with the fire blazing for a full three days (ADRC 2008). Thus some 44 percent of Japan's GDP in 1922 was lost either directly as a result of the earthquakes, or indirectly due to the fires, aftershocks,

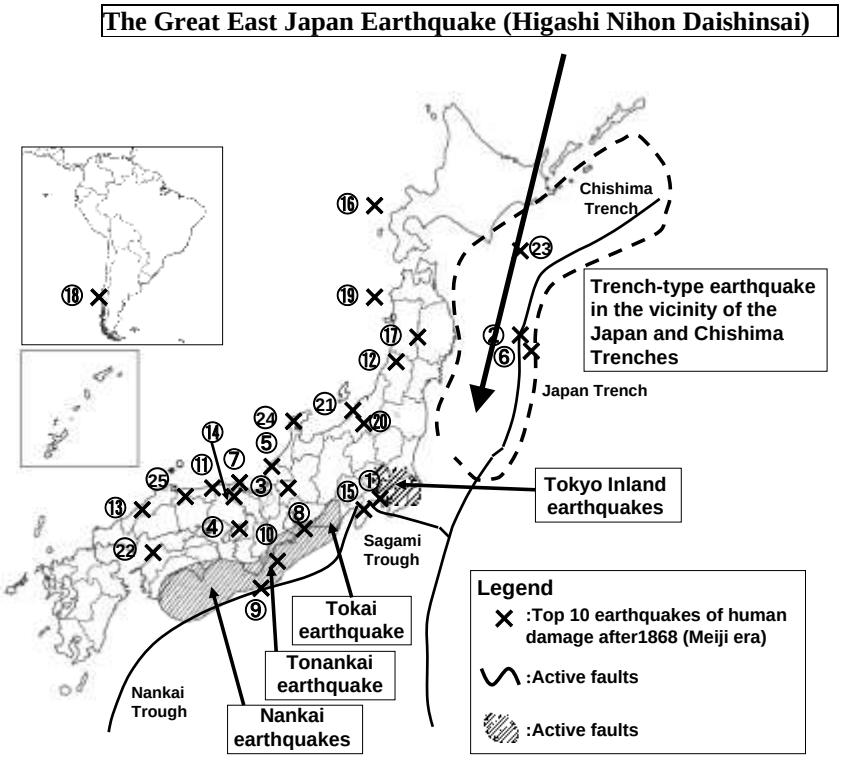
[2] According to Hayashi (2003), the Nankai earthquake occurred in 684, 790, 887, 1000, 1099, 1250, 1361, 1498, 1605, 1707, 1854, and 1946, and the Tokai earthquake happened in 1096, 1498, 1605, 1707, 1854, and 1944.

and tsunamis (Table 1).[3] Aiming never to forget the lessons of the Great Kanto earthquake, the Japanese government set September 1 as the annual date for a variety of earthquake disaster prevention exercises and related activities (ADRC 2008). Since this time, through the development of disaster management systems and enhanced disaster information communication systems, the death toll and number of missing persons from disasters, most particularly earthquakes, has declined ever since, with the two notable exceptions of the Great East Japan earthquake in 2011 and the Great Hanshin-Awaji (Kobe) earthquake in 1995 (Figure 3). Particularly, we see vividly the 2011 devastating earthquake, tsunami, and nuclear radiation crisis in Japan that has killed tens of thousands people and resulting in damages of around 200 to 300 billion dollars. These two exceptions highlight the significance of natural disasters which can generate the most serious consequences ever known (Sawada and Kotera, 2011).

[3] According to ADRC (2008), the damage was especially serious in Tokyo and Kanagawa Prefectures and the quake left 99,331 dead, 43,476 missing, 103,733 injured, 128,266 houses totally destroyed, and 126,233 partially destroyed.

## Figure 2

**Locations of the 26 major earthquakes and tsumanis in Japan with seismic intensity of 6.0 or greater in the last 30 years, ranked by human losses**




Source) Cabinet Office (2007), *Disaster management in Japan*.
Note: Numbers in the figure indicate, respectively, 1 the Great Kanto earthquake; 2 the Meiji-Sanriku earthquake; 3 the Nobi earthquake; 4 the Great Hanshin-Awaji earthquake; 5 the Fukui earthquake; 6 the Syowa-Sanriku earthquake; 7 the North Tango earthquake; 8 the Mikawa earthquake; 9 the Nankai earthquake; 10 the Tonankai earthquake; 11 the Tottori earthquake; 12 the Syonai earthquake; 13 the Hamada earthquake; 14 the North Tajima earthquake; 15 the North Izu earthquake; 16 the Hokkaido-Nansei-oki earthquake; 17 the Rikuu earthquake; 18 the tsunami of the Great Chilean earthquake; 19 the Nihonkai-Chubu earthquake; 20 the Chuetsu earthquake; 21 the Chuetsu offshore earthquake; 22 the Geyo earthquake; 23 the Tokachi offshore earthquake; 24 the Noto Peninsula earthquake; 25 the Tottoriken-Seibu earthquake; and The Great East Japan Earthquake (Higashi Nihon Daishinsai).

