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Quantifying through Ex Post Assessments the Micro-Level Impacts of Sovereign Disaster Risk Financing and Insurance Programs

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Abstract

Uninsured natural disasters can have devastating effects on human welfare and economic growth, particularly in developing countries where large segments of the population are in poverty and government resources and capacity to assist in relief, recovery, and reconstruction are limited. Therefore there is interest in exploring how these countries can design and implement disaster relief financing and insurance programs. This paper discusses four aspects of the microeconomics of disaster relief financing and insurance programs that are important for the ex post impact evaluation of such programs: (1) use of game setups to analyze the private willingness-to-pay for disaster protection through risk transfer or risk retention instruments; (2) use of ex post analysis of existing disaster relief financing and insurance schemes (such as Mexico's programs) to analyze the willingness to provide political support to such schemes; (3) use of ex post analysis of existing schemes to analyze not only ex post coping with shock, but also the ex ante risk management impact of disaster relief financing and insurance schemes, with the expectation that the latter can have a large effects on growth; and (4) use of mainly global data to do ex post impact analysis of natural disasters and the resilience-enhancing value of disaster relief financing and insurance schemes (examples exist for the disaster-impact relationship that can be extended to the role of disaster relief financing and insurance in risk reduction, coping with shock, and risk management). The paper proposes concrete research projects to pursue the analysis of these four dimensions of micro-level impacts of disaster relief financing and insurance.

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Quantifying through Ex Post Assessments the Micro-Level Impacts of Sovereign Disaster Risk Financing and Insurance Programs[1]

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About the Project

The UK Department for International Development (DFID), the World Bank Group and the Global Facility for Disaster Reduction and Recovery (GFDRR) have partnered to improve evaluation and evidence for sovereign disaster risk financing and insurance (DRFI). The $3.2 million, 3-year (2013-2016) project was launched in 2013, and will develop and test a quantitative impact appraisal framework for sovereign DRFI. The project aims to meet this need by developing a methodology to evaluate a range of DRFI programs and provide quantitative results based on five country-specific case studies, and seeks to understand whether forward-looking impact appraisals can help effectively target support for disaster risk activities. The results will help better target and prioritize future investments from national governments and international donors in sovereign DRFI programs. This paper forms part of the background research underpinning the draft operational framework, to be pilot tested in the case studies in Phase 2 of the project.

Introduction

With exposure to catastrophic natural disasters largely uninsured, developing countries and their populations have difficulties coping with such shocks and effectively managing the risks associated with their occurrences. The consequences are both large losses in welfare and reduced income growth. Livelihoods and assets are periodically destroyed, implying setbacks for capital accumulation and growth. Private investments are deterred by the risk of loss, implying lower growth even in years without catastrophic events. Since catastrophic events are low frequency, over the long run average risk management costs in normal years may exceed average shock coping losses when adversity strikes. Expectations are that the incidence and magnitude of such events will be increasing in the future, making it all the more important to address the problem.

This note explores the design of financial instruments to reduce these negative effects, and discusses how to assess the potential ex-ante and ex-post impact of these instruments on welfare and growth. Relevant financial instruments are multiple, including dedicated reserves/savings, contingent loans, traditional or index-based insurance, and emission of pre-approved catastrophic (CAT) bonds. Ex-ante impact analysis can be done by simulation in calibrated models. Ex-post evaluation can also be done at the more micro level for events with a sufficient frequency of occurrence across time and space. We focus in this note on micro-level analysis.

In the design of a SDRFI product, the decision maker is the state that engages in policy initiatives for protection against shocks. In making these decisions, the national state anticipates the responses of citizens (states, local governments, producer organizations, firms, and households) to reduced exposure to risk. Creating incentives for these agents to optimize risk management is an important motivation in state decision-making toward catastrophic risks. Key for this is commitment that post-shocks relief, recovery, and reconstruction expenditures will be forthcoming, and credibility with stakeholders that commitments will be honored. The choice of financial instruments thus corresponds to both risk layering (matching particular financial products with particular shocks) and the ability to commit that engagements will be honored. Credible commitment may be easier to achieve with instruments such as formal insurance (risk transfer) contracts than with discretionary sovereign reserves (risk retention). There may thus exist a tradeoff between the cost effectiveness and the commitment effectiveness of financial products in inducing agent risk-management responses and in helping agents cope with particular types of shocks. Inducing private risk management responses through better public shock coping must balance moral hazard in reducing private investment in protection against risk and incentives to risk taking in income-generating activities. Design of how public shock-coping services are offered thus requires careful attention, with experimentation or modeling and simulation according to opportunities.

