Aggregate Impacts of Natural and Human-Made Disasters in the Global Economy

(Are Global Market and Non-market Insurance Mechanisms Effective to Cope with Natural and Human-Made Disasters?)

by

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Abstract

This paper formally tests effectiveness of global market and non-market mechanisms against natural and human-made disasters using cross-country panel data of 189 countries between 1968 and 2001. By doing so, we compare the degrees of effective incompleteness of insurance mechanisms against various disasters quantitatively. We mostly reject the global consumption risk sharing hypothesis. Around 20-40% of income shocks arising from disasters could not be diversified away globally through a variety of market and non-market insurance mechanisms. In the short term, natural disasters generate the largest negative welfare impacts as captured by per capita GDP and consumption growth, followed by wars and economic disasters. Intriguingly, in the long term, natural disasters and wars have positive impacts on welfare. Wars affect large economies more than they affect small economies while natural disasters affect small economies disproportionately.

Keywords: Risks; Natural Disasters; Man-Made Disasters

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I. Introduction

Recently, a number of high-profile natural and man-made disasters have hit both developed and developing countries alike. We see vividly the ongoing 2011 devastating earthquake, tsunami, and nuclear radiation crisis in Japan that has killed tens of thousands people and resulting in damages of around 200 to 300 billion dollars (Cabinet Office, 2011), the Eyjafjallajökull volcanic eruption in 2010 in Iceland that gravely disturbed the European airline industry, and the 2010 oil spill in the Gulf coast cost about several billion in the short term. Hundreds of thousands of lives were lost in the Indian Ocean tsunami, Hurricane Katrina, and the earthquakes in central Chile, Haiti, Sichuan province of China, northern Pakistan, and the Hanshin area of Japan. The 2008 global financial and economic crisis has caused a worldwide problem, slowing global economic growth, with far-reaching effects similar to the Great Depression of the 1930s. As such, man-made disasters can also generate serious negative impacts not only on lives, but on the survivors' livelihoods (Barro, 2009).

Indeed, people around the world face a wide variety of risks arising from health, weather, and policy related shocks (Fafchamps, 2001; Dercon, 2006). However, natural disasters, (hydro-meteorological, geophysical, and biological disasters) and technology related disasters such as chemical spills and transportation accidents, can generate the most serious consequences ever known, disabling the head of a household or even an entire family or community. To compound issues, there is an apparent increasing trend of natural disasters over the years (Figure 1). In addition to natural and technological disasters, economies also face a specter of man-made disasters including financial crises, credit crunch, terrorist attacks, civil conflicts, and wars. The economic and social costs of such disasters have occurred continuously as per Figure 1, which indicates the frequency of man-made disasters over time.[1] We can notice, for instance, that for civil wars there is some volatility in the trend line, reflecting the frequent yet variable occurrence of such type of wars. With regards to big wars such as World War I and World War II, the frequency appears more constant over time, probably owing to the rare occurrence of large-scale conflict. Finally, with regards to economic crises, the frequency appears to go up over time and it peaks between1980 and 2000, coinciding with the timing of the Latin American debt crisis and the Asian financial crisis.

Against natural disasters, various formal insurance mechanisms are available, ranging from formal financial instruments such as the catastrophe bonds, the multi-country disaster risk pooling mechanism such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF). To cope with and reconstruct after domestic conflicts and wars, bilateral and multilateral international aid resources have been utilized. To mitigate and cope with risks of economic crises, countries employ different financial facilities provided by multilateral development banks such as International Monetary Fund (IMF), regional currency risk diversification schemes such as Chiang Mai Initiative (CMI), and hard institutions of common currency areas, e.g., the European Monetary Union (EMU). In addition to these formal mechanisms, informal insurance mechanisms such as remittances of foreign

[1] According to the Centre for Research on the Epidemiology of Disasters (2006), generally, a disaster is defined as an unforeseen event that causes great damage, destruction and human suffering, which overwhelms local capacity, necessitating a national or international level of assistance (CRED, 2010). Augmenting the classification system of CRED (2010), these disasters can be classified into three broad categories: natural disasters, technological disasters, and man-made disasters. 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; and 3) biological disasters such as epidemics and insect infestations. Technological disasters are mainly composed of two subgroups: 1) industrial accidents such as chemical spills, collapses of industrial infrastructures, fires, and radiation leak from nuclear power plant; and 2) transport accidents by air, rail, road or water. Finally, man-made disasters can be subdivided as follows: 1) economic crises including growth collapse, hyperinflation, financial, and currency crises; 2) violence such as terrorism, civil strife, riots, and wars.

emigrants and charitable giving are available for victims of different disasters to cope with them (Yang, 2008).

Yet, to the best of our knowledge, there has been no study to formally test effectiveness of global market and non-market mechanism against natural and human-made disasters.[6] Also, there has been no unified study to compare the welfare costs of different disasters, barring Barro (2009) who quantified aggregate welfare impacts of major consumption disasters. This paper aims at bridging this gap in the existing literature by

[6] There have been a number of macroeconomic and microeconomic studies undertaken on the causes and consequences of different natural and man-made disasters (Sawada, 2007). Hallegatte and Przyluski (2010) distinguish natural disaster impacts between direct and indirect losses where direct losses are defined as the immediate consequences of disasters on physical capital stock. Indirect losses are defined as damages which "are not provoked by the disaster itself, but by its consequences" such as the reduction in economic output. On the direct costs, Kahn (2005) finds that while richer nations do not suffer fewer shocks compared to poorer ones, the number of deaths, the number of people injured and the number of homeless decreases significantly as income rises. This finding is also confirmed by Skidmore and Toya (2007) and Noy (2009). With regards to the indirect costs of natural disasters, Stromberg (2007) notes that from 1980 to 2004, the estimated economic cost from natural disasters was around $1 trillion. Skidmore and Toya (2002) employ cross-country empirical analyses to examine the long run determinants of growth rate of real per-capita GDP between 1960 and 1990. Intriguingly, they find that higher frequencies of climatic disasters are associated with higher rates of human capital accumulation, increases in total factor productivity and long-run economic growth. Furthermore, disasters affect growth by leading to improvements in total factor productivity.