## Table 1

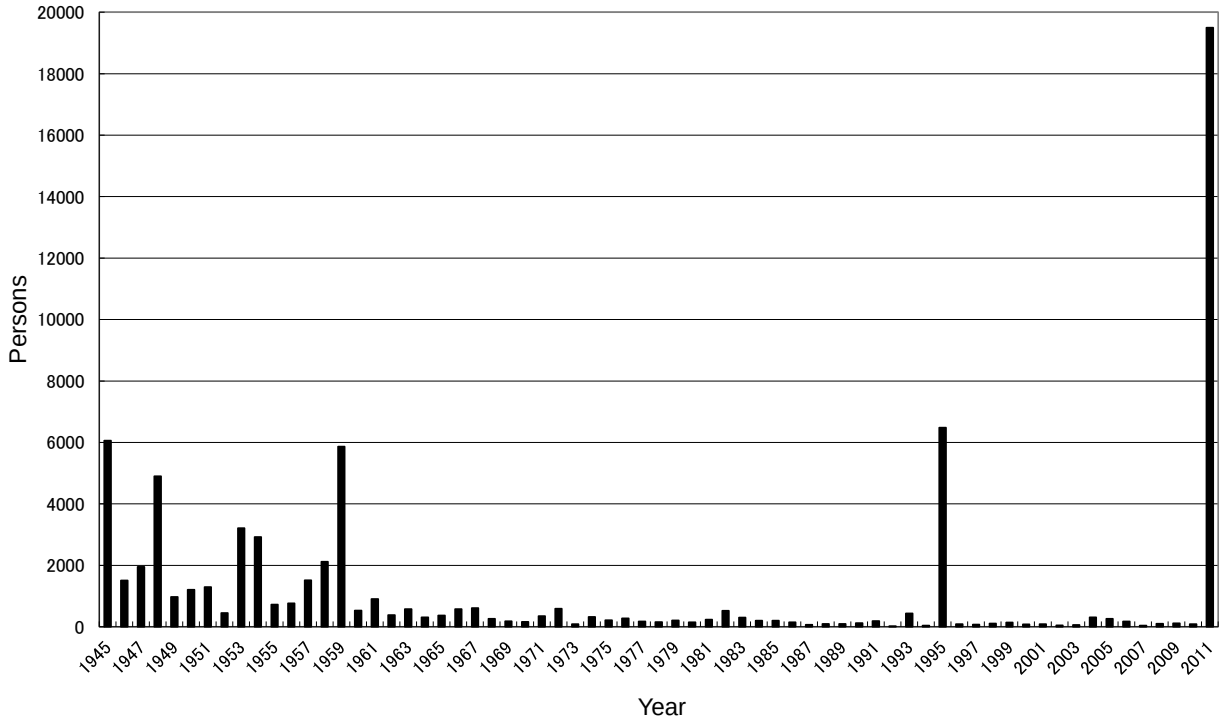
## Estimated Damages from Natural Disasters

| Event (Year) | Damages (USD billion) | Loss as percentage of GDP |
|---|---|---|
| Great East Japan Earthquake (2011) | 200-300[k] | 4.0 (approximately) |
| Hurricane Katrina (2005) | 125[h] | 1.7[j] |
| Tsunami in India (2004) | 1.02[a] | 0.17[e] |
| Tsunami in Indonesia (2004) | 4.45[b] | 2.14[e] |
| Tsunami in the Maldives (2004) | 0.47[c] | 2.58[e] |
| Tsunami in Sri Lanka (2004) | 0.97–1.00[d] | 4.4–4.6[e] |
| Chuetsu Earthquake in Japan (2004) | 28.3[f] | 0.6[g] |
| Hurricane Ivan in the United States (2004) | 3[h] | 0.04[h] |
| Earthquakes in Turkey (1999) | 22[i] | 5[i] |
| Hurricane Mitch in El Salvador (1998) | 2.9[i] | 14.6[i] |
| Great Hanshin-Awaji Earthquake in Japan (1995) | 95–147[i] | 2.5[i] |
| Hurricane Andrew in the United States (1992) | 26.5[i] | 0.5[i] |
| Cyclone/floods in Bangladesh (1991) | 1[i] | 5[i] |
| Great Kanto Earthquake (1923) | 32.6[g] (based on 2003 price) | 43.6[g] |

*Sources*: (a) Asian Development Bank, United Nations, and World Bank (2005). "India: Post-Tsunami Recovery Programme—Preliminary Damage and Needs Assessment"; (b) BAPPENAS and the international donor community (2005). "Indonesia: Preliminary Damage and Loss Assessment: The December 26, 2004 Natural Disaster"; (c) World Bank, Asian Development Bank, and UN System (2005). "Tsunami: Impact and Recovery"; (d) Asian Development Bank, Japan Bank for International Cooperation, and World Bank (2005). "Sri Lanka 2005 Post-Tsunami Recovery Programme—Preliminary Damage And Needs Assessment"; (e) author's calculation based on the World Bank's World Development Indicators; (f) Niigata Prefecture, Japan; (g) author's estimates using information from the Cabinet Office and the Ministry of Finance of the government of Japan; (h) author's calculation based on information from Risk Management Solutions (RMS); (i) Table 1 in Freeman, Keen, and Mani (2003); (j) United Nations International Strategy for Disaster Reduction; (k) Cabinet Office, the Government of Japan.

**Figure 3**

**Number of People Killed by Natural Disasters in Japan**




Source) Cabinet Office, the Government of Japan.

How urban earthquakes are different from rural earthquakes? How can people insure themselves against the devastating damages arising from earthquakes? What are the roles of markets and government in mitigating the negative impacts of earthquakes on households? This paper will attempt to address these questions based on household-level microevidence from Japan. The country's long history of earthquakes has enabled us to obtain unusually rich information. Our research strategy is to review the two contrasting cases of the Kobe and Chuetsu earthquakes and to discuss the role of public policy in facilitating risk management at the household level in the case of natural disasters. In spite of the downward trend of the number of deaths and missing persons in disasters in Japan, the Great Hanshin-Awaji (Kobe)

earthquake in 1995 caused more than 6,400 casualties mainly because the earthquake hit the Hanshin area, one of the most developed areas in Japan. Another earthquake we examine is the Chuetsu earthquake on October 23, 2004. The former and the latter earthquakes show a striking contrast. The Kobe earthquake hit the urban center, where industries and residence are densely located, while the Chuetsu earthquake occurred in mountainous and remote farming areas, where people aged 65 and older make up a significant proportion of the population. A comparison of Kobe and Chuetsu earthquakes shows differences in income, consumption, and other household level socioeconomic variables that help us to identify the effectiveness of formal and informal insurance mechanisms against urban disasters.

While it has been an important issue for households and firms to secure an effective insurance instrument against unexpected shocks such as earthquakes, micro-level studies on earthquakes using either household-level or firm-level data are largely absent. The existing economic studies on the earthquakes in Japan focus exclusively on macroeconomic and financial aspects (Horwich 2000; Skidmore 2001), except for the household-level analysis of Kohara, Ohtake, and Saito (2006), and Sawada and Shimizutani (2007, 2008, 2011).