In this note, we start by presenting a conceptual framework that places the role of SDRFI relative to the three channels through which a natural disaster affects development outcomes: risk reduction, risk management, and shock coping. We then explore four

issues at the micro/meso level: willingness to pay for DRFI, political support for DRFI, feedback loops between DRFI and risk management, and use of DRFI to enhance the resilience of economic systems. We use this discussion to propose areas of research that may deserve follow-up in the next phase of the SDRFI Impact Appraisal Project.

A proposed conceptual framework

The conceptual framework we propose is shown in Figure 1. It relates exposure to shocks to three types of government interventions that are part of an SDRFI program: risk reduction, ex-post shock coping, and ex-ante risk management (see Ghesquière and Mahul, 2010, and Mahul, 2011). Shocks (hazards) include such events as cyclones and high winds, floods and droughts, earthquakes and tsunamis, and heat waves and fires. Vulnerability to these shocks (exposure) depends on a large number of factors such as population density, GDP per capita, extent of poverty, corruption, property rights, quality of infrastructure, location of population relative to sources of risk (e.g., flood plains, coastal areas, earthquake faults), and type of economic activity. Kellenberg and Mobarak (2007) for example find that there exists an inverted-U relationship between GDPpc and the level of per capita damages and number of deaths due to natural disasters. Peak exposure is in the $4,000 to $7,000 range where moderate incomes induce individuals to engage in income-generating activities that are more exposed to natural disasters while still investing little in protection and mitigation that will only occur at higher levels of income.

