Disaster Risk Financing and Insurance: Issues and results

Edited by:

Daniel Clarke
Alain de Janvry
Elisabeth Sadoulet
Emmanuel Skoufias

Disaster Risk Financing and Insurance: Issues and results

Report on a workshop held at the Ferdi on June 4 and 5, 2015

edited by:
Daniel Clarke
Alain de Janvry
Elisabeth Sadoulet
Emmanuel Skoufias

This paper benefited from the financial support of the program
"Investissement d'Avenir" (reference ANR-10-LABX-14-01) of the French government.

The Authors

- Danamona **Andrianarimanana**, University of California at Berkeley.
- Laura **Boudreau**, University of California at Berkeley and The World Bank.
- Daniel **Clarke**, The World Bank Group / GFDRR.
- Stefan **Dercon**, Department for International Development (DFID).
- Alan **Fuchs**, Poverty and Equity Global Practice.
- Francis **Ghesquiere**, Word Bank and Global Facility for Disaster Reduction & Recovery (GFDRR).
- Ruth **Hill**, The World Bank Group.
- Alain **de Janvry**, University of California at Berkeley.
- Olivier **Mahul**, The World Bank Group / GFDRR.
- Craig **McIntosh**, University of California at San Diego.
- Francesca **de Nicola**, The World Bank Group.
- Bazoumana **Ouattara**, University of Manchester.
- Catherine **Porter**, Heriot-Watt University.
- Richard **Poulter**, The World Bank Group / GFDRR.
- Felix **Povel**, Kreditanstalt für Wiederaufbau (KfW), Frankfurt.
- Elizabeth **Ramirez Ritchie**, University of California at Berkeley.
- Lourdes **Rodriguez-Chamussy**, World Bank, Poverty and Equity Global Practice.
- Elisabeth **Sadoulet**, University of California at Berkeley and Ferdi.
- Emmanuel **Skoufias**, The World Bank Group.
- Eric **Strobl**, École Polytechnique.
- Tse-Ling **Teh**, The World Bank Group / GFDRR.
- Alejandro **del Valle**, Paris School of Economics.
- Jan **Vermeiren**, Kinetic Analysis Corporation.
- Stacia **Yearwood**, Caribbean Catastrophe Risk Insurance Facility.
- Emily **White**, The World Bank Group – Finance and Markets Department.

Table of contents

Introduction

Daniel Clarke
Alain de Janvry
Francis Ghesquiere

Why the need for disaster risk financing and insurance?

Losses due to natural disasters have increased sharply over the last 30 years. This has been caused by population growth, greater concentration of population in urban environments, and more accumulation of assets that can be destroyed by natural events. Hazards have also risen with climate change and are expected to grow exponentially. What is remarkable, however, is that the gap in insurance protection between uninsured and insured natural catastrophes has been increasing, with some $125 billion uninsured losses compared to $50 billion insured worldwide in 2014, an insurance coverage of less than 30% (Economist, 2015). Industrialized countries are exposed to larger absolute losses due to asset accumulation, while developing countries are exposed to larger relative losses (in percentage of GDP) and to greater human costs. Nearly 90% of disaster related deaths between 1991 and 2005 occurred in developing nations. In the 2015 Nepal earthquake, only some 3% of the damage reaching 25% of GDP was insured. Lack of financial protection against disasters leads to slow recovery, costly financing of relief and reconstruction, and political manipulation in the allocation of post-disaster assistance.

For this reason, many countries have started to introduce Disaster Risk Financing and Insurance (DRFI) schemes. A leading pioneer in doing this is Mexico with both a national strategy for financing the reconstruction of disaster-affected public assets, FONDEN, and a scheme specifically targeted at protecting smallholder farmers from yield losses due to drought, CADENA. Smaller countries have collaborated in regional risk pooling through such institutions as the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the African Risk Capacity for East and West Africa, and the Pacific Catastrophe Risk Insurance Pilot. These programs enable governments to make regular payments in good years in return for financial protection in bad years, making financial resources more readily available when natural catastrophes occur and at a lower long-term cost. The programs typically combine access to funding through different instruments according to the magnitude of the shock and the country capacity: accumulated reserves and precautionary savings, contingent credit, risk transfer through index-based insurance and re-insurance, post-disaster budget reallocations, and post-disaster borrowing. How to optimally layer these sources of financial liquidity is explored in the essays in this volume.

Well-designed and implemented DRFI schemes can have advantages both ex-ante for better risk management and ex-post for better shock coping. They help increase the timeliness of transfers, reduce the opportunity cost of transfers, increase discipline, improve information on risks and expected transfers, and enhance country control (ownership) over relief and reconstruction initiatives. Ex-ante risk management includes better risk planning and investments in more resilient infrastructure and livelihoods. Ex-post risk coping saves on loss of livelihoods and accelerates economic recovery. Essays in this volume provide us with unique results from rigorous impact evaluations of some existing schemes. They also look into the politics of DRFI. It is well known that incumbent politicians get blamed for the losses derived from natural catastrophes. Less well known is whether DRFI buys votes and helps discipline politicians in refraining them from using relief transfers for clientelistic purposes.

Summary of results from papers presented at the workshop

Impact of natural disasters

To develop appropriate policy responses to the threats posed by natural disasters, it is necessary to first quantify their impacts on welfare. In particular, we must consider heterogeneous impacts among different subsets of the exposed population, as well as the consequences of potential coping strategies adopted by vulnerable populations. Andrianarimanana (2015) addresses precisely this question as she analyzes the impact of cyclones on economic outcomes and other welfare indicators in Madagascar. This analysis finds that direct impact of cyclones is borne primarily by rural populations in Madagascar, affecting access to electricity, assets, and income, and resulting in higher poverty. While urban households are not directly impacted by cyclonic shocks, they do suffer indirect impacts, as they provide transfers to their rural counterparts. Urban to rural transfers ease the impact of the cyclone on perhaps the most vulnerable populations. However, these transfers could be quite costly for urban households, in terms of foregone consumption or investments. Thus, further research is needed to understand the net benefits of inter-household transfers as a coping strategy.

Natural disasters can have not only micro-level impacts, such as those detailed above, but also macro-level impacts. Strobl, Ouattara, Vermeiren, and Yearwood (2015) provide empirical evidence of these effects using data from the Caribbean region. In particular, they estimate the quantitative impact of hurricanes on fiscal revenue, expenditure and debt for a set of Caribbean countries. Their results show that total revenue is reduced by about 17%, but that only current expenditure, as opposed to total public expenditure, increases in response to the event. The average hurricane event increases current expenditure by approximately 17%. In total, they find a large and immediate impact of hurricanes on monthly budget deficits of about 20%.

Natural disasters can have a negative effect on welfare not only through their direct impact (e.g., destruction of infrastructure, crop losses) but also through decisions that households make to reduce their exposure to these events. Hill and Skoufias (2015) study the impact of weather risk on ex-ante risk-management strategies, which are frequently overlooked when considering the impact of weather risk. Ignoring adaptations that households make in order to reduce their vulnerability to shocks will underestimate the negative impacts of extreme climatic events. Irrespective of whether a shock is realized or not, low-risk, low-return strategies come at a cost in the sense that they have long-lasting negative effects on human development as well as on the accumulation of physical capital (investment) and growth. The emerging literature on poverty traps and chronic poverty underscores the relationship between risk and chronic poverty as well as the potential offered by innovations in risk management. Hill and Skoufias seek to quantify the impacts of uninsured risk in two studies. The first study uses observational data to explore the effect of weather risk on occupational choice. The analysis reveals that high rainfall variability reduces households' degree of specialization in agriculture relative to other occupations. The diversification in occupational choice serves as self-insurance against adverse weather shocks affecting agriculture but could come at a cost if specialization improves productivity. As further evidence of the effect of risk on occupational diversification, they find that the presence of irrigation attenuates this relationship, presumably by reducing ex-ante rainfall risk. The second study by Hill and Skoufias uses a randomized field experiment in Senegal and Burkina Faso to compare farmers who are offered index-based agricultural insurance with those who are offered a variety of savings instruments. They find that the insurance product provides a better way for farmers to manage risk as evidenced by the fact that insured farmers spend more on agricultural inputs, including fertilizer, which in turn increases yields at harvest time. This finding suggests that risk-avoidance strategies, such as decreasing risky planting-stage investments, are commonplace. Furthermore, these risk avoidance strategies have a clear cost for farmers – lower yield and ultimately lower incomes.

Models of DRFI

Given the body of evidence regarding the impact of extreme climactic events, a natural question is what actions governments can take to mitigate these effects and how to fund and organize these efforts. The collection of essays begins with a theoretical approach to understanding different disaster risk financing and insurance (DRFI) approaches, both in terms of their potential costs and benefits. This discussion is followed by evaluations of existing DRFI programs. The collection of essays concludes with an analysis of the political economy of these programs, since understanding the incentives politicians face is crucial to the eventual implementation of any successful DRFI scheme.

Economic analyses of vulnerability to poverty rely on historical weather shocks to develop a relationship between these shocks and poverty among affected households. Porter and White (2015) take an innovative approach of combining these vulnerability analyses with forward-looking catastrophe risk modeling to understand the potential welfare effects of extreme events not represented in the historical record. They use data from rural households in Ethiopia to develop a model relating drought hazard to household poverty outcomes, as measured by per capita consumption. The main objective of this exercise is to test the validity of this novel approach and develop recommendations for improving upon this method. In particular, they use a subset of their data to develop the model, and test the predictions of the model on a separate subset of data, allowing them to evaluate the predictive power of their model.

De Nicola (2015) takes a conceptually similar approach, combining data from the 2011 Living Standard Measurement Study (LSMS) survey in Niger to evaluate the potential impacts of rolling out a new social protection scheme in Niger. This case study answers two important questions. Firstly, can governments rely on meteorological and agronomic data to identify the potential beneficiaries of a social protection program? While existing social protection programs rely on household-level data to target aid to beneficiaries, this approach can be costly and slow. Thus, using meteorological and agronomic data to accurately target beneficiary households using index-based transfers could represent a substantial improvement over the current approach. Secondly, De Nicola explores the tradeoffs, in terms of welfare, of expanding the number of beneficiaries relative to increasing the level of benefits under a given cash-transfer program. Preliminary results indicate that index-based cash-transfer programs have the potential to substantially improve welfare, although additional research is necessary to confirm the reliability of this approach. Secondly, the pervasiveness of poverty across Nigerien regions suggests that expanding the number of program beneficiaries results in the greatest welfare gains compared to increasing the level of benefits.

McIntosh, Povel, and Sadoulet (2015) develop a theoretical model to explain patterns of demand for another tool that addresses weather risk, namely index-based weather insurance. Index-based weather insurance has had low effective demand in spite of the attractiveness of the product in avoiding moral hazard in insurance claims. This analysis uses a set of field experiments to assess willingness to pay for index insurance among coffee producers in Guatemala. Sadoulet et al. show that the probabilistic nature of the insurance is one of the main features that makes it unappealing to farmers. This result is due to a secular dislike of uninsurable risk that manifests itself even when the actual probability of contract non-performance is minimal, and is consistent with the overweighting of small probabilities in Prospect Theory. Thus, increasing demand for index insurance will require modifications of the insurance product to cover multiple risks, such as more effective indexing and/or directly indexing outcomes (e.g., average area yield) instead of the determinants of these outcomes such as rainfall.

While government interventions have immense potential to reduce the adverse consequences of natural disasters, adequate planning for their implementation and appropriate use of financial instruments to fund these efforts can greatly improve their efficacy and cost-effectiveness. Clarke and Dercon (2015) argue that in the aftermath of disaster events, a systematic recovery and reconstruction phase is often hampered by strategic interactions between the national government, subnational government, donors, and affected people. As a result, recovery processes may be characterized by delays in response, underutilization of economies of scale, and reliance on costly financing instruments. These pre- and post-disaster inefficiencies can lead to a sluggish recovery process and increase both the economic and human cost of disasters. By developing solid plans for disasters, such inefficiencies can be avoided and a better humanitarian and disaster risk reduction system can be achieved. In particular, Clarke and Dercon conclude that in order to better prepare for disaster events, governments should have (i) a coordinated plan for post-disaster action agreed in advance, (ii) clearly defined rules and triggers for disaster response, and (iii) risk financing to ensure that the plan can be implemented in the event of a disaster.

Disaster risk financing is identified as a crucial component of any plan for disaster response, and governments have shown increasing interest in implementing Sovereign Disaster Risk Financing and Insurance (SDRFI) programs in an attempt to be financially prepared for when disasters occur. However, to date limited attention has been given to developing and implementing a coherent quantitative framework for appraising the true economic cost of these various instruments. Therefore at present, governments have no way of determining whether the programs and financial strategies they are employing are appropriate and efficient, bearing in mind the risks they face. In post-disaster situations, the requirements for critical and rapid expenditures can lead to governments using high-cost instruments, such as budget reallocations and borrowing on unfavorable terms (Benson and Clay, 2004). Bevan and Cook (2015) provide guidelines as to how to value the cost of post-disaster public budget increases and reallocations. By comparison, sovereign DRFI instruments can protect the national budget and improve the speed at which capital is available and expenditure is undertaken, reducing the economic impact of natural disasters (Goes and Skees (2003), Linnerooth-Bayer and Mechler (2007)).

Clarke, Poulter, Mahul, and Tse-Ling (2015) carry out an analysis of DRFI with the intention of building an evidence base and developing a methodology to quantify the development impact of investments aimed at building financial protection against disasters. Evaluating sovereign DRFI programs is a difficult exercise as it requires research and insights from a variety of different disciplines, including risk modelling, micro-, macro- and public economics, actuarial science, and political economy. While it is not possible to quantify the development impact of sovereign DRFI strategies on every outcome that may be of interest, their analysis seeks to quantify the effects along two dimensions: the cost of capital, and the timeliness of financial instruments in providing funds. They analyze the cost of combining the following instruments: (1) reserves, contingency funds or ex-ante budget allocation of funds, (2) contingent credit at concessional interest rates, such as the World Bank Development Policy Loan with Catastrophe Deferred Drawdown Option, (3) risk transfer such as indemnity or parametric insurance, reinsurance, and catastrophe bonds or swaps, (4) post-disaster budget reallocations, and (5) post-disaster borrowing. The analysis first provides quantitative evidence that using different financial instruments in combination is indeed the most cost-efficient way to finance disaster losses. Furthermore, the proposed framework provides a methodology for selecting the sovereign DRFI strategy that meets one of either two goals: minimizing the cost of financing the average annual loss or minimizing the cost of financing losses at a given return period.

Impact evaluations of government interventions

To understand whether ex-ante budgeting allocations for post-disaster reconstruction provide a cost effective way of mitigating losses due to natural disasters, the model-based approach of Clarke et al. can be complemented with an empirical evaluation of an existing SDRFI program. By taking advantage of the sharp rules that govern the municipal level eligibility for infrastructure reconstruction funds in Mexico, de Janvry, del Valle, and Sadoulet (2015) provide estimates of the impact of disaster funds on local economic activity. Their main finding is that access to disaster funding increases local economic activity under the FONDEN program by as much as 2.6% one year after damage from heavy rainfall has occurred. They also find that the average benefit cost ratio of Mexico's disaster fund is 1.3.

Ramirez (2015) provides a second evaluation that looks at a different tool used by the Mexican government to insure states against adverse weather shocks. This program called CADENA currently insures small farmers, primarily against agricultural losses caused by extreme weather. A large portion of the agricultural land that the program covers is insured via weather index insurance. As in del Valle et al., this analysis exploits sharp thresholds determined by insurers to evaluate the impact of insurance payments in the case of a weather shock. Ramirez finds that insurance payouts increase the area of land growing insured crops in the subsequent growing season, while having no impact on yield. Preliminary results also point to positive effects on income and expenditure per capita in rural localities, particularly in municipalities where a large percentage of agricultural land is controlled by eligible producers.

