Estimating chronic risk from natural disasters in developing countries: A case study on Honduras

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1. Introduction

Each year, more than 700 major natural catastrophe events shatter lives, destroy assets, and disrupt communities across broad geographic regions, particularly in developing countries. What impact do these natural disasters have on the development of poor countries? It is well known that natural catastrophes cause sharp increases in poverty; what is uncertain is the extent of their long-term impact on the economic viability of developing nations.

The impact of natural disasters depends on two factors: the magnitude of the direct losses due to the event and the economic resilience of the country at the time the event strikes. A number of studies have examined the impact of catastrophes on a specific countries *after* an event occurred. (Benson and Clay 2000) Alone, however, a post-event analysis cannot capture the impact of chronic exposure to catastrophic events in that area. Absent adaptive behavior, each catastrophe renders the country more vulnerable to the next.

To estimate the economic impact of chronic exposure to natural disasters, one must first measure both the expected severity and the expected *frequency* of catastrophic events. One must then develop a methodology to integrate this loss exposure with the expected macroeconomic conditions of the country when the catastrophes strike. This process provides a tool to understand the potential chronic impact of catastrophes on the long-term development of a country and to incorporate catastrophes in the planning process.

In June, 1999, the World Bank, the International Institute of Applied Systems Analysis (IIASA), and the Swiss Reinsurance Company (Swiss Re) created a research partnership to provide such a tool for a series of case study countries. Swiss Re participates by estimating earthquake, windstorm, and flood risk for each case study. The World Bank contributes macroeconomic projection models and data sets to the research project. The IIASA team designed a methodology to integrate Swiss Re's direct loss estimates with the World Bank's estimates of expected macroeconomic conditions at the time of the events. This paper will describe IIASA's methodology and its application to one of the case studies: Honduras.

The paper will first discuss the increasing damages caused by natural disasters in the developing world. The next section will describe the methodology used to measure the chronic impact of catastrophes on the economic growth prospects of developing countries, and show an application of the methodology to Honduras. The last section will describe some potential policy implications of the research project's results.

2. Losses from Natural Disasters

Over the last decade, direct losses from natural disasters in the developing world averaged 35 billion USD annually. These losses are *more than eight times* greater than the losses suffered over the decade of the 1960's. These increasing losses are attributable to both social factors, increasing concentration in hazard-prone urban regions, as well as larger and more frequent weather events. (Munich Re 2000) The enormity of these losses has focused attention on how natural disasters undermine the developing countries' long-term efforts to attain sustainable growth.

Three main categories of natural disasters account for 90% of the world's direct losses: floods, earthquakes, and tropical cyclones (hurricanes and typhoons, primarily). These three events periodically revisit the same geographic zones.[2] Often, the losses can be significant portions of GDP. Swiss Re has identified a series of developing countries for whom losses from floods could be expected to exceed 1% of GDP. Among those countries are Argentina, Ecuador, Honduras, Nicaragua, and China. Brazil has potential losses that approach 1%. (Swiss Re 1998) Munich Re identifies 28 developing countries that have suffered direct losses of more than 1 billion USD from natural catastrophes in the past 20 years.[3] For small countries, losses much less than 1 billion USD can have significant long-term consequences.

[2] Earthquake risk lies along well-defined seismic zones that incorporate a large number of developing countries. High risk areas include the West Coast of North, Central and South America, Turkey, Pakistan, Afghanistan, India, China, and Indonesia. The pattern of hurricanes in the Caribbean and typhoons in South Asia, Southeast Asia, and the South Pacific is well established. Floods occur in 1% of the worldwide landmass. (Swiss Re, 1997)

[3] These are Algeria, Egypt, Mozambique, China, India, Bangladesh, Taiwan, Indonesia, Philippines, Korea, Afghanistan, Armenia, Georgia, Iran, Mongolia, Thailand, Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Venezuela (Munich Re 1998, 1999, 2000).