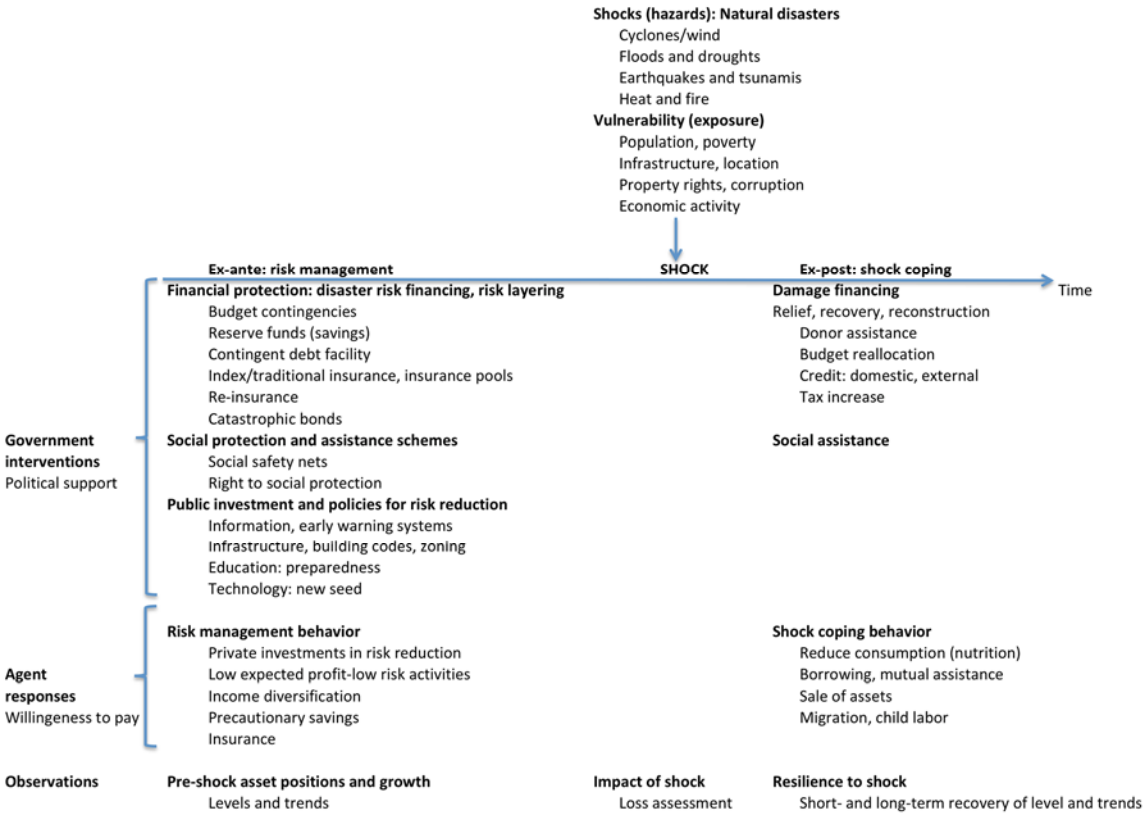

Figure 1. Conceptual framework for the design of SDRFI

Risk reduction is achieved through information on the risk of disasters such as early warning systems, better predictions of where disasters may strike, preventive infrastructure investments, building codes and zoning, education and technical assistance in preparedness, and technological innovations such as stress tolerant farming systems. Risk reduction implies less need for shock coping by agents (resulting in direct improvements in welfare), and also less need for risk management (resulting in indirect improvements in welfare and in greater incentives to invest).

Similarly, better public shock-coping services through relief, recovery, and reconstruction allow better private shock coping, and as a consequence less need for private risk management, inducing both welfare gains and greater incentives to invest. Sources of funding for damage expenditures can come from donor assistance, public budget reallocations, emergency credit from domestic or external sources, insurance payouts, and tax increases to mobilize additional funding.

Finally, long-term recovery and reconstruction depends on the resilience of the economic system that has been affected by a shock, where resilience is the ability to reduce short-term losses and to maximize the ability of "bouncing back". Resilience can be managed ex-ante and can be assisted ex-post, something that we explore further below in the report.

Public DRFI, as an element of public risk management, can thus be an important source of private efficiency gains and income growth, not only through avoidance of destruction of assets or replacement of lost assets, but also (and very importantly) through incentives to invest year after year when there are no shocks. With natural disasters being rare events, the main expected gains from public DRFI may be through the private risk management effect as opposed to through improved shock coping services for citizens.

We believe that calculation of the benefits from SDRFI tends to neglect the gains in private risk management that it induces, thus underestimating returns. Also yet poorly understood, and in need of additional empirical analysis, are the determinants of resilience of economic systems and use of policy instruments to enhance resiliency. We explore both in what follows.

Issues with SDRFI: A discussion

1. **Assessing the willingness to pay for disaster risk financing by national governments and stakeholders**

It is well known that agents tend to under-insure against catastrophic risks. This comes from both the supply and the demand sides of insurance. On the supply side, private insurance providers are reluctant to offer insurance for events with uncertain low probabilities, and high losses when disasters strike. Prohibitively costly and missing re-insurance markets limit the supply of private insurance. On the demand side, there are four reasons for under-insurance. The first is lack of information on the true level of risk.

This can be because information is simply missing, or because the search costs for this information and insurance coverage are too high. The second is a tendency to underestimate the true probability of disaster as it applies to oneself. There are well known behavioral inconsistencies associated with hyperbolic discounting, Monte Carlo fallacy with recency bias (reinforcement learning with negative updating as time passes), and denial of self-exposure to particular risks. The third is narrow bracketing, in the sense that consistency is not achieved in insurance coverage across categories of risk (Rabin, 1998). Some risks may be over-insured while most (background risks) are under-insured. The fourth is strategic behavior toward public shock-coping interventions. This is the typical Samaritan's dilemma due to moral hazard behavior. The fact that the state offers aid affects the recipient's behavior, inducing him to take more risks and under-insure, and consequently increase the "need" for future aid.

