The Impact of Natural and Manmade Disasters on Household Welfare

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by

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Abstract

In this paper, we provide selective evidence on the impact of natural and manmade disasters on household welfare. First, we consider ex ante risk management and ex post risk-coping behaviors separately, showing evidence from the Asian economic crisis, earthquakes, and tsunami disasters. Second, we differentiate idiosyncratic risks which can be diversified away through mutual insurance from non-diversifiable aggregate risks which characterize a disaster. We also discuss the difficulties of designing index-type insurance against natural disasters, which are often rare, unforeseen events. Then, we investigate the role of self-insurance against large-scale disasters under which formal or informal mutual insurance mechanisms are largely ineffective. Credit accessibility is identified as one of the key factors facilitating risk-coping strategies. We also discuss public policy issues of emergency aid after disasters.

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1. Introduction

In developed as well as developing countries, people are at a wide variety of risks to their livelihood. Accidents, sickness, or sudden death can disable the head of a household or even an entire family. Agricultural production involves a variety of price and yield risks which appear to be prevalent especially for small-scale, poor farmers in the semi-arid tropical areas in developing countries. Even for households in urban, industrial or commercial sectors, income fluctuates over time due to contractual and physical risks in the handling of products, intermediate goods and employees in LDCs. Macroeconomic instability or recessions, which tend to generate harsh inflation/deflation and widespread unemployment, can also significantly reduce the real value of household resources. However, natural disasters can generate the most serious consequences ever known. Recently, a number of natural disasters hit both developed and developing countries alike. We still remember vividly how a huge number of lives were lost in the Indian Ocean tsunami, Pakistan earthquake, Great Hanshin-Awaji (Kobe) earthquake, and Hurricane Katrina. In addition to disasters caused by natural events, man-made disasters such as economic crisis, terrorism, and wars also create serious damage.

In this paper, we will provide selective evidence on the impact of natural and manmade disasters on household welfare. Three aspects differentiate this paper from earlier related studies. First, while there has been a remarkable progress in the theoretical and empirical literature on risk and household behavior [Fafchamps (2003); Dercon ed. (2005)], shocks generated by a disaster, which potentially gives a clean experimental situation, have rarely been investigated or utilized. Secondly, unlike previous studies on household behavior against general idiosyncratic shocks, we explore quantitatively the role of savings, borrowing, and other risk-coping devices against disasters as a covariate shock. Finally, by using preliminary results based on a unique data set collected in the earthquake- and Tsunami-affected areas, we discuss the role of public policy to facilitate households' risk-coping behavior against disasters.

In general, a disaster is defined as an unforeseen event that causes great damage, destruction and human suffering, which overwhelms local capacity, necessitating a request to national or international level for external assistance (The Centre for Research on the Epidemiology of Disasters, 2006).[1] Disasters in this definition include warfare, civil strife, economic crisis such as hyperinflation and financial crisis, hazardous material or transportation incident (such as a chemical spill), explosion, nuclear incident, building collapse, blizzard, hurricane, drought, epidemic and pandemic, earthquake, fire, flood, or volcanic eruption.

Augmenting the classification system of UNISDR (2005), these disasters can be classified into three broad categories, natural disasters, technological disasters, and manmade disasters. Firstly, the natural disasters can be divided into three subgroups: 1) hydro-meteorological disasters including floods, storms, and droughts; 2) geophysical disasters including earthquakes, tsunamis and volcanic eruptions; 3) biological disasters such as epidemics and insect infestations. Secondly, the technological disasters are mainly composed of two subgroups: 1) industrial accidents such as chemical spills, collapses of industrial infrastructures, fires, and radiation; 2) transport accidents by air, rail, road or water means of transport. Finally, manmade disasters are also composed of two subcategories; 1) economic crises including growth collapse, hyperinflation, and financial, and/or currency crisis; 2) violence such as terrorism, civil strife, riots, and war. In this paper, we confine ourselves to analyze natural and manmade disasters.

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[1] The Centre for Research on the Epidemiology of Disasters (2006) recorded a disaster which fulfills at least one of the following criteria: 10 or more people reported killed; 100 people reported affected; declaration of a state of emergency; and call for international assistance.

Figure 1 shows the number of natural disasters registered in EM-DAT: the OFDA/CREAD International Disaster Database for 1900-2004. 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 natural disaster, followed by droughts and related disasters, epidemics, and earthquakes and tsunamis (Table 1). Table 1 also reveals that epidemics are serious in Africa, while Asia was hit by a large number of earthquakes and tsunamis.

As to manmade disasters, the number of complex economic crisis also seems to be increasing. A seminal work by Kaminsky and Reinhart (1999) reveals that the number of currency crises per year did not increase much during the 1980's and 1990's, while the number of banking crises and simultaneous banking and currency crises, i.e., *twin crisis*, increased sharply in the 1980's and 1990's (Table 2).

The number of people affected and killed by natural disasters has also been increasing in the last 30 years. Yet, the estimated damage from natural disasters does not necessarily increase with that of the numbers of disasters and victims (Figure 2). The amount of damage seems to depend on the location of the disaster (Figure 2). According to Table 3, the level of damages from natural disasters is much higher in developed countries than that in developing countries, while the impact of disasters to a national economy may be higher in developing countries. The Great-Hanshin (Kobe) earthquake and the hurricane Katrina recorded the two largest economic damages in history [Table 3, Horwich (2000)]. These changes in natural and manmade disasters suggest the increasing importance of research on disasters.

In response to the wide variety of shocks caused by natural and manmade disasters, households have developed formal and informal mechanisms. We classify such insurance mechanisms by two dimensions. First, we consider ex ante risk management and ex post risk-coping behaviors separately. Secondly, we divide insurance mechanisms into mutual and self-insurance through market and non-market mechanisms [Hayashi et al. (1996)]. The rest of this paper is organized as follows. In Section 2, we discuss risk management and coping behaviors. Some evidence from the Asian economic crisis, earthquakes, and tsunami is shown. In Section 3, we differentiate idiosyncratic risks which can be diversified away through mutual insurance from non-diversifiable aggregate risks which characterize a disaster. Then, we investigate the role of self-insurance against large-scale disasters under which formal or informal mutual insurance mechanisms are weak. In the final Section, we will discuss public policy issues of disasters, which will be followed by the concluding remarks.

2. Risk Management and Coping against Disasters

While people in developing countries, especially the poor, face many risks in their day to day lives, maintaining a stable consumption level above subsistence is essential for maintaining households' standard of living over time. Poverty occurs when a household's per-capita consumption level falls below a properly-defined poverty line. Hence, the central behavioral problem of LDC households becomes a reconciliation of income fluctuation and consumption smoothing. This problem can be theoretically captured as the problem of intertemporal consumption smoothing under a stochastic income process. Following Morduch (1995), we can capture the negative welfare costs of risks by calculating how much money households would be willing to pay to completely eliminate income variability. Mathematically, such an amount of money is represented by m which satisfies the following relationship:[2]

$$u(\bar{y}-m)=E[u(\tilde{y})]\,, \qquad (1)$$

where $u(\cdot)$ is a well-behaved utility function, $\tilde{y}$ is a stochastic income and $\bar{y}$ is its mean value. Taking a first-order Taylor expansion of the left-hand-side around m=0 and a second-order Taylor expansion of the right-hand-side around the mean income gives:[3]

$$\frac{m}{\bar{y}}=\frac{1}{2}\underbrace{\left(-\frac{u''(\bar{y})\bar{y}}{u'(\bar{y})}\right)}_{Coefficient\ of\ RRA}\times\underbrace{\left(\frac{\sqrt{Var(\tilde{y})}}{\bar{y}}\right)^{2}}_{Coefficient\ of\ Var}, \qquad (2)$$

Equation (2) indicates that approximately, the fraction of average income that a household would be willing to give up can be calculated as half of the coefficient of relative risk aversion multiplied by the square of the coefficient of variation of income. Table 4 shows the estimated welfare costs of risks in India and Pakistan. These results indicate that the welfare cost of risks is at least 10% and can be 30-50% of household income. Since natural and manmade disasters generate larger income volatilities than these income fluctuations, the welfare costs estimated here may be regarded as lower-bound estimates of the negative welfare impacts of natural or manmade disasters.

