CHAPTER 13

On the Effectiveness of Overall Insurance Mechanisms against Disasters in East and Southeast Asia

Yasuyuki Sawada

Faculty of Economics, University of Tokyo

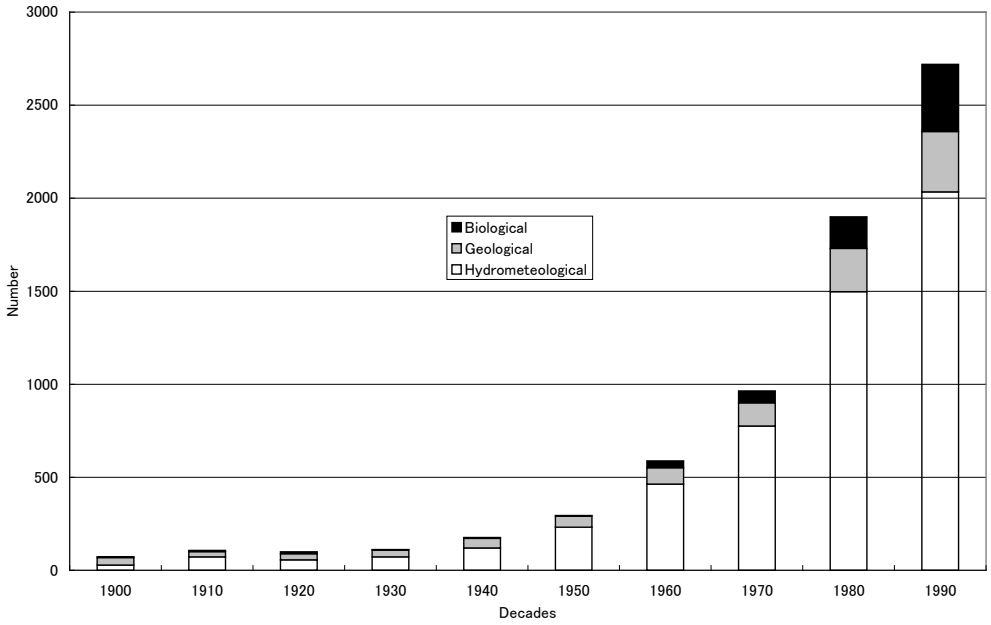
1. Introduction

Regardless of whether they live in developed and developing countries, people face a wide variety of risks in daily life. These risks can come from health-, weather-, contract-, or policy-related shocks. 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, especially for poor, small-scale farmers. Even households in urban areas and industrial or commercial sectors experience fluctuating income over time due to price, demand, and contractual shocks in business transactions. Macroeconomic instability, credit crunches, and recessions tend to generate harsh inflation/deflation and widespread unemployment, which negatively affect livelihoods.

By far the most serious consequences come from natural disasters of the hydro-meteorological, geophysical, and biological kind (Sawada, Bhattacharyay, and Kotera 2011). We remember vividly the natural disasters that hit the Asian region and took a huge toll on lives: the Great East Japan earthquake, the flood in Pakistan; Typhoon Fengshen (Frank) of the Philippines in 2008; the Indian Ocean tsunami in 2004; and the earthquakes in Sichuan, northern Pakistan, and Kobe, Japan. A disaster is defined as an unforeseen, large, negative event that overwhelms local capacity. Disasters are generally classified into four types. The first type is natural disasters, which may be hydrological (e.g., floods), meteorological (e.g., storms or typhoons), climatological (e.g., droughts), geophysical (e.g., earthquakes, tsunamis, volcanic eruptions) or biological (e.g., epidemics and insect infestations) in nature. The second type is technological disasters, such as industrial accidents (e.g., chemical spills, collapse of industrial infrastructure) and transport accidents (e.g., accidents involving air, rail, road, or water transportation). The remaining two types are economic crises (e.g., hyperinflation, banking crises, currency crises) and violence (e.g., terrorism, civil strife, riots, war).

Figure 1 shows the number of natural disasters registered in the Emergency Events Database (EM-DAT) covering the period 1900—2004. EM-DAT is the international disaster database maintained by the Office of U.S. Foreign Disaster Assistance and Centre for Research on the Epidemiology of Disasters (OFDA/CRED). From the figure, we can see the obvious increase in the number of natural disasters, especially hydro-meteorological disasters (Sawada 2007). A regional disaggregation shows that Asia, in particular, has suffered an uptick in natural disasters compared to other regions in the world. A closer look at the data for 1995—2004 by type of triggering hazards reveals that floods are the most common natural disasters followed by droughts (and related disasters), epidemics, and earthquakes and tsunamis (table 1). Table 1 also reveals that epidemics are a serious problem in Africa while Asia was hit by a large number of earthquakes and tsunamis.