Since earthquakes are typically an aggregate event, there are two major constraints in designing formal insurance. First, it is known that people have a tendency to underestimate the risk of an earthquake. In other words, there will be a systematic gap between the objective and subjective probabilities of earthquakes (Camerer and Kunreuther 1989). This suggests that the demand for earthquake insurance is systematically lower than the optimal level. Second, earthquakes are characterized by a rare and unexpected event, which makes it difficult to design actuarially fair insurance with the appropriate insurance premiums. Moreover, since earthquakes are highly covariate, risks that affect large areas simultaneously often cannot be diversified well

across a country. Accordingly, the insurers have the potential need to secure their financial position by using international reinsurance markets. It is known, however, that reinsurance markets and trade in catastrophe (CAT) bonds are still weak and with limited capacity.[4]

Interestingly, however, by using data on hurricane exposure, Yang (2008) found that the exposure of poor people to hurricanes leads to a substantial increase in migrant remittances, so that total financial inflows from all sources in the three years following hurricane exposure amount to roughly three quarters of the estimated damages. This suggests that the aggregated shock arising from natural disasters can be insured at least partially by household-level informal transfers. Therefore, it would be misleading to focus on the effectiveness of formal insurance markets only. It is, rather, indispensable to investigate the overall effectiveness of a wide variety of the informal insurance mechanisms, as well as the formal ones, available to households in order to mitigate damages arising from earthquakes. Moreover, in order to answer operational questions about the tools and timing of appropriate policies for earthquake victims, the micro-level household responses to various damages need to be investigated. To this aim, recent empirical research methodologies in microdevelopment economics should be adopted as an indispensable research strategy here because there has been remarkable progress in the theoretical and empirical literature on risk and household behavior (Fafchamps 2003; Dercon 2005).

The paper is organized as follows. First, we summarize the conceptual framework, then present case studies looking at the Great Hanshin-Awaji (Kobe) and the Chuetsu earthquakes. In the final section, we discuss the public policy implications of our review and draw lessons from these earthquakes in Japan.

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[4] Describing the overall effectiveness of mutual insurance across national borders, existing studies show that the extent of international risk-sharing remains surprisingly small (Obstfed and Rogoff 2001).

# 2. Conceptual Framework

## 2.1. Consumption Insurance

In order to approach one of the main questions of this paper, that is, whether people insure themselves against earthquakes, we can apply the framework of the full consumption insurance or consumption risk-sharing hypothesis of Cochrane (1991), Mace (1991), Hayashi, Altonji, and Kotlikoff (1996), and Townsend (1987, 1994). Under the full consumption insurance, we obtain the conditions by solving a benevolent social planner's problem to maximize the weighted sum of people's utilities (Cochrane 1991; Mace 1991):

(1) $$\frac{u'(c_{it})}{u'(c_{it-1})} = \frac{u'(c_{jt})}{u'(c_{jt-1})},$$

where $u$ (•) is the concave instantaneous utility of a household, $c$ is household consumption, and $i$, $j$ denotes $i, j$ the household, respectively. Equation (1) shows that full consumption insurance necessitates that the intertemporal marginal rates of substitution are equalized across agents for all states. Supposing that the utility function takes the form of a constant absolute risk aversion function, that is, $u(c_{it}) = -(1/\alpha) \exp(-\alpha c_{it})$, we obtain:

(2) $$\Delta c_{i\,t} = \Delta\left(\frac{1}{N}\sum_{j=1}^{N} c_{\;j\,t}\right)$$

where $\Delta$ is a first-difference operator and $N$ represents the number of households in an insurance network, including formal credit or insurance market transactions. Under full insurance, idiosyncratic household income changes should be absorbed by all other members in the same insurance network and these shocks should not affect changes in consumption. As a result, idiosyncratic income shocks should not affect consumption changes. However, a household's

consumption level is affected by aggregate factors. This is the empirically testable implication of the full consumption insurance model.

While the above framework of the full consumption insurance may appear extremely unrealistic, *de facto* household-level insurance can be attained through a wide variety of real-world market and nonmarket mechanisms, through credit and security markets, the government's state-contingent transfers—such as unemployment insurance and disaster insurance schemes, and informal transfer networks among family members or close communities. Our intention in applying this framework as a benchmark is to test the overall effectiveness and efficiency of informal/formal networks and markets as a whole to achieve efficient resource allocation.

## 2.2 Risk Management Strategies

As a second framework, we also discuss how people in the area used risk-coping measures to mitigate changes in consumption arising from the natural disaster. In response to the wide variety of shocks caused by natural disasters, including earthquakes, households have developed formal and informal mechanisms to deal with the consequences. In the more general context, such insurance mechanisms can be divided into *ex-ante* risk management and *ex-post* risk-coping behaviors (Alderman and Paxson 1992; Dercon 2005; Fafchamps 2003). Risk management strategies can be defined as activities for mitigating risk and reducing income instability before the resolution of uncertainties in order to smooth income (Walker and Jodha 1986; Alderman and Paxson 1992). Risk management methods include accumulation of precautionary savings, participation in formal earthquake insurance, and investments in earthquake-proof housing structures.

Precautionary savings can take the form of bank deposits, cash holdings, jewelry, and physical assets such as land and real estate. In Japan, a major proportion of household assets is commonly held in the form of cash and cash equivalents, including in bank accounts, as well as land and real estate (Allen and Gale 2000). Zhou (2003) observed that precautionary savings arising from earnings uncertainty comprises 5.56 percent of the total savings of salaried worker households and a remarkable 64.3 percent of the total savings of agricultural, forestry, fishery, and self-employed households. While Japan has been criticized for its excessive savings behavior in the 1980s and early 1990s, which created large current account surpluses, the frequency of geological and climatic disasters such as earthquakes, landslides, and typhoons was significantly correlated with household saving rates (Skidmore 2001). According to Skidmore's (2001) estimation results, of Japan's saving rate of 12.4 percent, 10.1 percent can be explained by the past damages caused by natural disasters. This illustrates the significance of precautionary saving against disasters in Japan.

In Japan, earthquake insurance is complementary to fire insurance (homeowner insurance), and the amount insured ranges from 30 percent to 50 percent of that insured by fire insurance, with a cap of 50 million yen ($550,000) for houses and 10 million yen ($110,000) for assets. While the Japanese government provides reinsurance schemes to the private insurance companies that sell earthquake insurance, the government strictly regulates earthquake insurance premiums and there are only four different insurance premium categories across Japan.[5] For example, as shown in Figure 2, the Kinki region, which includes the Kobe area at its center, was rated as a "Tier 3" area in terms of earthquake insurance premiums, implying that the risk of

[5] In each category, there are two premiums: one for nonwooden houses and another for wooden houses. In addition, there are four premium discount programs, depending on the quality of house, but these discounts do not vary much. Moreover, the government sets the overall cap on the total insurance payments for an earthquake—set at 5 trillion yen or $50 billion since April 2005.

earthquake damage was considered to be lower than in the "Tier 4" areas. Since premiums do not vary much across regions and serious limitations do exist in private but highly regulated insurance markets for earthquakes in Japan (Saito 2002; Yamaguchi 1998),[6] it has been known that insurance participation is rather limited in Japan in spite of it having the world's highest earthquake risk (table 11.2). For instance, only a small fraction of households in Kobe had earthquake insurance at the time the earthquake hit. In December 1994, only 3 percent of the population in Hyogo Prefecture, where Kobe is located, was covered by such insurance. Another reason for this is likely to be that people have an inherent tendency to underestimate the probability of rare bad events (Camerer and Kunreuther 1989), and thus there seems to be a systematically lower earthquake insurance participation rate than the optimal level.