Modeling Natural Catastrophe Exposure

During the past decade, scientific understanding of the causes and consequences of natural catastrophes has dramatically improved. Models to predict the frequency and severity of catastrophe events have been blended with sophisticated techniques to measure economic vulnerability to catastrophic losses. In the developed world, these models have been used extensively to evaluate potential exposure to natural disaster losses and expand the tools available to absorb these risks. (Kleindorfer and Kunreuther 2000) This activity has not only increased the predictability of natural catastrophes, but also the ability to estimate potential consequences of these events.

For the research partnership's evaluation of hazard risk in Honduras, Swiss Re conducted studies to estimate the country's potential losses from hurricanes, floods, earthquakes, and landslides. Swiss Re derives its estimates of potential losses using geological and meteorological models and its extensive databases of historical catastrophic events and resulting economic losses.

The results of Swiss Re's analysis, combined with an estimate of capital stock in Honduras in 2000 at 13 billion USD, are presented in Tables 1 and 2 below. The return periods in the tables below represent the inverse of the probability of *exceeding* the indicated loss. The term 1-in-100-year event means that there is a 1-in-100 chance, a 0.01 probability, of a catastrophe with equal or greater losses occurring in any given year. Table 1, for example, reads that there is a 0.01 probability of a storm or flood event causing at least 1.6 billion USD of damage, destroying at least 12% of the capital stock.

Storm and Flood Peril		
	Expected capital stock loss	
	in mill. USD	as % capital stock
10-year-event	100	1%
50-year-event	650	5%
100-year-event	1,600	12%
500-year-event	4,000	31%

Table 1: Swiss Re's assessment of storm and flood risk in Honduras

Graphing the results in Table 1 generates the loss-frequency distribution shown on a logarithmic scale in Figure 1 below.

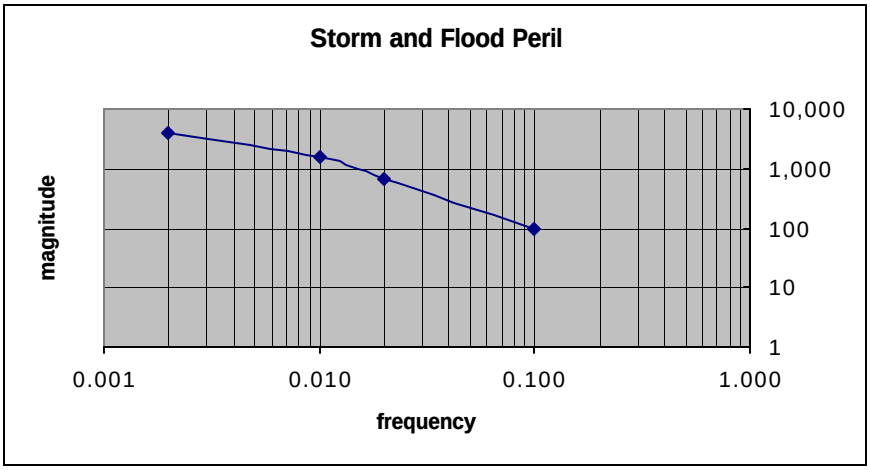

Figure 1: Loss-frequency distribution of storm and flood risk in Honduras.

The annual expected loss is the sum of all the possible losses[4] weighted by the probability of each loss occurring in any given year. The annual expected loss represents the amount of money that on average will need to be set aside every year to fund catastrophic losses when they occur. Since natural catastrophes represent events with low probability and high consequences, it is important to know the potential extremes of the events. The extreme-value losses of the loss-frequency distribution provide this information.

The curve in Figure 1 yields an annual loss estimate of 72 million USD per year due to storm and flood damages.[5] A similar analysis for earthquakes yields an annualized earthquake exposure estimate of 10 million USD. Total annualized hazard exposure is therefore 82 million USD per year, representing approximately 0.63% of the capital stock each year. The extreme values of the distribution are1.6 billion USD losses associated with 1-in-100 year event and 4 billion USD losses associated with 1-in-500 year events.