Based on the framework of the Life-Cycle Permanent Income Hypothesis (LC-PIH), the recent micro-development literature examines the role of risks in determining the nature of

[2] The variable m represents a standard risk premium.
[3] This is the so-called Arrow=Pratt risk premium.

poverty. These studies address the effectiveness of formal and informal risk management or coping mechanisms of households [Alderman and Paxson (1992); Besley (1995); Deaton (1997); Dercon ed. (2005); Fafchamps (2003); Morduch (1995); Townsend (1994, 1995); Udry (1994)].

2.1 Risk Management and Risk Coping Strategies

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). Farmers have traditionally managed agricultural production risks by crop diversification, inter-cropping, flexible production investments, the use of low-risk technologies, and special contracts such as sharecropping. Even in commercial and industrial sectors, ethnicity or kinship-based long-term business relationships are often formed in order to alleviate various contractual risks beforehand. It has been argued that ex ante investments in mitigating the risk of natural disasters are very cost effective in providing ex post compensations for losses from disasters. However, it is often difficult by nature to elaborate proper risk management strategies against natural disasters because they are typically rare, events, and sometimes even worse, they are unforeseen.

Accordingly, even if households adopted a variety of risk management strategies, a disaster can happen unexpectedly, causing serious negative impacts on household welfare. For example, crops and livestock may be destroyed by a natural disaster on an unprecedented scale. Sudden accidents, sickness, or death can disable the household head or family unexpectedly. Against unexpected natural disasters, ex post risk-coping will be indispensable where risk-coping strategies are defined as ex post strategies to reduce consumption fluctuations, provided income fluctuations due to these ex-post risks [Alderman and Paxson (1992)]. In general, the existing literature identified the following different ways of risk-coping mechanisms. First, households can reduce consumption expenditure with maintaining total calorie intakes. Second, households can use credit to smooth consumption by reallocating future resources to today's consumption. Third, households can accumulate financial and physical assets as a precautionary device against unexpected income shortfalls. Finally, locating household members and/or receiving remittances in emergency is a form of risk-coping.

2.2 The Asian Crisis in Late 1990's

First, a household can maintain total nutritional intake, while it reduces food purchases and other expenditures. This is accomplished by changing the quality and composition of food expenditures or by reducing non-food expenditures, such as those for luxuries. As revealed in recent studies on the aftermath of the currency crisis in Indonesia, Korea, Thailand and Mexico, consumption reallocation is indeed an important coping strategy (Frankenberg, Smith, and Thomas, 2003; Frankenberg, Thomas, and Beegle, 1999; Kang and Sawada, 2003, McKenzie, 2003, 2004; Strauss et al., 2004; Townsend, 1999). According to Table 5, Indonesian households seem to have weathered the crisis by cutting back meat consumption, medical and education expenses, and leisure expenditure by approximately 40-60% while maintaining stable food consumption. In Korea under the financial crisis, a decrease in leisure expenditure would be an important coping behavior as well (Table 6). Yet, unlike Indonesian households, Korean households did not cut back medical and education expenses significantly. This difference between Indonesia and Korea may cause a different long-term impact of the manmade disaster because human capital accumulation might be disrupted seriously in Indonesia.

Second, facing a disaster, households can use credit to smooth consumption by reallocating future resources to current consumption. The lack of consumption insurance can be compensated for by having access to a credit market (Eswaran and Kotwal, 1989; Besley, 1995; Glewwe and Hall, 1998). However, poor households usually only have limited access to credit markets and are constrained from borrowing for a variety of reasons such as the lack of collateral assets. In any case, the existence of credit constraints has important negative impacts on the risk-coping ability of poor households. According to Table 6, average amount of Korean household debt increased by 28% during the financial crisis, but the nature of the financial crisis worked negatively on the role of credit as a risk coping behavior [Goh, Kang, and Sawada (2005)]. Kang and Sawada (2003) revealed that between 1997 and 1998, the likelihood of facing credit constraints increased significantly. The expected welfare loss from binding credit constraints is estimated to increase by 45% during the crisis, suggesting the seriousness of the credit crunch at the household level.

Third, households can accumulate financial and physical assets as a precautionary device against unexpected income shortfalls caused by a disaster. This is also called "self-insurance." Forms of precautionary savings in developing countries include grain storage [Townsend (1995); Park (2006)], cash holdings [Townsend (1995)], liquidation of bullocks [Rosenzweig and Wolpin (1993)], and sales of goats and sheep [Fafchamps, Czukas, and Udry (1997)]. However, according to Table 6, during the Korean crisis, sales of assets did not increase significantly, and assets declined by a mere 2%, implying that such sales did not serve as an important coping device. This may indicate that households were reluctant to sell their assets to cope with the negative shock since land and stock prices declined sharply [Goh, Kang, and Sawada (2005)].

On the other hand, private and public transfers rose by 8 and 11 percent, respectively. Yet, transfers constituted only 4% of total income, and merely 22% of total households received transfers. Particularly, the amount of private transfers was still not sufficient to support households living in urban areas [Kang and Sawada (2003)]. Public transfers consisted predominantly of pensions, which take 82% of public transfers on average, since most of the social safety net programs were not yet in place during the initial phase of the crisis.

2.3 Hanshin Awaji (Kobe) Earthquake

In the early hours of January 17, 1995, the Hanshin (Kobe) area in Japan was hit by a major earthquake. The area is densely populated comprising more than 4 million people and is a part of the second largest industrial cluster in Japan. The earthquake induced a human loss of more than 6,400, a housing property loss greater than USD 60 billion, and a capital stock loss of more than USD 100 billion, making it the largest economic damage recorded in history [Figure 2, Table 3, Horwich (2000); Sawada and Shimizutani (2005)]. Given the fact that only 3% 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.

Sawada and Shimizutani (2005) utilize an unique household-level data which was collected with the earthquake affected households in October 1996, 22 months after the earthquake. With this data set, Sawada and Shimizutani (2005) employ binary-dependent variables of the three risk-coping strategies, i.e., borrowing, receiving public and private transfers, and dissaving. According to Table 7, among the respondents who faced a negative impact due to the earthquake, more than half utilized their dissavings. Borrowing and receiving transfers were also considered as significant risk-coping strategies for approximately 10% and 12% of valid responses, respectively.