If the state considers designing a DRFI program, it needs to assess two behavioral responses to make an optimum decision. The first is agent responses to changes in exposure to residual risk after a DRFI program has been introduced; the second is the degree of political support the state will get if it engages in fiscally costly risk protection. These two behavioral responses need to be known to appraise the expected impact of risk of DRFI.

We have experience in assessing willingness-to-pay in insurance games (de Janvry, McIntosh, Povell, and Sadoulet, 2013). In these games-in-the-field, agents such as farmers are presented with randomized risk scenarios combined with access to different financial instruments. Decisions are made and rewards collected according to outcomes. Games can be managed to approximate stakes in real-life situations. Results show that the demand for index-based insurance varies in relation to background and basis risk (as predicted by Clarke, 2011). Specifically, we find that demand for insurance against a particular risk declines with the level of background risk. Demand for hybrid insurance can also be assessed. In the particular case of coffee cooperatives in Guatemala, there is a great deal of interest in institutional level index-based insurance, but rules for the intra-group distribution of payouts on an observed damage basis need to be clearly codified to have ex-ante credibility and induce demand for the hybrid product. Since most catastrophic insurance is index-based and contracted at the level of an institution, credible commitments on how payouts will be allocated intra-institution is equally key to mobilize willingness to pay (or political support) for this type of insurance.

Results from insurance games also show that willingness-to-pay is typically well below fair price. Hence the need for subsidies to initiate take-up. This has raised the important question of how best to use one-time subsidies to induce repeated purchase of insurance coverage. Using an RCT to study weather insurance take-up in China, Cai et al. (2014) find that people learn about insurance not by holding an insurance policy (habit formation from use) but by witnessing insurance payouts either to oneself (learning-by-doing) or to others in your social network (learning-from-others). Subsidies may have the disadvantage that they undermine attention given to learning from observed payouts, but the advantage of broadening immediate adoption and hence the occurrence of payouts that can be witnessed and on the basis of which learning takes place. Since most

insurance products need initial subsidies to be taken up, careful RCT experimentation on how best to use subsidies to induce stable demand at fair price is an important issue. Similar games can be organized to reveal how agent behavior will adjust to protection against extreme events, and willingness to co-pay for such protection in a public-private partnership.

Given the extent of behavioral inconsistencies in the decision to invest in risk-reduction and to insure, and the need to anticipate agent responses to design public-private partnerships in SDRFI, we believe that conducting such experiments is a necessary first step.

2. Is there political support for DRFI?

It is well known that disasters are politically risky. Inadequate response to shocks has cost their tenure to many governments. At the same time, governments will only devote fiscal resources to DRFI if they receive electoral support for this initiative. Assessment of electoral support to DRFI can be done ex-post through the analysis of natural experiments with existing schemes of protection against natural disasters, or ex-ante in insurance games eliciting responses on political support.

Mexico offers a unique opportunity to analyze ex-post electoral responses to disaster protection. As we describe it in the country case study for Mexico, there are three schemes that can be analyzed as natural experiments in that perspective: FONDEN at the federal level, CADENA at the state level, and Fondos de Aseguramiento at the local institutional level.

CADENA provides insurance against drought for farmers through a state-level insurance that is free to farmers. It has been shown to induce positive risk management responses as observed through higher yields where coverage is available (Fuchs and Wolff, 2011). Fuchs and Rodriguez-Chamussy (2011) have analyzed the impact of insurance payouts on voter behavior in the 2006 presidential election. The unit of analysis is the electoral section, and the question is whether payments received by farmers in the electoral section in 2005 (by which time Agroasemex insured 15 states) affected voting behavior toward the incumbent political party in the 2006 election. The identification strategy is a regression discontinuity design based on the index insurance threshold rainfall levels to trigger payments. They find that disaster relief buys votes. The incumbent party is estimated to have garnered 8% more votes where indemnity payments had been made prior to the election, a gain attributed to voter switching political party rather than to increased electoral turnout.