As for man-made disasters, inflation crises induced by a large currency depreciation or a global food crisis can also create negative welfare effects (Heady and Fan, 2010; Joachim von Braun, 2008). Indeed, the number of complex economic crises also seems to be increasing. A cerebrated 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 of simultaneous banking-and-currency crises, i.e., "twin crises," increased sharply over the same period. A credit crunch arising from a financial crisis is likely to damage small firms disproportionately because unlike large listed firms, the only source of their external funding for investments are bank loans (Claessens et al., 2002, p.26). As a result, many owners of small firms or businesses went bankrupt (Kang and Sawada, 2008). Such negative welfare impacts will also appear with increased unemployment, decreased wage rates, and stagnant consumption (Sawada et. al, 2011).

With regards to violence related man-made disasters such as terrorisms, riots, civil conflicts, and wars, it should be noted that the number of conflicts is not necessarily declining over time according to information from the Uppsala Conflict Data Program <www.ucdp.uu.se/database>. Hess (2003) combines the framework of Lucas' (1987) welfare cost estimates with cross-country data sets, finding that the welfare cost of conflicts and wars amounts to approximately eight percent of people's current level of consumption. Furthermore, Davis and Weinstein (2002), Battman and Miguel (2010), and Miguel and Roland (2011) find that while the short-run impact of war is clearly disastrous, there is mixed evidence on how long the economic effects on human capital and quality of life persist. Blomberg et al. (2004) finds that, on average, the incidence of terrorism may have an economically significant negative effect on growth, albeit one that is considerably smaller and less persistent than that associated with either external wars or internal conflict. They also find that there are heterogeneities in the incidence and the economic consequences of terrorism.

making two contributions. First, we formulate and test the global risk sharing hypothesis against disasters by using disaster related information as instrumental variables. Seocnd, we carefully compare the relative impacts of damages arising from a wide variety of disasters, ranging from hydro-meteorological disasters to civil conflicts. Our approach is to employ cross-country panel data to quantify the degrees of negative welfare effects by these disasters over time and across countries.

To preview our findings, we find overall evidence against consumption risk sharing at the global level. in the short term, natural disasters generate the largest negative welfare impacts which are followed by wars and economic disasters. Intriguingly, in the long term, natural disasters and wars have positive impacts on per capita GDP growth. Wars affect large economies more than small economies while natural disasters affect small economies disproportionately.

The rest of this paper is organized as follows. In Section II, we set up the econometric framework to estimate relative welfare impacts of different natural and man-made disasters. Section III outlines the data sources, variables, and descriptive statistics in our study. In Section IV, we present and interpret the empirical findings and discuss the relative magnitude of welfare impacts of different disasters. The last section provides concluding remarks together with related policy implications.

II. Theoretical and Econometric Framework

In the last fifteen years, there has been a 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; Kinnan, 2010). Since the test of full consumption risk sharing can be interpreted as a test of overall insurance mechanisms which are composed of formal market mechanisms, informal or non-market mechanisms, and self-insurance mechanisms, the framework is an appropriate benchmark model to compare the welfare impacts of various disasters quantitatively.

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. To derive these implications of complete consumption risk sharing or of consumption insurance, we could solve a benevolent social planner's problem by maximizing the weighted sum of representative agent's lifetime utilities given social resource constraints (Mace, 1991; Cochrane, 1991; Townsend, 2004).[7] In addition, we would follow the approach of Lewis (1996) who incorporated consumption of nontradables to test the international consumption risk sharing hypothesis.

Suppose that the world economy is composed of *N* infinitely-lived countries, each facing serially independent income or endowment draws. In this pure exchange economy, we can set up a social planner's problem to derive conditions for full consumption risk-sharing with non-tradables (Lewis, 1996):

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[7] In order to derive tractable and testable implications, we impose additional assumptions: First, all market participants can perfectly observe uncertainty realizations. In other words, there is no private information and thus the information structure is symmetric. Second, the contingent securities span the state space and thus markets are complete. Third, the probability distribution of state realization, $\pi^{i}(s^{t})$, is identical across agents; i.e., agents have identical beliefs about future. Fourth, agents have identical utility functions with identical time discount rates.

$$
\begin{aligned}
&\max_{\{c^T, c^N\}} \sum_{j=1}^{N} \lambda^j \left\{ \sum_{t=1}^{\infty} \sum_{s^t} \left(\frac{1}{1+\delta^j} \right)^t \pi\left(s^t\right) u\left[c_{jt}^T\left(s^t\right), c_{jt}^N\left(s^t\right)\right] \right\} \\
&s.t. \sum_{j=1}^{N} c_{jt}^T\left(s^t\right) \le \sum_{j=1}^{N} y_{jt}^T\left(s^t\right), \forall s^t, \\
&c_{jt}^N\left(s^t\right) \le y_{jt}^N\left(s^t\right), \forall s^t,
\end{aligned} \tag{1}
$$

where δ is a agent's subjective discount rate, π denotes the probability of realization of a 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 country, and y^N represents non-transferable initial endowment of each country, i.e., non-tradables. 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 tractable equation:

$$\gamma \Delta \log (c_{it} / c_{jt}) = \Delta \log (e_{ijt}), \tag{2}$$

where c is a composite consumption of tradables and nontradables, and e_{ij} is a 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 to their relative goods price.