Political economy of disaster relief

Lastly, the collection of essays turns to an element of disaster risk financing where perhaps less evidence exists but that is equally important for successful implementation of an SDRFI scheme, the political economy of disaster relief. Fuchs and Rodriguez-Chamussy (2015) provide evidence on this question by estimating the effect of a government climatic contingency transfer on Presidential election results in Mexico. These transfers are allocated through the same weather index insurance program CADENA cited above. Using the discontinuity in payment based on a pre-established rainfall threshold, they show that voters reward the incumbent presidential party for delivering drought relief compensation. Fuchs and Rodriguez-Chamussy find that receiving indemnity payments leads to an increase in average electoral support for the incumbent party of approximately 7.6 percentage points. Their analysis also suggests that the incumbent party is rewarded by disaster aid recipients and punished by non-recipients. This paper provides evidence that voters evaluate government actions and respond to disaster spending, contributing to the literature on retrospective voting.

Given evidence suggesting that voters punish politicians for the occurrence of natural disasters but reward them for the allocation of post-disaster aid, a natural question is how politicians respond to these incentives. More importantly, do SDRFI programs help to eliminate these incentives through transparent rules that govern politicians' behavior (Dana and Von Dahlen, 2014). Boudreau (2015) examines these questions in the context of Mexico, using Mexico's FONDEN SDRFI strategy. Her analysis finds that voters punish incumbent political parties for the occurrence of natural disasters. It also finds that the Mexican governors are more likely to request, and the Federal Government is more likely to declare, natural disasters during election years. Finally, evidence suggests that while using parametric thresholds to determine natural disaster declarations may help to discipline politicians in election years, the fact that some types of events do not use thresholds may erode parametric thresholds' disciplining value.

Policy implications for governments and donors

The objective of disaster risk financing and insurance is to help minimize the cost and optimize the timing of meeting post-disaster funding needs without compromising development goals, fiscal stability, or wellbeing. It promotes comprehensive financial protection strategies to ensure that governments, homeowners, small and medium-sized enterprises, agricultural producers, and the most vulnerable populations can meet post-disaster funding needs as they arrive.

Disaster risk financing and insurance sits at the nexus of four major policy practices: disaster risk management, in terms of how it contributes to building resilience; public financial management, in terms of how it addresses the impact of shocks on public finances; financial sector development, in terms of how it builds a strong financial sector for risk transfer; and social protection, in terms of how it supports contingent financing to reach the poorest.

Experience suggests that disaster risk financing and insurance strategies are best advanced when integrated into broader strategies in one or more of these fields.

Disaster Risk Financing and Insurance strategies can assist countries in addressing their disaster risks in a sound and sustainable manner. Without adequate disaster risk management strategies, disaster events can jeopardize efforts to end poverty and reverse hard-won development gains. Experience has shown that in the immediate aftermath of a disaster, countries can experience significant economic instability and public sector budget variability, leading to reduced coverage and quality of public services and higher debt levels transferred onto future generations. As an increasing body of evidence shows, financial protection against disaster risks can assist countries in mitigating these adverse impacts of disasters by providing liquidity in the immediate aftermaths of disasters.

Through financial protection against disaster risks, countries receive timely and targeted assistance, thereby reducing the economic and human costs associated with disasters. In the aftermath of a disaster, a sluggish reconstruction process may lead to significant economic costs as the provision of public services is interrupted and business opportunities are lost. Delays in relief can unleash epidemics that worsen the immediate cost of destruction. This interruption may have effects on poverty levels, as those that are vulnerable are pushed into poverty. It may also create irreversibility in child schooling and health. Evidence shows that immediate assistance following disasters is crucial in reducing the economic and human costs of disasters.

Financial protection against disasters can assist countries in reducing their dependence on post-disaster budget reallocation and emergency calls for donor assistance. To finance the immediate needs following a disaster, countries often continue to rely on ad-hoc budget reallocation and the provision of humanitarian aid. However, by diverting public spending away from other budgeted lines, needs in other sectors of the economy remain unmet. Moreover, humanitarian aid is often related to media coverage, making it difficult to predict, and may arrive late during the onset of the disaster. Also, humanitarian aid is often provided at the expense of pre-established programs, thus leading to opportunity costs as the benefits of other programs are lost. The establishment of a Disaster Risk Financing and Insurance Strategy can reduce countries' dependence on budget reallocation and humanitarian assistance, thereby achieving a more timely disaster response, safeguarding the public budget from post-disaster expenditure, uncoupling humanitarian response from media coverage, and providing the type of assistance the country requires.

While the benefits of using disaster risk financing and insurance instruments to manage disaster risks can be large, the specific situation of the country is important. Many different options are available for addressing post-disaster financial needs. Some of these are available after disasters strike – such as borrowing, budget reallocation, and humanitarian aid – and others need to be established ex ante – such as a disaster risk fund, contingent credit, and insurance. These options differ in their cost, amount of funding made available, and timeliness of disbursements. Thereby, each instrument addresses different needs, and may be more or less adequate depending on the specific situation of the country. For instance, to efficiently address the needs of a country, understanding the timing of needs is essential. While immediate liquidity is required to finance relief and early recovery efforts, more time is available to mobilize funding for the longer-term recovery process. On the other hand, market-based risk transfer is effective but expensive, making it particularly suitable to finance immediate post-disaster needs following low frequency, high intensity events. By combining different risk instruments such that a government is able to meet the contingent liabilities of its disaster response plan as these liabilities fall due, governments can manage their disaster risks in a cost-efficient, timely, and effective manner.

Managing disaster risks well requires strong leadership by a country's ministry of finance and clear risk ownership. Disaster risk financing and insurance brings together disaster risk management, fiscal risk and budget management, public finance, private sector development, and social protection. Strong stewardship by the ministry of finance in coordination with other public agencies is crucial to successfully advance this agenda. Moreover, risk ownership is crucial to clearly define who is responsible for covering risks. By establishing the respective responsibilities of the government, donors, the private sector and households in advance, governments can achieve greater transparency, accountability and predictability, thereby creating a better environment for businesses to thrive in.

The private sector represents a key counterpart for successful disaster risk financing and insurance. By providing capital, technical expertise and innovative solutions, the private sector may complement government initiatives to advance their disaster risk financing and insurance agenda. For instance, private insurance and reinsurance companies represent key counterparts to transfer disaster risks to the market, thereby acting as risk bearers. A further important contribution of the private sector is the provision of technical expertise, such as, for instance, in assessing losses, designing insurance products, underwriting catastrophe exposure and settling claims. By bringing together the government's capacity to lead a country's overall Disaster Risk Financing and Insurance agenda and the private sector's financial and technical capacity, public-private partnerships can represent an efficient solution to manage disaster risks.

Looking ahead, Disaster Risk Financing and Insurance will form an increasingly important part of government's broader disaster risk management and climate change adaptation agenda. A report by the IPCC (2012) finds that economic losses from weather- and climate-related disasters have increased. Moreover, the report holds that "it is virtually certain that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century at the global scale". In light of these findings, managing the risks associated with disaster events will become increasingly important. To systematically address disaster risks, a country's Disaster Risk Financing and Insurance strategy should be integrated into a holistic risk management framework, ensuring a coordinated approach to reaching both disaster and climate-related policy goals.

Conclusions and implications for research

Despite the significant gains made in some countries in managing the financial costs of disasters, many countries continue to rely on post-disaster budget reallocations and humanitarian assistance to manage the financial liabilities associated with disasters. To advance further towards a more sustainable strategy for managing disaster risks, it is important to be able to quantify the government's contingent liability associated with disaster events, and to develop a comprehensive risk financing strategy to achieve faster, cheaper, and more reliable financing of disaster risk.

Disaster Risk Financing and Insurance is a long-term agenda that requires political will, technical expertise, and time. While simple measures can quickly support improved financial protection, more complex financial solutions and institutional change require technical expertise and political support. Effective partnerships within and between governments, and with the private sector can support governments on this path.

The research presented in this collection of briefs paints quite an encouraging portrait of the potential for Disaster Risk Financing and Insurance solutions to have meaningful development impact. However, what is also clear is that the details of such solutions matter tremendously for impact and sustainability. Not all attempts to strengthen Disaster Risk Financing and Insurance have led to the operational success of the programs discussed above, and future work in this area needs to build on a strong evidence base, a clear understanding of successes and mistakes, and of how solutions can be structured to be both technically sound and politically sustainable.

Countries differ in their exposure, vulnerability and risk, and in their financial and technical capacity to sustain post-disaster losses. Through a stronger evidence base on what programs work where, Disaster Risk Financing and Insurance frameworks can be adapted better to the specific needs of the countries. Some of the benefits will be quantifiable and tangible, as planning for disasters in advance will lead to lesser costs of post-disaster needs. Some of the benefits will, however, also be less tangible, such as for instance, the knowledge of being well prepared for when a disaster strikes the next time.

References

- **Andrianarimanana, D.** 2015. "The role of inter-household transfers in coping with post-disaster losses in Madagascar." Ferdi Workshop.
- **Benson, C.** and **E. Clay.** 2004. "Understanding the economic and financial impacts of

natural disasters: Disaster risk management." Washington D.C.: The World Bank.
- **Bevan, D.** and **S. Cook.** 2015. "Public Expenditure Following Disasters." The World Bank, Disaster Risk Financing and Insurance Program, Policy Research Working Paper 7355.
- **Boudreau, D.** 2015. "Discipline and disasters: The political economy of Mexico's sovereign disaster risk financing program." Ferdi Workshop.
- **Clarke, D.** and **S. Dercon**. 2015. "Planning for disasters and the economics of disaster risk financing and insurance." FERI Workshop.
- **Clarke, D.**, **R. Poulter**, **O. Mahul** and **Tse-Ling**. 2015. "Ex-ante evaluation of the cost of alternative sovereign DRFI strategies." Ferdi Workshop.
- **Dana, J.** and **S. von Dahlen**. 2014. "An overview of potential pathways to appraising impact of sovereign drfi: Where should we be looking to assess benefits?" The World Bank: SDRFI Impact Appraisal Project.
- **de Janvry, A.**, **A. del Valle**, and **E. Sadoulet**. 2015. "Insuring Growth: The Impact of Disaster Funds on Economic Development." Ferdi Workshop.
- **De Nicola, F.** 2015. "Expanding or increasing: Index-based scalable social protection in Niger." Ferdi Workshop.
- **Economist (The)**. 2015. "Insurance in Asia: Narrow-minded. Asia can do more to protect itself from the risk of natural catastrophes." June 13 printed edition.
- **Fuchs, A.** and **L. Rodriguez-Chamussy**. 2015. "Voters Response to Natural Disasters Aid: Quasi-Experimental Evidence from Drought Relief Payment in Mexico." Ferdi Workshop.

- **Goes, A.** and **J. Skees**. 2003. "Financing Natural Disaster Risk Using Charity Contributions and Ex Ante Index Insurance." Paper presented at the annual meetings of the American Agricultural Economics "Association, Montreal, Canada, July 27–30.
- **GFDRR**. 2014. "Financing Protection Against Natural Disasters; An operational Framework for Disaster Risk Financing and Insurance." The World Bank.
- **Hill, R.** and **E. Skoufias**. 2015. "Ex-Ante Risk Management and Implications for Sustainable Poverty Reduction." Ferdi Workshop.
- **Intergovernmental Panel on Climate Change (IPCC)**. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. (C. B. Field, V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, et al., Eds.) (pp. 1–582). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- **Linnerooth-Bayer**, **J. and R. Mechler**. 2007. "Disaster Safety Nets for Developing Countries: Extending public-private partnerships." *Environmental Hazards* 7(1): 54-61.
- **McIntosh, C.**, **F. Povel** and **E. Sadoulet**. 2015. "Utility, Risk, and Demand for Incomplete Insurance." Ferdi Workshop.
- **Porter, C.** and **E. White**. 2015. "The application of a probabilistic catastrophe risk modeling framework to poverty outcomes: General form vulnerability functions relating household poverty outcomes to hazard intensity in Ethiopia." Ferdi Workshop.
- **Ramirez, E.** 2015. "Weather-indexed insurance and productivity of small-scale farmers: An impact evaluation of Mexico's CADENA program." Ferdi Workshop.
- **Strobl, E.**, **Bazoumana O.**, **J. Vermeiren**, and **S. Yearwood**. 2015. "The Fiscal Implications of Hurricane Strikes in the Caribbean." Ferdi Workshop.

Impacts of natural desasters

Chapter 1

The role of inter-household transfers in coping with post-disaster losses in Madagascar

Danamona Andrianarimanana

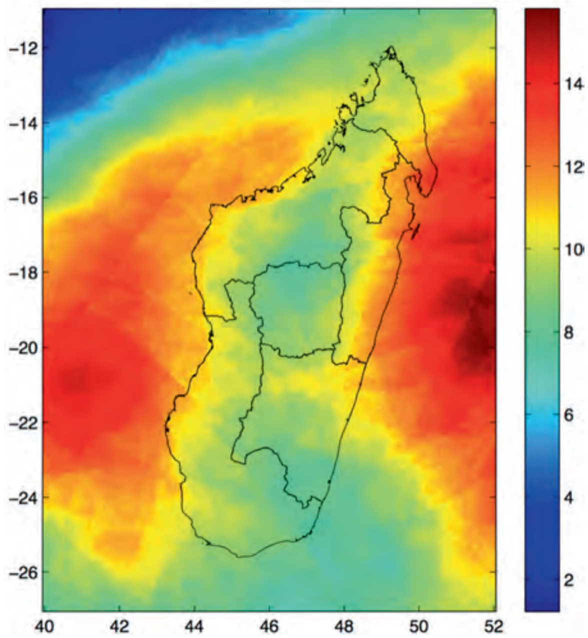
Abstract
While the intensity of a natural disaster can be uniformly measured across space, its impact largely depends on the economic conditions of the receiving households and communities. Richer countries can experience greater absolute financial losses but poorer nations often suffer greater relative financial losses (relative to GDP) and significantly more human losses: nearly 90% of disaster-related deaths between 1991-2005 occurred in developing nations. Moreover, setbacks from loss of businesses, assets, and livelihoods can have irreversible or very long-term consequences in developing countries. Therefore, how policy makers and communities cope with post-disaster losses is extremely important. In this paper, I evaluate the impacts of cyclones on households in Madagascar and find that inter-household transfers play an important role in coping with post-disaster losses.

•••/••• I first identify rural households as being most affected by weather shocks: for them, cyclones have a negative and significant impact on access to electricity, assets, and income, resulting in higher poverty. While urban households are not directly impacted by cyclonic shocks, they do suffer from the indirect impacts of rural shocks through transfers. A rural shock in the previous year leads to reduced expenditure and higher probability of being poor among surrounding urban households. The net effects of benefits to rural households from urban transfers versus any possible missed opportunities of urban households due to social assistance is unclear and needs further research.

Introduction

Madagascar is the second most exposed country to multi-disaster risks in Africa, and experiences multiple episodes of cyclones, droughts, floods, and locust invasions every year. In particular, Madagascar experiences three to five cyclones a year, which results in a high exposure varying in intensity across the island (Figure 1).

Figure 1. Madagascar's cyclone exposure, calculated as average of yearly maximum wind speeds (in meter per second) achieved over provinces between 1950 and 2008.



Five out of the twenty million people inhabiting the island were identified as living in zones at risk of natural disasters (Global Facility for Disaster Reduction Recovery, 2013). Using a lagged exposure model following Anttila-Hughes and Hsiang (2012)'s empirical estimation of post-disaster losses within households in the Philippines, I evaluate the impacts of tropical cyclones on urban and rural households in Madagascar and the role of inter-household transfers in coping against post-disaster losses. I find that, in rural households, the average cyclone that hits during the previous year leads to a 2.4% decrease in the probability of having access to electricity in the current year, has a significant negative impact on households' assets and expenditure, hence increasing the probability of being poor in the year following the cyclone. While urban households do not appear to be directly impacted by cyclonic shocks, they do indirectly suffer from cyclones impacting rural households due to the negative income shocks in the form of transfers.

Research question

What are the direct and indirect impacts of weather shocks on households' well-being (access to public goods, assets, and income) in a developing country setting?