**Table 2**

**Earthquake Insurance Participation Rate in Japan, 1993–2003, percentage**

| Year | 1993 | 94 | 95 | 96 | 97 | 98 | 99 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Japan overall | 7.0 | 9.0 | 11.6 | 13.1 | 14.2 | 14.8 | 15.4 | 16.0 | 16.2 | 16.4 | 17.2 |
| Hyogo | 2.9 | 4.8 | 8.4 | 10.2 | 11.2 | 11.5 | 12.0 | 12.3 | 12.4 | 12.4 | 12.9 |
| Tokyo | 16.1 | 17.9 | 20.7 | 22.6 | 23.7 | 24.2 | 24.7 | 24.9 | 24.6 | 24.2 | 24.8 |

*Source*: Non-Life-Insurance Rating Organization of Japan.

It has been argued that *ex-ante* investments in mitigating the risk of earthquakes are very cost-effective in providing *ex-post* compensations for losses. By their very nature, however, it is often difficult to elaborate proper risk management strategies against earthquakes as they are typically rare and unforeseen events.

[6] Froot (2001) also observed that, in the United States, most insurers purchased relatively limited catastrophe reinsurance against natural disasters. He concluded that this is attributable to supply restrictions associated with capital market imperfections and market power exerted by traditional reinsurers. Nonetheless, Brookshire et al. (1985) showed that the housing market in the United States exhibits an effective response to the risk of damage caused by natural disasters.

## 2.3 Risk-Coping Strategies

Accordingly, even if households adopt a variety of risk management strategies, an earthquake can happen unexpectedly, causing serious negative impacts on household welfare. Therefore, *ex-post* risk-coping strategies—those used to reduce consumption fluctuation—will be indispensable (Alderman and Paxson 1992). In general, the existing literature identified the following different types of risk-coping mechanisms against different risks.

First, households can reallocate or reduce luxury consumption expenditure (McKenzie 2006; Kang and Sawada 2008). Affected households changed their consumption behavior substantially after the Kobe and Chuetsu earthquakes (Sawada and Shimizutani 2005, 2007, 2008; Ichimura, Sawada, and Shimizutani 2007). For example, according to Sawada and Shimizutani (2005, 2007, 2008, 2011), who analyzed a household survey conducted among the Kobe earthquake victims, around 62.7 percent of respondents answered that their consumption behavior changed prior to and after the earthquake, suggesting a trend of consumption reallocation after facing an unexpected disaster.

Second, households can use credit market transactions to weather the shock and smooth out consumption by reallocating future resources to current consumption. The lack of *ex-ante* formal insurance is compensated for by easy access to credit markets. For various reasons, however, households often have limited access to credit markets, a fact that can be attributed to high information costs and/or lack of assets for collateral. Indeed, using a unique household dataset from the Great Hanshin-Awaji (Kobe) earthquake, Sawada and Shimizutani (2008) showed that households with a large amount of collateralizable assets before the catastrophe, that were free from a binding borrowing constraint, were able to maintain their consumption levels by borrowing. In contrast, households subject to a binding borrowing constraint before the

disaster were unable to borrow to cope with the losses inflicted by the earthquake. While the existence of credit constraints limits the risk-coping abilities of households, Horioka and Kohara (1999), and Sawada, Ii, and Nawata (2011) observed that less than 10 percent of households face credit constraints in Japan and therefore the overall impact of credit constraints may not be very significant.

Third, households can accumulate financial and physical assets as a precautionary device against unexpected income shortfalls. In the event of such shocks, households can use their own financial and physical assets. In fact, using household panel data, Horioka, Murakami, and Kohara (2002) examine how Japanese households cope with risk in a usual nondisaster situation and find that when they encounter unforeseen contingencies, households rely mostly on their savings. Similarly, according to Sawada and Shimizutani's (2005) analysis of subjective questions of Kobe earthquake victims, among those respondents who faced an expenditure shock due to the earthquake, more than half said that they used their savings. Yet, after carefully controlling for other factors, Sawada and Shimizutani (2005) found that savings were used only to cope with smaller asset damage, not large damages. Along with the finding that savings were used to compensate for smaller losses while larger shocks were dealt with by borrowing, our empirical findings suggest the existence of a hierarchy of risk-coping measures, ranging from dissaving to borrowing.

Finally, private and public transfers can be used as an *ex-post* risk-coping mechanism. For private transfers, through informal arrangements of state-contingent mutual transfers among relatives, friends, or neighbors, a household can weather the shocks and achieve consumption smoothing (Cochrane 1991; Mace 1991; Townsend 1987; Kohara, Ohtake, and Saito 2002, 2006; Sawada and Shimizutani 2007). Public transfers meanwhile (whether direct cash or in-kind

transfers)—through means-tested targeting, tagging, or geographical/group targeting such as unemployment insurance or workfare—can act as a formal safety net for households facing difficulties. Horioka, Murakami, and Kohara (2002), using a household panel data set, find that Japanese households also rely on supports from family members, relatives, friends, and the government. Using a unique household data set from the Great Hanshin-Awaji (Kobe) earthquake, Sawada and Shimizutani (2008) showed that households relied on private transfers to weather the losses caused by the earthquake, depending on the extent of the damage.

As for public support, there existed three formal frameworks at the time of the Kobe earthquake in 1995. First, the Disaster Countermeasures Basic Act, established in 1961, formulated a comprehensive and strategic disaster management system with clearly defined roles and responsibilities for the national and local governments (Cabinet Office 2007). Second, the Disaster Relief Act of 1947 defines a variety of disaster emergency supports, including the construction and provision of temporary shelters for victims. Third, there is the Payment of Compensation for Disasters Act through which the death of the head of the household, or another household member, were compensated for by payments of five million yen ($55,000) and 2.5 million yen ($27,500), respectively. For serious disabilities caused to the head of the household or another member, 2.5 million yen ($27,500) and 1.25 million yen ($13,800) is paid out.