The Econometric Model

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

$$\Delta \log c_{it} = a_1 \frac{1}{N} \sum_{j=1}^{N} \Delta \log c_{jt} + a_2 \frac{1}{N} \sum_{j=1}^{N} \Delta \log e_{ijt} + \zeta \Delta \log y_{it}, \quad (3)$$

where Δ is a first-difference operator, and y is per capita GDP. Note that, in equation (3), income shock variables, Δ log y, are added where the full consumption risk sharing hypothesis implies that ζ =0. In actual empirical implementation of equation (3), we follow Ravallion and Chaudhuri (1998) and replace network average consumption by time dummies. The average real exchange rate in the second term of equation (3) is replaced by country fixed effects and the log first difference of real effective exchange rate, *REER*. Accordingly, an estimable version of equation (3) becomes:

$$\Delta \log c_{it} = a_0 + \alpha_t + \alpha_i + \alpha_R \Delta \log REER_{it} + g \Delta \log y_{it} + u_{it}, \quad (4)$$

where α_i is the country fixed effect, α_t is the time effect, and u_{it} is a well-behaved error term. In equation (4), we are interested in estimating the sensitivity parameter, g: A null hypothesis that g=0 corresponds to the full consumption risk sharing hypothesis. Also, the parameter, g, summarizes welfare impact of income change on consumption change.

Yet, estimating equation (4) by OLS may involve the endogeneity bias arising from the correlation between unobserved consumption growth factor in the error term and per capita GDP growth rate. Since this correlation is likely to be positive, an OLS estimate of equation (1) may generate an upward bias in the estimated level of the sensitivity parameter g. To handle this endogeneity problem and also to capture the impacts of disasters, our basic idea is to use natural and man-made disaster information as identifying instrumental variables for income change, $\Delta \log y$, in equation (4). While natural and man-made disasters will affect income level significantly, by nature, disasters, especially natural disasters, are not necessarily manipulated by human beings or individuals.[8] Disasters are less likely to correlate with the error term of equation (4). Hence, we believe that our identification approach will mitigate the endogeneity bias effectively. Accordingly, we postulate the following first stage regression equation:

$$\Delta \log y_{it} = N_{it}\,\beta_N + W_{it}\,\beta_W + E_{it}\,\beta_E + \gamma_i + \gamma_t + \varepsilon_{it}, \tag{5}$$

where N, W, and E represent a set of variables related to natural disasters, wars and conflicts, and economic crises, respectively. We also include country fixed effects, γ_i, and time effect, γ_t. Our econometric model is a standard instrumental variable estimation with fixed effects based on equations (4) and (5).

In equation (5), we can utilize the estimated coefficients, b_N, b_W, and b_E, respectively, for β_N, β_W, and β_E to decompose per capita GDP change rate into three subcomponents: per capita GDP change rate driven by natural disasters, $N_{it}b_N$; wars and conflicts, $W_{it}b_W$; and economic crises, $E_{it}b_E$. By comparing these values, we can formally compare which disaster has the greatest impact on welfare: by combining equations (4) and (5), the total welfare impact of each disaster can be quantified by $\hat{g}N_{it}b_N$, $\hat{g}W_{it}b_W$, and $\hat{g}E_{it}b_E$

[8] In fact, Kahn (2005) found that an increase in GDP per capita has no effect on the probability that a natural disaster takes place.

for natural disasters, conflict & wars, and economic crises, respectively, where $\hat{g}$ is the estimated income growth coefficient, g, in equation (4). In other words, we quantify and compare the impacts of a variety of natural and man-made disasters on welfare by setting per capita GDP and per capita consumption as the criteria for welfare evaluation.

III. Data Sources, Variables, and Descriptive Statistics

For the empirical analysis, we focus primarily on three broad categories: first, natural and technological disasters; second, economic disasters; and third, war and conflicts. The list of variables used, their definitions, and their data sources is shown in Table 1. We use these variables on natural and man-made disasters as instrumental variables in equation (2). First, with regards to the macroeconomic data such as per capita consumption and GDP, we use the Penn World Table (PWT) Version 6.3 and World Development Indicators (WDI) of the World Bank covering the 189 nations in our study. The real effective exchange rate index, *REER*, is taken from International Monetary Fund's International Financial Statistics. The index represents a nominal effective exchange rate index, i.e., the ratio of an index of a currency's period- average exchange rate to a weighted geometric average of exchange rates for the selected benchmark currencies, adjusted for relative movements in national price.