Figure 1. Number of natural disasters, 1900—1990



***Source*:** EM-DAT at www.em-dat.be , Université Catholique de Louvain (UCL), Brussels, Belgium.

Table 1. Number of Natural Disasters by Type of Triggering Hazards, Regional Distribution, 1995—2004

	Hydrometeorological 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

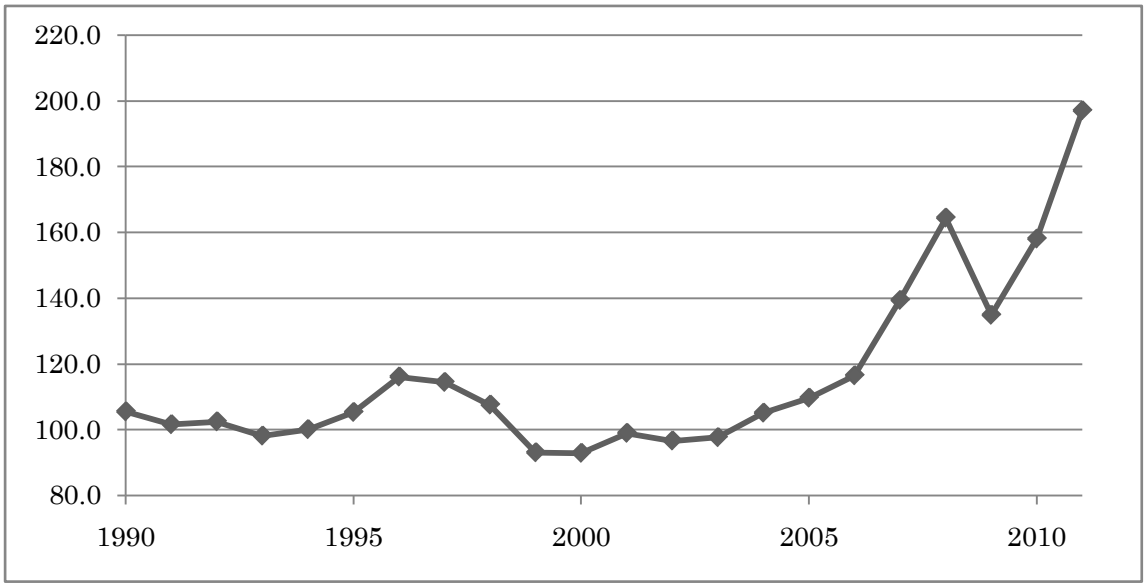
***Source*:** EM-DAT at www.em-dat.be, Université Catholique de Louvain (UCL), Brussels, Belgium.

Economic disasters such currency crises, financial crises, and credit crunches can also inflict serious negative impacts on people's livelihoods. While its impact in the Asian region was smaller than initially expected, the ongoing global financial crisis still caused serious economic problems in Asia. Indeed, the number of complex economic

crises seems to be increasing over the years. A seminal work by Kaminsky and Reinhart (1999) reveals that the number of currency crises per year did not increase much during the 1980s and 1990s while the number of banking crises and simultaneous banking and currency crises (i.e., twin crises) increased sharply in the 1980s and 1990s.

Inflation is another type of economic disaster. There were repeated spikes in the price of food on the global market in 1997—98, 2007—08, and 2010 (figure 2). Since price stability is the key to food and livelihood security, especially for the poor, instabilities in the global food price (which also usually involve social and political instabilities) directly affect the choice of trade regime of developing countries. In any case, it should be noted that economic crises also cause loss of human lives—many people in Japan and Korea committed suicide when financial crises hit these countries (Chenet al. 2009).

Figure 2. Annual real food price indices (2002—2004 = 100)



Source: Food and Agriculture Organization (FAO) at www.fao.org/worldfoodsituation/FoodPricesIndex/en/

By nature, it would be difficult for private credit and/or insurance markets to cover extreme contingencies arising from natural and economic disasters.[1] Hence, *ex post* informal insurance mechanisms through family and community networks as well as self-insurance mechanisms should play an important role in handling shocks from disasters. In this paper, we will investigate the overall effectiveness of formal and informal insurance mechanisms against natural and economic disasters in East and Southeast Asian countries. By doing so, we will also explore possible regional cooperation in disaster management. To this aim, we will employ the test framework of international consumption risk sharing, which will enable us to investigate the overall effectiveness of mutual insurance across national borders. While existing papers show that the extent of international risk-sharing remains small (Obstfed and Rogoff 2001; Lewis 1996), some studies show that aggregated shock arising from natural disasters can be insured, at least partially, through international financial flows (Yang 2008).

The rest of this paper is organized as follows. Section 2 presents the theoretical and econometric frameworks addressing two main questions:

- Are market and nonmarket (i.e., formal and informal) insurance mechanisms effective in diversifying disaster risks across Asian economies?
- If overall insurance mechanisms are not effective, which risk affects welfare significantly?

Section 4 shows data and empirical results followed by the final concluding section.