Data

Cyclone data are obtained from the International Best Track Archive for Climate Stewardship (IBTrACS) database compiled by the National Oceanic and Atmospheric Administration (NOAA). This database contains cyclone tracks for Madagascar from the year 1970 to 2010 and are recorded as 6-hour observations over every 1/34°×1/34° pixel. Information on household assets, income, consumption and transfer is obtained from the cross-sectional periodical household survey, EPM (Enquête Périodique Auprès des Ménages), conducted by Madagascar's National Statistics Bureau (INSTAT). The EPM consists of a series of multi-thematic surveys, representative at the national and the regional levels. The EPM survey was collected in 1993, 1997, 1999, 2001, 2004, 2005, and 2010.

Empirical strategy

I use the following cyclone lagged exposure model:

$$Z_{hct} = \Sigma_{L=0}^{5} [\alpha_L W_{c,t-L}] + \tau_t + \mu_c$$
$$+ \xi X_{(hct)} + \epsilon_{(hct)}$$

where h indexes households, c indexes communes, and t indexes years.
Z is the outcome of interest (asset, income, health outcome, etc) while W is the cyclone windspeed. τ is a year fixed-effect, μ is a commune fixed-effect, and X is the vector of observable household characteristics.ϵ_{hct} is an error term for household-level disturbance. Five-year lags are included and Conley clusters are used for calculation of standard errors. Finally, maximum windspeed, the variable of interest in all future regressions is calculated as the maximum windspeed reached by each cyclone within the commune (maximum windspeed over all 1/34°×1/34° pixels constituting a commune).

Identification comes from the random nature of the timing, path, frequency, and intensity of cyclones. Furthermore, I have conducted a randomization check (running the baseline regression on household characteristics) that showed that there is no self-selection of certain types of households based on exposure. This is also consistent with the analysis on migration that showed that migration movements are extremely rare among the households in the sample.

Results

To estimate the impacts of weather shocks on household well-being, I focus on three categories of outcomes: 1) access to public goods measured as access to electricity, 2) households' short run outcomes: assets and expenditure, and 3) poverty status which is a composite measure calculated based on assets, income, and consumption. Since rural and urban households are expected to be differentially impacted by cyclones due to differences in quality of infrastructure and choices of economic activities, estimation of the main regression above is always done separately for the two subgroups.

Impact on rural households

As expected and as reported in Table 1 panel A, cyclones lead to significant reduction in wellbeing among rural households:

- **Access to electricity:** Column 1 reports the impact of being hit by a cyclone on a household's probability of living in a house with electricity: a one-meter per second increase in maximum windspeed is associated with a 0.1% decrease in the probability of living in a house with electricity the year after the cyclone, significant at the 5% level. Given that the average cyclone has a maximum windspeed of 24.6 meter per second (88.6 kilometer per hour), the average effect of a cyclone on a rural household is a 2.4% decrease in probability of having access to electricity. This small effect is not surprising given that access to electricity in rural household is as low as 26%.

- **Assets:** The dependent variable in the regression reported in column 2 is the variable "Solid Walls", a dummy equal to 1 if the household lives in a house made with brick, concrete or hard wood and equal to 0 otherwise. It can be seen that the impact of cyclones on housing is persistent, significant, negative and extremely large in magnitude: -0.009*** for the same year and for the first lag (22.1% per cyclone), -0.016*** for two lags (40% per cyclone). The negative and significant sign of the cyclone occurring in the past twelve months is expected as this is saying that assets reconstruction takes time: if parts of the house (a wall, the roof), were taken down by a cyclone in the past year, it might take a household more than twelve months to rebuild a sturdy replacement, regardless of whether previous walls were solid or not, due to high costs of building such asset. The persistence of the coefficients on the lagged years however seem to suggest that solid walls are not build or rebuild even for shocks that have happened as far as three years before the survey.

- **Expenditure:** The impact of cyclones on household expenditures (logarithmic form) is reported in column 3. In rural households, the average cyclone is associated with a 12.3% (0.5 percentage change * 24.6) decrease in household expenditure. Since this is the impact on general expenditure, it must be a result of decrease in income or increase in savings. The earlier is a much more probable explanation as agricultural yield and income were also shown to have significantly decreased due to cyclones (Table not shown).

- **Poverty:** Finally, column (4) of Table 1 reports the effects of being hit by a cyclone on the probability of being below the national poverty line. The national poverty line is calculated by INSTAT based on an evaluation of households' assets, income, and consumption. A cyclone occurring during the 12 months prior the survey is associated with a 7.4% increase in the probability of being categorized as poor during that same year.

Impact on urban households

As shown in Table 1 Panel B, none of the coefficients for cyclones occurring in the immediate year prior to survey are significant, even for electricity and solid walls, consistent with the fact that urban areas have better infrastructure. Lagged cyclone coefficients suggest that in urban areas, a household that was hit by a cyclone three years ago has an 8.4% higher probability of being poor in the current year, a result that has no obvious explanation.

Overall, these results are not too surprising and add to the literature of weather shocks showing that natural disasters are important phenomena that lead to statistically significant differentiated effects: urban households seem unaffected whereas rural households suffer from cyclones along several dimensions. These results are robust to functional form of wind speed variable (quadratic and cubic form), number of lags included in the model as well as lengths of lags (from three-month lags to three-year lags instead of yearly lags). We expect that both rural and urban households will be negatively impacted by extreme events, with higher magnitudes of losses for urban households. However, we do not have enough data points to test this and we are left with the story of urban households being unaffected by storms. However, this is not the full story. There is a more complex coping mechanism that can be understood by looking at inter-household transfers.

Table 1. Impacts of cyclones on household wellbeing

VARIABLES	(1) Electricity	(2) Solid Walls	(3) Log Exp	(4) Poverty
Maximum Windspeed	Panel A: Rural			
t and t-12 months	-0.001**	-0.009***	-0.005**	0.003***
t-12 and t-24 months	0.001**	-0.009**	-0.001	0.005
t-24 and t-36 months	0.001	-0.016***	-0.005	0.005**
	Panel B: Urban			
t and t-12 months	0.000	-0.004	-0.000	-0.002
t-12 and t-24 months	0.000	0.001	-0.001	-0.001
t-24 and t-36 months	-0.000	-0.006	-0.001	0.004***

Robust standard errors in parentheses /// *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Note: Coefficients are estimated using Year and Commune Fixed-Effects and Conley clustered standard errors. Demographic covariates are controlled for in all regressions. Five year lags are included but only the first three lags are reported here.

Indirect effect on urban households through transfers

Transfers play an important role in the Malagasy society: intra-household transfers alone amounted to USD 160 millions in 2010. 59.7 % of households in the household survey sample were involved in such transactions (35% of the households in the sample have sent a transfer to another household and 24% have received a transfer).

Transfer data consist of records of whether a household has received (sent) a transfer as well as the amount, reason, and frequency of the transfer received (sent). The categorized reasons of transfer are: pension, indemnization, scholarship, festivities and customs, support, support to family, taxes and other. The transfer data have some limitations. First, the existing categorization of reasons for transfer does not include natural disasters hence I define my "Received relief transfer" variable as having received a non-regular transfer while living in a commune that had experienced a cyclone. I only focus on transfers that were labeled for support, support to family, and others. Second, data on the other end of the transfer including sender location is not available so that I am not able to directly code the flow of transfers by location (urban-rural, rural-urban, rural-rural and urban-urban).

Focusing on disaster relief related transfers, 87% of transfers come from family members and less than 1% of relief comes from the government. As reported in Table 2, windspeeds are important predictors of relief transfers in both urban and rural areas: the probability of receiving a transfer for a household that lives in a commune hit by a cyclone increases with windspeed. The average cyclone is associated with a 12.3% higher probability of receiving a transfer in urban areas and a 7.4% higher probability of receiving a transfer in rural areas. This evidence is in support of strong solidarity between households and a good response of transfers to natural disasters.

Table 2. Probability of receiving and sending a relief transfer

	(1)	(2)
VARIABLES	Received a transfer	
Maximum Windspeed	Urban	Rural
t and t-12 months	0.005***	0.003***
t-12 and t-24 months	0.001**	-0.001
t-24 and t-36 months	0.000	-0.000

Robust standard errors in parentheses /// *** p < 0.01, ** p < 0.05, * p < 0.1
Note: Coefficients are estimated using Year and Commune Fixed-Effects and Conley clustered standard errors. Demographic covariates are controlled for in all regressions. Five year lags are included but only the first three lags are reported here.

Finally, Table 3 shows the indirect effects of a shock impacting rural (urban) households on urban (rural) households. Since the unit of observation is at the household level, it is impossible to observe a shock for both rural and urban. So far, what we have seen is the impact of cyclones on households that were actually hit by cyclones or direct effects. To look at indirect effects, we want to test whether urban (rural) households'wellbeing are affected when rural (urban) households receive a weather shock. To test this, I proxy for rural (urban) shocks by calculating the average windspeed across rural (urban) communes within a district. A higher rural (urban) shock will reflect a higher intensity of storm or a higher share of the rural (urban) communes within the district being hit by a cyclone. In both cases, the likelihood of receiving a transfer should be higher. This implies that we assume that ties between rural and urban households are bound within district (recall Madagascar is divided into 111 districts and 1200 communes), an assumption that we have to make given the data limitation. We are then able to not only look at how urban (rural) households themselves are affected by cyclones themselves, but also to control for shocks happening to their rural (urban) counterparts.

Table 3. Direct and indirect impacts of cyclones

VARIABLES	(1) Log Exp	(2) Poverty	(3) Log Exp	(4) Poverty
Maximum Windspeed	Urban households		Rural households	
t and t-12 months	-0.000	-0.002	-0.005**	0.004***
t-12 and t-24 months	-0.000	-0.001	-0.001	0.006
	Indirect shocks through rural		Indirect shocks through urban	
t and t-12 months	-0.007	-0.007	-0.007	-0.005
t-12 and t-24 months	-0.028***	0.017*	-0.003	-0.013

Robust standard errors in parentheses /// *** p < 0.01, ** p < 0.05, * p < 0.1
Note: Coefficients are estimated using Year and Commune Fixed-Effects and Conley clustered standard errors. Demographic covariates are controlled for in all regressions. Five year lags are included but only the first three lags are reported here.

As can be seen from column (1) and (2), while the coefficients of windspeed on expenditure and poverty are not significant for urban households, cyclones impacting rural households within the same district lead to large and significant decreases of expenditure and increases in poverty for urban households. While the coefficients for the same year are not significant, for the year before the survey, a one-meter per second increase in the average windspeed in rural areas surrounding urban households within a same district is associated with a 3% reduction in expenditure. That is, if all rural areas in the district experienced an average cyclone then this would lead to a 70% decrease in urban households' expenditure. It is of course unlikely that all communes of a district would be hit by a cyclone. Similarly, a one-meter per second increase in the average rural shock is associated with a 2% increase in the probability of the urban household of being poor. (Average effect of a cyclone hitting all rural communes within a district on urban household is 42% increase in the probability of being poor.) For rural households, direct shocks of being themselves hit by cyclones on expenditure and poverty are significant but there are no indirect impacts from urban shocks.

Conclusion

To sum up, we have seen that, while looking at access to electricity, assets, expenditure, and poverty, rural areas are most vulnerable to cyclones and urban areas appear to be largely unaffected. These results are not surprising given the better infrastructure in urban areas (cyclones have no significant impact on housing) and since urban households do not rely as much on agricultural income and activities as rural households do. These results do not change when conducting several robustness checks.

When looking at transfers, however, we find that transfers to both rural and urban areas are very responsive to cyclone shocks. A very large majority of transfers come from relatives and from urban households. Looking into the possible indirect effects of rural shocks on urban households, we find a large and significant reduction in well-being of urban households associated with rural shocks happening the year before the survey. That is, a rural shock in the previous year leads to lower expenditure and higher poverty. A possible explanation for this is that relief transfers might divert resources away from urban households that could have been used on insuring basic needs as well as on investments on productive assets in the current year. I do not find a similar indirect impact channel for rural households. The net effects of benefits to rural households from receiving urban transfers versus the costs to urban households of social assistance as well as the potential impacts of having formal insurance are unclear and require further research.

References

- **Anttila-Hughes, J. K.** and **S. M. Hsiang**. 2012. "Destruction, Disinvestment, and Death: Economic and Human Losses Following Environmental Disaster." isites.harvard.edu.
- **Global Facility for Disaster Reduction Recovery**. 2013. Country Program Update, Madagascar, May 2013.

Chapter 2

The Fiscal Implications of Hurricane Strikes in the Caribbean

Bazoumana Ouattara
Eric Strobl
Jan Vermeiren
Stacia Yearwood

Abstract

Tropical storms put considerable strain on the government sector of those countries affected. This has led to, for instance, in the Caribbean, to the creation of the mulit-country insurance pool, the Caribbean Catastrophe Risk Insurance Facility, which can provide some coverage for fiscal shortages to those countries affected. Nevertheless there is still not clear idea to what exact extent countries will suffer shortages in fiscal funds. In this study we compile data and estimate the quantiative impact of hurricanes on fiscal revenue, expenditure and debt for a set of Caribbean countries. Our results whow that total revenue is reduced, but that only current expenditure increases in response to the event, resulting in an overall rise in debt. We also predict that expected losses are likely to differ widely across the region.

Worryingly losses associated with tropical storms have risen considerably over the last few decades and are currently estimated to be about $US 26 billion a year. Moreover, some predict that the intensity of these phenomina may increase with climate change. In this regard, arguably the small disaster prone island economies in the Caribbean are particularly vulnerable, as their limited budgetary capacity prevents them from establishing sufficient financial reserves to absorb such potentially large negative shocks. Added to this, their high level of debt restricts their ability to access credit in the aftermath of a natural disaster, while high transaction costs associated with the relatively small market restricts access to private catastrophe insurance covering potential losses. International aid also does not provide a solution since, when it comes, it is often too little and too late.

A demonstrative example of the consequences of such financial shortfalls in the Caribbean was the case of Hurricane Ivan, which struck Grenada in 2004 causing losses twice the size of the island's GDP. In the immediate aftermath the country was no longer able to finance its public service bill, but had had no budget contingency in place or access to the private insurance given the relatively small market. It was thus was forced to introduce a number of revenue enhancing measures and delay efforts of recovery and reconstruction in order to address the fiscal shortfall, thus likely further amplifying the long term effects of the hurricane. In fact it is in response to such fiscal vulnerability to natural disasters that in 2007 a number of Caribbean economies established the Caribbean Catastrophe Risk Insurance Facility (CCRIF), a multi-country risk pooling scheme that can provide members with almost immediate fiscal relief when a natural disaster occurs. As a matter of fact, since its inception the CCRIF has issued over US$ 23 million as a consequence of 4 tropical storm events alone.

Payouts to participating members under the CCRIF as a consequence of a tropical storm are made according to the storm's physical characteristics, predicted losses, a country's risk profile, and a country's loss coverage, the latter being the only choice parameter of a country. Ultimately the country's chosen coverage will, however, depend on its expectations with respect to the impact of a tropical storm event on its fiscal sector. In this regard, there are only a handful of statistically based studies which can provide quantitative indication as to the actual short-term fiscal shortfalls in response to a natural disaster event, and these provide mixed evidence of an impact on the fiscal gap of countries. However, all existing studies only look at the impact of natural disasters events in terms of annual data. One suspects in this regard that much of the true short-term fiscal reaction is likely `netted out' in annual terms, and thus can only provide limited insight into how severe such fiscal shortages in reality are likely to be.

In this study we address the limitations of the current literature by explicitly examining higher frequency, i.e., monthly, fiscal reactions to natural disaster events. Additionally, and unlike previous studies, we also provide estimates of return periods of fiscal shortages in an extreme value theory framework. To these ends, we compile a data set of monthly potential hurricane losses and fiscal expenditure and revenue over the 2000-2012 period for a set of Caribbean countries. We combine these data with destruction estimates derived from actual hurricane tracks and a detailed spatial distribution of assets. Our econometric analysis on this data shows that government revenue drops immediately after a shock, while there is no discerning significant effect on total public expenditure. More specifically, an average hurricane reduces revenue by 17.6 per cent, while the largest observed event reduced it by more than 200 per cent. Examining the main components of expenditure, however, we discover that current expenditure increases temporarily two months following the shock.