The survey was also carried out in order to record the details of the damage caused to the respondents by the earthquake, such as damages to the house, household assets, and the health of the family members.[4] In Table 7, it should be noted that 85.6% and 86.7% of the respondents suffered from damages to their house and household assets, respectively. These figures are indicative of the seriousness of the economic loss caused by the unexpected earthquake.

Sawada and Shimizutani (2005) investigated further the relationship between the damages and coping strategies. They found that transfers may be particularly ineffective as insurance against losses for co-resident households. Households borrow extensively against housing damages, whereas dissavings are utilized for smaller asset damages, implying a hierarchy of risk-coping measures, from dissaving to borrowing.

The Kobe earthquake caused historically-large damages to the economy and the people. In order to identify the peculiarity of the large-scale disaster, we can compare it with a smaller natural disaster. Ichimura, Sawada, and Shimizutani (2006) collected data of about 650 victims of the Chuetsu earthquake which occurred in October 2004. The total economic-losses caused by the Chuetsu earthquake were around one fifth of that caused by the Kobe earthquake (Table 3). According to the data set, about 32.3% managed to cope with the damages by dissavings and about 9% utilized borrowings from banks, relatives, friends, and

[4] It should be noted that, shortly after the earthquake, the local governments conducted metrical surveys and issued formal certificates for housing damages using which the households could later obtain government compensations. Therefore, we believe that the information obtained on housing damages is fairly objective and accurate.

government schemes. More importantly, receiving public and private transfers were considered as a significant risk-coping strategy for approximately 47% of respondents. This high proportion reveals that government support and an informal social safety net can be quite effective if the scale of the disaster is not too large.

2.4 Indian Tsunami Disaster

In the morning of December 26, 2004, a Tsunami caused by the Sumatra earthquake hit the eastern and southern coastal areas of India (Figure 3). Estimated damages were highest in Tamil Nadu State (815.0 million USD) and the fishery sector was affected most (Table 8). The number of deaths caused by tsunami was also the highest in Tamil Nadu State, especially in the Nagapattinum district, where 6,065 people perished (Table 9). The majority of the victims were women and children.

In January-April 2006, we conducted a survey of 400 households from eight villages in the Nagapattinum district that were affected by the Tsunami (Sawada, 2006). A stratified random sampling scheme was adopted to obtain representative information of the damaged villages. Table 10 summarizes the damages caused by tsunami and households risk-coping means adopted against the damages. As for the damages, the majority of households lost productive assets such as boats and faced income losses. It is notable that receiving aid from government, relatives and neighbors, self-help groups, and NGOs were important means of coping for more than 90% of households, followed by borrowing for around 41% of households (Table 10).

3. The Role of Market and Non-Market Institutions

The next issue we will discuss in this paper is the role of market and non-market institutions against disasters. For this, it is useful to classify different types of risks by the level at which they occur. Idiosyncratic shocks affect specific individuals while aggregate shocks affect groups of households, an entire community and region, or a country as a whole. This distinction is important because the geographic level at which risks arise determines the effectiveness of market and non-market institutions against risk. On one hand, a risk that affects a specific individual can be traded with other people in the same insurance network through informal mutual insurance as well as a well-functioning formal insurance or credit market. On the other hand, a risk that affects an entire region cannot be insured within the region and necessitates a formal market in which region-specific risks are diversified away across regions. In fact, the extent to which a risk is idiosyncratic or correlated depends considerably on the underlying causes. Table 11 presents a useful typology of risks constructed by the World Bank (2001).

Households have developed formal and informal risk coping mechanisms against these wide variety of shocks [Cochrane (1991); Mace (1991); Townsend (1994); Besley (1995); Fafchamps (2003); Dercon ed. (2005)]. Largely, we classify such insurance opportunities as mutual and self-insurance opportunities. Mutual insurance provides consumption insurance opportunities across households through a variety of either market or non-market mechanisms such as formal insurance markets, credit market transactions that reallocate future resources to current consumption [Eswaran and Kotwal (1989)] and informal reciprocal transfers and credit among relatives, friends, and neighbors.[5] The government can also complement the household risk coping behavior by direct public transfers, such as unemployment insurance. Regarding self-insurance, in the event of unexpected negative shocks, households can utilize their own financial and physical assets that have been accumulated beforehand [Caroll and Samwick (1998); Zhou (2003)].

3.1 Full Insurance through Market or Non-Market Mechanisms

In order to investigate the implications of the complete mutual insurance, we can solve a benevolent social planner's problem by maximizing the weighted sum of people's lifetime utilities given intertemporal resource constraints [Mace (1991)].[6] A solution to this problem is that under full insurance, idiosyncratic household income changes should be absorbed by all other members in the same insurance network. As a result, after controlling for aggregate shocks, idiosyncratic income shocks should not affect consumption when risk sharing is efficient. The theoretical implications for the existence of complete risk-sharing arrangements within an insurance network are widely tested in the literature [Townsend (1994, 1995), and Udry (1994)].

The theoretical model employed here is based on Mace (1991), Cochrane (1991), Udry (1994) and Townsend (1993)'s full insurance model in a pure exchange economy. In the model, an economy with an insurance network, which can be a village or a district, is composed of N infinitely-lived households, each facing serially independent income draws. The Pareto-optimal consumption allocation problem of a hypothetical social planner becomes the Negishi-weighted

[5] The self-enforcement mechanisms of this self-interested mutual insurance scheme could be sustained as subgame perfect Nash equilibria in a repeated game [Coate and Ravallion (1993); Kocherlakota (1996)].
[6] This condition is also derived from solving the household optimization problem with complete contingent market.

utility maximization subject to the economy's goods market equilibrium condition:

$$\max \sum_{j=1}^{N} l^{j} \left\{ \sum_{t=1}^{\infty} \sum_{s^t} \left(r^{j}\right)^{t} p^{j}\left(s^{t}\right) u\left[c_{jt}\left(s^{t}\right)\right] \right\}$$
$$s.t. \sum_{j=1}^{N} c_{jt}\left(s^{t}\right) \leq \sum_{j=1}^{N} e_{t}^{j}\left(s^{t}\right), \forall s^{t}, \qquad (3)$$

where r is a household's subjective discount rate, p denotes the probability of realization of a state of nature, *s*, and *e* represents consumable initial endowment of each household. As is well known, a full insurance contract or social planner solves the above maximization problem for some Pareto-Negishi weight l. Several assumptions, however, are required. Firstly, all market participants can perfectly observe uncertainty realizations. In other words, there is no private information and thus information structure is symmetric. Secondly, the contingent securities span the state space and thus markets are complete. Thirdly, the probability distribution of state realization, $p(\bullet)$, is identical across households; i.e., households have identical beliefs about future. Finally, households have identical utility functions with identical time discount rates.

From the FOC of this problem, we have an optimal condition for intertemporal allocation of consumption for the *j*th and *i*th consumers:.

$$l^{j} \cdot u'\left(c_{jt}\right) = l^{i} \cdot u'\left(c_{it}\right) \qquad (4)$$

This equation indicates that this hypothetical social planner will allocate endowments so as to equalize households' weighted marginal utility (Figure 4). Therefore, the full consumption insurance hypothesis implies that a household's consumption allocation should be independent of idiosyncratic variables. Under the CARA utility, i.e., $u(c)$=-(1/s)exp(-$s\,c$), we have

$$c_{ti} = \underbrace{\frac{1}{N}\sum_{j=1}^{N} c_{jt}}_{village level\ average} + \underbrace{(1/s)\left(\ln l^{i} - \frac{1}{N}\sum_{j=1}^{N} \ln l^{j}\right)}_{household\ fixed\ effects} \qquad (5)$$

Equation (5) indicates that, under full insurance, idiosyncratic household income changes should be absorbed by all other members in the same insurance network. As a result, idiosyncratic income shocks should not affect consumption.