Second, our data on natural disasters and technological disasters come from the publicly available Emergency Events Database (EM-DAT) maintained by the Center for Research on the Epidemiology of Disasters (CRED). The CRED classifies natural disasters based on the following criterion: ten or more people were killed; 100 or more people were affected, injured, or homeless; significant damage was incurred; a declaration of a state of emergency and/or an appeal for international assistance was made. We use six variables related to natural disasters 1) geological disasters including earthquakes and volcanic eruptions; 2) meteorological disasters including storms; 3) hydrological disasters such as floods, 4) climatological disasters such as droughts; 5) biological disasters such as epidemics and insect infestations; and 6) technological disasters including industrial accidents and transport accidents.[9]

Finally, data on man-made disasters is classified into two subcategories: first, we use economic crises variables including growth collapse, hyperinflation, and financial, and/or currency crisis. Data are extracted from the Carmen Reinhart's Crisis Database (Reinhart and Rogoff, 2010). As for violence related disasters relating to wars and conflicts, we extract available information from multiple data sources, i.e., Correlates of War (COW) database (Correlates of War, 2010); UPPSALA database (UPPSALA Conflict Database, 2010); and Carmen Reinhart Crisis database (Reinhart, 2010).

Descriptive statistics of the variables used are summarized in Table 2. According to Table 2, on average, a country encounters 3.75 natural disasters per year; one war every five years; and one economic crisis, i.e., banking, debt, currency or inflation crisis, every other year.

IV. Empirical Findings

[9] Strobl (2011) notes in his paper that, at least for hurricanes strikes in the in the Central American and Caribbean regions, using EM-DAT data may not be appropriate. However, the purpose of our paper is to compare the relative impacts of different natural and man-made disasters. Hence, we believe that our empirical strategy is the most suitable among feasible approaches.

In actual estimation of equations (4) and (5), we use six different lags for growth rates, i.e., one year, three years, ten years, 15 years, 20 years, and 25 years. By investigating short run and long run impacts separately, we believe we can separately consider the direct immediate net costs and indirect long term net losses from disasters as addressed in Hallegatte and Przyluski (2010) and Skidmore and Toya (2007). In all specifications reported in the following tables, we have also included the country fixed effects and the year dummies.

Short Term Impacts

Table 3 shows the basic results of equation (2), i.e., the first stage per capita GDP growth regression over a year. First, overall disasters have a significant negative impact on GDP per capita. Moreover, once we incorporate detailed disaster variables, the climatological disasters variable takes negative and statistically significant coefficient. Intriguingly, biological disasters involve positive effects. In addition, wars and banking crises have significant negative impacts.

Table 4 presents the results of the second stage regression, in reference to Equation (4), which allows us to observe the relationship between consumption growth and income growth rates. The estimated coefficients of income growth rate are consistently positive and statistically significant in three out of four cases using the instrumental variable method, indicating that global risk sharing is not necessarily working. Moreover, the point estimates for the income coefficient using OLS are larger than those based on the instrumental variable method, suggesting that there may be upward bias arising from positive correlation between income and unobserved heterogeneities in the error term in equation (4). These results indicate that natural and man-made disasters negatively affect per capita GDP which may be translated into negative per capita consumption level. To interpret the post estimates, around 20-40% of income shocks arising from disasters could not be diversified away globally through a variety of market and non-market mechanimsms. Note that the F statistics from the first stage regression and the Hansen's *J* statistics for the over identification tests support the validity of our econometric model. Moreover, even if we use data of three year lagged log per capita GDP and consumption, basic qualitative results are maintained.[10]

To capture the overall impacts of each disaster category, we decompose the predicted average income growth rates into components of natural disasters, wars and economic disasters evaluated at mean values. The decomposition results, i.e., the values of $N_{it}b_N$, $W_{it}b_W$, and $E_{it}b_E$. evaluated at their average levels, are shown in Table 5.[11] According to the second specification in Table 3, natural disasters decrease per capita GDP growth rate by 1.1% points because the average number of natural disasters in log is 0.012 per year (Table 2). Similar computations have been made to construct Table 5 which shows impacts of different disasters on per capita GDP growth rate. There are two findings we can see from Table 5. First, we can see that natural disasters, wars, and economic disasters generate statistically significant negative welfare impacts jointly. Second, we can verify that, on average, natural disasters generate the largest negative welfare effects in short term which is followed by wars and economic disasters.

[10] The results are available from the corresponding author upon request.

[11] Even using the results of the first stage regression for 3 years lag, the qualitative results are maintained. These results are not shown in this paper but are available from the corresponding author upon a request.

Long Term Impacts

So far, our analyses are based on one-year and three year lagged variables, implying that the results reflect the very short term impact of disasters. In order to examine long term impacts of disasters on consumption growth rate, we employ 15 years, 20 years, and 25 years lags. In estimating these models, we follow Skidmore and Toya (2002) to include initial log income per capita as an additional explanatory variable in the first stage regression equation (2).[12]

Based on the results in Table 6 which shows that the results based on 20 years lag, we find that numbers of natural disasters in total have positive and statistically significant coefficients.[13] In contrast, with regards to economic disasters, the results of debt, currency and inflation crises reveal negative effects over 20 years. To quantify the overall welfare impacts, Table 7 represents the decomposition results of the model of 20 years lags. As we can see, natural disasters have the largest *positive* impact on per capita GDP growth in the long term. The estimated average negative impact of natural disasters ranges from 8.3% to 23.1% losses of per capita GDP over 20 years. In fact, these results are consistent with Skidmore and Toya (2002) who find that climatic disasters are associated with higher rates of long-run economic growth.[14] As a new finding in the literature, our results show that

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[12] This is a version of the estimable transition equation of the Solow model.