However, these acts did not provide any government compensation for households' asset losses after the Kobe earthquake.[7] The low levels of official compensation for the reconstruction of houses in Kobe proved controversial. As a result, the government passed the Support for Livelihood Recovery of Disaster Victims Act in 1998. As a result of which, each household whose home collapses now receives compensation of up to 3 million yen ($33,000).

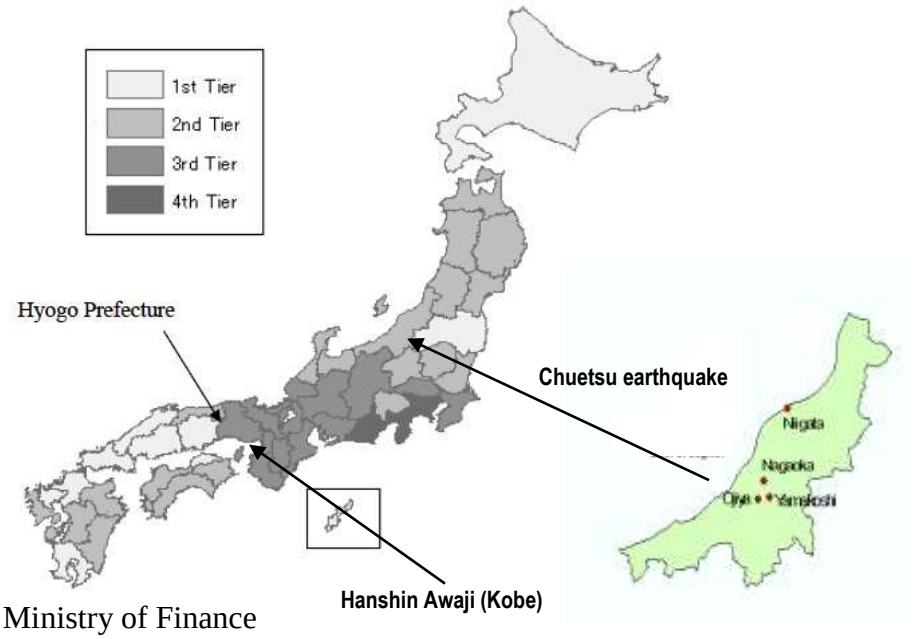
[7] Hayashi (2003) however pointed out that the total government compensation in the form of free meals in the initial stage, temporary shelters, public housing, etc. to the victims of the Kobe earthquake amounted to about 13 million yen ($143,000) per person.

Government transfers include not only the above-mentioned benefits from publicly provided schemes for victims but also people's donations to a variety of nonprofit organizations. After a natural disaster in Japan, the allocation of collected donations to victims is usually centrally determined by a special semi-public committee, with transfers allocated to households based on the certified level of damages. In the case of the Kobe earthquake, while 80 billion yen ($0.88 billion) in private donations was collected, because of the large number of victims, a mere 100,000 yen ($1,100) was paid out to each household with a completely destroyed house by this special committee, *Hyogo-Ken Nanbu-Jishin Saigai Gienkin Kanri-Iinkai.*

## 3. The Great Hanshin-Awaji (Kobe) and the Chuetsu Earthquakes

In order to capture an overall picture of the impact of earthquakes on households' welfare in Japan, we review selected evidence from the two contrasting cases of the Kobe and Chuetsu earthquakes (Figure 4). While the Kobe earthquake hit the urban center, with its dense concentration of industry and residential areas, the Chuetsu earthquake occurred in mountainous and remote farming areas, where people aged 65 and older make up a significant proportion of the population.

**Figure 4. The Two Earthquakes**




Original data source) Ministry of Finance
Note) The 4th tier represents the area with the highest insurance premium. Source: Ministry of Finance

## 3.1 The Great Hanshin-Awaji (Kobe) Earthquake

In the early hours of January 17, 1995, the Hanshin (Kobe) area in Japan was hit by a major earthquake of magnitude 7.2 on the Richter scale (Figure 4). The epicenter was located on the nearby northern Awaji Island, with the movements of the active fault causing the earthquake. The area is densely populated—home to more than four million people—and part of the second largest industrial cluster in Japan. As a result of the earthquake, more than 6,400 people died, 43,792 were injured, and 104,906 houses were completely destroyed. The housing property loss amounted to more than $60 billion, while capital stock loss was calculated to be more than $100 billion, making the event one of the largest economic disasters ever recorded (Horwich 2000; Scawthorn, Lashkari, and Naseer 1997). Given the fact that, in 1994, only 4.8 percent of the property in Hyogo Prefecture, where Kobe is located, was covered by earthquake insurance, it is reasonable to assume that the earthquake was entirely unexpected in this area (Table 2). In

comparison, the insurance coverage for the Tokyo Metropolitan Area, which was hit by a massive earthquake in 1923, was 17.9 percent in 1994 (Table 2). Stock prices dropped sharply after the quake (up to 20 percent), taking a year to recover to their pre-earthquake levels. Similarly, the value of yen against the US dollar dropped by 15 percent within three months.

There are several studies on the Kobe earthquake, notably Horwich (2000), Scawthorn, Lashkari, and Naseer (1997), Toyoda and Kawachi (1997), and Hagiwara and Jinushi (2004). Horwich (2000) conducted a useful calculation of the total damages caused by the Kobe earthquake. Taking Japan's capital stock to be three times its annual GDP of $5 trillion in 1995, the Kobe earthquake damage of $114 billion was only 0.8 percent of the capital stock of 3 × 5 = $15 trillion. Moreover, assuming that the value of human capital of an average Japanese person is $2 million, the total physical and human asset loss amounted to $127 billion ($114 million + 6,500 × $2 million). Considering that the total national wealth of Japan in 1995 was $167 trillion under a discount rate of 3 percent ($5 trillion/0.03 = $167 trillion), the physical and human asset loss of the Kobe earthquake was only 0.08 percent of the total wealth of Japan. While this back-of-the-envelope calculation from Horwich (2000) is very informative, capturing one of the core reasons why the Kobe earthquake barely affected the Japanese economy as a whole, these numbers should not be interpreted as a justification for ignoring individual micro-level impacts of the earthquake.