Townsend (1994) and Ravallion and Chaudhuri (1997) test this full insurance model using data from the three poor and high risk Indian ICRISAT villages. Although the model is rejected statistically, household consumption is found to move with village average consumption, which indicates that household consumption is only partially influenced by idiosyncratic shocks. From information collected by field research in northern Thai villages, Townsend (1995) concluded that risk-response variations across households suggest that Pareto improvements are possible in a full-information risk-sharing or an information-constrained version of the same model.

Hence, the very strict full-insurance hypothesis does seem to be rejected statistically in most data sets, especially for the poorest farmers. Yet, the empirical consensus tells that in general, the degree of missing markets is much smaller than many had assumed, and many better-off households seem to face almost complete insurance and credit markets against idiosyncratic shocks [Morduch (1995), Townsend (1995)].

However, natural disasters are often rare, unexpected events by which people become burdened by abrupt damages. Hence, it is even harder to design mutual insurance for natural disasters. In fact, Sawada and Shimizutani (2006) investigate whether people were insured against unexpected losses caused by the Great Hanshin-Awaji (Kobe) earthquake in 1995. They found that the full consumption insurance hypothesis is rejected overwhelmingly, suggesting the ineffectiveness of formal/informal insurance mechanisms against the earthquake.

Market versus Non-Market Insurance

These tests of the complete consumption insurance hypothesis can examine the validity of a wide variety of formal and informal insurance mechanisms such as borrowing and receiving private and/or public transfers *as a whole* [Mace (1991)]. Yet, it is not easy to disaggregate the effectiveness of formal and informal insurance mechanisms. In fact, there is very little research on formal insurance consumption [Outreville (1990); Galabova and Lester (2001); and Enz (2000)]. In order to capture the relative importance of market (formal) and non-market (informal) mechanisms, we can utilize cross-country data on life and non-life insurance penetration, the *Sigma* database, complied by Swiss Re. This data set is supposed to capture formal insurance traded in markets.

According to Figure 5, there is a positive relationship between volume of life and non-life premiums per capita and GDP per capita. Moreover, it is evident that the fitted slope will be larger than unity. This suggests that formal insurance appears to be a luxury especially in low and middle-income countries and that people's preferences are characterized by increasing risk aversion. Yet, provided that the poor should have higher potential demand for insurance because their marginal utility loss from a downside risk is higher than the rich, more informal insurance devices should be demanded in developing countries. For example, community-based burial societies without legal status can be found all over the world against mortality risks [Morduch (2004)]. Moreover, Galabova and Lester (2001) found that micro-data from several countries support the notion of insurance as a necessary item. The macro-micro paradox in demand for insurance, especially whether luxury formal insurance arises from demand or supply side, should be examined carefully in future studies [Nakata and Sawada (2006)].

Idiosyncratic versus Aggregate Shocks

Having discussed the role of mutual insurance to diversify idiosyncratic risks, we should note that full insurance schemes against aggregate shocks such as region-wide weather shocks, droughts, and natural or manmade disasters cannot be constructed within a village because these sources of risk are village, region, or even nation specific. Yet, even across a village or region, households can build informal insurance networks that are not necessarily complete. For example, Lucas and Stark (1985)'s evidence from Botswana shows that remittances from urban family members are particularly large when the drought is severe, which implies that there is a concern for preserving assets; households buy insurance by placing members in markets whose outcomes are not highly positively correlated. By analyzing Indian data, Rosenzweig and Stark (1989) found that marriage cum migration contributes significantly to a reduction in the variability of household food consumption and that farm households afflicted with more variable profits tend to engage in longer distance marriage cum migration; the marriage of daughters aims at mitigating income risks and facilitating consumption smoothing.

Yet, a formal analysis of the validity of inter-village full risk sharing using IFPRI's rural Pakistan data over three years reveals that district or nation-wide full risk sharing hypotheses are rejected strongly [Kurosaki and Sawada (1999)]. Their result suggests that a larger scale formal or informal insurance network is far from complete. As we can see from Table 11, natural disasters and manmade disasters are characterized by correlated nature of their shocks, affecting many people at the same time. This implies that it may be difficult for existing social safety networks to insure people from natural or manmade disasters effectively.

Index Insurance

As an effective insurance instrument against covariate shocks, index insurance contracts have been attracting wide attention [Hazell (2003); Morduch (2004); Lilleor, Gine, Townsend, Vickery (2005); Skees, Varangis, Larson and Siegel (2006)]. Index insurance contracts are written against specific events such as drought or flood defined and recorded at a regional level. As such, index insurance involves a number of positive aspects; they can cover the aggregate events; they are affordable and accessible even to the poor; they are easy to implement and privately managed; and they are free from moral hazard, adverse selection, and high transaction costs that have plagued traditional agricultural insurance contracts such as crop insurance schemes. The World Bank and other institutions have been piloting weather-based index insurance contracts in Morocco, Mongolia, Peru, Vietnam, Ethiopia, Guatemala, India, Mexico, Nicaragua, Romania, and Tunisia.

Since natural disasters are typically an aggregate event, index insurance is thought to be an appropriate instrument to combat them. Yet, there are three major constraints to design index type insurance against natural disasters. First, natural disasters are often characterized by a rare event which makes it difficult to design actuarially fair insurance. Since obtaining historical data on natural disasters pattern is hard, it is almost impossible to set appropriate premiums for insurance [Morduch (2004)].

Secondly, related to the first issue, even if appropriate premiums are set, the poor who potentially should demand insurance against natural disasters may find it difficult to recognize the value of index type insurance against natural disasters. This may be an inevitable consequence because natural disasters are often characterized by unforeseen contingencies by nature and because the poor often are often myopic with high time discount rates [Pender (1996)]. Moreover, the existence of the "basis risk" with which an individual could incur damage but cannot be compensated enough, will also deter demand for index insurance. This problem has been identified as an inevitable drawback of index insurance because index contracts essentially tradeoff basis risk for transaction costs [Morduch (2004); Hazell (2003)].

Finally, since natural disasters are highly covariate risks which often cannot be diversified within a country. Accordingly, the insurers have a potential need to secure their financial position by utilizing international reinsurance markets. However, it is known that reinsurance markets and trades of catastrophe (CAT) bonds are still thin with limited capacity. Also, as an overall effectiveness of mutual insurance across national borders, recent studies show that the extent of international risk-sharing remains surprisingly small [Obstfed and Rogoff (2001); Lewis (1996)].[7] However, using data on hurricane exposure, Yang (2006) found that

[7] Another approach to secure insurers is that the government provide reinsurances. This means that the aggregate shocks are diversified intertemporally, rather than spatially. An example of this kind of reinsurance policy is the Japanese earthquake insurance in which the government provides a reinsurance scheme.

the poor's hurricane exposure leads to substantial increase in migrants' remittances, so that total financial inflows from all sources in the three years following hurricane exposure amount to roughly three-fourths of estimated damages. This suggests that aggregated shock arising from natural disasters can be insured at least partially depending on the income level and the situation.