We propose to analyze these three schemes in a political economy perspective. This is important to assure governments that there is political support for DRFI and to help determine how political support can be enhanced without falling into the temptations of populism. FONDEN started operating with a combination of risk-retention and risk-transfer instruments in 2006 (World Bank, 2012). Data on payments can be obtained and matched onto electoral outcomes at the presidential, governor, and municipal levels.

Analysis of CADENA can be extended to state and municipal level elections with better use of the discontinuities in payments for identification purposes. Fondos is one of the most advanced experiences in the world in hybrid insurance, with an interesting combination of risk retention and risk transfer instruments (Ibarra and Mahul, 2004). It also deserves careful attention, including in the political economy dimension due to the role of the public sector (Agroasemex) in helping manage the scheme. Political economy considerations should be both in the direction of payouts to votes (swing voter model) and of votes to payouts (core supporter model). A key issue here is the role of information in order to discipline public expenditures, thus avoiding clientelistic use of shock coping expenditures and achieving electoral accountability (Ferraz and Finan, 2008).

3. Feedback loops: Evaluating the impact of commitment in risk reduction and risk coping on household-level decisions toward risk management

Risk reduction and better risk coping services can help households reduce costly risk management. If this is the case, disaster risk financing can have a double gain for households: a **direct** welfare gain in reducing post-shock losses through various types of expenditures for relief, recovery, and reconstruction; and an **indirect** efficiency gain through incentives to invest in risky income earning activities while controlling for moral hazard behavior. This indirect effect can be very large, especially if losses associated with disaster events are large and infrequent.

We give here two examples. One is risk reduction through technological innovations delivered as international public goods. The other is social safety net programs with access provided as a legally enforceable right.

Example of flood resistant rice, Swarna-Sub1

In India, 30% of the area cultivated in rice is subject to flash flooding, leading to crop destruction when flooding lasts more that 3-4 days. The CGIAR and its local partners developed a new rice variety, Swarna-Sub1, that can survive under water for up to 17 days, and resume its growth once flooding has receded. It is thus a technological innovation that reduces vulnerability to climate shocks, which are becoming more frequent with climate change. What are the consequences of this increased resilience to climatic shocks on shock-coping and risk management? Use of this example is to show that the expected gain over time from risk reduction can be as, if not more, important due to risk management than it is from shock-coping.

Based on the results of a randomized control trial (RCT) in Orissa, we observe that Swarna-Sub1 offers a 45% yield gain relative to the current most popular variety, Swarna, when plots are submerged during a 10 days period (Dar et al., 2013a). The avoided yield loss through use of this improved seed is on average 232hk/ha. We also find that this variety protects differentially more producers from the disadvantaged social casts who, over the course of history, have been pushed onto the lands most exposed to

flood risks. This risk-reducing innovation is thus both efficient in enhancing capacity to cope with shocks, but also equitable in favoring the most excluded social groups.

Reduction of the risk of crop loss in case of flooding induces behavioral changes among farmers who cultivate Swarna-Sub1. Using the RCT in Orissa, we observe that, during the second year of the experiment, producers who use the technology cultivate more land in rice, use more fertilizer early in the season in spite of the risk of flooding, reduce the use of traditional seeds which are less productive but also less risky, and use more costly labor-intensive transplantation methods that result in higher yields. The yield gain derived from all these practices is, on average, 283kg/ha. The technology also induces less holding of precautionary savings and more use of credit (Dar et al., 2013b).

The lesson from this micro-level experiment in risk reduction for SDRFI is that the gain by avoided loss in bad years (improved shock-coping) can be more or less equal to the gain that would not have been obtained in good years (reduced need for risk-management). If there are two normal years for one bad, the expected gain from risk management in good years can be double the expected gain from shock coping, even though the intervention (like SDRFI) is typically motivated just by the latter. This is an important result in establishing the economic rationale and in mobilizing political support for SDRFI in reducing the consequences of a natural disaster.