[13] When we use the first stage regression for 15 years and 25 years lag, the qualitative results are maintained. These results are not shown in this paper but are available from the corresponding author upon a request.

[14] Cavallo and Noy (2009) and Skidmore and Toya (2002) suggest that a rationale for this counterintuitive positive growth effect of natural disasters is that disasters maybe accelerating the "Schumpeterian" creative destruction process.

wars have a similar positive effect on per capita GDP growth in the long term. In contrast, economic disasters generate negative effects for 20 years.

Large versus Small Economies

To investigate the differentiated impacts of natural disasters depending on the varying size of economies, we follow Noy (2009) to divide the countries in our sample into large and small countries on the basis of their GDP. We use GDP data in 1960 or 2006 to split countries into two groups: "small" countries with below-median GDP and "large" countries with above-median GDP. Based on the regression results for large countries and small economies by the threshold of GDP data in 1960,[15] overall decomposition figures are summarized in Table 8. While wars indicate the largest negative welfare effect in the case of large economies, impacts of natural disasters are biggest in small economies.

Moreover, in the 1960 GDP split, natural disasters have a smaller impact in large economies than in small economies, as natural disasters are, in general, geographically concentrated by nature. Hence, smaller economies, which occupy smaller area size on average, are more detrimentally impacted by the effects of natural calamities. In contrast, wars can affect a whole nation regardless of the size of the economy. As to the second stage regression results of the log of consumption growth for the case of small and large economies, as the estimated coefficients of income growth rate are positive and significant in most cases, our results indicate that international consumption risk sharing is not working within each group.

[15] The regression results are available from the corresponding author upon request.

The Nexus between Natural and Man-made Disasters

While our study as well as Barro's (2009) analyses both natural and man-made disasters, the existing studies including ours treat natural and man-made disasters as independent incidents. Yet, there may be an interrelationship between them. For example, in the case of Japan's 1923 earthquake, one of the most devastating earthquakes in the country's history, the impact of the earthquake was followed by a sharp decline in the country's GDP. Japan's earthquake can be considered as an example of an exogenous economic shock, whose effects are temporary-as a result of the earthquake, there was a slowdown in output growth, and higher current account deficits in 1923 and 1924 (Obstfeld, Rogoff, p76). In our study, we tried to examine if there existed any systemic relationship between natural disasters and economic disasters. We looked at the simple pairwise correlations between the numbers of different natural and man-made disasters. As per our findings we conclude that natural disasters are not systematically related to man-made disasters. In contrast, Miguel et al. (2004) used data from 41 African countries during 1981–99 to identify the causal impact of negative economic growth on civil conflict. Intriguingly, they also find that the impact of negative growth shocks on conflict is not significantly different in richer, more democratic, or more ethnically diverse countries. Further investigations on the inter-relationships among natural disasters, wars, and economic disasters should be undertaken in future research.

V. Concluding Remarks

In this paper, we compared the impacts of various man-made and natural disasters quantitatively. We carefully constructed cross-country panel data of 189 countries from

1968 to 2001 on a wide variety of natural disasters such as hydrological, geophysical, and biological disasters as well as man-made disasters such as economic crises, civil conflicts and wars.

There are four main empirical findings that have emerged from our analysis. First, in the short term, natural disasters, wars, and economic disasters involve statistically significant negative impacts, i.e., declines in per capita GDP growth rates. Furthermore, natural disasters generate the largest negative welfare effects which are followed by wars and economic disasters. Second, in the long term, natural disasters and wars have *positive* impacts on per capita GDP growth and welfare. In contrast, economic disasters continuously generate negative impacts. Third, wars affect large economies more than small economies; while natural disasters affect small economies disproportionately. Finally, we test the full consumption risk sharing hypothesis in our model by regressing per capita consumption growth rates on per capita GDP growth rates as their idiosyncratic shock variables. Based on our results, overall, we find evidence against global consumption risk sharing. Our empirical results suggest that stronger emphasis should be placed on short-term post-disaster rehabilitations for natural disasters, conflicts and warfare and on long-term continuous interventions against economic crises. In terms of policy implications, it is important to note that losses and damages caused by natural disasters are physical, and thus they are visible for reconstruction and rehabilitation. In the longer term, these damages fade away by a variety of rehabilitation and reconstruction investments. However, the impacts of economic crises are largely intangible. Thus there is a need for devising long term reconstruction measures for addressing the after-effects of economic crises, such as the recent global financial crisis. Furthermore, in addition to ex-post policy emphasis, it is also extremely important to focus and invest in ex-ante risk mitigation strategies such as formal regional and/or global risk pooling facilities.

In our paper we examine cross-country variation in consumption welfare. Future studies should explore heterogeneities within countries. It would be worth investigating how within a country consumption variation or income distribution is affected by disasters.