3.2 Self-Insurance

As we have seen, efficient risk sharing are likely to be absent especially for natural disasters as a rare, covariate event. However, even for such risks, households are able to insure themselves against unexpected shocks by using self-insurance measures. For example, Shoji (2006) examines the effective coping strategy against the huge historical flood in Bangladesh in 1998, finding that under severe aggregate shocks, a group of people surrendered livestock assets even when quasi-credit was available only for idiosyncratic shocks.

Following Zeldes (1989) and Ljungqvist and Sargent (2000, Chapter 13), we derive a self-insurance model by assuming a household chooses a path to maximize the conditional expectation of discounted lifetime utility subject to a non-negativity constraint for assets and usual intertemporal budget constraints. As a solution to this household problem, we obtain an augmented consumption Euler equation with the possibility of a liquidity constraint [Zeldes (1989)]:

$$u'(c_{it}) = E_t\left[u'(c_{it+1})\left(\frac{1+r}{1+d}\right)\right] + m_{it}, \qquad (6)$$

where $u\ (c_{it})$ is a utility function of the i-th household's consumption, c, at time t, r is an exogenous interest rate, and d is a household's subjective discount factor. The variable m

represents the Lagrange multiplier associated with liquidity constraints, indicating negative welfare effects generated by binding liquidity constraints.[8] Note that the self-insurance model represented by equation (6) involves weaker restrictions than the full risk sharing model [Saito (1999), p. 53]. From the intertemporal budget constraints, we obtain: $y_t^{PRT} + y_t^{PUT} + y_t^{N} - n_t = s_t + c_t$, where y_t^{PRT}, y_t^{PUT}, y_t^{N}, n_t, and s_t are private transfer income, public transfer income, non-transfer income, a negative shock to assets, and net savings, respectively. Combining this intertemporal budget constraint and Equation (6), if the utility function is supposed to take the form of a constant absolute risk aversion (CARA) function, then we have the following optimal self-insurance equation [Flavin (1999); Kochar (2003); Sawada and Shimizutani (2005)]:

$$\Delta b_{it} + \Delta y_{it}^{PRT} + \Delta y_{it}^{PUT} + \Delta d_{it} = -\Delta y_{it}^{N} + \Delta n_{it} + \frac{1}{a}\left[\ln\left(\frac{1+r}{1+d}\right)\right] - m'_{it-1} + h_{it}, \qquad (7)$$

where b and d are borrowings and dissavings, respectively. The last two terms on the right-hand side represent the effects of liquidity constraints and mean zero independent expectation error. Equation (7) formally shows that there are four possible risk coping strategies, namely, borrowing additional amounts, receiving additional private transfer income, receiving additional public transfer income, and increased dissaving, against realized negative shocks, whose absolute values are represented by $-? y^N_t + ?\, n_t$. Equation (7) indicates that when a household is under a borrowing constraint, i.e., when µ is positive, the sum of the left-hand variables become smaller, suggesting that the sensitivity of different coping strategies against the same shock is weakened. In this case, the household is forced to reduce its consumption level.

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[8] Since the household is constrained from further borrowing but not from further saving, m has a positive sign.

By analyzing a 1998 survey of areas affected by Hurricane Mitch, Morduch (2004) found that for 21% of households, the main response to the hurricane was not to use savings, nor to borrow money; the main response was a drastic reduction in consumption. This suggests that these households are constrained from borrowing against the shocks. By investigating how victims of the Great Hanshin-Awaji (Kobe) earthquake in 1995 coped with their unexpected losses, Sawada and Shimizutani (2005) found that households without borrowing constraints can borrow and/or dissave to respond to damages caused by the earthquake, while those under a constraint are unable to either borrow or dissave against the losses. However, private transfers are used for both types of households, depending on the magnitude of the damages.

These findings suggest that credit market accessibility seriously affects the effectiveness of self-insurance possibilities. As we have seen in Table 6, facing lower accessibility of credit market due to the credit crunch during the financial crisis, Korean households did not liquidate assets significantly. The effectiveness of risk coping strategies against natural and manmade disasters was weakened by increased seriousness of credit constraints.

3. Policy Implications and Concluding Remarks

Our selective evidence confirms a serious lack of insurance markets for damages arising from natural and manmade disasters. Without effective ex ante measures, the actual economic losses caused by a disaster can be enormous. For example, the Great Hanshin-Awaji (Kobe) earthquake proved to be extremely large for the government to support effectively. In fact, 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 economic recovery of the victims. Despite the extensive support provided by the government, direct transfers to victims who lost their houses were merely USD 1,000-1,500 per household.

In the process of preparing well-designed social safety nets against future natural disasters, there are three policy implications based on our analyses. Firstly, 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 required [Horwich (2000)]. Theoretically, index type insurance should be free from moral hazard problems, but as we have discussed, such an insurance contract would be difficult to design and sell in the case of rare, unexpected events. Since our empirical results from the Korean financial crisis, the Hanshin-Awaji and Chuetsu earthquakes, and the Tsunami in India indicate that credit played an important role as a coping device and often the poor are excluded from credit transactions, providing subsidized loans, rather than direct transfers, to victims can be a good example of facilitating ex post risk-coping behavior; such interventions are less likely to create serious moral hazard problems.

Secondly, having discussed the difficulty of designing index insurance, it would be imperative to design ex ante risk-management policies against the disasters if at all possible. For example, development of markets for earthquake insurance would lead to the efficient pricing of insurance premiums and efficient land market prices reflective of the level of risk [Saito (2002)]. This development would generate proper incentives to invest in mitigations such as investments in earthquake-proof constructions against future earthquakes. These ex ante measures would significantly reduce the overall social loss caused by the earthquake.

Issues such as these will be important research topics in the future.

Third, under the first "emergency rescue" phase of the recovery actions against a disaster, matching of emergency demands and massive proliferations of aid supply under imperfect information and uncertainties will be a major problem which should be solved properly. This phase is plagued by standard failures of traditional targeting programs. The first problem can be called a problem of *"targeting failure"* in which wrong people are targeted (inclusion error) or right targets are excluded (exclusion error).

Finally and more importantly, even if the government can identify the proper target group without problems, the stakeholders of public aid or subsidies might act inappropriately ex post. Considering the lack of income information and the moral hazard problems of the means-test targeting, benefit eligibility in developing countries tends to be conditioned on personal or household characteristics or Akerlof's (1975) "*tags*" that are thought to be manipulation-free [Conning and Kavene (2002)]. Tags may be based on employment status, age, gender, number of dependents, location, and ethnicity. In the case of disaster relief, damage status can be used to tag households. Yet, tagging may not be entirely free from moral hazard problems. Even under "tagged" targeting interventions, which are thought to be better than the means-test targeting, there are perverse incentives for people to change their characteristics in order to gain eligibility.

In the tsunami affected areas of India, a new phenomenon of "tsunami marriages" emerged from the government's well-intended policy. After the tsunami, the government announced its financial assistance policy to the survivors, who had planned their marriages before the tsunami. This policy induced a spate of "unplanned" marriages. Moreover, promises of providing a permanent home to newlyweds also induced unnecessary or even harmful marriages. According to our data, attendance to wedding ceremonies per family in October 2005 has almost doubled from 1.11 times per month in November 2004 to 2.05 times per month in November 2005. There is also evidence that these marriages involve very young women. Moreover, this perverse moral hazard problem may even perpetuate a vicious cycle of dependency on the government's financial aid.