More specifically, an average event caused a 16.8 per cent rise in current expenditure. Overall, we find that there is an immediate and sizable impact on Caribbean economies' monthly budget deficit, namely 20.3 per cent for the mean hurricane strike. Using our estimates and extreme value modeling we that return periods of significant fiscal impacts may be considerable for many of the island economies in the Caribbean. For instance, a 100 per cent debt increase is likely to occur within the next 57 to 174 years, depending which island one considers.

Chapter 3

Ex-Ante Risk Management and Implications for Sustainable Poverty Reduction

Ruth Hill
Emmanuel Skoufias

Introduction

The recent global financial crisis, and the food and fuel price increases in 2008-2009, unfolding in the context of increasing concern and awareness about the negative impacts of climate change on the poor have highlighted the fragility of progress in the fight against global poverty.

These crises together with the apparent slowdown in growth globally reveal that progress in poverty reduction and shared prosperity may be easily undermined by the high levels of vulnerability prevalent in many developing countries. Economic crises and price shocks aside, the incidence of natural disasters, extreme weather events and climate change-related shocks, civil conflicts, crime and violence, health shocks and illnesses, infectious diseases and pandemics may also contribute separately and sometimes in unison, to pushing the vulnerable households below the poverty line, and the poor into deeper poverty.

Depending on the ability of households to protect themselves through formal or informal arrangements, and the capacity of existing social safety net programs (when available) to expand coverage to the "new" poor in times of need, the impacts of such covariate and idiosyncratic shocks on poverty may be large, and associated with potentially severe and long-lasting negative effects in human development.

The increased appreciation of vulnerability as a potential threat to the sustainability of poverty reduction efforts has led to renewed interest among policymakers in risk management systems.[1] Disaster risk financing and insurance (DRFI) strategies are at the core of efforts to allow governments of developing countries to cope with weather shocks, natural disasters and other shocks in a rapid, predictable, and cost effective fashion.

The purpose of the two papers summarized in this brief is to reinforce the point that DRFI strategies are important not only for protecting household welfare from covariate and idiosyncratic shocks but also for fostering economic growth, and maintaining social stability. We argue that neglecting to take this properly into account, and valuing DRFI solely based on the impact of disasters on welfare when they occur, will result in a systematic under-estimation of the value of DRFI strategies for reducing poverty.

In a risky environment and in the absence of finance and insurance markets, people typically resort to self-insurance strategies whereby they use their productive assets in low-risk low-return activities that guarantee survival and a minimum level of consumption independently of the extent and intensity of the realized shock.[2] These actions minimize the negative impacts of the shocks if and when such shocks materialize and have important consequences that tend to be underappreciated. In the aftermath of a shock, self-insured households are likely to appear as more "resilient" than other households in the sense that the shock may have a smaller impact on their asset holdings and welfare, and their speed of recovery to the pre-shock level of assets and welfare faster. In addition, irrespective of whether a shock is realized or not, low-risk, low-returns strategies come at a cost in the sense that they have long-lasting negative effects on human development as well as on the accumulation of physical capital (investment) and growth. The emerging literature on poverty traps and chronic poverty underscore the relationship between risk and chronic poverty as well as the potential offered by innovations in risk management.[3]

The papers summarized in this brief quantify the impact of uninsured risk on income growth using two commonly used econometric methods in two geographically distinct settings. The first paper uses observational data to quantify the impact of uninsured risk on household occupational choice in rural India and the implications of this for poverty reduction. The second

1. Risk management, is the process of confronting risks, preparing for them (ex-ante), and coping with their effects (ex-post). The goal of risk management is to increase the capacity to prepare for and deal with risk, and increase resilience to negative shocks (ability to cope with shocks). A risk management system refers to the set of institutions and programs such as early warning systems, safety nets and social transfers, as well as the increased availability and utilization of index-based risk transfer instruments all aimed at facilitating risk management in the target population.
2. Even if these markets are present, problems like moral hazard and adverse selection may limit the benefits from risk sharing.
3. The assets based approach to risk and chronic poverty is outlined in Carter and Barrett, (2006 and 2013). Barrett, et al. (2008) explore the implications of these ideas on the design of safety net programs, while Kraay and McKenzie (2014) provide an up to date assessment of the empirical evidence available on the existence of poverty traps.

paper uses experimental data—the randomized introduction of insurance—to quantify the impact of uninsured risk on smallholder investment in agriculture in the Sahel. Both papers contribute to an extant literature on the use of these method to examine the costs of uninsured risk.

Occupational choice in rural India

The first paper "Occupational Diversification as an Adaptation to Rainfall Variability in Rural India" investigates occupational diversification among household members in rural India as an adaptation strategy against the risks arising from the historical variability of local rainfall. Households in poor rural economies, where weather-related risks are prevalent and credit and insurance markets are absent, may adapt through precautionary and reactive actions protecting their welfare, but at the cost of lower returns (e.g., Morduch, 1995; Rosenzweig & Binswanger, 1993; Dercon 2003, 2004). Such conservative portfolio choices and low-risk low-return strategies for the use of productive assets may reduce the likelihood that households accumulate the assets needed to escape poverty through their own savings and investment (Rosenzweig & Wolpin, 1993; Morduch, 1995; Carter and Barrett, 2006, 2013). Recent studies suggest that the effect of risk in the absence of effective formal insurance and credit markets is very important for investment and growth. Elbers et al., (2007), for example, estimate that households in Zimbabwe would accumulate much more capital in the absence of risk (46% lower than in the absence of risk) and that the total effect of risk is dominated by the *ex-ante* effect. In contrast, the *ex-post* impact of shocks appears to be less important. In such contexts, identification of the ways in which government actions and policies can remove constraints to adaptation, facilitate the process of adaptation as well as minimize the negative consequences of adaptation is essential.

Motivated by these considerations, this study investigates household adaptation to the historical variation in local rainfall in terms of the employment and occupational selection of the members of households in rural India. With approximately 70 percent of India's population living in rural areas in 2010, and about 58 percent of the total numbers of workers employed in the agricultural sector, local rainfall variability during the monsoon season comprises the primary source of production and income risks. The sector of employment of the millions of rural households in India as well as many other developing countries is an important determinant of household welfare. Considering that there is a variety of factors involved in the decision of households to allocate labor between agricultural and non-agricultural occupations (on-farm and off farm), it is important to establish empirically the extent to which occupational diversification among household members represents an adaptation to the historic climatic variability as opposed to "pull" factors such as expanded opportunities to earn higher wage rates in other sectors. In principle, household members could also specialize by working in the same occupation or sector and increase productivity by learning from each other's experience (Menon & Subramanian, 2008; Shenoy, 2013). However, lack of access to credit and capital, and the presence of idiosyncratic and uninsured risks may "push" rural households and their members away from specializing in the agricultural sector to diversified activities off the farm (Lanjouw & Lanjouw, 2001). For example, Deininger & Olinto (2001), demonstrate in rural Colombia, that although households stand to gain by choosing a single specialized farm-based source of income, they choose to diversify into non-farm economic activities to reduce risks. Thus, at the household level, occupational diversification may result in more income security but at the cost of a lower level of welfare and overall growth.[4]

4. Households may also self-insure against weather risks by "saving for the rainy day." However, savings for self-insurance as opposed

Much of the empirical literature in developing economies is concerned with the impacts of extreme weather events on key welfare outcomes.[5] Yet, these studies can only provide indirect inferences about the relationship between climatic norms and adaptation as measured by the prevalence of occupational diversification, other common practices among households, or the prevalence of social institutions and customs. Empirical studies shedding direct light and evidence on the relationship between climatic norms and adaptation are quite scarce. Rosenzweig and Stark (1989), for example, provide one of the early empirical studies on the role of marriage of daughters to locationally distant, dispersed yet kinship-related households, as an adaptation strategy facilitating consumption smoothing in an environment characterized by information costs and spatially covariant risks. They find that marriage with migration contributes significantly to a reduction in the variability of household food consumption, and that farm households afflicted with more variable profits tend to engage in longer-distance marriage with migration. However, the external validity of this study regarding adaptation behavior in the context of a changing climate is limited by the specificity of the sample used (a small 10 year panel of households from only 6 villages of semi-arid India).

The current study complements related studies (Menon, 2009, Ito & Kurosaki, 2009, and Bandyopadhyay & Skoufias, 2013) in two ways. First, this study covers all of rural India which is characterized by diverse agro-ecological zones, different levels of rural infrastructure as well as a tremendous variation in climate, ranging from the desert-like western Rajasthan to the moist eastern foothills of the Himalaya to the tropical south. The studies above either covered less heterogeneous countries with specific features such as mountainous Nepal (Menon, 2009) and flood prone Bangladesh (Bandyopadhyay & Skoufias (2013), or a couple of northern states of India with relatively homogenous agro-ecological features (Ito & Kurosaki, 2009). Second, this paper carries out a more systematic investigation of the extent to which government investments in various types of rural infrastructure such as irrigation, roads, and information and communication, or credit services or education can facilitate household adaptation to increased risks due to climatic change.[6]

A variety of data sources are merged together for the purpose of this analysis. These data sources include household survey data from National Sample Survey (NSS), Indian National Sample Survey (NSS59: Schedule 18.2 collected in 2002-2003) district level data on topography from the Food and Agriculture Organization (FAO) data, infrastructure from the Indian Village Census, and daily rainfall data from the India Meteorological Department. The analysis also employs, high resolution gridded (on 1 degree latitude by 1 degree longitude cells) daily rainfall data from the India Meteorological Department (IMD) covering the years 1951 to 2003 based on daily records from more than 1800 weather stations. Normal (i.e. mean) precipitation and normal variability, as measured by the coefficient of variation (the ratio of the standard deviation to the mean rainfall in each district) during the 1960-2000 period for a district are interpolated from the 296 cells covering India.

The occupational choices of working non-head members are based on both pull and push factors. As noted above the main sources of push factors in rural India is local variability of rainfall. Thus, it is hypothesized that in districts where the variance of rainfall is high, household members other than the head of household are more likely to choose occupations unrelated to agriculture.

to investment in productive capital also hinders growth.

5. For example, see Mueller and Osgood (2009) on the impacts of droughts on income and wages in Brazil, and the literature on consumption smoothing through precautionary savings, conservative cropping choices, and intra-household risk sharing (Dercon S. , 1996; Dercon & Krishnan, 2000; Dercon & Hoddinott, 2003).

6. This line of work is very much in line with Smit, et al. (2000) who point out that adaptations vary not only with respect to their climatic stimuli but also with respect to other non-climate conditions sometimes called intervening conditions, which serve to influence the nature and sensitivity of the adjustments taking place.

Similarly, in districts where the variance of rainfall is high, the head and other members of the household may diversify between self and wage employment in agriculture.

The analysis reveals that high rainfall variability has a significant negative effect on the agricultural specialization within-household occupational choices. This confirms the hypothesis that local variability in rainfall "pushes" household members towards employment in non-agricultural sector. Data limitations do not allow the measurement of the extent to which being pushed out of agriculture affects household welfare or wage and non-wage earnings. However, the strong correlations between local rainfall variability and intra-household sectorial diversity points towards the predominance of the ex ante "push" factor rather than the "pull" of higher potential earnings in the non-agricultural sectors driving the agricultural household members to choose non-agricultural employments and likely lower household earnings for those exposed to this ex ante risk.

To a large extent this finding is reinforced by the results of the more systematic investigation of the extent to which government investments in various types of rural infrastructure can facilitate household adaptation to increased risks due to climatic change. Policies that improve access to education, credit, roads, and information, such as postal services, have two kinds of potential effects. First, better access to education, markets, and information may make agriculture more productive, and thus reduce the need for seeking low return non-agricultural activities for the purpose of minimizing *ex ante* rainfall risks. If this is the predominant channel through which access to education, information, and markets, affects intra-household employment choices, one would expect households with access to these services to be more specialized in agriculture. On the other hand access to the same set of services, namely, education, information, and markets, also allows employment in high-return non-agricultural sectors. If access to these services predominantly extends the "pull" of high-returns non-agricultural activities, then one would expect the combination of high *ex ante* rainfall risks and access to education, information, and markets, to reduce the household specialization in agriculture. Given that the results are not always robust across specifications, it is not possible to determine with certainty whether access to these services diminishes the "push" ex ante rainfall risks or increases the "pull" of high-return non-agricultural employments. In either case, the agricultural households are likely to gain from a higher level of access to these services.

However, the empirical analysis did reveal that expansion of irrigation projects has a strong potential of facilitating household adaptation to increased risks due to climatic change. The results confirm that irrigation weakens the effect of rainfall variability on the incentive to diversify the occupational portfolio of household members. Therefore, as a component of "climate-smart" policy packages in India, irrigation may not only stabilize and increase agricultural yields directly, but also indirectly through the increase in potential output associated with the gains from specialization in agriculture.

Agricultural investment in the Sahel

The second paper titled "Managing Risk with Insurance and Savings: Experimental Evidence for Male and Female Farm Managers in the Sahel" uses a randomized field experiment in Senegal and Burkina Faso to compare male and female farmers who are offered index-based agricultural insurance with those who are offered a variety of savings instruments. By comparing the behavior change that results when offered insurance, the paper is able to offer some insights on the cost of uninsured risk against climatic shocks. This cost remains unobserved when the welfare impact of the disasters is assessed only by considering changes after they occur.

A considerable literature has emerged in recent years that examines the impact of financial instruments that can help households manage agricultural risk. Cole et al. (2013), Karlan et al. (2014), Berhane et al. (2014), Elabad and Carter (2014), and Mobarak and Rosenzweig (2013) assess whether weather index insurance can help households increase investment in agriculture using data from randomized control trials. In Ghana the 25th percentile increases expenditures on agricultural investments by about US$300, from a base of a little more than US$375 (Karlan et al 2014), in Ethiopia insurance resulted in a 13% increase in the likelihood that fertilizer is used (Berhane et al 2014). In Mali the introduction of area-yield insurance for cotton increased the areas planted to cotton by 15% and the spending on inputs by 14% (Elabad and Carter 2014). The paper summarized here contributes to this literature by providing estimates from field experiments in Burkina Faso and Senegal of the impact of weather insurance and three types of savings on a variety of agricultural investments and outcomes.

The experiment was designed to test how demand for and impact of financial products varies with gender. This was done by randomizing the offer of financial instruments to a selected individual within a household. We contend that this is important in the Sahel as---as in much of the developing world—women and men have quite distinct spheres of activity and the risks they face are different as a result. Specifically, women are exposed to much greater physical risk through their child-bearing years than are men and they are more involved in caring for children than are men. As a result, although drought risk affects men and women equally, women appear less immediately concerned than men about drought and more vulnerable to health-related shocks to them and their children. This is perhaps especially the case in parts of rural Sahel where fertility rates are still particularly high.

In 40 experimental sessions conducted in Burkina Faso and Senegal prior to the onset of the planting season, 800 farmers and ROSCA members were endowed with $12 (the cost of half a bag of fertilizer) and randomly offered one of four products, at an exogenously determined price or interest rate. One instrument was a weather index insurance that was being sold in both countries by local insurance companies sponsored by an international NGO. The other three instruments were savings devices: one was an encouragement to save for agricultural inputs at home through labeling, a second was a savings account for emergencies that was managed by the local group treasurer (either a ROSCA or a farmer's group to which the individual belonged), and a third was a savings account for agricultural input investments that was managed by the same treasurer. The field experiment was conducted in Senegal and Burkina Faso at the same time to allow us to begin to assess the external validity of results within the Sahel.

Although few differences in welfare outcomes were observed one month after the intervention, the insurance product offer resulted in better ability to manage risk among these farmers post-harvest. As a result, insurance was more effective at encouraging agricultural investment than savings. Those in the insurance treatment spent more on inputs and used more fertilizer than those in the savings treatments (Table 1). These findings are quite consistent with those from other studies cited above, although somewhat higher, most likely because these are LATE rather than ITT to estimates.