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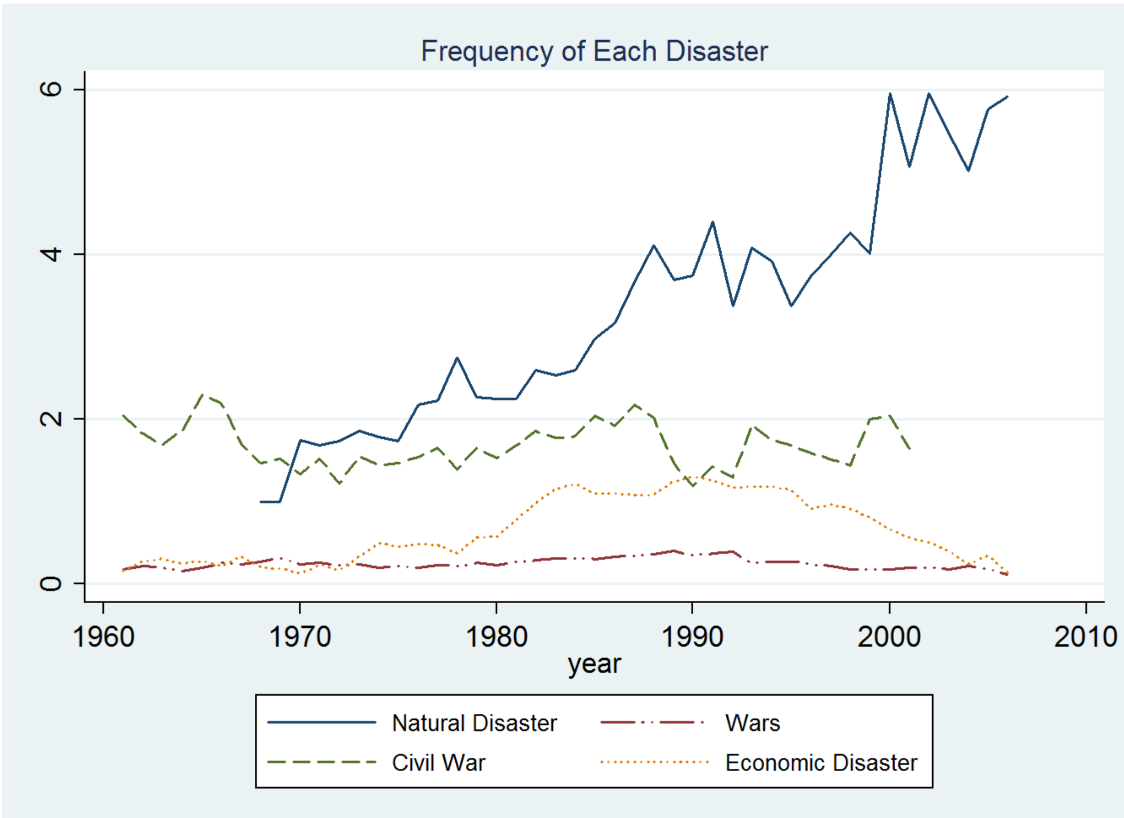
Figure 1

Frequency of Natural and Man-made Disasters, 1960s-2006



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

Table 1 Definition and Sources of Variable

Variables	Definition	Source
Per capita consumption growth rate (in log)	Logarithm of per capita consumption rate	PWT
Per Capita GDP growth rate (in log)	Logarithm of percentage change in per capita GDP	PWT
Real effective exchange rate	Real effective exchange rate index	IFS
Geophysical disasters	Geophysical disasters (originating from solid earth Earthquake, Volcano, Mass Movement)	EMDAT
Meteorological disasters	Events caused by short-lived/small to meso scale atmospheric processes (in the spectrum from minutes to days) such as storms	EMDAT
Hydrological disasters	Hydrological disasters (caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up) such as floods	EMDAT
Climatological disasters	Climatic disaster events caused by long-lived/meso to macro scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability) such as extreme temperature, droughts, wildfire	EMDAT
Technological disasters	Industrial accidents such as chemical spills, collapses of industrial infrastructures, fires, and radiation; or transport accidents by air, rail, road or water means of transport	EMDAT
Biological disasters	Biological disaster events caused by the exposure of living organisms to germs and toxic substances such as Epidemics, Insect infestations, Animal Stampedes	EMDAT
Number of civil wars	Number of militarized interstate disputes, i.e., disputes that are united historical cases of conflict in which the threat, display or use of military force short of war by one member state is explicitly directed towards the government, official representatives, official forces, property, or territory of another state. Disputes are composed of incidents that range in intensity from threats to use force to actual combat short of war.	COW
Big wars	Wars that occurred over the years (1800-2008)	REINHART
Currency crises	An annual depreciation versus the US dollar of 15 percent or more	REINHART
Inflation crises	An annual inflation rate 20 percent or higher (Hyperinflation)	REINHART
Banking crises	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 institutions (or group of institutions), that marks the start of a string of similar outcomes for other financial institutions	REINHART
Debt crises domestic	Default or rescheduling on domestic debt (includes deposit freezes)	REINHART
Debt crises external	Default or rescheduling on foreign debt	REINHART

Data Sources) COW: Correlates of War (2010), COW Militarized Interstate Disputes (v.3.10), http://www.correlatesofwar.org/; EMDAT:"EM-DAT: The OFDA/CRED International Disaster Database www.em-dat.net; IFS: International Financial Statistics online, International Monetary Fund; PWT: Penn World Tables (2010); WDI: World Development Indicators (2010); UPPSALA: UPPSALA Conflict Database (UCDP); REINHART: Database for Reinhart and Rogoff (2010).