Tsunami marriages are an example of the difficulties of public or non-public interventions for victims of disasters. As a future task, researchers should investigate the effectiveness and efficiency of matching supply and demand of emergency aid by gathering and analyzing data from areas after disasters. As a potential scheme, researchers can explore how the government can make use of the role of community to design community-based aid allocation schemes through which imperfect information and pervasive incentive problems of the traditional programs are effectively mitigated [Bardhan (2002)].

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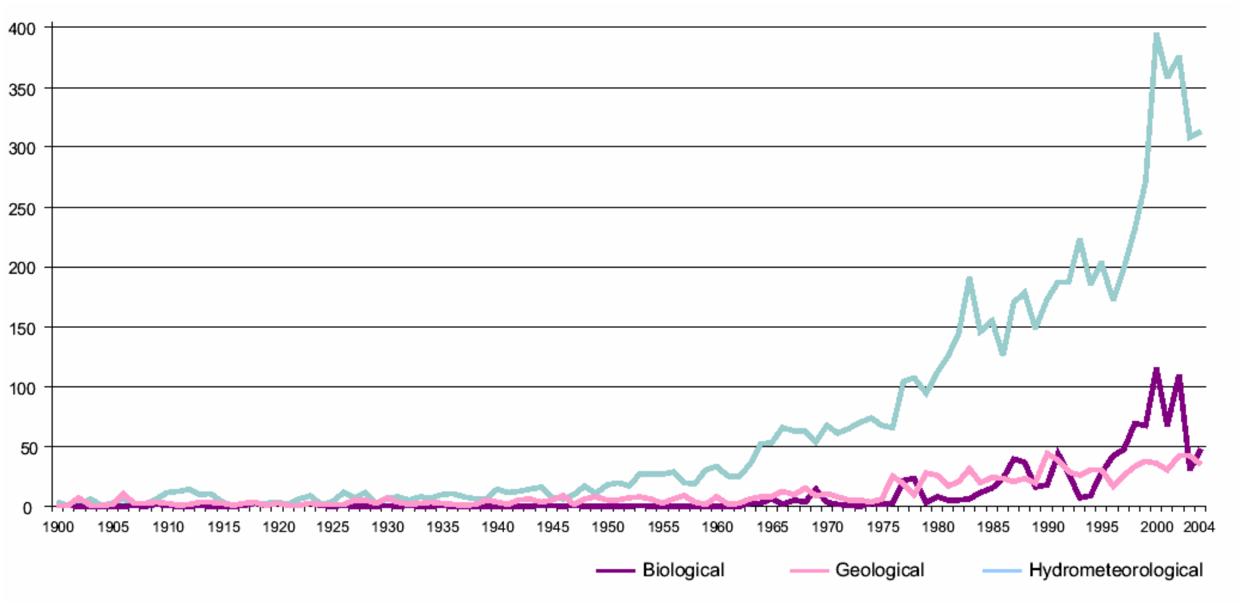
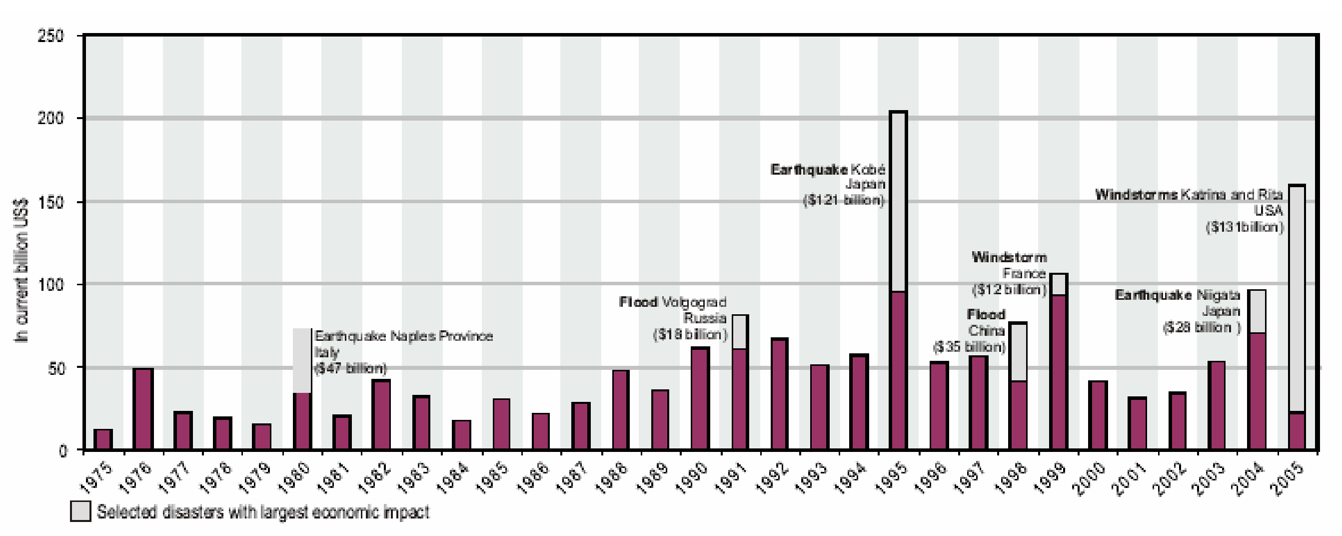
Figure 1
Number of Natural Disasters, 1900-2004



Source: Disaster statistics, Occurrence: trends-century <http://www.unisdr.org/disaster-statistics/occurrence-trends-century.htm>, EM-DAT : The OFDA/CRED International Disaster Database. <http://www.em-dat.net> UCL - Brussels, Belgium

Figure 2
Annual reported economic damages from natural disasters: 1975-2005



Source: 2005 Disasters in numbers, International Strategy for Disaster Reduction, United Nations