Table 1: the cost of uninsured risk on foregone investments in agriculture

	Increase as a result of insurance	
	Average	Robust standard error
Spending on inputs (FCFA)	56.0%	(18.8)**
Amount of fertilizer used (fertilizer per acre)	37.5%	(18.8)**
Yields	18.8%	(8)*

Source: Dellavalade et al (2014)

The changes in behavior induced by insurance increased yields suggesting that the year to year cost of uninsured disaster risk on income growth in sub-Saharan Africa is quite substantial. The higher input use that insurance encouraged resulted in yields that were 18.8% higher on average (Table 1) than those without insurance.

The paper also finds much stronger demand for weather insurance among men than among women, and stronger demand for emergency savings among women. This is not driven by access to informal insurance such as transfers, area cropped or types of crops grown. The results thus imply that different patterns of demand for financial products among men and women can result in welfare differences in the long-run. A further exploration of why these differences in demand arise is needed. The paper conjectures that it is as a result of the different nature of risks faced by men and women. If this is the case it would suggest that these differences need to inform how new financial products, such as index insurance products currently becoming more available, are designed to meet the needs of both men and women.

There are limits to the quality of insurance indexed products can provide. The paper is one contribution to the emerging literature on the benefits and concerns of offering indexed agricultural insurance to rainfall dependent smallholder farmers in low income countries. This literature has documented the potential beneficial impact of these products and also concerns. Because these products provide insurance through an index rather than observed losses experienced on a farmer's field, they can have substantial basis risk. Basis risk is the risk that the index differs from the loss. Index insurance typically insures just one source of risk to agricultural yields—local weather conditions—whereas in the contexts in which it is provided there are often many sources of risk such as pests, floods, and health shocks to agricultural labor. Theoretically it can be shown that basis risk depresses the value and demand for these products (Clarke 2011), and Dercon et al. (2013) and Rosenzweig and Mobarak (2013) provide empirical evidence consistent with the theory. In documenting both the beneficial impact of index insurance and further evidence consistent with the idea that basis risk does limit demand, this paper is one contribution to this broader literature.

Conclusion

Risk-avoidance strategies are commonplace and costly to poor and vulnerable households across the developing world. We argue that neglecting to take this properly into account, and valuing DRFI solely based on the impact of disasters on welfare when they occur, will result in a systematic under-estimation of the value of DRFI strategies for reducing poverty. This brief has presented two empirical case studies, reflective of a broader literature, to reinforce the point that DRFI strategies are important not only for protecting household welfare from covariate and idiosyncratic shocks but also for fostering economic growth, and maintaining social stability.

References

- **Bandyopadhyay, S.** and **E. Skoufias**. 2013. "Rainfall variability, occupational choice, and welfare in rural Bangladesh." *Review of Economics of the Household*, DOI 10.1007/s11150-013-9203-z.
- **Barrett, C.B.**, **M.R. Carter** and **M. Ikegami**. 2008. "Poverty traps and social protection" *SP Discussion Paper* No. 0804. The World Bank.
- **Barnett, B. J.**, **C.B. Barrett**, and **J.R. Skees**. 2008. "Poverty Traps and Index-Based Risk Transfer Products" *World Development*, 36(10): 1766-1785.
- **Berhane, G.**, **S. Dercon**, **R.V. Hill**, **A. Seyoum Taffesse**. 2014. "Formal and informal insurance: experimental evidence from Ethiopia". Mimeo.
- **Carter, M. R.** and **C. B. Barrett**. 2006. "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach". *Journal of Development Studies*, 42: 178–199.
- **Carter, M. R.** and **C. B. Barrett**. 2013. "The economics of poverty traps and persistent poverty: Empirical and Policy Implications." *Journal of Development Studies*, 49(7):976-990.
- **Cole, S.**, **X. Giné**, **J. Tobacman**, **P. Topalova**, **R. Townsend**, and **J. Vickery**. 2013. "Barriers to Household Risk Management: Evidence from India." *American Economic Journal: Applied Economics*, 5(1): 104-35
- **Deininger, K.** and **P. Olinto**. 2001. "Rural Nonfarm Employment and Income Diversification in Colombia". *World Development*, 29(3): 455–465.
- **Dercon, S.** 1996. "Risk, Crop Choice and Savings: Evidence from Tanzania." *Economic Development and Cultural Change*, 44(3):485–514.
- **Dercon, S.** 2004. "Growth and Shocks: Evidence from Rural Ethiopia." *Journal of Development Economics,* 74(2):309–29.
- **Dercon, S.** and **J. Hoddinott**. 2003. "Health, shocks and poverty persistence." *WIDER Discussion Papers* // World Institute for Development Economics (UNU-WIDER) 2003/08.
- **Dercon, S.**, and **P. Krishnan**. 2000. "Vulnerability, seasonality and poverty in Ethiopia." *The Journal of Development Studies*, 36(6): 25-53.
- **Dercon, S.**, **R. Vargas Hill**, **D. Clarke**, **I. Outes-Leon** and **A. Seyoum Taffesse**. 2014. "Offering rainfall insurance to informal insurance groups: Evidence from a field experiment in Ethiopia." *Journal of Development Economics,* 106(1): 132-143
- **Elabed, G.** and **M. Carter**. 2014. "Ex-ante Impacts of Agricultural Insurance: Evidence from a Field Experiment in Mali". Mimeo.
- **Elbers, C.**, **J.W. Gunning**, and **B. Kinsey**. 2007. "Growth and Risk: Methodology and Micro Evidence." *The World Bank Economic Review*, 21(1):1-19.
- **Ito, T.** and **T. Kurosaki**. 2009. "Weather Risk, Wages in Kind, and the Off-Farm Labor Supply of Agricultural Households in a Developing Country." *American Journal of Agricultural Economics*, 91(3): 697-710.
- **Karlan, D.**, **I. Osei-Akoto**, **R. Osei**, and **C. Udry**. 2014. "Agricultural Decisions after Relaxing Credit and Risk Constraints." *Quarterly Journal of Economics*, 129(2):597-652.

- **Lanjouw, J. O.** and **P. Lanjouw**. 2001. "The rural non-farm sector: issues and evidence from developing countries." *Agricultural Economics*, 26(1): 1-23.
- **Macours K.**, **P. Premand**, and **R. Vakis**. 2012. "Transfers, Diversification and Household Risk Strategies: Experimental Evidence with Lessons for Climate Change Adaptation" *World Bank Policy Research Working Paper*, 6053.
- **Menon, N.** 2009. Rainfall Uncertainty and Occupational Choice in Agricultural Households of Rural Nepal. *Journal of Development Studies*, 45: 864-888.
- **Menon, N.**, and **N. Subramanian**. 2008. Learning, diversification and the nature of risk. *Economic Theory*, 35: 117–145.
- **Mobarak, A. M.**, and **M. Rosenzweig**. 2012. "Selling formal insurance to the informally insured." Yale University Economics Department Working Paper No. 97, *Economic Growth Center Discussion Paper* No. 1007.
- **Morduch, J.** 1995. "Income Smoothing and Consumption Smoothing." *Journal of Economic Perspectives* 9, Summer, 103-114.
- **Mueller, V. A.**, and **D. E. Osgood**. 2009. Long-term Impacts of Droughts on Labour Markets in Developing Countries: Evidence from Brazil. *Journal of Development Studies*, 45(10): 1651-1662.
- **Rosenzweig, M.**, and **H. Binswanger**. 1993. "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments." *The Economic Journal*, 103(416): 56–78.
- **Rosenzweig, M.**, and **K. Wolpin**. 1993. "Credit Market Constraints, Consumption Smoodiing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India." *Journal of Political Economy*, 101(2): 223-244.
- **Shenoy, A.** 2013. *Risk and Economic Under-specialization: Why the Pin-Maker Grows Cassava on the Side*. Working paper available at SSRN: http://dx.doi.org/10.2139/ssrn.2211799.
- **Smit, B.**, **I. Burton**, **R. Klein**, and **J. Wandel**. 2000. "An Anatomy of Adpatation to Climate Change and Variability" *Climatic Change*. 45: 223-251.

Models of DRFI

Chapter 4

The application of a probabilistic catastrophe risk modelling framework to poverty outcomes: General form vulnerability functions relating household poverty outcomes to hazard intensity in Ethiopia*

Catherine Porter
Emily White

Abstract
We bring together two strands of research that have thus far been developed independently: catastrophe risk modelling, and economic analysis of vulnerability to poverty. We focus on a specific example to fix ideas: the impact of drought hazard on the welfare of rural households in Ethiopia. The aim is to determine the validity of applying a derived set of damage (vulnerability) functions based on realized shocks and household expenditure/consumption outcomes, onto a forward-looking view of drought risk. We outline the contribution that combining the two analyses can bring, show preliminary results and outline future plans.

...

* Very Preliminary Draft for comments, 21st May 2015. Authors: Catherine Porter (Heriot-Watt University) and Emily White, Finance and Markets Department. The project is co-ordinated by Daniel Clarke, Disaster Risk Financing and Insurance Unit, Workd Bank. Please contact authors for latest draft. Correspondence and comments welcome, to Catherine.porter@hw.ac.uk

Probabalistic Catastrophe Risk (CAT Risk) Models have proved invaluable to international insurance markets. They develop a view of risk beyond the historical occurrence of catastrophes, for calculation of potential future impacts. Their strength is that they consider an extensive range of possible event scenarios well beyond the historical record (see Box 1.1). To date, CAT risk models have been primarily developed to output risk in financial terms. However, the potential to use them to support disaster risk management more broadly have been recognized in schemes such as the Pacific Risk Information System [2], CAPRA [3] Program and Africa RiskView platform. [4]

CAT risk modelling frameworks have yet to be applied to poverty outcomes at the household level. Poverty is conceptualized as a level of consumption that is below an "acceptable standard of living". Vulnerability broadens the concept to include the probability that consumption will fall below the poverty threshold (see Hill and Porter, 2014 for a discussion). A growing number of microeconomic studies now link specific stochastic events such as hurricanes, droughts or floods *ex-post*.

CAT Risk Modelling and Poverty Analysis

CAT risk modelling frameworks comprise models of: 1) Geo-referenced exposure, as assets or population at risk (exposure module); 2) Frequency, severity and location of possible hazard occurrence (hazard module); and 3) The relationship between the modelled hazard occurrence and the impact on the exposure (vulnerability module).

This modular structure is illustrated in Box 1.1. **The principal challenge in the application of probabilistic catastrophe risk modelling frameworks to household-level welfare outcomes is the development of general form relationships between hazard occurrence and indicators of welfare outcome (vulnerability module).**

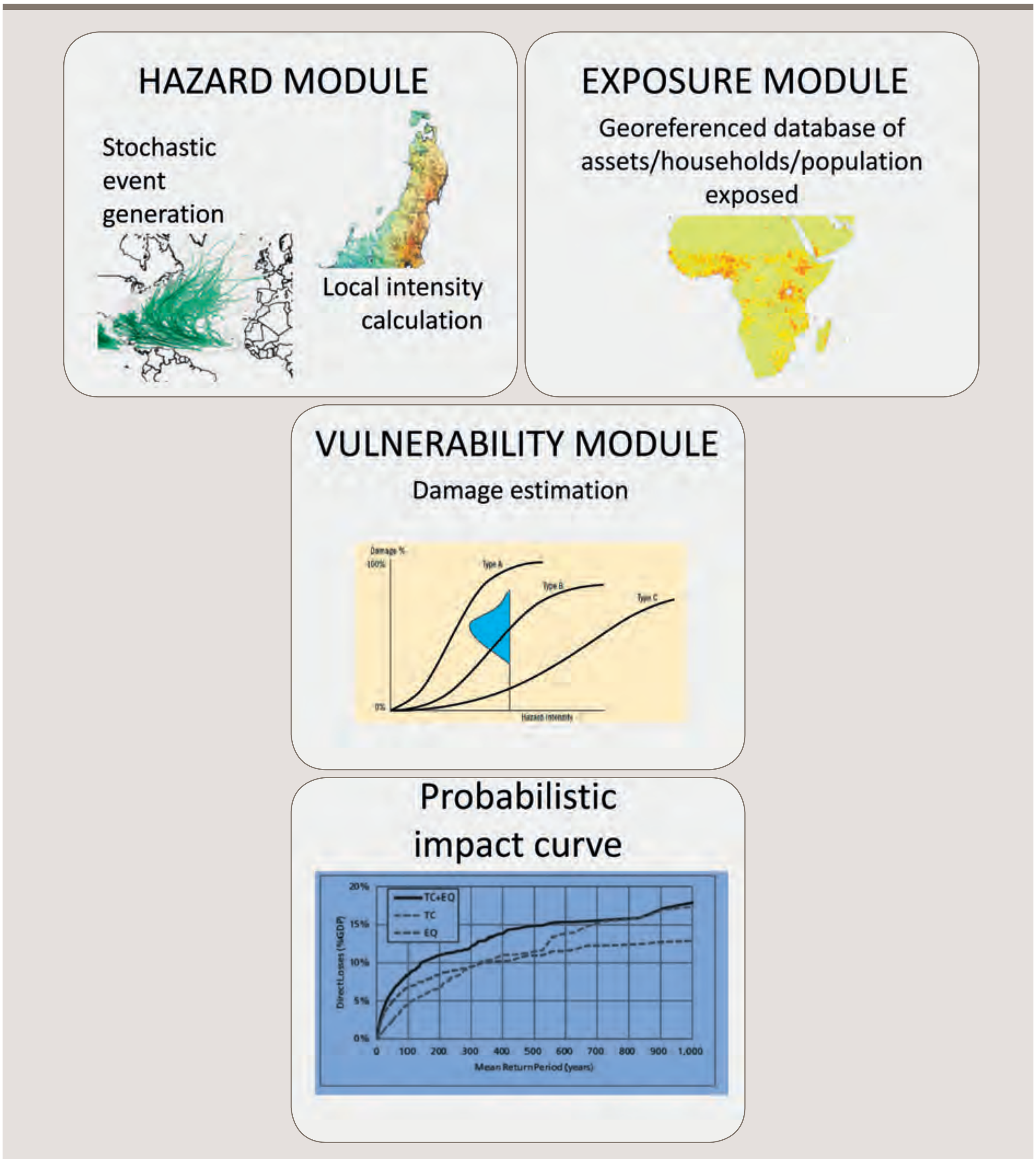
To evaluate the feasibility of developing such a module we undertook two activities:

1) **Develop a suitable model to derive quantitative relationships between a selected drought hazard measure and household poverty outcome.** The regression model combines nationally representative household data with historical data on drought hazard, which effectively constitutes our 'vulnerability module' for rural households in Ethiopia;
2) **Testing of the derived 'vulnerability module' to evaluate its robustness**, and therefore the validity of its future application onto a forward-looking probabilistic view of drought occurrence generated from a catastrophe risk modelling framework.

The base **regression specification** is based on initial work by Hill and Porter (2014) that derived a general model of consumption for Ethiopian households using all areas, rural and urban, and focused on the impact of drought, food prices, and other idiosyncratic shocks on ln consumption per adult. **The dependent variable** is the natural logarithm of consumption per adult equivalent at household level, as used by Hill and Porter (2014). The measure of drought is an index of crop yield shortfall (WFP).

2. http://pcrafi.sopac.org/about/
3. http://www.ecapra.org/
4. http://www.rockefellerfoundation.org/uploads/files/fa08d48b-08ef-4fc7-8991-4872f6e929b0-africa.pdf

Box 1.1: Probabilistic Catastrophe Risk Modelling Frameworks



Other variables include HH head gender, age and education; HH assets including cattle, sheep, chickens, land, good roof, toilet; Idiosyncratic shocks including crop-loss, animal illness or death, hh member illness or death, food price shocks; other characteristics including financial capital and household composition. Community characteristics: agro-climactic zone, region, distance to town, market access.

As noted above, the model also seeks to capture what in CAT risk-modelling are termed attenuating factors, in econometrics as heterogeneous impacts, through interaction terms included in the model (e.g. DROUGHT*varname).