2. Theoretical and Econometric Framework

In the last fifteen years, there has been remarkable progress in formulating and testing full consumption risk sharing (Mace 1991; Cochrane 1991; Townsend 1994; Hayashi, Altonji, and Kotlikoff 1996; Ligon 1998; Ogaki and Zhang 2004; Dubois et al. 2008;

[1]According to the Go Risk Research of NatCatSERVICE of Munich RE, it is apparent that global formal insurance against natural disasters is very limited.

Kinnan 2010). The canonical model of consumption risk sharing shows that under complete markets, idiosyncratic 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. We will employ this testable implication to evaluate the overall effectiveness of the insurance network in East Asian countries. More concretely, we will regress per capita consumption growth rates (or changes) in per capita growth rates (or changes) in gross domestic product (GDP) as their idiosyncratic shock variables to test the full consumption risk-sharing hypothesis.

The test of full consumption risk sharing can be interpreted as a test of overall insurance mechanisms, which consist of formal market mechanisms, informal or nonmarket mechanisms, and self-insurance mechanisms. The first market mechanism includes credit markets to reallocate future resources to today's consumption, formal insurance market transactions involving *ex ante* insurance contracts, and *ex post* labor market participation to use returns to human capital. The second mechanism (i.e., informal or nonmarket mechanisms) includes public and private transfers. The third and final mechanism (i.e., self-insurance mechanisms) is meant to reduce consumption expenditure by maintaining total calorie intakes or to use accumulated financial and physical assets (i.e., precautionary saving).

To investigate the implications of complete consumption risk sharing (or insurance), we will solve a benevolent social planner's problem by maximizing the weighted sum of people's lifetime utilities given social resource constraints (Mace 1991; Cochrane 1991; Townsend 2004).[2] In addition, we will follow the approach of Lewis (1996) who incorporated consumption of nontradables to test the international consumption risk-sharing hypothesis.

[2]Strictly speaking, in order to derive tractable and testable implications, we need to impose additional assumptions. The first assumption is that all market participants can perfectly observe uncertainty realizations. In other words, there is no private information and thus the information structure is symmetric. The second assumption is that the contingent securities span the state space and markets are thus complete. The third assumption is that the probability distribution of state realization, $\pi^{i}(s^{t})$, is identical across agents (i.e., agents have identical beliefs about the future). The fourth assumption is that agents have identical utility functions with identical time discount rates.

Suppose an East Asian regional economy is composed of N infinitely lived country members or representative agents from N countries, each facing serially independent income draws. In this pure exchange economy, there is no possibility of lending, borrowing, and storing. Hence, the self-insurance possibility is ruled out. Thus, we can set up a social planner's problem of deriving conditions for full consumption risk sharing with nontradables (Lewis1996):

$$\max_{\{c^T, c^N\}} \sum_{j=1}^{N} \lambda^j \left\{ \sum_{t=1}^{\infty} \sum_{s^t} \left(\frac{1}{1+\delta^j} \right)^t \pi(s^t) u\left[c_{jt}^T(s^t), c_{jt}^N(s^t) \right] \right\}$$

$$s.t. \sum_{j=1}^{N} c_{jt}^T(s^t) \leq \sum_{j=1}^{N} y_{jt}^T(s^t), \forall s^t, \quad (1)$$

$$c_{jt}^N(s^t) \leq y_{jt}^N(s^t), \forall s^t,$$

where δ is an agent's subjective discount rate, π denotes the probability of realizing state of nature s, c^T is tradable consumption, c^N is the amount of consumed nontradables, y^T represents consumable and transferable initial endowment of each agent, and y^N represents nontransferable initial endowment of each agent (i.e., nontradables). As is well known, a full insurance contract or social planner solves the above maximization problem for some Pareto-Negishi weight λ.

Following Backus and Smith (1993), the first-order conditions of the above problem under an isoelastic utility function gives the following testable equation:

$$\gamma \Delta \log (c_i/c_j) = \Delta \log (e_{ij}), \quad (2)$$

where c is a composite consumption and e_{ij} is the real exchange rate of country i against country j. This equality holds across all N countries at any point in time. The

intuition behind this first-order equation is that the real marginal utilities of country *i* against country *j* are equalized.

By summing across these *N* equalities of equation (2), we have the following testable equation:

$$\Delta \log c_i = a_1 \underbrace{\frac{1}{N}\sum_{j=1}^{N} \Delta \log c_j}_{\text{region level average}} + a_2 \underbrace{\frac{1}{N}\sum_{j=1}^{N} \Delta \log e_{ij}}_{real\_exchange\_rate} + \zeta \Delta \log y_i + u_i, \quad (3)$$

where u_{it} is a well-behaved error term. Note that in equation (3), income shock variables are added and the full consumption risk-sharing hypothesis implies that ζ=0.

However, per capita GDP is not necessarily exogenous, resulting in possible estimation biases arising from endogeneity when we estimate equation (3). As an unexpected, exogenous event, a natural disaster provides an unusual and clean experimental situation under which we can test whether agents are able to insure because a disaster cannot be affected by agents. Hence, we use disaster variables as instrumental variables when we test the risk-sharing hypothesis.