Figure 3

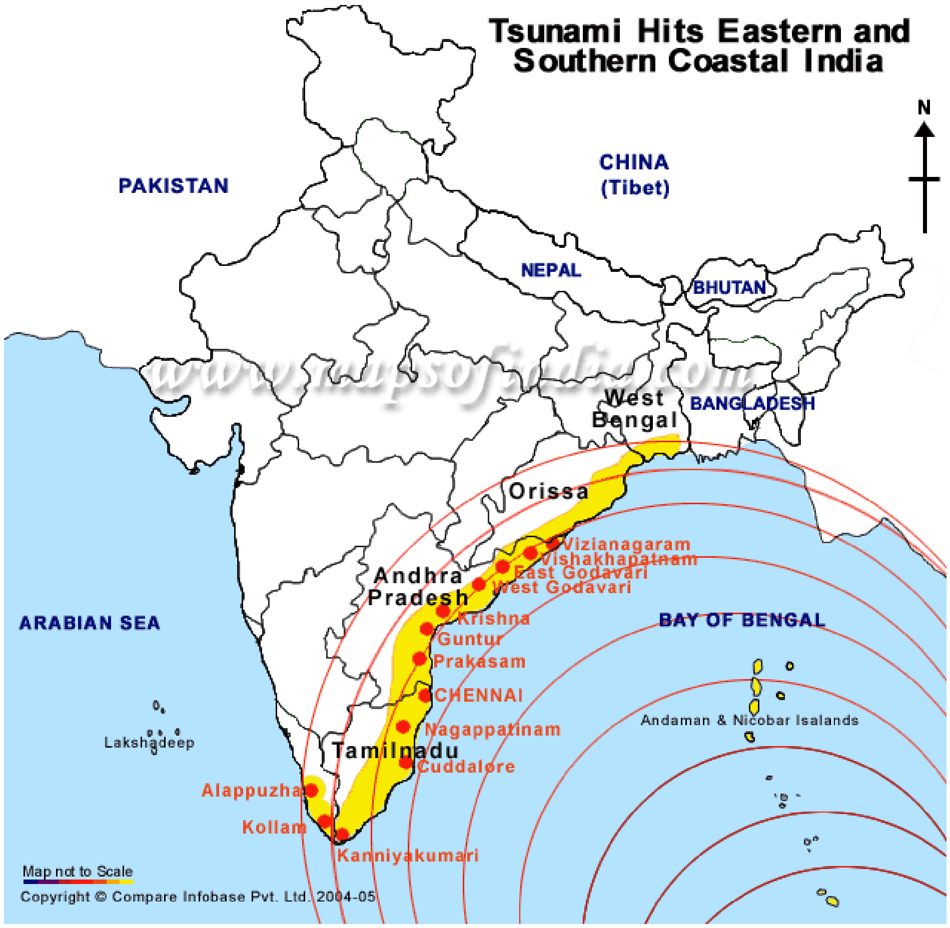


Figure 4
The Full Insurance Model

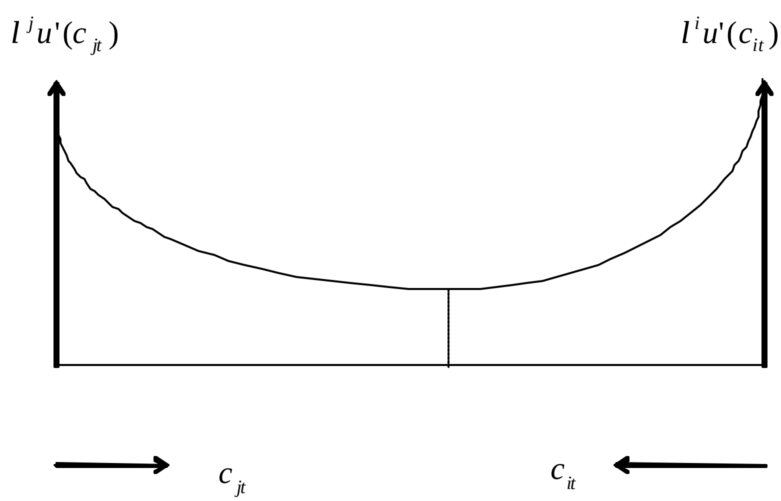
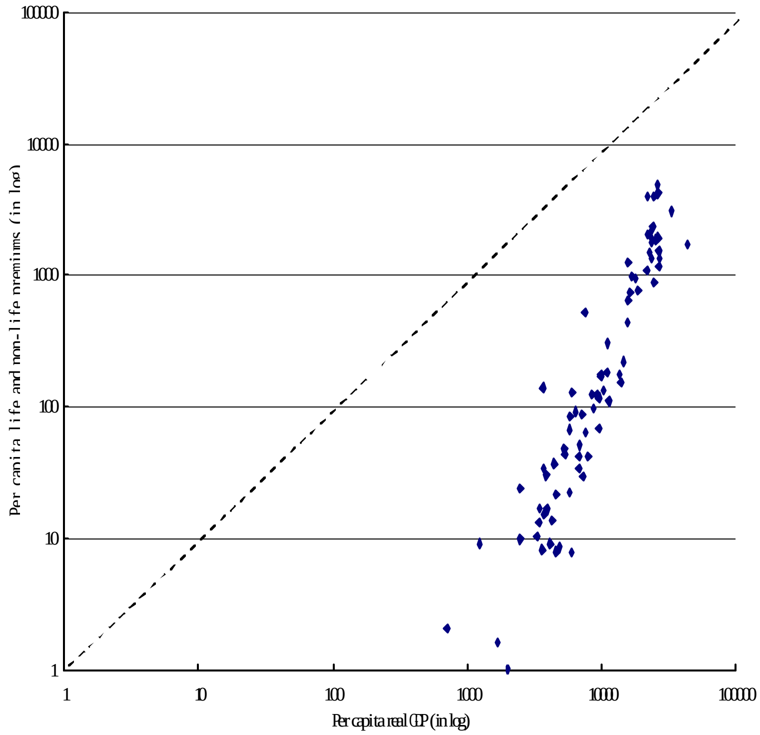


Figure 5
Cross-Country Income Elasticity for Life and Non-life Formal Insurance Demand In 2000



Source: Penn World Tables Version 6.1, and Sigma, Swiss Re.

Table 1
Number of Natural Disasters by Type of Triggering Hazards:
Regional Distribution 1995-2004

	Hydrometerorological disasters						Geological disasters		Biological disasters	
Region	Floods	Wind Storms	Droughts and related Disasters	Landslides	Avalanches	Waves and Surges	Earthquakes and Tsunamis	Volcanic Eruptions	Epidemics	Insect Infestations
Africa	277	70	123	11	0	0	18	4	346	14
America	269	298	205	43	1	1	51	23	48	2
Asia	444	326	229	97	16	6	193	13	154	3
Europe	180	86	156	7	10	0	28	2	37	1
Oceania	35	68	37	8	0	0	9	6	10	3
World	1205	848	750	166	27	7	299	48	595	23

Source: EM-DAT: The OFDA/CRED International Disaster Database. <http://www.em-dat.net> UCL - Brussels, Belgium

Table 2
Frequency of Economic Crises Over Time

	1970-79		1980-1995	
Type of crisis	Total	Average per year	Total	Average per year
Balance-of-payments	26	2.6	50	3.13
Twin	1	0.10	18	1.13
Single	25	2.50	32	2.00
Banking	3	0.30	23	1.44

Source: Table 1 of Kaminsky and Reinhart (1999)

Table 3 Direct Damages from Natural Disasters

Event (Year)	Damages (USD billion)	Loss as percentage of GDP
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 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]
Earthquakes in Turkey (1999)	22[i]	5[i]
Floods in China (1998)	30[i]	0.7[i]
Hurricane Mitch in Ecuador (1998)	2.9[i]	14.6i
Hurricane Mitch in Honduras (1998)	3[i]	20[i]
Hurricane Mitch in Nicaragua (1998)	1[i]	8.6[i]
Hurricane Mitch in the United States (1998)	1.96[i]	0.03[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] (in 2003 price)	43.6[g]

a: "Program-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 Program-Preliminary Damage and Needs Assessment"; e: the authors' calculation based on World Bank's World Development Indicators; f: Niigata Prefecture, Japan; g: the authors' estimates using information from the Cabinet Office and the Ministry of Finance of the Government of Japan; h: the authors' calculation based on the information from Risk Management Solutions (RMS); i: Table 1 in Freeman, Keen, and Mani (2003); j: United Nations International Strategy for Disaster Reduction.