Ensuring that estimates of damage functions are both internally and externally valid is the major econometric challenge in the development of general form damage functions from historical data on disaster impacts. We consider internal validity as the extent to which impacts statistically associated with disaster occurrence can actually be causally stated, i.e., that the estimates are econometrically "well-identified." External validity is considered as the extent to which the model can be generalized to other contexts and locations. CAT Risk modelling allows for the application of the derived functions out of the context in which they were derived. For example, damage functions developed for buildings in one region can be modified for use in another, if sufficient detail around differences in construction types and quality is available.

This out-of-context application is more challenging when considering the impact of hazards on poverty, rather than physical damage, outcomes. The pathway of impact of disasters on household welfare outcomes is complex and involves many indirect mechanisms. The complexity of causal mechanisms demands substantial data to be sure of the validity of the apparent relationships observed in the data. Mechanisms of impact are also influenced by specific factors such as adaptive behaviors that may not be applicable beyond the local context in which they are observed within the data.

The second issue is **over what length of time relationships established can be considered as valid**. For the purpose of CAT risk modelling, it is helpful to consider relationships to be stable over a five-year horizon. We do not deal with the concern of recurrence times and macroeconomic (or second order) effects. E.g. in one crisis households with livestock may sell something in order to protect their consumption, but if another crisis hits soon after, the impact of the second shock is likely to be higher. Finally, in the context of this broader external validity we attempt to check if the specified mode is valid across Ethiopian agro-climactic zones.

Summary of results: We do find significantly different impact for households with cattle, access to the PSNP, and financial access: these characteristics are seen to be mitigating the impact of the drought. However, households that suffered other crop damage experienced a heavier impact of the drought. We note the potential concern that financial access and shocks such as crop damage are self-reported.

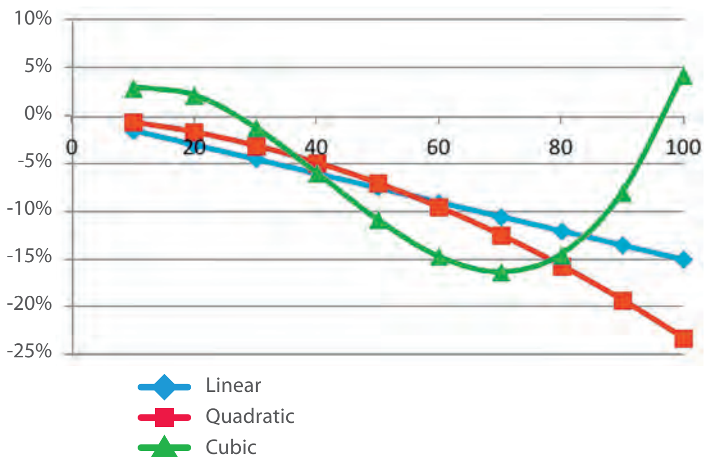
To establish external validity of any statistical results across time and contexts beyond reasonable doubt, it would be necessary to conduct identical analysis many times (replication) and then derive bounds for the relationships. This is not possible in the timeframe of the initial analysis, but has potential for a future exercise, attempting to validate results across as many countries and time periods as data permit.

To test the predictive power of the vulnerability relationships we use Statistical Learning Methods of re-sampling and cross-validation (James et al, 2013). K-fold Cross validation: randomly divide the data into training and testing datasets, and check performance of the model using Mean Squared Error. We also compare the bootstrap estimates of the drought parameter across all models.

We treated 2005 and 2011 separately as training and testing data. For all the models the 2005 dataset fits the model predicted by the 2011 dataset better than the 2011 dataset fits the model predicted by the 2005. This is a somewhat unexpected result, given that the 2005 dataset has more variation in the rainfall/drought variable. (though note the timing of PSNP safety net introduction in mid-2005). In all cases there is only a small (n.s.) difference in the fit of the model, which suggests that the relationship between drought and consumption is actually fairly homogenous, and stable. **Using 2005 as the training datatset also appears to fit all models better for the 2012 dataset than 2011**, though in all cases the fit is much worse.

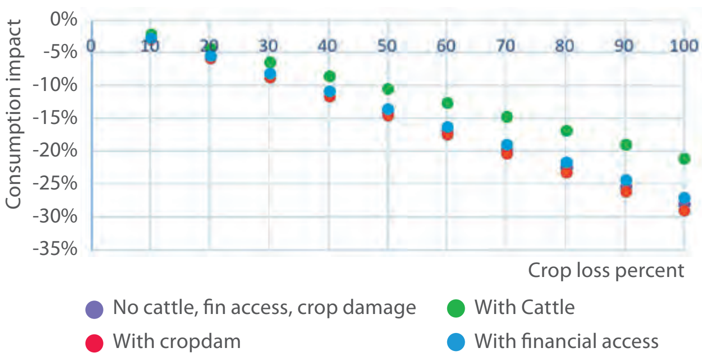
Results: Non-linear impacts of drought: Figure 1 shows the simulated shape of the curve using the squared and cubic models. The cubic model appears to have a second turning point around 70% crop loss- which is around the point at which we lose support for the data in 2011, so we may not have enough values of the data to create a plausible estimate for any further nonlinearity than a squared term. This means that the **results for more extreme drought should still be treated with a high level of uncertainty**.

Figure 1 Comparison of non-linear models



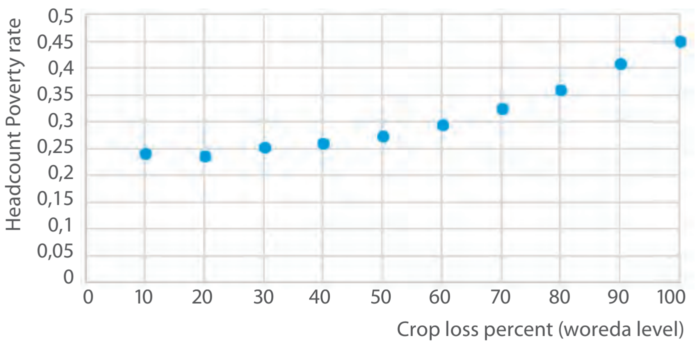
In the absence of a probabilistic hazard model for rainfall variability in Ethiopia at the resolution required, we have produced illustrative examples (figure 2):

Figure 2: Simulated crop loss, heterogeneous "types"



Finally, if the policy interest is in ***poverty impacts of drought***, then this should be incorporated into the module. E.g. a 20% drop in consumption will push households already below the poverty line into deeper poverty, those well above the line may not fall into poverty but those whose consumption is less than 20% above the poverty line will fall below the line. Figure 3 illustrates with headcount poverty rates, this can also be extended to incorporate poverty gap with associated fiscal costings.

Figure 3: Simulated headcount poverty



As a potential extension of the exercise, we recommend that a full probabilistic catastrophe risk model be used to replace the example approach applied above for the hazard module. Sensitivity analyses could be applied within the hazard modelling to consider potential outcomes in the longer term under climate change scenarios. For example, increases in the rates of occurrence of extreme rainfall variability could be used to look beyond the near term view. Similarly, projections of population increase and composition change could be applied to the exposure dataset to demonstrate different future outcomes.

Chapter 5

Expanding or increasing: index-based social protection in Niger

Francesca de Nicola

This case study documents the risks and shocks Nigerien households are exposed to and examines the welfare implications of expanding versus increasing a cash transfer program in Niger.

What is the case study about?

Niger suffers from widespread poverty, extreme weather conditions, and social distress. Nearly half of the population lives below the national poverty line, with 41% or 6.7 million of Nigerien citizens living on less than US$1.25 a day (PPP). The 2011 Living Standard Measurement Study (LSMS) survey indicates that unemployment and weather calamities are perceived as the main causes of poverty. In the year prior to the survey, almost 20% of respondents experienced the negative consequences of drought and irregular rain.

.../...

…/… The pervasiveness of these events are met with limited public resources to provide assistance. As a result, the LSMS survey indicates that the most common coping strategies in the face of a weather calamity are to either engage in spiritual activities or do nothing. The inability to cope with shocks imposes substantial consumption and welfare losses, calling for the development of a sustainable safety net system.

This case study contributes to these efforts by tackling two sets of questions. First, can we rely on meteorological and agronomic data to identify the potential beneficiaries of a social protection program? The targeting of beneficiaries is typically based on household-level data that would allow to accurately single out the most vulnerable and poor individuals. However, collecting and updating this information is a costly and time-demanding exercise which may call for alternative solutions. In this study we assess whether meteorological and agronomic data can be used to rapidly deliver assistance in response to weather shocks. Second, what are the welfare implications of expanding the number of beneficiaries relative to increasing the level of benefits under a given cash-transfer program?

How do we answer these questions?

We pool information from two main data sources to assess the sources of risk and the extent of the shocks affecting Nigerien households. First, the 2011 Living Standard Measurement Study (LSMS) survey provides insights on the typology and frequency of the shocks experienced by a national representative sample as well as a host of household- and community-level information. We apply a multilevel analysis to decompose the consumption shocks into an idiosyncratic and a covariant component. Second, we rely on meteorological and agronomic information that inform the calculations of the Water Requirement Satisfaction Index (WRSI) according to the methodology developed by the Food and Agriculture Organization of the United Nations. The WRSI provides a synthetic measure of crop yield losses under different weather conditions given the crop water requirement at different growth stages. We compare the WRSI distribution with that of the covariant shocks computed using LSMS data to assess the robustness of the alternative approaches used to quantify the aggregate shocks.

We then undertake a thought experiment to assess the welfare implications of changing the extensive or the intensive margin of the safety net program. Specifically, we assume that a fixed budget equivalent to 5% of GDP is allocated to fund a safety net program, in line with the amount spent on humanitarian interventions in Niger during the period 2001-2006. We assume that the program is progressively rolled out in an increasing number of regions, keeping constant the overall envelop and consequently reducing the level of transfer per capita. We account for the cost of acquiring data and determining the region-specific weather realizations that would lead to a severe shock and trigger the payment of the cash-transfer program. In order to quantify the impact on welfare we need to make assumptions about the utility function. We select a Constant Relative Risk Aversion (CRRA) utility function whose concavity implies that higher consumption is more beneficial for poorer than richer households. This is consistent with the preferences of a Government that aims to improve the wellbeing of its most vulnerable and poor citizens.

What Do We Find?

Preliminary results indicate that index-based cash-transfer programs have the potential to substantially improve welfare. We compare the welfare gains achieved from an index-based program against those from a typically used proxy-mean-test targeting. Under a set of simplifying assumptions, targeting beneficiaries using meteorological instead of costly-to-acquire households data is preferable since it frees resources for additional funding for transfers. However, the lack of consistency between covariant shocks derived from LSMS survey and those based on the WRSI warns against relying only on remote data to identify beneficiaries (Figure 1).

Figure 1: Measuring aggregate shocks.

with LSMS data:

with meteorological and agronomic data:

Note: The shocks are normalized to range between 0 and 1 (best).
Darker colors correspond to higher values.

Chapter 6

Utility, Risk, and Demand for Incomplete Insurance

Craig McIntosh
Felix Povel
Elisabeth Sadoulet

Abstract

Index-based weather insurance has had low effective demand in spite of attractiveness of the product in avoiding moral hazard in insurance claims. We use a set of field experiments to assess willingness to pay for index insurance among coffee producers in Guatemala. We show that the probabilistic nature of the insurance is the main reason that makes it unappealing. This is due to a secular dislike of the presence of uninsurable risk that manifests itself even when the actual probability of contract non-performance is minimal, and is consistent with the overweighting of small probabilities in Prospect Theory. This implies that increasing the demand for index insurance needs modifying the product to cover multiple risks. This can be done by more effective indexing and/or by indexing outcomes such as yield instead of indexing the determinants of yields.

Introduction and Objective

Index insurance, in which payouts are based on a pre-defined index (such as local rainfall), can provide insurance without creating moral hazard. These products appear ideal in that they insure precisely the correlated shock that cannot be smoothed locally. Yet, almost universally these products have met with disappointing demand when introduced in the field (Cole et al., 2013; Carter et al., 2014). In explaining the puzzle of low adoption, the literature has focused primarily on the issues of 'basis risk' in the index (Barnett, Barrett, and Skees, 2008), and on the extent to which ambiguity or compound risk aversion may affect demand (Bryan, 2010; Elabed and Carter, 2015; Barham et al., 2014). In this paper we bring the lens of prospect theory to bear on index insurance demand, and demonstrate that the over-weighting of small probabilities (Tversky and Kahneman, 1992) leads to a decrease in the demand for index insurance in multi-peril environments that is an order of magnitude larger than can be explained by expected utility theory alone.

Our objective is to test two central theoretical propositions in the nature of demand for index insurance. First, that the over-weighting of small probabilities can explain the dramatic decrease in demand that is observed when insurance is probabilistic (may not pay out when a shock occurs) versus partial (may not fully pay out when losses occur). Secondly, an influential paper by Clarke (2011) has suggested that low demand for index insurance can be ascribed to the non-monotonicity of demand with respect to risk aversion in the face of basis risk. If it is possible for the worst state of nature to occur without a payout, then it is possible that insurance moves income from bad states to good states, and the most risk-averse will be most sensitive to this possibility.

Settings and Game Design

We proceed with a set of controlled lab-in-the-field experiments conducted with a very risk-exposed group: cooperative-based smallholder coffee farmers in Guatemala. Yield in the coffee sector is quite variable with excess rainfall and hurricanes posing the primary source of weather risk exposure. In early 2010 we conducted a census of every registered first-tier coffee cooperative in the country. For this exercise, we selected the 71 cooperatives that reported being vulnerable to excess rainfall risk, devised a set of games to understand the nature of index insurance demand, and invited 10 individual members to participate in a day of laboratory experiments.

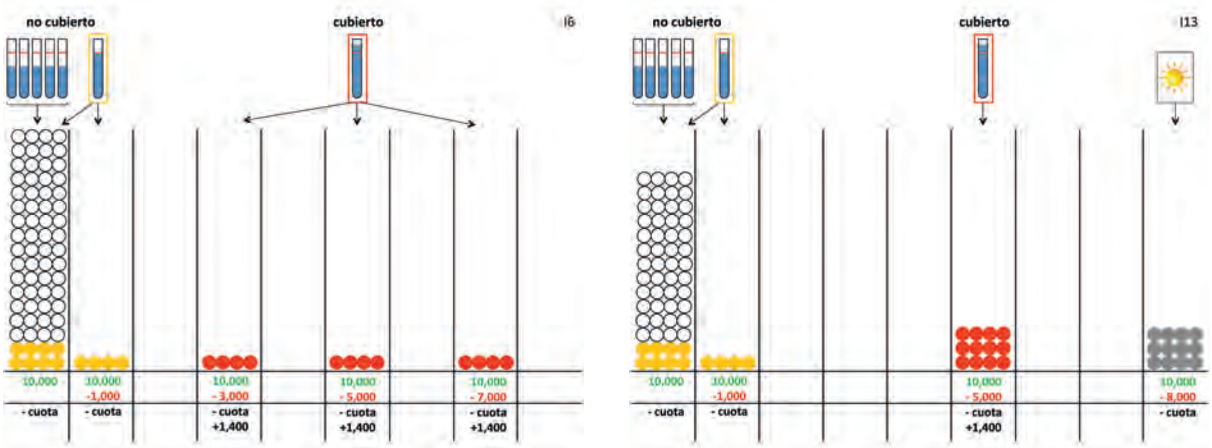
Subjects in the study were presented with a sequence of scenarios, each featuring a carefully designed graphic illustrating the probability distributions of states of nature that included normal rainfall, heavy rainfall, excess rainfall, or drought. Experiments had quantities that were carefully calibrated based on information about average yields and typical losses from the baseline household survey. Examples are given in Figure 1. The states of nature are represented by columns, with little circles indicating the probability of occurrence. In the 'Risk' game in panel a, for example, normal rainfall occurs with probability 5/7, heavy rainfall with either no loss or Quetzales1,000 loss with probability 1/7, and excessive rainfall with losses of Q3,000, Q5,000, or Q7,000, each with probability 1/21. The 'Severe Drought' game of panel b features a risk of a severe drought entailing a loss of Q8,000 with probability 1/7. We analyze here seven similar "Risk" games in which the intensity and the variance of the excess rainfall losses vary, and six "Drought" games, with constant excess rainfall risk but varying probability and loss intensity from the drought.