## 3.2 Consumption Insurance and Risk-Coping Strategies against the Great Hanshi-Awaji (Kobe) Earthquake

Most existing economic studies on the Kobe earthquake, including the above, focus on production, the macroeconomy, or rehabilitation policies, rather than on households, with the

exception of Kohara, Ohtake, and Saito (2002, 2006), who tested the full consumption risk-sharing hypothesis shown by equation (2). Nevertheless, the latter's data set suffers from a serious attrition problem, as it retains only one quarter of the original households in the areas hit by the earthquake. To mitigate the estimation bias involved in Kohara, Ohtake, and Saito (2002, 2006), Sawada and Shimizutani (2005, 2007, 2008) used a unique micro data set from the victims of the Kobe earthquake—*Research report on changes in lifestyles and consumption behaviour following the disaster* (*Shinsai-go no Kurashi no Henka kara Mita Shouhi Kouzou ni Tsuite no Chousa Houkokusho*), collected by the Hyogo Prefecture in October 1996. The survey was completed by 1,589 women over the age of 30, and who were selected on the basis of a stratified random sampling scheme in the six areas seriously affected.[8]

Shortly after the earthquake, local governments conducted metrical surveys and issued formal certificates for damage to houses. The information on damage is objective and accurate. A total of 71.3 percent of the respondents suffered damage to their house and 78.6 percent suffered damage to their household assets (Table 3).

[8] Respondents were those who still lived there after the earthquake. Hayashi and Tatsuki (1999) found that the degree of damage to houses caused by the earthquake was on average larger for those who had moved outside the earthquake-hit areas than those who remained within the areas. This suggests that Sawada and Shimizutani's (2005, 2007, 2008) results can be interpreted as lower-bound estimates of the negative impact of the Kobe earthquake.

**Table 3**

**Household-Level Damages Caused by the Kobe and Chuetsu Earthquakes**

| | Kobe | Chuetsu (the village) |
|---|---|---|
| Proportion of respondents who encountered | Percentage | Percentage |
| Major housing damage caused by the earthquake | 17.4% | 53.1% |
| Moderate housing damage caused by the earthquake | 25.1% | 30.3% |
| Minor housing damage caused by the earthquake | 43.1% | 0% |
| Major household asset damage caused by the earthquake | 9.4% | N.A. |
| Minor household asset damage caused by the earthquake | 77.3% | N.A. |
| Health-related shocks to the family caused by the earthquake | 21.3% | 25.8% |

*Source*: Sawada and Shimizutani (2005, 2007, 2008) and Ichimura, Sawada, and Shimizutani (2008).

By testing the implications of equation (2) with an econometric model applied to the above-mentioned data set, Sawada and Shimizutani (2007) found that households suffering larger nonincome shocks are more likely to change their consumption than those experiencing small nonincome shocks. Similar qualitative results can be verified by looking at numbers in table 4(b) of Sawada and Shimizutani (2008). The table shows the share of households reporting a substantial, slight, or no change in consumption behavior classified by the extent of damage they suffered. More than 80 percent of households that experienced major damage to their home changed their consumption behavior, while only half the households without any damage to their home changed their consumption behavior. The table thus shows that the share of households that changed their consumption behavior is positively correlated with the extent of housing asset damage, implying a rejection of efficient risk-sharing in the entire area. A similar pattern can be found with regard to the change in consumption behavior in relation to the extent of damage to household assets.

To sum up, similar to the results from Kohara, Ohtake, and Saito (2006), the full consumption insurance hypothesis of equation (2) is rejected strongly, suggesting the overall ineffectiveness of the formal/informal insurance mechanisms against the earthquake. This finding suggests that the lack of insurance for real estate and physical assets is a particularly serious issue. These findings are consistent with the fact that very few properties in Kobe were covered by earthquake insurance in January 1995.

Even in the absence of full consumption insurance, households may be able to insure themselves against unexpected shocks through a wide variety of risk-coping behavior. Sawada and Shimizutani (2005, 2008) also investigate possible factors that inhibit consumption insurance by comparing the effectiveness of different risk-coping strategies, that is, dissaving, as well as borrowing and receiving private and/or public transfers. According to their descriptive statistics, among the respondents who faced an unexpected increase in their expenditure due to the earthquake, approximately 25 percent managed to cope by changing the constituents of consumption and more than half used their savings. Borrowing and receiving transfers were also considered as significant risk-coping strategies for approximately 10 percent and 12 percent of valid responses, respectively. Further careful econometric analyses by Sawada and Shimizutani (2005, 2008) reveal that the risk-coping means exploited by households are specific to the nature of the loss caused by the earthquake. For instance, households borrow extensively against housing damage, whereas savings are used to compensate for smaller damages caused to assets. This implies the existence of a hierarchy of risk-coping measures, starting from dissaving to borrowing. Also, Sawada and Shimizutani (2008) found that credit market accessibility plays an important role in weathering housing damage as credit-constrained households faced difficulties coping with such damage.

## 3.3 The Chuetsu Earthquake

On the evening of Saturday, October 23, 2004, the Chuetsu earthquake struck the middle part of Niigata prefecture (Figure 4), registering 6.8 on the Richter scale, with a hypocenter depth of 13 km—not very deep underground. The earthquake resulted in the deaths of 68 people, serious injuries to 632, and minor injuries to more than 4,000 in Niigata prefecture (Niigata Prefecture 2009). The housing property and capital stock losses were estimated to amount to more than $20 billion, making it one of the largest economic disasters in the new millennium.

We now examine Ichimura, Sawada, and Shimizutani (2007) to discuss the case of the village of Yamakoshi, which was located close to the epicenter and thus was one of the most heavily hit areas. It is fair to say that people in Yamakoshi did not expect a large earthquake. Since the most recent large landslides in the village took place in 1824 due to a thaw, the current villagers had never experienced such a disastrous catastrophe. Also, Figure 4 shows that Niigata prefecture belongs to the area whose earthquake insurance premium is at the third tier level out of four different regions, in the ranking of the different risk of earthquakes (Figure 4).