Thus, an alternative specification is the one of reduced form equations in which income shocks are caused by natural and economic disasters. More specifically, we estimate the following equation:

$$\Delta \log c_i = b_1 \underbrace{\frac{1}{N}\sum_{j=1}^{N} \Delta \log c_j}_{\text{region level average}} + b_2 \underbrace{\frac{1}{N}\sum_{j=1}^{N} \Delta \log e_{ij}}_{real\_exchange\_rate} + S_i \gamma + \varepsilon_i, \quad (4)$$

where *S* is a vector of natural and economic disasters. In equation (4), full

consumption risk sharing can be tested using a joint test in which all the elements of γ equal zero.

In actual empirical implementation of equations (3) and (4), we follow Ravallion and Chaudhuri (1998) and replace regional average consumption and average real exchange rate in the first and second terms, respectively, on the right hand side by time dummies.

3. Data and Descriptive Statistics

For the empirical analysis, we focused primarily on two broad categories of disasters—natural disasters and economic disasters. The list of variables used, their definitions, and data sources are shown in table 2.

First, for the macroeconomic data of per capita consumption and GDP growth rates, we used data from the Penn World Table (PWT). In computing both growth rates, we took the differences of per capita variables in logarithms.

Second, the data on economic disasters pertain to economic crises, including currency, inflation, and banking crises. A currency crisis is defined as an annual depreciation rate against the US dollar of 15 percent or more. An inflation crisis is defined as an annual inflation rate above 20 percent. A banking crisis is composed of two types of events: (1) bank runs that lead to the closure, merging, or takeover by the public sector of one or more financial institutions and (2) if there are no bank runs, the closure, merging, takeover, or large-scale government assistance of an important financial institution (or group of institutions) that marks the start of a string of similar outcomes for other financial institutions' growth collapse, hyperinflation, financial crisis, or currency crisis. For data on economic disasters, we used data from the Carmen Reinhart Crisis database (Reinhart and Rogoff2010).

Third, our data on natural disasters come from the publicly available, CRED-maintained EM-DAT. The Belgium-based CRED classifies natural disasters based on the following

criteria: ten or more people were killed; 100 or more people were affected, injured, or rendered homeless; significant damage was incurred; and a declaration of a state of emergency and/or an appeal for international assistance was made.[3] We used five subgroups of natural disasters: (1) meteorological disasters (e.g., storms or typhoons); (2) hydrological disasters (e.g., floods); (3) climatological disasters (e.g., droughts); (4) geophysical disasters (e.g., earthquakes, tsunamis, and volcanic eruptions); (5) and biological disasters (e.g., epidemics and insect infestations). We then constructed dummy variables for each disaster. These variables take the value of one if there is at least one disaster and zero otherwise.

We used the dataset covering the period 1980 to 2007. Twelve countries were used for natural disasters (Cambodia, China, Indonesia, Japan, Korea, Laos, Malaysia, Mongolia, the Philippines, Taiwan, Thailand, and Viet Nam) and eight for economic disasters (China, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan, and Thailand).

Table 2. Definition and Sources of Variables

Variables	Definition	Source
Log (consumption growth rate)	Logarithm of per capita consumption rate	PWT
Log (per capita GDP growth rate)	Logarithm of percentage change in per capita GDP	PWT
Nominal exchange rate and PPP	Rate per U.S. dollar	PWT
Currency crises	Currency crises over the years defined as an annual depreciation rate against the US dollar of 15 percent or more	REINHART
Inflation crises	Annual inflation above 20 percent	REINHART
Banking crises	Banking crises over the years including two types of events: (1) bank runs that lead to the closure, merging, or takeover by the public sector of one or more financial institutions and (2) if there are no runs, the closure, merging, takeover, or large-scale government assistance of an important financial	REINHART

[3] http://www.emdat.be/

	institution (or group of institutions) that marks the start of a string of similar outcomes for other financial institutions	
Geophysical disasters	Total number of geophysical disasters, defined as events originating from solid-earth movement (earthquakes, volcanic eruptions, or mass movement)	EM-DAT
Meteorological disasters	Events caused by short-lived small-scale to mesoscale atmospheric processes in the spectrum, spanning minutes to days (e.g., storms)	EM-DAT
Hydrological disasters	Total number of hydrological disasters caused by deviations in the normal water cycle and/or overflow of bodies of water due to wind set-up (e.g., floods or wet mass movement)	EM-DAT
Climatic disasters	Total number of climatic disaster events caused by long-lived mesoscale to macroscale processes in the spectrum, spanning intraseasonal to multidecade climate variability (e.g., extreme temperatures, droughts, wildfires)	EM-DAT
Biological disasters	Total number of biological disaster events caused by the exposure of living organisms to germs and toxic substances (e.g., epidemics, insect infestations, animal stampedes)	EM-DAT