Table 2: Descriptive Statistics

Variable Name	Description	Date Source	Number of observations	Mean	Standard Deviation
Log Consumption Growth	Consumption growth (in log)	PWT	6568	0.053	0.169
Log Income Growth	Income growth (in log)	PWT	6568	0.056	0.113
Natural Disasters					
Total Number of Disasters	Total Number of Disasters	EMDAT	3910	3.765	6.476
Log Total Natural Disasters	Total Number of Natural Disasters (in log)	EMDAT	3780	0.012	0.007
Log Geophysical Disasters	Total Number of Natural Disasters that are Geophysical (in log)	EMDAT	3780	0.002	0.004
Log Meteorological Disasters	Total Number of Natural Disasters, that are Meteorological (in log)	EMDAT	3780	0.003	0.005
Log Hydrological Disasters	Total Number of Natural Disasters that are Hydrological (in log)	EMDAT	3780	0.004	0.005
Log Climatological Disasters	Total Number of Disasters that are Climatological (in log)	EMDAT	3780	0.002	0.004
Log Biological Disasters	Total Number of Disasters that are Biological (in log)	EMDAT	3780	0.002	0.004
Log Technological Disasters	Total Number of Disasters that are Technological (in log)	EMDAT	3780	0.005	0.007
Conflicts and Wars					
Wars	Dummy Variable on wars that occurred over the years (1800-2008)	REINHART	3933	0.243	0.429
Occurrence	Number of Civil War	COW	2250	1.760	1.553
Log of Number of Civil Wars	Number of militarized interstate dispute (in log)	COW	2240	0.925	0.384
Economic Disasters					
Banking Crises	Banking Crisis (dummy)	REINHART	2640	0.148	0.356
Debt Crisis Ext	Debt Crisis External (dummy)	REINHART	3535	0.155	0.394
Currency Crisis	Total Number of Currency Crises (in log)	REINHART	3744	0.093	0.394
Inflation Crisis	Total Number of Inflation Crisis (in log)	REINHART	3737	0.132	0.330
Currency Crisis (Dummy)	Dummy Variable for Currency Crisis	REINHART	3613	0.177	0.396
Inflation Crisis (Dummy)	Dummy Variable for Inflation Crisis	REINHART	3794	0.155	0.362

Table 3
Results of the First Stage Regression
Dependent Variable: Per Capita GDP Growth Rate (One Year Lag)

Specification	(1)	(2)	(3)	(4)
Total Number of Natural Disasters (in log)	-0.785* (0.449)		-0.573 (0.460)	-
Log Geophysical Disasters		-0.665 (0.507)		-0.739 (0.561)
Log Meteorological Disasters		0.006 (0.412)		0.034 (0.422)
Log Hydrological Disasters		-0.338 (0.403)		-0.256 (0.398)
Log Climatological Disasters		-1.456*** (0.523)		-1.303** (0.538)
Log Biological Disasters		1.553 (0.994)		1.984* (1.079)
Log Technological Disasters		-0.36 (0.351)		-0.348 (0.353)
Wars	-0.016** (0.006)	-0.016*** (0.006)	-0.019*** (0.006)	-0.019*** (0.006)
Log of Number of Civil Wars	0.001 (0.006)	0.001 (0.006)	0.001 (0.006)	0.001 (0.006)
Banking Crisis	-0.015*** (0.005)	-0.014** (0.005)	-0.015*** (0.005)	-0.013** (0.005)
Debt Crisis Ext	-0.009 (0.010)	-0.0011 (0.011)	-0.016 (0.011)	-0.018 (0.011)
Currency Crisis	0.004 (0.014)	0.003 (0.013)		
Inflation Crisis	-0.029 (0.027)	-0.018 (0.026)		
Currency Crisis (Dummy)			-0.003 (0.009)	-0.006 (0.009)
Inflation Crisis (Dummy)			0.017 (0.011)	0.020* (0.011)
Observations	512	512	503	503
Year Dummy	No	No	No	No
Fixed Effect	Yes	Yes	Yes	Yes
R-squared	0.63	0.64	0.64	0.65
F test: coeff. of IV = 0	4.34	3.55	4.96	3.86
Prob > F	0.01	0.00	0.00	0.00

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4
Results of the Second Stage Regression
Dependent Variable: Per Capita Consumption Growth Rate (One Year Lag)

Specification		**(1)**	**(2)**	**(3)**	**(4)**
Method of Estimation	OLS	IV	IV	IV	IV
Log Income Growth	0.471***	0.449*	0.316*	0.435**	0.192
	(0.000)	(0.271)	(0.177)	(0.201)	(0.223)
Real Effective Exchange Rate	0.421	1.264	0.056	0.047	0.057
	(1.978)	(2.224)	(0.201)	(0.203)	(0.205)
Constant	0.081***	0.131***	0.105***	0.093***	0.119***
	(0.020)	(0.028)	(0.032)	(0.035)	(0.037)
Observations	399	365	365	358	358
Year Dummy	Yes	Yes	Yes	Yes	Yes
Fixed Effect	Yes	Yes	Yes	Yes	Yes
R-squared	0.54	0.47	0.47	0.47	0.47
Overid-Test		5.7	14.9	7.94	10.8
Chi-sq P-val		0.4	0.49	0.49	0.12

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5
Impacts of Disaster on Per Capita GDP Growth Rate (*One Year* Lag)

Specification	**(1)**	**(2)**	**(3)**	**(4)**
Method of Estimation	IV	IV	IV	IV
Natural Disaster	-0.011***	-0.008***	-0.006***	-0.007***
	(0.0002)	(0.0007)	(0.0001)	(0.0005)
War	-0.004***	-0.001*	-0.002***	-0.001***
	(0.0003)	(0.0003)	(0.0002)	(0.0003)
Economic Disaster	-0.007***	-0.007***	-0.004***	-0.004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)

These prediction values for $N_{it}b_N$, $W_{it}b_W$, and $E_{it}b_E$ are computed by the coefficient shown in Table 3 evaluated at the mean values of N_{it}, W_{it}, and E_{it}. * significant at 10 %, ** significant at 5 % *** significant at 1 %.