In Yamakoshi, five people died, 12 people were seriously injured, and an additional 13 people sustained minor injuries. In addition to the human losses, almost all the houses in the village were damaged, but the size of the losses was diverse, with 285 collapsed houses, 56 half-collapsed houses, 234 houses with moderate damage, and 106 houses with partial damage (Table 3). Moreover, the resulting landslides forced the closure of highways and smaller roads, leaving most localities in Yamakoshi isolated. Since a continuous series of aftershocks increased the danger of further landslides, the government announced an evacuation order for the entire village, with all the villagers successfully evacuated two days after the earthquake. Two months

later, around 80 percent of the villagers moved to temporary shelters (Kasetsu Jyutaku) provided by local governments in the neighboring city of Nagaoka.

Ichimura, Sawada, and Shimizutani (2007) designed a household survey exclusively for their study. The survey was conducted in April and May 2006 among the former residents of Yamakoshi. The sample is the registered Yamakoshi households at the time of the disaster. With strong cooperation from local governments, the survey covered 597 households out of the total of 663 registered households in the village.

In the village, more than half of all houses were seriously damaged: 43.2 percent of houses completely collapsed and 9.9 percent almost completely collapsed. Hence, the proportion of respondents who encountered major housing damage caused by the earthquake was amounted to 53.1 percent (Table 3). In addition, 30.3 percent were classified as half-collapsed (Table 3). While the level and intensity of damages seem to be more serious than those in Kobe, the effectiveness of overall insurance mechanims give us a different picture: according to Ichimura et al. (2007), unlike in the case of the Kobe data, the full consumption insurance hypothesis of equation (2) cannot be rejected.

In order to investigate possible factors behind the full consumption insurance, we can compare the important risk-coping strategies against unexpected costs caused by the earthquake. According to responses to subjective questions, approximately 70 percent of households managed to cope with the damages by drawing on their savings, while only 4 percent borrowed funds. Receiving insurance payments was also a significant risk-coping strategy for approximately half the households. Moreover, private and public transfers were used by 52 percent and 74 percent of the respondents, respectively.

Using parametric and nonparametric econometric models, Ichimura, Sawada, and Shimizutani (2007) compared the effectiveness of different risk-coping strategies, that is, dissaving, as well as borrowing and receiving public and private transfers. Similar to the case of the Kobe earthquake, borrowing played an effective role in coping with damage to houses, whereas dissaving played a minor role. Interestingly, households seem most likely to receive private transfers when they encounter health and unemployment shocks. Moreover, Ichimura, Sawada, and Shimizutani (2007) found that formal earthquake insurance, donation, and government transfers functioned effectively in Yamakoshi. Indeed, the earthquake insurance participation rate in Yamakoshi before the earthquake was more than 80 percent. This high participation rate may not be attributed to people's prior expectation of an earthquake. Rather, this is mainly because most households participated in the housing insurance program provided by farmers' cooperatives, Japan Agriculture (JA), and the program automatically includes the earthquake insurance contract. Such earthquake insurance market penetration may reflect a peculiar nature of communities with tight social network and social capital. Yet this was not the case for a much larger urban earthquake such as the Kobe earthquake in 1995 (Sawada and Shimizutani 2008), or disasters in developing countries (Sawada 2007). Insurance companies may effectively extend their product by using such rural social network. In fact, this observation is consistent with the fact that existing index insurance products in developing countries can be found mostly in rural areas, not urban areas.

## 4. Lessons from Earthquakes in Japan

The feature that distinguishes most sharply the Kobe and Chuetsu earthquakes is in the effectiveness of consumption insurance. While the full consumption insurance hypothesis was strongly rejected in the case of an urban center, Kobe, the hypothesis seems to hold in a rural area, Yamakoshi village. These results suggest that there is a serious lack of de facto insurance markets for damage to real estate and physical assets caused by the earthquake in Kobe, which is densely populated urban center. We may attribute this difference to two distinctive causes.

First, there is a significant difference in the total amount of public transfers. In Kobe, allocation of donations per victim was very limited—a mere $1,000 for a collapsed house, with no other government transfers provided mainly because the total number of the victims defined as those killed or injured in Kobe as an urban center—50,225 individuals—was more than 10 times as large as the total number of the victims of the Chuetsu earthquake which hit sparsely populated villages—4,862 individuals. By contrast, there were two different additional public transfers made in the case of the Chuetsu earthquake: publicly distributed donations (*gienkin*) and Livelihood Recovery Transfers, that is, a government cash transfer program for the victims of the earthquake.

Second, in Yamakoshi, the earthquake insurance participation rate was very high mainly because of the JA's sales efforts in housing insurance products before the earthquake, compared to a participation rate of only 4.8 percent in Hyogo prefecture, where Kobe is located, in 1994. These differences may arise from a peculiar nature of insurance market penetration in rural Japan utilizing tight social capital. By looking at difference disaster cases such as the Great Kanto and Kobe earthquakes, Hurricane Katrina, and Indian Ocean Tsunami, Aldrich (2012) pointed

the important role of social capital in resilience against disasters: he finds that those with robust social networks were better able to coordinate recovery; and that in addition to quickly disseminating information and financial and physical assistance, communities with an abundance of social capital were able to minimize the migration of people and valuable resources out of the area.

Under these different conditions, it would be reasonable to find full consumption insurance in Yamakoshi, not in Kobe. These differences indicate the importance of further cross-disaster comparisons focusing on urban and rural differences. Yet, in both earthquakes, we observe that the means for coping are specific to the nature of shocks caused by the earthquake. For example, borrowing was extensively used to recover losses resulting from housing damage, while savings were used to compensate for the loss of smaller household assets. These findings suggest the existence of a hierarchy of risk-coping, ranging from dissaving to borrowing.

Our empirical results imply a serious lack of effective formal insurance markets as well as informal mechanisms for damage to real estate and physical assets in densely populated urban areas. Without effective *ex-ante* measures, the actual economic losses caused by an earthquake as strong as the Great Hanshin-Awaji earthquake prove to be too large for the government to compensate affected households effectively. After the Kobe earthquake, the central and local governments provided the largest financial support in the history of Japan to reconstruct the affected areas and to facilitate the economic recovery of the victims. However, despite the extensive support provided by the government, consumption insurance was not effectively achieved.