Other examples of committed risk coping

The argument made here is that a key aspect of SDRFI is availability of a credible commitment device that relief, recovery, and reconstruction expenditures will be forthcoming post-disaster at a given pace, in a given magnitude, and for well-identified stakeholders. It is well known that one of the main weaknesses of public programs, and policy reforms in general, is lack of commitment devices for governments when there is a time consistency problem (Hoff and Stiglitz, 2008). “Read my lips” statements are not credible, and democratically elected leaders have short-term horizons and can be challenged in re-election. Authoritarian regimes cannot guarantee length of tenure and may consequently be seen as “roving bandits” (Olson, 1993). For this reason, a number of governments have turned to constitutional rights, enshrining at the highest levels of the law the right to social protection (HLPE-CFS, 2012). This has applied to the right to work through India’s Mahatma Gandhi National Rural Employment Guarantee Act (NREGA). Countries like Brazil, India, and South Africa have introduced major programs to implement the right to food (de Schutter, 2013). In Brazil, this is done through the Zero Hunger Program, Bolsa Familia, and the National School Meals Program. In India, the right to food is implemented through subsidized food delivered by the Public Distribution System running Fair Price Shops. The right to work is delivered through the NREGA that guarantees 100 days of employment per adult and per year. In South Africa, the rights to food and to social security are implemented through seven social grants including Old Age Pensions and Child Support programs.

The key point here is that legally enforceable rights not only improve shock coping, but also can induce sharp reductions in risk management, with the associated

welfare and investment/growth costs. These social protection programs have typically been evaluated for their shock-coping value. Largely left to be done is to quantify their risk management value so that expected benefits can be fully assessed. Public protection will induce moral hazard behavior, but efficiency gains may surpass losses due to moral hazard. The Mexican CADENA program of disaster protection for agriculture induced positive efficiency gains in spite of moral hazards (Fuchs and Wolff, 2011). If SDRFI schemes can achieve credible commitment, then their expected benefits could be significantly enhanced. How to do this is an important design issue, including recognition of trade-offs between cost efficiency and commitment value of different financial instruments.

We propose to analyze the three Mexican programs from the angle of shock coping and risk management. From what we know of the programs, identification strategies should be feasible for all three programs.

4. Understanding and managing resilience: Natural experiments

Reducing a system's vulnerability to shocks implies building its resilience. A SDRFI scheme could be designed to maximize the resilience of a socio-economic system. For this, we need to understand how resilience is achieved and could be assisted through financial services.

Resilience is a dynamic concept, associated with the process of "bouncing back". It is the ability of a system to absorb a shock, maintain its structure and functions with a minimum of losses, and resume pre-event functionality in a relatively short period of time. For an economic system, it is the ability to return to its pre-shock growth trajectory. Resilience can fail if the system is sufficiently diminished as to lose its ability to bounce back. In this case, the opposite of resilience is falling into a poverty trap.

The literature offers numerous analyses of the conditions that secure the resilience of ecological systems and the derived concept of sustainability. Ciriacy-Wantrup (1969) thus proposed the concept of a "Safe Minimum Standard", a threshold below which loss is catastrophic, negating sustainability. A high level of resilience is associated with a high level of biodiversity. Loss of biodiversity beyond a minimum threshold can prevent an ecological system from bouncing back. In economics, the modeling of resilience contrasts the acceleration of growth following a shock according to the neo-classical Solow model, to a level of per capita income falling below a subsistence consumption threshold implying that saving and investment are zero (Azariadis and Drazen, 1990). Unless the subsistence consumption level is exceeded again, growth cannot resume and the economy is in a poverty trap. Resilience thus requires a minimum transfer to resume the ability to save and grow. At the firm level, there typically is a threshold level of capital endowment below which accumulation cannot occur (Eswaran and Kotwal, 1986). Decapitalization below this level prevents bouncing back into accumulation. At the community or district level, lack of resilience may be due to the destruction of assets, the displacement of population, and the discontinuity of education and health services. Prior economic conditions are important determinants of resilience, with poverty, corruption,

and weak administrative capacity diminishing resilience. Lack of factor mobility across regions can also reduce resilience in responding to a shock. Incomplete and uncertain property rights over land also undermine resilience as they reduce incentives to invest in risk reduction and hamper relief and reconstruction efforts.