Table 4
Quantifying the Seriousness of Risks

	Coefficient of Relative Risk Aversion	Coefficient of Variation	Estimated *m* as a percentage of income (%)
Pakistan	1.12-3.34[1)]	42.1-54.3[2)]	9.93-49.24
India	1.39[2)], 1.77-3.10[3)]	47.0[4)]	15.35-34.24

1) Table 5-3, 5-4, and 6-3 of Kurosaki (1998); 2) Morduch (1990); 3) Fafchamps (2003), p.184; 4) Table 10.6 of Walker and Ryan (1990)

Table 5
Changes in per capital consumption in Indonesia
(unit: 1000Rupiah, per month value at Dec 1997 price)

	1997 (Rp)	1998 (Rp)	Change rate (%)
Urban households			
Per capita consumption	319	184	-42
Staple	41.4	37.9	-8
Meat	40.5	19.1	-53
Medical	5.5	2.7	-50
Education	15.7	8.3	-47
Leisure	8.2	3.8	-54
Rural households			
Per capita consumption	194	128	-34
Staple	59.3	50.4	-15
Meat	24.2	12.5	-48
Medical	2.3	0.9	-61
Education	4.6	2.3	-50
Leisure	3.6	2.2	-39

Source: Frankenberg, Thomas, and Beegle (1999)

Table 6
Changes in per capital consumption in Korea
(unit: 10,000 Won, per year value at 1995 price)

	Aug 1996 – July 97	Aug 1997 – July 98	Change rate (%)
	mean (std. error)	mean (std. error)	
Consumption expenditure			
Food expenditure	351.54 (216.26)	297.99 (177.63)	-15.2
Education & medical expenditure	304.17 (371.30)	242.21 (336.21)	-20.4
Expenditures for luxuries (cultural activities, entertainment, dining out, and durable goods)	147.25 (333.75)	53.98 (86.36)	-63.3
Income, Asses, and Debts			
Wage income or earnings from work	2064.81 (1734.66)	1523.41 (1264.16)	-26.2
Private transfers received	51.38 (214.14)	54.90 (209.45)	6.9
Public transfers received	19.18 (116.35)	20.99 (134.08)	9.4
Sales of assets (land, real estate, securities, and withdrawal of time deposits)	195.01 (1305.44)	203.62 (1089.94)	4.4
Total assets (savings account, shares, bonds, insurance, loan clubs, current value of house)	7681.19 (9403.04)	7533.37 (11895.05)	-1.9
Outstanding debt (formal banks, informal banks, and personal)	842.02 (2177.78)	1074.34 (5252.27)	27.6

Source: Kang and Sawada (2003)

Table 7
Damages and Coping-Strategies under the Great Hanshin-Awaji (Kobe) Earthquake

Variable Description	Mean
Coping Variables	
Dummy = 1 if reallocations of the constituents of the consumption were the most significant means of coping	0.250
Dummy = 1 if dissaving was the most significant means of coping	0.537
Dummy = 1 if borrowing was the most significant means of coping	0.096
Dummy = 1 if receiving transfers was the most significant means of coping	0.117
Shock Variables	
Dummy = 1 if major housing damage was caused by the earthquake	0.174
Dummy = 1 if moderate housing damage was caused by the earthquake	0.251
Dummy = 1 if minor housing damage was caused by the earthquake	0.431
Dummy = 1 if major household asset damage was caused by the earthquake	0.094
Dummy = 1 if minor household asset damage was caused by the earthquake	0.773
Dummy = 1 if the family suffered health-related shocks caused by the earthquake	0.213

Source: Sawada and Shimizutani (2005)

Table 8
Damages caused by Tsunami in India

Location	AP	Kerala	Pondicherry	TN	Total
Districts Affected*	7	7	2	13	29
Villages Affected*	301	187	33	376	935
Dead*	106	170	428	7921	10380
Injured*	N.K.	1616	N.K.	3324	5602
Missing*	7	2	81	N.K.	12098
Displaced*	N.K.	157417	30000	433048	631994
Damage to Fishery Assets**	51.8	50.8	94.7	801.3	998.6
Fishery Income Loss**	88.6	117.8	107.3	2105.3	2469.8
Damage to Agriculture and Livestock Asset**	1.99	19.59	3.70	40.53	65.81
Agriculture and Livestock Income Loss**	1.80	8.70	4.59	82.27	97.36
Damaged Houses***	481	13,042	10,061	130,000	153,585

* As of 5 Jan, UNICEF "Tsunami Relief Operation: Tamil Nadu" (Internal Information)
** In crore Rs., Asian Development Bank, United Nations, and World Bank (2005) "India Post Tsunami Recovery Program Preliminary Damage and Needs Assessment"
*** Asian Development Bank, United Nations, and World Bank (2005) "India Post Tsunami Recovery Program Preliminary Damage and Needs Assessment"

Table 9
Damages caused by Tsunami in Tamil Nadu State by District

District affected	Population affected	Houses damaged	# Human live lost	# Injured
Chennai	73000	17805	206	55
Cuddalore	99704	15200	617	198
Kancheepuram	100000	7043	129	14
Kanyakumari	187650	31175	828	727
Nagapattinum	**196184**	**39941**	**6065**	**1922**
Pudukkottai	66350	1	15	0
Ramanathapuram	0	6	6	0
Thanjavur	29278	3	33	482
Thiruvallur	15600	4143	29	0
Thiruvarur	0	0	28	0
Tirunelveli	27948	630	4	4
Tuticorin	110610	735	3	0
Villupuram	78240	9500	47	30
Total	984564	126182	8010	3432

Source: Tamil Nadu Government HP <www.tn.gov.in/tsunami> as of Feb. 3, 2005

Table 10
Damages and Coping-Strategies under the Tsunami in India

Variable Description	Mean
Coping Variables during the relief phase (Dec 26, 2004-April 30, 2005)	
Dummy = 1 if sales of assets was the most important means of coping	0.088
Dummy = 1 if borrowing was the important means of coping	0.405
Dummy = 1 if receiving transfers was the important means of coping	0.905
Shock Variables	
Dummy = 1 if lost house	0.04
Dummy = 1 if house seriously damaged	0.16
Dummy = 1 if lost utensils	0.15
Dummy = 1 if lost productive assets such as boats	0.785
Dummy = 1 if lost job	0.24
Dummy = 1 if income declined	0.603
Dummy = 1 if lost members	0.053
Dummy = 1 if members got injured or sick	0.013

Source: Sawada (2006)

Table 11
A Typology of Risks

Type of risk	Idiosyncratic: Risks affecting an individual or household (micro)	Covariant: Risks affecting groups of households or communities (meso)	Covariant: Risks affecting regions or nations (macro)
Natural		Rainfall Landslide Volcanic eruption	Earthquake Flood Drought High winds
Health	Illness Injury Disability Old age Death	Epidemic	
Social	Crime Domestic violence	Terrorism Gang activity	Civil strife War Social upheaval
Economic		Unemployment Resettlement Harvest failure	Changes in food prices Growth collapse Hyperinflation Balance of payments, financial, or currency crisis Technology shock Terms of trade shock Transition costs of economic reforms
Political		Riots	Political default on social programs Coup d'état
Environmental		Pollution Deforestation Nuclear disaster	

Source: Adapted from Sinha and Lipton (1999) and World Bank (2000q).

Source: Table 8.1., World Bank (2001), World Development Report 2000/2001, Attacking Poverty, World Bank.