Capacity to Absorb Loss

Swiss Re's loss figure estimate the direct costs of natural catastrophes. Long-term development impacts of catastrophes depend on how direct losses lead to indirect and secondary costs depending on the country's economic capacity to absorb losses. Generally, losses from natural catastrophes can be grouped in three categories: direct,

[4] This analysis considers exclusively events expected less frequently than once every 10 years.
[5] The annual loss is calculated by integrating to measure the area under the loss-frequency curve.

indirect and secondary effects. Direct losses represent the financial value of damage to and loss of capital assets. In economic terms, direct losses like these can be equated to stock losses. Indirect losses arise from interrupted production and services, measured by loss of output and earnings. These losses can be equated to flow losses in economic terms. Secondary impacts are the short- and long-term impacts upon aggregate economic performance. Secondary impacts could include disruption of development plans, increased balance of payment deficits, increased public sector deficits and debt, and worsened poverty. (Benson and Clay 2000) The following analysis will show that high hazard risk and high vulnerability to macroeconomic losses amplify the indirect and secondary impacts of catastrophes.

Modeling Assumptions

IIASA developed a catastrophe module to incorporate Monte Carlo simulations sampling from Swiss Re's loss-frequency distribution into the World Bank's macroeconomic projection model.[6] In order to shock the capital stock and effective labor force with simulated catastrophe events, the module contains a Cobb-Douglas production function with both capital and labor inputs. The following basic assumptions for countries similar to Honduras, described in Box 1, regulate post-catastrophe response in the module.

- Replacement investment of infrastructure is undertaken by the government sector; replacement investment of non-infrastructure capital stock is undertaken by the private sector;
- The government increases spending on relief efforts for the poor in proportion to their losses in income;
- As incomes fall, the propensity to consume wage income rises to maintain consumption at pre-catastrophe levels;
- Exports decrease proportionally to the loss in total output and imports increase to replace lost food production and to replace lost capital goods;
- In the case of Honduras, foreign financing is supplied at IDA rates[7].

Box 1: Assumptions regulating post-catastrophe response

[6] RMSM, a consistency framework model that tracks the flows of funds through an economy. Refer to (World Bank 1997) for more details.
[7] IDA rates represent 0.75% interest/holding fees, 10-year grace period, and 40-year maturity.

Government expenditures rise post-catastrophe because of emergency rescue and relief spending and investment in reconstruction and repair of infrastructure and other public structures. At the same time, direct and indirect tax revenues decrease because both output and incomes are lower. The government may reduce some of the budget pressure by diverting funds away from other planned projects, but the overwhelming need for short term relief and reconstruction will lead to a net increase in the government deficit.

The sources for financing this fiscal deficit are limited. Since monetary accommodation will magnify inflationary forces already set in motion by the catastrophe, generally the only option for financing the additional government deficit is through additional external borrowing. Foreign aid, if available, may be limited.[8]

Estimating the macroeconomic impact of chronic exposure in Honduras

Integrating loss exposure with macroeconomic projections and the assumptions described in Box 1 shows that planners in Honduras should expect an *average* of 170 million USD annually in additional external funding requirements to meet expected direct and indirect losses, or nearly twice the cost of the annual expected loss.[9]

If this foreign funding is not available, the catastrophe could flat-line growth estimates for Honduras over the next 8 years. Figure 2 demonstrates the effect of incorporating catastrophe exposure into GDP projections. The first trajectory, marked with boxes, represents World Bank projections for expected annual growth rates of 5% to 6%. Sampling from catastrophe events from the loss distribution function in Monte Carlo fashion and averaging over all of the resulting trajectories generates a new growth trajectory, marked with triangles, that incorporates the effects of catastrophe exposure. This new growth trajectory demonstrates that the direct, indirect, and secondary impacts of catastrophe exposure on the Honduran economy are large enough to impede future

[8] As the damages from catastrophes continue to escalate, multilateral aid has been declining. (Red Cross 1999) Aid recipients should question the ability and willingness of donors to support increasing demand for post-disaster assistance.

[9] To demonstrate the potential damage of an extreme event, to finance additional post-catastrophe consumption and full restoration of productive capacity after a 1-in-100-year storm in 2000, Honduras would need 2 billion USD from foreign sources.

growth. This result will occur unless Honduras can consistently obtain sufficient external borrowing to finance post-disaster losses.