An empirical application that has analogies with natural disasters is exposure to bombing during a war. Miguel and Roland (2011) thus studied the long-term effects of bombing during the war in Vietnam. The unit of analysis is the district level. They find no effect on poverty, consumption levels, electricity infrastructure, literacy, and population density after a 25-year period. Others have similarly found no impact of war on long-term economic conditions in Japan and Germany, with a 15-20 years lag. Other studies have identified the long-term impact of weather shocks or civil wars (Alderman et al., 2006; Akresh et al., 2011) on human welfare using a combination of intensity of shock and cohort analysis.

County-level analysis of the long-term consequences of the Dust Bowl in the United States shows that environmental destruction (soil erosion) led to sustained decline in agricultural land values and revenues for some 30 years after the event (Hornbeck, 2012). While a turning point in land value is observed 30 years after, in the high erosion counties recovery had still not been achieved more than 60 years later. A decline in population rather than agricultural adjustments has been the main form of economic response. So, resilience may be difficult to achieve, and recovery may remain incomplete for a very long period of time, if the natural disaster quasi-permanently affected the stock of natural resources as in the case of loss of top soil accumulated over the millennia.

Countries can however successfully invest in enhancing their resilience to particular repeated natural disasters. Hsiang and Daiju (2012) analyze the deaths and damages provoked by tropical cyclones worldwide for the period 1950 to 2008. They find that countries with more intense tropical cyclone climates suffer lower losses from similar events, indicating successful investment in adaptation to tropical cyclone risk. Jina (2014) finds that exposure to floods in Bangladesh increases child stunting, but that the effect is less severe where exposure to floods is more frequent, suggesting adaptation and the buildup of resilience.

Destruction of assets and loss of human life may continue for some time after disaster before recovery occurs. Analyzing post-hurricane disasters in the Philippines, Anttila-Hughes and Hsiang (2014) find that unearned income and excess infant mortality in the years after typhoon exposure outnumber immediate damages and death tolls roughly 15-to-1. This suggests that speed in relief expenditures is important for resilience, an important objective of a DRFI scheme. The role of aid in post-conflict recovery has been analyzed by Collier and Hoeffler (2004), Demekas et al. (2002), and Elbadawi et al. (2008). Biases in the allocation of post-disaster aid have been analyzed by Strömberg (2007). Issues of endogeneity in both conflict and aid need to be carefully addressed.

A study of resilience is thus not only an analysis of the long-term consequences of a shock, but of the time path of the process of asset destruction, decumulation, and

subsequent accumulation and recovery. We propose that additional econometric analyses can be done of the extent of resilience following a natural disaster, with the purpose of identifying heterogeneity of resilience capacity and the factors that contribute to resilience and can be financed through DRFI. Ideally, a survey is conducted immediately after a shock to measure the stock of assets, and the loss of assets using recall data for periods prior to the event. The unit of analysis can be the community/district, the firm, and/or the household. Follow-up surveys allow tracking the process of recovery. Questions can be asked about the channels through which recovery was achieved, including access to public sources of assistance and their sources of financing. Contrasts can be made according to the intensity of shock and the degree of exposure of the specific population group (e.g., a cohort of age) to which the unit of analysis belongs.

Alternatively, recent availability of global data such as the Global Climate Data (www.worldclim.org/) and the WHO's International Emergency Disasters Database (EMDAT) allows to characterize the occurrence of natural disasters in time and space at a world scale. This information can be overlaid with socio-economic data from sources such as the DHS and Population Censuses to measure the impact of natural disasters in well-identified natural experiments. An example is the analysis of the health impact of forest fires in Indonesia by Jayachandran (2009). If expenditures in risk reduction and/or expenditures in relief, recovery, and reconstruction operations are similarly documented in time and space, their roles in enhancing resilience and mitigating impacts of natural disasters can be measured. This opens a new set of possibilities for ex-post impact analyses of SDRFI that should be explored.

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