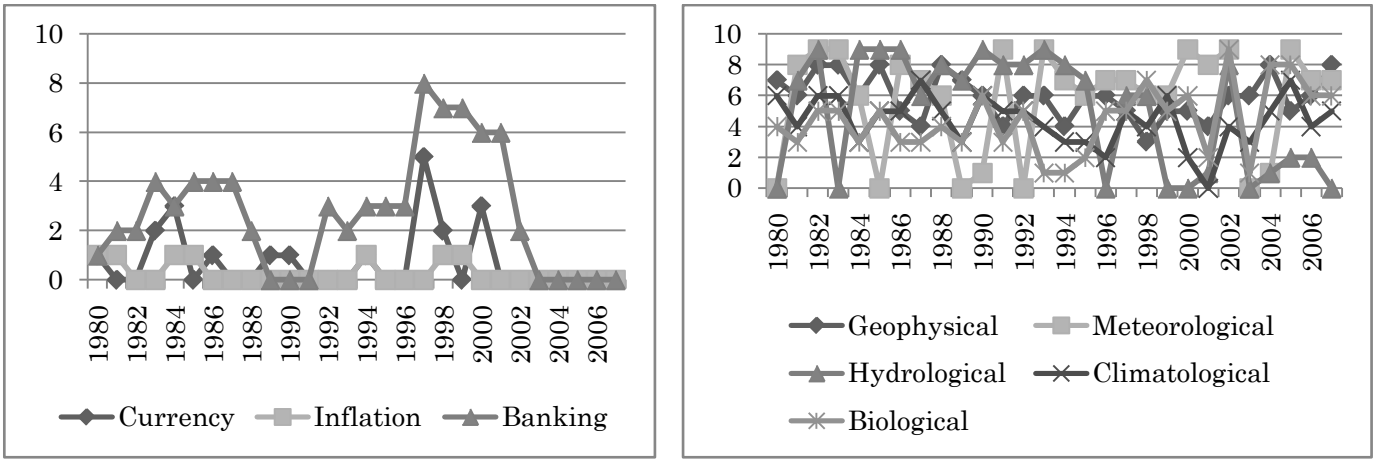
Tables 3 and 4 show descriptive statistics of the variables used and the incidence of disasters for each year, respectively. Figure 3 shows the time series data of incidence of disasters. While we can verify that after there have been only a few occurrences of economic disasters after the Asian financial crises, natural disasters have occurred continuously in the region.

Table 3. Descriptive Statistics of Variables Used

	Number of sample	Mean	Standard deviation
Per capita consumption growth rate	336	-0.002	0.085
Per capita GDP growth rate	336	-0.001	0.061
Currency crises	223	0.090	0.286
Inflation crises	223	0.031	0.175
Banking crises	214	0.355	0.480
Geophysical disasters	336	0.494	0.501
Meteorological disasters	336	0.688	0.464
Hydrological disasters	336	0.741	0.439
Climatic disasters	336	0.366	0.482
Biological Disasters	336	0.399	0.490

Source: Author's calculation using data shown in table 2.

Figure 3. Incidence of disasters



***Source*:** See table 2.

Table 4. Incidence of Disasters in East and Southeast Asia

	Currency	Inflation	banking	Geophysical	Meteorological	hydrological	climatological	biological
# of countries	**8**	**8**	**8**	**12**	**12**	**12**	**12**	**12**
Year								
1980	1	1	1	7	0	0	6	4
1981	0	1	2	6	8	7	4	3
1982	0	0	2	8	9	9	6	5
1983	2	0	4	8	9	0	6	5
1984	3	1	3	6	6	9	3	3
1985	0	1	4	8	0	9	5	5
1986	1	0	4	5	8	9	5	3
1987	0	0	4	4	7	6	7	3
1988	0	0	2	8	6	8	5	4
1989	1	0	0	7	0	7	3	3
1990	1	0	0	6	1	9	6	6
1991	0	0	0	4	9	8	5	3
1992	0	0	3	6	0	8	5	5
1993	0	0	2	6	9	9	4	1
1994	1	1	3	4	7	8	3	1
1995	0	0	3	6	6	7	3	2
1996	0	0	3	6	7	0	2	5
1997	5	0	8	5	7	6	5	5
1998	2	1	7	3	6	6	4	7
1999	0	1	7	5	6	0	6	5
2000	3	0	6	5	9	0	2	6
2001	0	0	6	4	8	1	0	2
2002	0	0	2	6	9	8	4	9
2003	0	0	0	6	0	0	3	1
2004	0	0	0	8	1	1	5	8
2005	0	0	0	5	9	2	7	8
2006	0	0	0	6	7	2	4	6
2007	0	0	0	8	7	0	5	6

Twelve countries were covered for natural disasters (Cambodia, China, Indonesia, Japan, Korea, Laos, Malaysia, Mongolia, the Philippines, Taiwan, Thailand, and Viet Nam) and eight for economic disasters (China, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan, and Thailand).