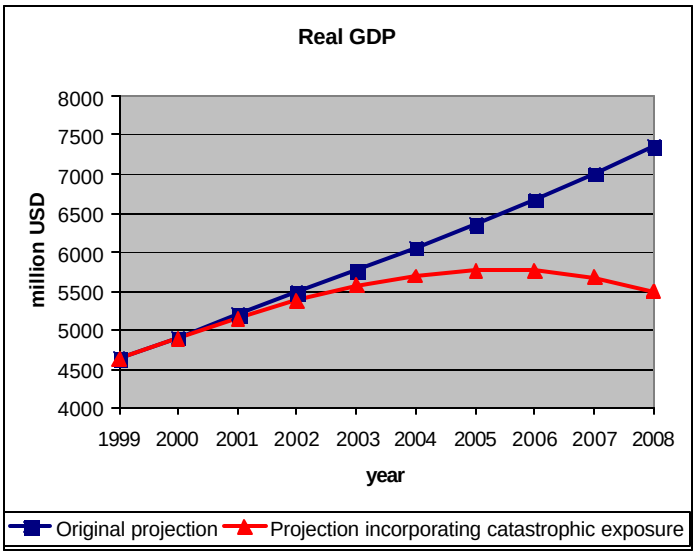

Figure 2: Effect of incorporating catastrophe exposure on GDP projections

Financing Post Disaster Reconstruction

For countries like Honduras, the issue of increased foreign borrowing to finance post disaster reconstruction raises important policy issues. Like other heavily indebted developing countries, Honduras depends on external public borrowing from multilateral and bilateral lenders to sustain its program of infrastructure investment, including post disaster reconstruction. (IMF 1999) In this regard, Honduras is similar to 56 countries since 1980 that have borrowed 7.5 billion USD from the World Bank for post disaster reconstruction, mainly for infrastructure projects. (Gilbert and Kreimer 1999)

Borrowing to fund reconstruction after a catastrophe increases a country's debt but does not increase its ability to repay relative to pre-catastrophe conditions because post-disaster reconstruction focuses on repairing lost infrastructure. With "sustainable" debt an important issue for developing countries, their reliance on external debt as the primary means to finance post disaster reconstruction may exacerbate existing budgetary constraints. (UNDP 2000) Honduras, with a net present value debt-to-revenue ratio of 338 percent and a debt-service-to-revenue ratio of 40 percent in 1998, (IMF 1999)

already has an unsustainable level of external debt. Reliance on external debt to finance post-disaster reconstruction may not be the best long-term policy option for highly indebted countries with high catastrophe exposure.

3. Planning for Disaster

The recognition of natural disaster exposure and its impacts is an important component of long-term development planning[10] for vulnerable countries. Recently, the World Bank has expressed the need for disaster planning to be incorporated at the country assistance strategy level, as part of the benefit/cost analysis at the project approval level, and in formulating long-term strategy for integrating climate change vulnerability into World Bank work. (Burton and van Aalst 1999) Currently, planning for vulnerable countries fails to account for natural catastrophe exposure. Although Hurricane Mitch caused direct and indirect damages to Honduras of 5 billion USD, equivalent to Honduras' total GNP in 1998, and Hurricane Fifi caused a 1999 equivalent of 1.7 billion USD of losses in 1974, the recent joint IMF and World Bank long-term financial projections do not include expected direct losses from future catastrophes in their forecasts. (IMF 1999) It is likely that natural disasters will be the most significant external shock to Honduras in the next 15-20 years.

Summary

Developing countries can improve their ability to absorb the cost of natural disaster events if they incorporate an analysis of the chronic economic impact of catastrophes into their planning process. The methodology created by the IIASA, World Bank, and Swiss Re partnership represents one tool to measure the long-term impacts of catastrophic exposure and macroeconomic vulnerability and identify those countries for which focused attention on disaster planning should be a significant tool in promoting economic growth and reducing poverty.

[10] Planning also extends to loss prevention and mitigation measures. Benefit/cost analysis of infrastructure projects should include the benefit of retaining the returns of long-term, expensive infrastructure projects in countries with a measurable risk of loss, and limited means to restore damaged infrastructure. For those countries, risk prevention and mitigation measures may have very high returns.

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