All scenarios feature an excess rainfall index insurance product paying out a given amount in case of excess rainfall losses. Hence if the individual is insured, payment of premium (cuota) occurs in all states of nature, and the payout of Q1,400 occurs in states of excess rainfall. For each exercise subjects were asked to record their willingness to pay (WTP) for the product, with the actuarially fair price remaining fixed at 200 Quetzales ($31.73) across all games.

This insurance product is partial for two reasons. First, the rainfall index is imperfectly correlated with yields on farmers' plots, thus providing some risk that is covered by the insurance product and some that is not (often referred to as basis risk in this literature). Furthermore the payout is calibrated to cover average input cost and not losses. For each scenario we hold the basic attributes of the insurance itself constant (likelihood of payout, size of payout), and so all variation in the stated WTP across games arises from variation in the nature of the risk. The demands are incentivized by paying out experimental 'yields' that are 1/100th of the outcomes in in a randomly chosen group of scenarios.

Figure 1: Examples of Representations Used in Games

a. A 'Risk' Game (I6) b. A 'Severe Drought' Game (I13)



Expected Utility and Demand for Partial Insurance

We begin by analyzing the set of "Risk" games. These games vary the probability and severity of losses while keeping the insurance product fixed, and hence provide a very simple environment in which to understand marginal utility: what is people's willingness to pay to transfer income from good states to bad ones as bad states become worse?

Average WTP are reported in Table 1. Column 1 shows that WTP increases as the severity of the shocks increases across games I1 to I3, indicating an overall risk aversion among all participants. WTP also increases as the variance in losses increases across games I4 to I7, suggesting the presence of an overall prudence in preference (i.e., with third derivative of utility positive). Hence the behavior of participants in the risk games is consistent with risk aversion and prudence under expected utility theory.

We then proceed to use the stated WTP in the seven Risk games to estimate a fairly flexible utility function for each participant. Using these estimated parameters we can compute for each individual predicted utility and all of its derivatives at any level of income. Among all participants 76% exhibit prudence and 10% have an almost quadratic utility function. Furthermore we can compute for any risk scenario the predicted WTP, which is what the player ought to be willing to pay for the insurance under an expected utility behavioral model with the preference expressed in the risk games and the risk profile of the scenario. The predicted WTP is thus a sufficient statistic that summarizes risk and preference. Table 1, column 2 reports the average of these predicted values. For the risk games, they are as expected close to the observed average WTP since these were used to estimate the model.

Table 1: Actual and Predicted WTP in Risk and Drought Games

Game	Description	Actual Willingness to Pay	Predicted EU Willingness to Pay
Panel A: Variation in Insured Risk		(1)	(2)
I1	Risk, small shock	24.38	22.73
I2	Risk, med shock	29.51	29.92
I3	Risk, large shock	33.87	35.02
I4	Risk, base (no variability)	25.72	28.49
I5	Risk, some variability	29.10	29.41
I6	Risk, med variability	32.31	31.42
I7	Risk, large variability	35.58	33.40
Panel B: Variation in Uninsured Risk			
I4	No drought	25.72	28.49
I8	Drought, rare & small	21.59	28.05
I9	Drought, rare & med	18.71	26.48
I10	Drought, rare & worst	15.58	12.36
I11	Drought, freq & small	17.22	27.24
I12	Drought, freq & med	14.26	23.50
I13	Drought, freq & worst	11.72	9.86

All figures are in US Dollars.

Demand for Probabilistic Insurance

With these explicit utility functions in hand, we now proceed to the analysis of WTP for probabilistic insurance, where a large behavioral literature has suggested that the possibility of contract non-performance has a larger effect on dampening the level of demand that we would expect. It is difficult to validate these statements without a precise measure of what the WTP 'should' be if agents were standard expected utility maximizers. With a WTP predicted off of individually estimated utility curves, we have a straightforward solution to this problem. The estimated demand is a dollar-value WTP under expected utility theory, and the difference between this amount and the observed WTP provides a monetary estimate of the extent to which decreases in demand for probabilistic insurance are driven by behavioral concerns.

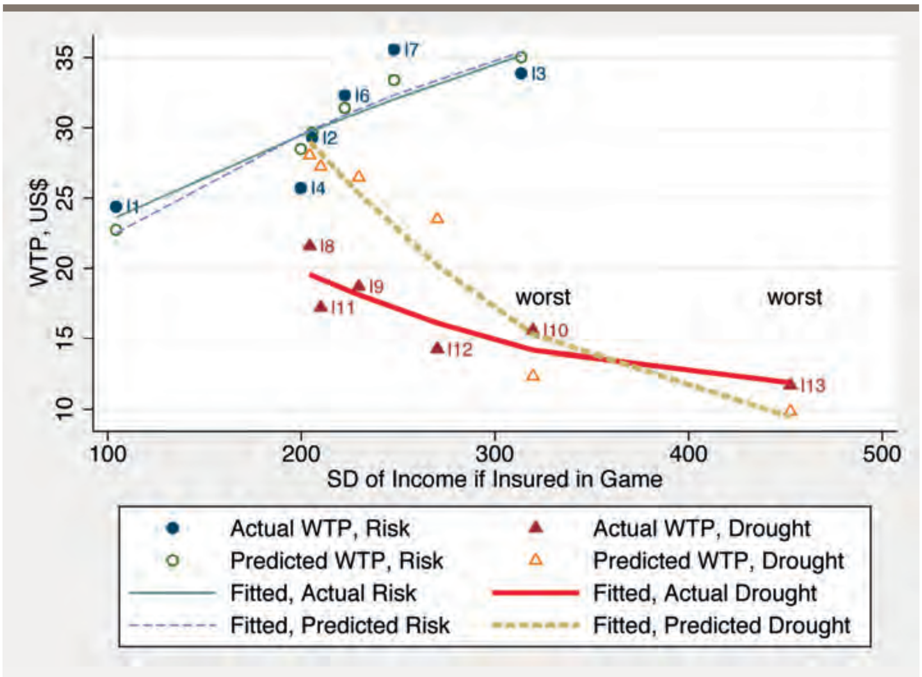
While the index insurance literature has typically referred to all variation in income that is not covered by the index as 'basis risk', there are sharply contrasting theoretical predictions surrounding increases in uncovered risk in insured states versus risk in uninsured states. As the severity of shocks in insured states increases (holding the payout constant), expected utility theory predicts that insurance will become more valuable because its expected marginal utility in the insured states rises. Thus, while the insurance product appears worse in the sense that it covers a smaller fraction of the risk, it should in fact yield a higher WTP. In contrast, when the risk is uninsurable, the demand for insurance decreases with the severity of the risk, as the marginal utility cost of paying the premium increases. This is best seen in Figure 2, which shows predicted WTP as a function of the residual risk. The predicted WTP increases as residual risk increases in Risk games (I1 to I7), while it decreases with residual risk in Drought games (I8 to I13). The dotted lines show non-parametric smooth relationships.

Looking now at actual WTP observed across the drought games. While the signs of the responses are consistent, the magnitudes display quite a distinct pattern. Actual WTP proves to be very sensitive to small amounts of drought risk (games I8, I9, I11, and I12) and then to display little additional sensitivity to the magnitude or likelihood of risk posed by the most severe droughts (I10 and I13). This indicates that there is a secular dislike of probabilistic insurance that manifests itself even when the actual probability of contract non-performance is minimal.

The clear story emerging from these two ways of analyzing the data is that there is a response to small probabilistic risk that cannot be squared with our expected utility predictions, and if anything the surprise in the response to very large probabilistic risk is that the actual WTP displays less of a decrease than we might expect. Hence, we can conclude very clearly that there is a behavioral puzzle in demand that decreases as the probabilistic nature of the insurance is magnified.

Looking at heterogeneity across producers, we find that the risk averse, for whom insurance is more important overall, are less likely to show large drops in demand as a result of the small drought risk. Similarly, those with a high trust index are less put off by the presence of drought risk and maintain demand. The ambiguity averse, on the other hand show much larger drops in demand when faced with the possibility of mild drought. This latter fact is particularly relevant in that it suggests that the simple survey question eliciting ambiguity aversion does indeed capture meaningful information in predicting economically relevant parameters. On the other hand we find no evidence at all that actual risk exposure of the farmers explain the over-reaction to small drought risks. Consequently, our results show very clearly that this over-response to small risks is driven by the behavioral attributes of the decision-maker and is not driven by the actual exposure to risk.

Figure 2: Actual versus Predicted WTP in Risk and Drought Games



Risk Aversion and Demand for Insurance Against Severe Risk

We now focus on the response to the 'worst state' drought risk, because the literature on demand for index insurance has paid particular attention to this specific type of contract non-performance as a candidate explanation for low demand. As shown by Clarke (2011), the possibility of the worst state being uninsured can introduce non-monotonicity into the relationship between risk aversion and insurance demand. The drop in WTP for insurance that features this worst possibility should be particularly pronounced among those with high risk aversion. Similarly, the Maximin Expected Utility framework used by Gilboa and Schmeidler (1989) and Bryan (2010) evokes a pessimism in which decision makers fixate on the worst thing that could possibly happen in making insurance purchase decisions, another context in which the effect of these extreme tail risks would be accentuated.

To investigate this, we use data from all the drought games and the risk game with the same insurable risk but no drought, distinguishing among the drought games between the severe drought where the drought loss is worse than the rainfall loss and mild drought for the other cases. We interact dummies for mild drought and severe drought with the measure of risk aversion to study the extent to which WTP drops differentially with the risk of severe drought for the most risk averse.

Consistent with the argument in Clarke (2011), we show that while mild drought risk leads to differentially higher predicted WTP among the more risk averse, this relationship flips over and the 'worst possible' severe drought leads to a substantial and negative differential effect. In sharp contrast to this, the patterns of actual WTP are reversed: WTP in the most risk-exposed uninsured scenarios is highest for the most risk averse, even though the premium must be paid in this state. Thus the non-monotonicity in demand over risk aversion as the severity of probabilistic risk increases is not observed in actual WTP.

In conclusion, while the overall aversion to insurance featuring large probabilistic risk is largely in line with expected utility theory, the mechanism of high risk aversion leading to large drops in WTP does not appear to be the operative one.

Conclusion

Our results have isolated several reasons for the low demand that index insurance products have met in the developing world. Index insurance will struggle to generate demand in environments with multiple risks. Our results indicate that the probabilistic nature of index insurance is the dominant factor making it unattractive, and this is driven both by expected utility issues as well as by behavioral factors. This study therefore reinforces the need to push agricultural insurance products to cover multi-peril risks, as can be achieved with more sophisticated indexes, or to find ways of going directly towards insuring yield.

References

- **Barham, B. L.**, **J.-P. Chavas**, **D. Fitz**, **V. Ríos Salas**, and **L. Schechter**. 2014. "The roles of risk and ambiguity in technology adoption." *Journal of Economic Behavior & Organization* 97:204–218.
- **Barnett, B. J.**, **C. B. Barrett**, and **J. R. Skees**. 2008. "Poverty traps and index-based risk transfer products." *World Development* 36 (10):1766–1785.
- **Bryan, G.** 2010. "Ambiguity and insurance." Unpublished manuscript.
- **Carter, M.**, **A. de Janvry**, **E. Sadoulet**, and **A. Sarris**. 2014. "Index-based weather insurance for developing countries: A review of evidence and a set of propositions for up-scaling." *FERDI Working Paper* P112. http://www.ferdi.fr/en/publication/p112-index-based-weather-insurance-developing-countries.
- **Clarke, D. J.** 2011. "A theory of rational demand for index insurance." Department of Economics, University of Oxford. Working paper.
- **Cole, S.**, **X. Giné**, **J.Tobacman**, **R. Townsend**, **P. Topalova**, and **J. Vickery**. 2013. "Barriers to Household Risk Management: Evidence from India." *American Economic Journal: Applied Economics* 5 (1):104–35.
- **Elabed, G.** and **M. R. Carter**. 2015. "Compound-risk aversion, ambiguity and the willingness to pay for microinsurance." forthcoming *Journal of Economic Behavior & Organization*.
- **Gilboa, I.** and **D. Schmeidler**. 1989. "Maxmin Expected Utility with Non-unique Prior." *Journal of Mathematical Economics* 18 (2):141–153.
- **Tversky, A.** and **D. Kahneman**. 1992. "Advances in prospect theory: Cumulative representation of uncertainty." *Journal of Risk and Uncertainty* 5 (4):297–323.

Chapter 7

Planning for Disasters and the Economics of Disaster Risk Financing and Insurance

Daniel Clarke
Stefan Dercon

Introduction

In the aftermaths of disaster events, a systematic recovery and reconstruction phase is often hampered by strategic interactions between the national government, subnational government, donors, and affected people. As a result, recovery processes may be characterized by delays in response, underutilization of economies of scale, and reliance on costly financing instruments. These pre- and post-disaster inefficiencies can lead to a sluggish recovery process and increase both the economic and human cost of disasters. By developing solid plans for disasters, such inefficiencies can be avoided and a better humanitarian and disaster risk reduction system can be achieved. In particular, in order to better prepare for disaster events, governments should have (i) a coordinated plan for post-disaster action agreed in advance, (ii) clearly defined rules and triggers for disaster response, and (iii) risk financing to ensure that the plan can be implemented in the event of a disaster.

Coordination and planning for outcomes

Disaster response plans often focus on the inputs available – such as people to be mobilized, goods to be deployed, and health services on stand-by – rather than on the outcomes envisaged. Moreover, often each institution has its own disaster plan on how to employ available resources. However, this approach may create inefficiencies, as it can lead to coordination issues and costly time delays. In the absence of a single, solid disaster response plan, responsibilities may be ill-defined, work steps may be either duplicated or omitted and the exploitation of economies of scale in logistics may be lost.

To avoid such inefficiencies, a good plan should be made before disasters strike. This should include a clear choice by all the relevant stakeholders stating who or what will be protected, against what, and who will pay for what. In making such decisions, typically trade-offs need to be made, particularly with respect to the question of how resources are to be used. However, while such trade-offs are by nature difficult, they are necessary and thus best made in advance of a disaster, as delays following a disaster may be costly.

A sound disaster response plan could start by giving a clear statement of how costs are divided between the national and sub-national government, what building standards should be observed in order to "build back better", and that infrastructure should be registered to be eligible for protection. By forming such clear plans ahead of a disaster, governments can ensure a smoother, better coordinated and less onerous disaster response phase.

Rules rule

Disaster response should be based on clear, objective rules and triggers, such that when a disasters strikes, well-defined processes are set off and implemented. For instance, this can be achieved through the use of early warning and the determination of actions based on early warning data. Through the pursuit of this approach, disaster response would become a simple logistics implementation problem, dissociating disaster response from the display of political leadership.

Clear triggers for early action can help in streamlining disaster response. For instance, a clear trigger would be one that would specify the strength of a natural event or number of people infected with a particular disease such that response actions are set in motion. This process would be automatically prompted as soon as the trigger event occurs.

Of course, rules for early action are never perfect: Sometimes a rule will trigger action too early, and sometimes too late. However, response actions could be stopped through political decisions if actions were triggered erroneously. Moreover, evidence shows that acting early can help in reducing the cost of disasters. For instance, providing cash or food to households early in the face of an ensuing droughts is more cost effective in reducing food insecurity than waiting until the drought is at its peak. Similarly, by agreeing in advance on a procedure to reconstruct damaged infrastructure – such as schools, hospitals and roads - following a disaster, costly time delays can be avoided.

Credible rules and risk financing

Financing disasters ex ante can ensure that financial needs in the event of disasters are met, make disaster response plans credible and reduce uncertainty following disasters. In particular, a disaster risk insurance contract will detail what disaster events are insured and how large the payment in the event of the disaster would be. By insuring against disasters events, governments can cover immediate financial needs following a disaster in a cost-effective and timely manner.