## 4.1 Policy Implications

Regarding public and/or private provision of safety nets covering fallout from natural disasters, our findings teach three main lessons. First, it is imperative that *ex-ante* risk management policies be designed. For example, investments in physical and social infrastructure to enhance resilience against disasters will be indispensable especially in the urban setting. Such investments include not only those in high quality physical infrastructure but also investments in strengthening social capital and network which effectively reduce disaster vulnerability and improve resilience because communities with robust social networks were better able to coordinate recovery and to minimize outflows of people and resources from them (Aldrich, 2012). Also, formal market mechanisms such as further development of markets for earthquake insurance would lead to the efficient pricing of insurance premiums and efficient land market prices reflective of the amount of risk involved (Saito 2002). This development would generate proper incentives to invest in mitigation, including investments in earthquake-proof construction. In Japan, housing rent is substantially lower in risky areas than in safer areas, while rent for apartments built prior to the Building Standard Law being amended is discounted more substantially in risky areas than those built after this date (Nakagawa, Saito, and Yamaga 2007). Similarly, Nakagawa, Saito, and Yamaga (2009) found that land prices were low in areas with substantial exposure to earthquake risk. Houses with inferior earthquake-resistant quality may generate serious negative externalities in the neighborhood because, if collapsed houses block roads, it will delay the rescue effort substantially. Our paper suggests that more efficient resource allocation can be achieved effectively by price interventions as these *ex-ante* measures would significantly reduce the overall social loss caused by the earthquake especially in urban areas.

Second, in its attempt to provide *ex-post* public support in the event of a natural disaster, the government may create a moral hazard problem by encouraging people to expose themselves to greater risks than they otherwise would if there were no expected support (Horwich 2000). Experiences of the two earthquakes suggest that providing subsidized loans, rather than direct transfers, to victims can be a good example of facilitating risk-coping behavior, and such interventions are less likely to create moral hazard problems. Having said this, based on these experiences of the two earthquakes, it should be also noted that our analysis raises important questions about the ability of those affected by the East Japan earthquake to rebuild given that those who recently lost homes tend to be older than those who lost home in the earlier Kobe earthquake. According to a simple calculations, in a typical tsunami-affected city, such as Rikuzen Takada, where approximately 3,600 homes were lost, the median age is 52, and 30 percent of the population is 60 years or older. Yet, financial institutions will be reluctant to provide a 20-25 years home loan to a 60 years old person. In Japan, reverse mortgages and home equity lines of credit are both very rare. Yet, since those who recently lost homes by the Great East Japan earthquake tend to be older than those who lost home in the earlier Kobe earthquake, new complementary financing instruments such as reverse mortgage programs to victims are indeed indispensable to facilitate the asset recovery process.

Finally, while advanced nations can deal with a major disaster by managing their financial resources, developing countries, which carry diverse risks of major disasters, have weak financial groundwork and are less tolerant and resilient of such risks. This is why a global system of pooling the disaster risks should be considered for both developing and advanced nations to diversify the risks of disasters. In other words, we should also work on the securities and reinsurance markets to develop a global disaster insurance system that would

encompass various regional frameworks such as Caribbean Catastrophe Risk Insurance Facility (CCRIF), which is a parametric, multinational hazard insurance fund for hurricanes and earthquakes that works with the international reinsurance market and was established as the first of its kind in the world. Haiti was a member of the Facility, and after the Haiti Earthquake in January last year, the government received 7.75 million dollars in earthquake insurance—around twenty times its premium—as soon as two weeks after the quake. This is evidence of the importance of designing and scaling up a new insurance system such as CCRIF. When we consider the actual form of such a global insurance system, there are numerous issues involved, such as whether it would be a statutory system such as a ruled disaster fund, or something more discretionary and flexible such as an emergency disaster coordination forum. Issues such as these will be important research topics in the future especially for urban areas in developing countries which are most likely to be vulnerable against different disasters.

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**Appendix Table**

The Locations of the 25 Major Earthquakes and Tsunamis in Japan with Seismic Intensity of 6.0 or Greater in the Last 30 Years, Ranked by Human Losses

| Rank | Date (Year. Month. Day) | Magnitude | Name of earthquake | Total human losses (dead and missing) |
|---|---|---|---|---|
| 1 | 1923. 9. 1 | 7.9 | Great Kanto earthquake | 142,807 |
| 2 | 1896. 6. 15 | 8.5 | Meiji-Sanriku earthquake | 21,959 |
| | 2011.3.11 | 9.0 | Great East Japan earthquake | 19,371 |
| 3 | 1891. 10. 28 | 8 | Nobi earthquake | 7,273 |
| 4 | 1995. 1. 17 | 7.3 | Great Hanshin-Awaji earthquake | 6,437 |
| 5 | 1948. 6. 28 | 7.1 | Fukui earthquake | 3,769 |
| 6 | 1933. 3. 3 | 8.1 | Syowa-Sanriku earthquake | 3,064 |
| 7 | 1927. 3. 7 | 7.3 | North Tango earthquake | 2,925 |
| 8 | 1945. 1. 13 | 6.8 | Mikawa earthquake | 2,306 |
| 9 | 1946. 12. 21 | 8 | Nankai earthquake | 1,330 |
| 10 | 1944. 12. 7 | 7.9 | Tonankai earthquake | 1,223 |
| 11 | 1943. 9. 10 | 7.2 | Tottori earthquake | 1,083 |
| 12 | 1894. 10. 22 | 7 | Syonai earthquake | 726 |
| 13 | 1872. 3. 14 | 7.1 | Hamada earthquake | 550 |
| 14 | 1925. 5. 23 | 6.8 | North Tajima earthquake | 428 |
| 15 | 1930. 11. 26 | 7.3 | North Izu earthquake | 272 |
| 16 | 1993. 7. 12 | 7.8 | Hokkaido-Nansei-oki earthquake | 230 |
| 17 | 1896. 8. 31 | 7.2 | Rikuu earthquake | 209 |
| 18 | 1960. 5. 23 | 9.5 | Tsunami by Great Chilean earthquake | 142 |
| 19 | 1983. 5. 26 | 7.7 | Nihonkai-Chubu earthquake | 104 |
| 20 | 2004. 10. 23 | 6.8 | Chuetsu earthquake | 68 |
| 21 | 2007. 7. 16 | 6.8 | Chuetsu offshore earthquake | 15 |
| 22 | 2001. 3. 24 | 6.7 | Geyo earthquake | 2 |
| 23 | 2003. 9. 26 | 8 | Tokachi offshore earthquake | 2 |
| 24 | 2007. 3. 25 | 6.9 | Noto Peninsula earthquake | 1 |
| 25 | 2000. 10. 6 | 7.3 | Tottoriken-Seibu earthquake | 0 |

*Source*: The Cabinet Office (2005), Disaster Management in Japan; and Fire and Disaster Management Agency.