4. Empirical Results

Table 5 shows the estimation results of the consumption risk-sharing model with year dummy variables. To cope with potential biases arising from omitted variables and endogeneity, we included country fixed effects. Specifications (1) to (4) show the results based on equation (3). First, we verified that the estimated coefficients on per capita GDP growth rate are all positive and highly significant. These robust results indicate that the full consumption risk-sharing model is strongly rejected. Second and intriguingly, the income sensitivity parameter exceeded one for specifications (1) and (2), implying that a 1 percent increase in income will lead to more than 1 percent increase in consumption. Yet, once we control for the potential endogeneity problem using disaster variables as instrumental variables, the point estimates dramatically drop. This indicates that there is serious endogeneity bias in estimating equation (3) by the ordinary least squares (OLS) method. There would be unobserved factors affecting income and consumption simultaneously in the same direction. The estimated income coefficients in specifications (3) and (4) are 0.426 and 0.897, respectively. Hence, in specification (3), 57 percent of income shocks caused by natural and economic disasters are diversified among eight middle- or high-income countries in the region. On the other hand, only 10 percent of income shocks from natural disasters are shared in the wider set of countries. Third, we found that inflation and climatological disasters cause serious income shocks. These results indicate that market and nonmarket insurance mechanisms within the region are incomplete, especially against extreme shocks caused by changes in commodity prices and climate.

Specifications (5) and (6) show the results of estimating the reduced form equation (4). While individual point estimates are largely insignificant, the joint test results indicate the rejection of the full consumption risk-sharing hypothesis. In specification (5), the joint F test statistics of natural and economic disaster variables is 10.06 with p-value of 0.0035. In specification (6), the joint F test statistics of natural disasters is 9.60 with p-value of 0.0010. These results are consistent with the incomplete consumption risk sharing within East and Southeast Asian countries. According to the point estimates of equations (5) and (6), a currency crisis may generate serious, adverse impacts on

consumption change in addition to inflation and climatological disasters.

Table 5. Test of Full Consumption Risk-Sharing Hypothesis (with per capita consumption growth rate as dependent variable)

	(1)	(2)	(3)	(4)	(5)	(6)
Method	OLS	FE	IV-FE	IV-FE	FE	FE
Per capita GDP growth rate	1.009***	1.010***	0.426***	0.897***		
	(0.128)	(0.179)	(0.093)	(0.090)		
			1st stage significance	1st stage significance		
Currency_crises			-		-0.0114	
					(0.009)	
Inflation_crises			**		-0.0031	
			-		(0.006)	
Bankingcrises					0.0028	
			-		(0.003)	
Geophys				-	-0.0120	0.0064
			-		(0.008)	(0.016)
Meteo				-	0.0009	-0.0085
			-		(0.011)	(0.014)
Hydro				-	-0.0017	-0.0090
			-		(0.005)	(0.010)
Climate			**	*	-0.0163	-0.0131
					(0.010)	(0.008)
Bio			-	-	-0.0052	-0.0149
					(0.009)	(0.015)
Constant	0.0108	0.0108	-	-	0.0025	0.0332
	(0.013)	(0.014)			(0.019)	(0.026)
Observations	336	336	214	336	214	336
Adjusted R-squared	0.538	0.539	0.506	0.514	0.350	0.070
Number of countries	8	12	8	12	8	12
First stage joint F statistics			7.28	8.40		
Sagan's over identification test (p-value)			0.2239	0.1885		

Note: Robust standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1. Year dummies are included.

5. Policy Discussions

In this paper, we investigated whether market and nonmarket (i.e., formal and informal) insurance mechanisms are effective in diversifying disaster risks across Asian economies. Our approach was to employ the test framework of international consumption risk sharing so that we could examine the overall effectiveness of formal and informal insurance mechanisms against natural and economic disasters in East and Southeast Asian countries. Using data from twelve countries covering the period 1980—2007, two empirical findings emerged from our econometric analysis. The first

finding was that the full consumption risk-sharing model was significantly rejected. However, point estimates show that 57 percent of income shocks caused by natural and economic disasters are diversified among the eight middle- or high-income countries in the region. On the other hand, only 10 percent of income shocks from natural disasters were shared among the wider set of countries. The second finding was that inflation and climatological disasters cause the most serious and significant income shocks. The findings on the negative impact of inflation and climatological disasters on income imply that overall insurance mechanisms against agricultural-commodity price jumps within the region are rather incomplete. These results highlight the necessity of developing more regional cooperation mechanisms in disaster management.