Table 6
Results of the First Stage Regression
Dependent Variable: Per capita GDP Growth Rate (20 Years Lag)

Specification	**(1)**	**(2)**	**(3)**	**(4)**
Initial per capita GDP	-0.086* (0.051)	-0.086 (0.066)	-0.091* (0.051	-0.095 (0.067)
Total Number of Natural Disasters (in log)	1.807** (0.742)		1.483** (0.663)	
Log Geophysical Disasters		-0.363 (1.219)		-0.197 (1.292)
Log Meteorological Disasters		-0.012 (1.168)		-0.109 (1.194)
Log Hydrological Disasters		0.142 (1.417)		-0.406 (1.478)
Log Climatological Disasters		1.186 (1.146)		0.889 (1.174)
Log Biological Disasters		-0.591 (1.775)		-1.023 (1.787)
Log Technological Disasters		1.85 (1.306)		1.825 (1.301)
Wars	-0.172 (0.104)	-0.2 (0.128)	-0.089 (0.099)	-0.128 (0.116)
Log of Number of Civil Wars	0.059 (0.075)	0.128 (0.106)	0.049 (0.075	0.113 (0.116)
Banking Crisis	-0.092 (0.106)	-0.1 (0.121)	-0.133 (0.109)	-0.166 (0.135)
Debt Crisis Ext	-0.191 (0.120)	-0.196 (0.156)	-0.222** (0.101)	-0.256* (0.096)
Currency Crisis	-0.036 (0.100)	-0.017 (0.18)		
Currency Crisis (Dummy)			0.258 (0.139)	0.365 (0.183)
Inflation Crisis (Dummy)			-0.243* (0.129)	-0.284* (0.150)
Wars (Dummy)	0.382* (0.213)	0.307 (0.252)	0.209 (0.224)	0.104 (0.284)
Log of Number of Civil Wars (Dummy)	0.001 (0.136)	-0.068 (0.169)	0.015 (0.139)	-0.047 (0.174)
Banking Crisis (Dummy)	0.229*** (0.053)	0.353** (0.145)	0.158 (0.161)	0.277 (0.230)
Debt Crisis Ext (Dummy)	-0.145 (0.102)	-0.113 (0.122)	-0.187* (0.092)	-0.173 (0.108)
Currency Crisis (Dummy 2)	-0.204 (0.181)	-0.292 (0.246)		
Currency Crisis (Dummy 3)			-0.029 (0.178)	-0.136 (0.210)
Inflation Crisis (Dummy 2)			0.131 (0.246)	0.192 (0.270)
Constant	1.111*** (0.362)	1.244** (0.491)	1.175*** (0.358)	1.331** (0.506)
Observations	91	91	91	91
R-squared	0.17	0.2	0.19	0.22
F test: coeff. of IV = 0	8.8	4.67	10.02	19.01
Prob > F	0	0	0	0

Robust standard errors in brackets. * significant at 10%; **significant at 5%; *** significant at 1%

Table 7
Impacts of Disaster on Per Capita GDP Growth Rate (20 Years Lags)

Specification	**(1)**	**(2)**	**(3)**	**(4)**
Method of Estimation	IV	IV	IV	IV
Natural disaster	0.231***	0.120***	0.190***	0.083***
	(0.013)	(0.016)	(0.016)	(0.010)
War	0.129***	0.095***	0.080***	0.039***
	(0.012)	(0.010)	(0.007)	(0.005)
Economic disaster	-0.066***	-0.44***	-0.009	-0.019**
	(0.009)	(0.008)	(0.007)	(0.008)

These prediction values for $N_{it}b_N$, $W_{it}b_W$, and $E_{it}b_E$ are computed by the coefficient shown in Table 6 evaluated at the mean values of N_{it}, W_{it}, and E_{it}. * significant at 10 %, ** significant at 5 % *** significant at 1 %.

Table 8
Impacts of Disaster on Per Capita GDP Growth Rate for Small and Large Economies
(Base Year 1960, one year lag)

	Small Economies				Large Economies			
Specification	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Prediction	IV	IV	IV	IV	IV	IV	IV	IV
Natural Disaster	-0.014***	-0.009***	-0.009***	-0.008***	-0.005***	-0.003***	-0.001***	-0.003***
	(0.0013)	(0.0013)	(0.0002)	(0.001)	(0.0003)	(0.000)	(0.0003)	(0.0003)
War	0.007***	0.008***	0.005***	0.008	-0.006***	-0.005***	-0.006***	-0.005***
	(0.0014)	(0.0012)	(0.0012)	(0.001)	(0.0002)	(0.000)	(0.0002)	(0.0002)
Economic Disaster	-0.001	-0.002***	-0.001***	-0.007***	-0.001***	-0.001	-0.001	-0.001***
	(0.0005)	(0.0002)	(0.0002)	(0.002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)

These prediction values for $N_{it}b_N$, $W_{it}b_W$, and $E_{it}b_E$ are computed by the regression coefficients of equation (5) evaluated at the mean values of N_{it}, W_{it}, and E_{it}. The countries are divided into large and small economies by the median GDP in 1960. * significant at 10 %, ** significant at 5 % *** significant at 1 %.