In addition to the estimation results reported in this paper, estimated coefficients on time dummies in equation (3) or (4), which are not reported in the paper, show that there was a dip in per capita consumption growth rates in 1997 or 1998. This means that the average consumption level within the region declined temporarily in either of these two years. This decrease may have been caused either by the financial crisis or the El Niño phenomenon. Indeed, according to the Food and Agriculture Organization's (FAO) World Food Prices Index presented in figure 2, there was a sharp worldwide increase in food prices in 1997 and 1998 due to El Niño-caused droughts. This price increase might have led to the dip in per capita consumption. Using household survey data for 1998, Datt and Hoogeveen (2003) found that in terms of its impact on poverty, the 1998 economic crisis in the Philippines was more of an El Niño phenomenon than a financial crisis. While our data did not cover the year 2008 when the global food crisis occurred, a future study with updated data may uncover the reasons behind the lack of insurance mechanisms against inflation and climatological disasters.

There are some implications we can derive from these empirical results. Our results highlight the need and potential for regional cooperation in disaster management. First, it is imperative to develop formal mechanisms to diversify aggregate disaster risks. We may need to elaborate on multicountry risk-pooling schemes (e.g., a regional fund to cover sovereign disaster risk). As for economic disasters, the Chiang Mai Initiative (CMI) has been playing, and will be continue to play, an important role. CMI is a

bilateral or multilateral currency swap arrangement that involves pooling foreign exchange reserves. It was designed as an *ex post* coping mechanism against a financial crisis. It is important to note that the Chiang Mai Initiative Multilateralization (CMIM), i.e., a uniform facility to manage regional financial crises, has been agreed upon.

Further development of the Asian bond markets will also be indispensable. It was commonly thought that the Asian financial crisis was driven by the vulnerability of the bank-led financial system within the region. Naturally, the crisis created an awareness of the need for better-diversified debt markets, specifically for bond markets, to supplement the availability of bank finance (Eichengreen 2006). Since bond markets are composed of a large number of individual bond holders, idiosyncratic risks can be diversified effectively. Hence, bond markets are generally considered to offer better risk-sharing mechanisms than credit markets, which are composed of a limited number of creditor banks. In order to diversify the shocks caused by disasters, developed bond markets can play an important role.

Second, for natural disasters, a regional natural-disaster fund or some other alternative formal mechanisms are worth pursuing. Since 2007, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) has been functioning effectively as the world's first multinational risk pool fund to cover sovereign risk via parametric insurance against hurricanes and earthquakes (see box). A key feature of the CCRIF is its structure. The CCRIF combines the pooled reserves of insurance premiums paid by member countries with the financial capacity of the international reinsurance markets. By doing so, the CCRIF can achieve its cost-effectiveness in diversifying risks among member countries and international reinsurance markets. Similarly, in the formal insurance market, insurers need international reinsurance markets to pool disaster risks. It is a known fact, however, that reinsurance markets and trades of catastrophe (CAT) bonds are still thin. At the microlevel, microcredit programs can play the role of disaster insurance through a flexible repayment system (Shoji 2010). Moreover, index insurance contracts, which are written against specific aggregate events such as droughts or floods defined and recorded at a regional level will be a promising formal insurance

mechanism.

It is also important to note that we found that climatological disasters significantly affect income and consumption. This suggests that such risks cannot simply be diversified within the region just yet. This finding indicates the importance of adaptation issues against global climate change in Asia. In addition to the possible formal insurance facilities discussed above, efforts to tackle adaptation issues should include research and extension (R&E) services on drought-resistant varieties, investments in irrigation infrastructure, and preventive infrastructure against floods and landslides.

BOX: Caribbean Catastrophe Risk Insurance Facility (CCRIF)

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is a mutual pooling mechanism of catastrophic risks arising from hurricanes and earthquakes to Caribbean member countries. The CCRIF was developed with funding from the Japanese government and is the result of collaborative work between governments in the region and donor partners. A key feature of the facility is that insurance policies are designed on a pre-established parametric trigger basis. In the case of hurricanes, the hurricane index, which is computed by location-weighted wind speed, is used. In the case of earthquakes, ground-shaking thresholds are employed. By its parametric nature, the CCRIF can provide short-term liquidity to a government at the onset of a catastrophe. Unlike traditional indemnity insurance, which requires time-consuming loss verifications and estimations, payouts under the CCRIF can be calculated and made very quickly based on the predetermined triggers together with quickly observed data.

Another feature of the CCRIF is its structure. It combines the pooled reserves of insurance premiums paid by member countries with the financial capacity of the international reinsurance markets. By doing so, the CCRIF can achieve its cost-effectiveness in diversifying risks among member countries and international reinsurance markets.

The CCRIF is now expanding its facility to cover excess rainfall coverage during the 2010/11 policy year. The excess rainfall product will utilize the rainfall amounts generated by the model as the parameter that triggers coverage. The CCRIF is now also considering developing a product for the agriculture sector (i.e., index-based agricultural insurance for farmers).

Theoretically, it is also possible to set a parametric insurance on extreme food price changes. However, a potential problem is that while winds and earthquakes cannot be manipulated by humans, food prices can be affected by government policies and market transactions or speculations. Hence, there is room for creating moral hazard problems, which may undermine the transparency and efficiency of parametric insurance facilities.

Source: *Caribbean Catastrophe Risk Insurance Facility (CCRIF) < www.ccrif.org/>*

References

Bacus, David K. and Gregor W. Smith. 1993. “Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods.” *Journal of International Economics* 35, no. 3—4 (November): 297—316.

Baxter, Marianne and Urban J. Jermann. 1999.“Household Production and the Excess Sensitivity of Consumption to Current Income.” *American Economic Review* 89,no. 4 (September): 902—920.

Baxter, Marianne, Urban J. Jermann, and Robert G. King. 1998. “Nontraded Goods, Nontraded Factors, and International Non-Diversification.” *Journal of International Economics* 44,no. 2 (April): 211—229.

Centre for Research on the Epidemiology of Disasters (CRED). EM-DAT for 12 countries: The International Disaster Database, CRED. http://www.emdat.be/classification

Chen, Joe, Yun Jeong Choi, Kohta Mori, Saki Sugamo, and Yasuyuki Sawada. “The Jump, Inertia, and Juvenization of Suicides in Japan.” Discussion paper CIRJE-F-628, July 2009.

Cochrane, John H. 1991. ”A Simple Test of Consumption Insurance.” *Journal of Political Economy* 99, no.5 (October): 957—976.

Datt, Gaurav and J.G.M. Hans Hoogeveen. 2003. “El Niño or El Peso? Crisis, Poverty and Income Distribution in the Philippines.” *World Development* 31, no. 7: 1103—1124.

Dubois, Pierre, Bruno Jullien, and Thierry Magnac. 2008. “Formal and Informal Risk Sharing in LDCs: Theory and Empirical Evidence.”*Econometrica* 76, no. 4: 679—725.

Eichengreen, Barry. 2006. “The Development of Asian Bond Markets,” in “Asian Bond Markets: Issues and Prospects,” BIS Papers No. 30, Bank of International Settlements.

Fafchamps, Marcel and Susan Lund. 2003.“Risk-Sharing Networks in Rural Philippines.” *Journal of Development Economics* 71, no. 2 (August): 261—287.

Freeman, Paul K., Michael Keen, and Muthukumara Mani. 2003. “Dealing with Increased Risk of Natural Disasters: Challenges and Options.” IMF Working Paper WP/03/197.

Hayashi, Fumio, Joseph Altonji, and Laurence Kotlikoff. 1996. “Risk-Sharing Between and Within Families.” *Econometrica* 64, no. 2 (March): 261—94.

Kunreuther, Howard and Adam Rose, eds. 2004. *The Economics of Natural Hazards: The International Library of Critical Writings in Economics #178*. 2 vols. Edward Elgar Publishing, Inc.

Lewis, Karen. 1996. “What Can Explain the Apparent Lack of International Consumption Risk-Sharing?” *Journal of Political Economy* 104,no. 2 (April): 267—297.

Ligon, Ethan. 2008. “Risk Sharing.” In *The New Palgrave Dictionary of Economics*. 2nd ed. Edited by Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan.

Ligon, Ethan. 1998. “Risk Sharing and Information in Village Economics.” *Review of Economic Studies* 65, no. 4 (October): 847—864.

Mace, Barbara J. 1991. “Full Insurance in the Presence of Aggregate Uncertainty.”

Journal of Political Economy 99, no. 5 (October): 928—996.

Ogaki, Masao and Qiang Zhang. 2001. "Decreasing Relative Risk Aversion and Tests of Risk Sharing."*Econometrica* 69, no. 2 (March): 515—526.

Reinhart, Carmen and Kenneth Rogoff. 2010. Data on Varieties of Crises: 1800-2009, "This Time is Different Chartbook: Country Histories on Debt, Default, and Financial Crises," *NBER Working Paper 15815*, March 2010.Forthcoming in American Economic Review. http://terpconnect.umd.edu/~creinhar/Courses.html

Sawada, Yasuyuki. 2007. "The Impact of Natural and Manmade Disasters on Household Welfare." *Agricultural Economics* 37 (s1): 59—73.

Yasuyuki Sawada, Rima Bhattacharyay, and Tomoaki Kotera. 2011. "Aggregate Impacts of Natural and Man-made Disasters: A Quantitative Comparison," RIETI Discussion Paper, Research Institute for Economy, Trade, and Industry (RIETI), Japan.

Shoji, Masahiro. 2010. "Does Contingent Repayment in Microfinance Help the Poor During Natural Disasters?" *Journal of Development Studies* 46 (2): 191—210.

Townsend, Robert M. 1994. "Risk and Insurance in Village India." *Econometrica* 62, no. 3 (May): 539—591.

Yang, Dean. 2008. “Coping with Disaster: The Impact of Hurricanes on International Financial Flows, 1970—2002,”B.E. Journal of Economic Analysis and Policy Advances 8 (1).