Financial planning for disasters doesn't merely ensure that money is available following a disaster; it can also make a plan credible that ensures money is available quickly when—and only when—it is required. A credible and pre-agreed plan will commit different stakeholders to pay their shares and coordinate the amounts of funds that will be used. This, in turn, will ensure that financial needs are met, adequate resources are available, and coordination issues following disasters are reduced.

Finally, a disaster risk financing strategy can create certainty in the face of disasters. In particular, by insuring against disaster events, governments can be certain that immediate financial assistance will be available following a disaster, and will be aware of the extent of their coverage. In this way, governments can reduce their contingent liability in the event of disasters.

Conclusion

Faced with potentially rising numbers of extreme events, disaster preparation is essential in order to offer better protection at the lowest possible cost. To facilitate this process, arrangements are necessary so that contingent liabilities—who covers what, whom, and how—are well defined and appropriately financed. By agreeing on cost-sharing rules and commitment incentives, governments can structure their financial needs and use resources efficiently. Disaster response plans can then be made credible through the use of disaster financing strategies, which will clearly detail the different sources of financing following a triggering event. Through the use of coordination, clear triggers and risk financing, disasters will becomes less sensational, but also less costly both in terms of human suffering and financially.

Chapter 8

Ex-ante evaluation of the cost of alternative sovereign DRFI strategies

Daniel Clarke
Olivier Mahul
Richard Poulter
Tse-Ling Teh

Background

The increasing frequency and severity of climate extremes has forced governments to consider new ways of meeting the financial consequences of natural disasters, and there is a growing interest in implementing sovereign Disaster Risk Financing and Insurance (DRFI) programs in an attempt by governments to be financially prepared for when disasters occur. This has resulted in tremendous growth in the number and type of financial and budgetary instruments available, ranging from disaster reserve funds and lines of contingent credit to insurance instruments, but to date limited attention has been given to developing and implementing a coherent quantitative framework for appraising the true economic cost of these various instruments. Therefore at present, governments have no way of determining whether the programs and financial strategies they are employing are appropriate and efficient bearing in mind the risks they face.

.../...

•••/••• In post-disaster situations, the requirements for critical and rapid expenditures can lead to government using high-cost instruments, such as budget reallocations and borrowing on unfavorable terms (Benson and Clay, 2004). By comparison, sovereign DRFI instruments can protect the national budget and improve the speed at which capital is available and expenditure is undertaken, reducing the economic impact of natural disasters (Goes and Skees (2003), Linnerooth-Bayer and Mechler (2007)). Many developing countries and donors are taking steps to prepare against disasters, and are increasingly considering sovereign DRFI strategies as a way to improve their financial position in the event of a natural disaster. However, there exists very little evidence to guide how such strategies should be designed and compared.

The World Bank-GFDRR Disaster Risk Financing and Insurance (DRFI) Program[1] is a joint effort to mainstream disaster risk financing and insurance across the World Bank's development agenda. The program builds on a partnership between the Finance & Markets Global Practice (GFMDR) and the Global Facility for Disaster Reduction and Recovery (GFDRR), in close coordination with the World Bank Treasury. In 2013, the UK Department for International Development (DFID) and the DRFI Program partnered to launch the sovereign DRFI impact appraisal project. The three-year project is seeking to build the evidence base and develop a methodology to quantify the development impact of investments aimed at building financial protection against disasters. At its inception, the project highlighted the strong need for more evidence on the expected humanitarian and development impact of sovereign DRFI programs to ensure future investments are properly targeted and prioritized, and fulfil their potential in a development context.

Evaluating sovereign DRFI programs is a difficult exercise as it requires research and insights from a variety of different disciplines, including risk modelling, micro-, macro- and public economics, actuarial science and political economics. In order to make the overall problem more tractable it is necessary to first consider the key issues in isolation, before summarising these in a broader impact appraisal framework. The analysis in this paper restricts the environment under which governments make decisions regarding sovereign DRFI to provide a framework for evaluating the cost of alternative sovereign DRFI strategies. While simplifying assumptions are made, the analysis is able to provide powerful insights to guide policy-makers in making decisions regarding sovereign DRFI.

The DRFI Program introduce five ways in which sovereign DRFI can contribute to building financial resilience. While it is not possible to quantify the development impact of sovereign DRFI strategies in some of these areas (for example, it is not possible to assess the impact sovereign DRFI may have on increased discipline over budget mobilisation and execution), this analysis seeks to quantify the effects in two of these areas: the cost of capital and timeliness of instruments which can provide financing for relief, recovery and reconstruction after a disaster. While the results provided can provide important insights as to the cost implications of different financial instruments, it is important to appreciate that the cost and timeliness are only two elements in assessing the impact of decisions regarding sovereign DRFI strategies.

1. http://www.worldbank.org/en/programs/disaster-risk-financing-and-insurance-program

Source: GFDRR and World Bank Group. Financial protection against disasters: an operational framework for disaster risk financing and insurance. World Bank, 2014

By assuming that a government's contingent liability to disasters is fixed, this analysis explores the questions of whether and how a government can choose an optimal combination of financial instruments to finance this liability. For many years the World Bank has been recommending to governments that using different financial instruments for different layers of risk is appropriate and cost effective (Gurenko and Mahul, 2003), but there has not been rigorous evidence to support this. This analysis first provides quantitative evidence that using different financial instruments in combination is indeed the most cost-efficient way to finance disaster losses. Furthermore, the proposed framework provides a methodology for selecting the sovereign DRFI strategy which minimizes the cost of financing the average annual loss, or the strategy which minimizes the cost of financing losses at a given return period. This allows the framework to provide useful insights for decision-makers who wish to minimize average costs, or for those who wish to minimize the cost of financing a disaster of particular magnitude.

This framework and analysis will be published as a package of two academic research papers to be published through the sovereign DRFI impact appraisal project. The first will be an economic theory paper, outlining the proposed methodology and calculations; the second will be a paper highlighting case studies and practical applications of the framework for policy-makers. While the main theoretical results of the framework are provided, this policy brief mainly provides a summary of the second of the research papers, and is therefore focussed on the potential policy implications of the framework and analysis.

Theoretical framework

The proposed framework evaluates the cost of funding disaster losses through alternative sovereign DRFI strategies. The model is based on key assumption that a government's contingent liability to disasters is known, and this liability can be financed using a combination of the following instruments:

- Reserves, contingency funds or ex-ante budget allocation of ring-fenced funds
- Contingent credit at concessional interest rates, such as the World Bank Development Policy Loan

with Catastrophe Deferred Drawdown Option (CAT DDO)
- Risk transfer such as indemnity or parametric insurance, reinsurance, and catastrophe bonds or swaps
- Post-disaster budget reallocations
- Post-disaster borrowing

Formulae are proposed for calculating the economic cost of each of these financial instruments, with the following two key results:

1. *The findings provide evidence that a tiered approach to sovereign DRFI (where different financial instruments are used for different layers of risk) is the most cost-efficient method of financing disaster losses.*
2. *It is possible to define the sovereign DRFI strategy which will minimize the long term average cost of financing disaster losses based on the calculated marginal opportunity cost of each financial instrument.*

Case studies

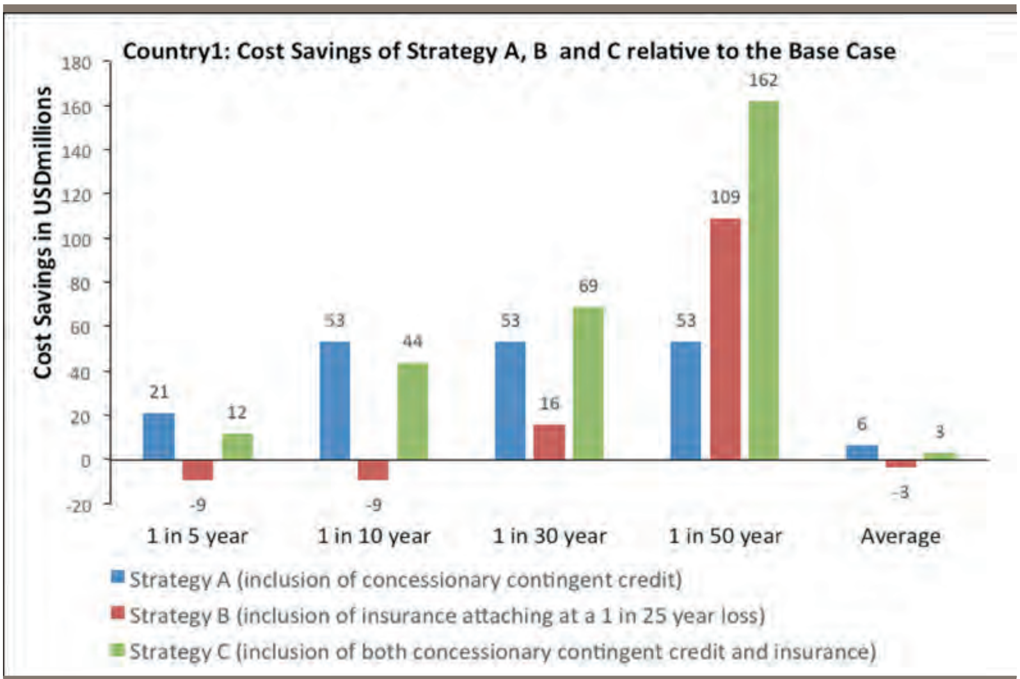
The theoretical framework is applied to two case studies, with results calculated based on country-specific risk profiles and economic assumptions. The two countries considered are described as follows:

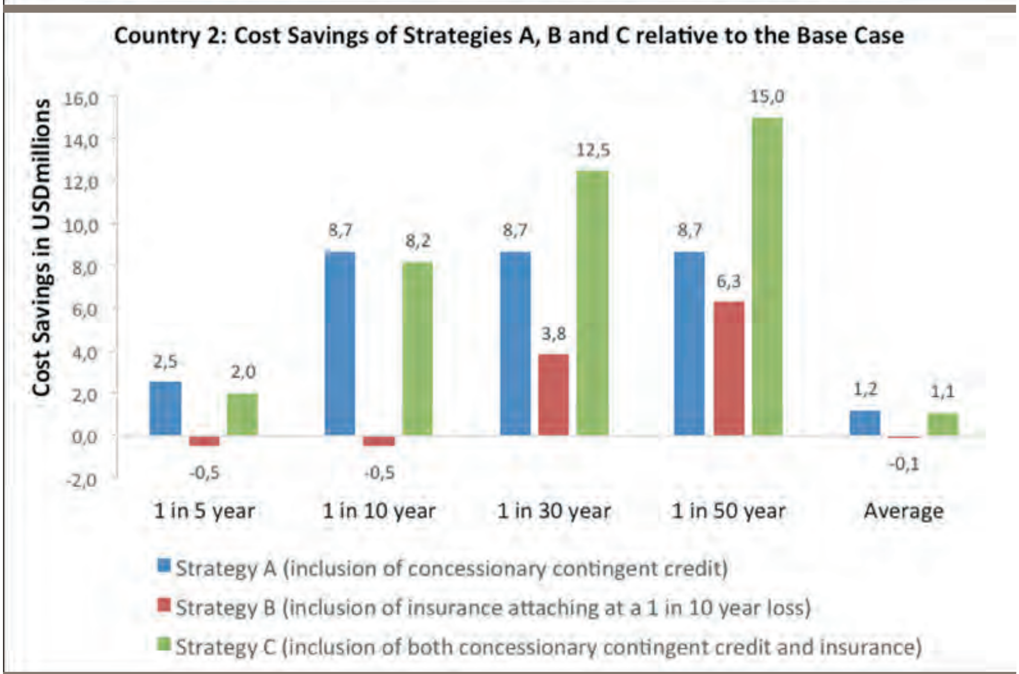
Country 1 is a country with a large diversified economy and very high recurrent risk of disasters from both earthquakes and tropical cyclones. The country has very high borrowing capacity and does not face any delays or increased cost of borrowing in the commercial market following disaster events.

Country 2 is a small-island country with a small service-based economy heavily reliant on tourism. The country has relatively low recurrent risk but is highly exposed to catastrophic tropical cyclone events. While the country has the ability to borrow easily in a non-disaster environment, following a disaster it is both timely and expensive for the country to borrow in the commercial market.

In both cases we consider the current sovereign DRFI strategy which involves a mixture of reserves, post-disaster budget reallocations and emergency borrowing after the disaster event. We then consider three alternative strategies of the country utilizing a concessionary contingent credit facility from the World Bank[2] (Strategy A), purchasing market-based parametric insurance (Strategy B), or both (Strategy C).

2. The instrument considered here is the World Bank Development Policy Loan with Catastrophe Deferred Drawdown Option (CAT DDO). This facility is a pre-arranged line of credit that a country can draw upon in the aftermath of a natural disaster. Amounts drawn down are subject to repayment at the same (concessionary) interest rates as amounts borrowed through existing World Bank Development Policy Loans. The Cat DDO has a "soft trigger" (as opposed to a parametric trigger), where funds become available for disbursement after the declaration of a state of emergency due to a natural disaster. See here for my information: http://treasury.worldbank.org/bdm/pdf/Handouts_Finance/CatDDO_Product_Note.pdf





Country 1 results

The diagram above shows that:

- Financing losses through contingent credit at concessional rates is cheaper on average. The inclusion of a concessionary contingent credit facility (Strategy A) results in a saving of $6m on average, or $53m when funding losses more extreme than a 1-in-10 year loss.
- When insurance is considered as part of the strategy (Strategy B), we see higher costs on average (increased costs of $3m), but the savings at extreme return periods are very significant. If a Government is concerned about financing frequent events (e.g. anything above 1 in 10 year losses) then insurance is expensive and will result in a higher cost on average. However if the government is concerned about more extreme events then insurance will be beneficial from a cost perspective.

- When both instruments are combined, we see savings range from $3m on average to $162m when financing a 1-in-50 year loss. If you use both concessionary contingent credit and insurance together then the government receives the benefit of the concessionary credit at the low return periods, and even greater savings at more extreme return periods when compared to using insurance alone. This supports the concept that a tiered DRFI strategy is the most cost effective way of financing disasters.

Country 2 results

The diagram above shows that:

- Financing losses through contingent credit at concessional rates is again cheaper on average, resulting in a saving of $1.2m on average, or $8.7m when funding losses more extreme than a 1-in-10 year loss.
- Insurance also has a similar effect as in country 1, with higher costs on average (increased costs of $0.1m), but the savings of $6.3m for a 1-in-50 year loss. However, when we consider these savings relative to the sizes of the losses being financed we find that the effect of insurance has a greater impact for Country 2 than Country 1. Due to the high cost of borrowing faced by country 2 after a disaster, including ex-ante instruments within the DRFI strategy results in much greater relative savings than country 1.
- When both instruments are combined, we see savings range from $1.1m on average to $15.0m when financing a 1-in-50 year loss. This again supports the concept that a tiered DRFI strategy is the most cost effective way of financing disasters.

The observations from both case studies are consistent with the theoretical results from the framework. In both cases a tiered strategy of different financing instruments offers the greatest savings when compared to the base case of reliance on only financing disaster losses through post-disaster borrowing. Ex-ante financing instruments lead to greater savings at higher return periods for the small-island country due to the high cost of borrowing in a post-disaster environment.

Conclusion

The proposed framework looks at evaluating the cost and timing of alternative sovereign DRFI strategies, which is a key (but not the only) factor for governments to consider when setting appropriate strategies to ensure financial resilience to disasters. The results of the analysis can therefore assist in the decision-making process regarding which financial instruments are best suited to different layers of risk, although there are other considerations (such as political economy aspects) which are not captured by the analysis.

The results are intuitive and fairly robust to parameter assumptions, and are consistent across the case studies where the framework has been applied. The framework provides evidence to support the tiered approach to sovereign DRFI, and provides a methodology for selecting the strategy which minimizes the long term average cost of financing disaster losses.

A key assumption in this framework is that a government's contingent liability is known. In order to understand the full costs and benefits of different sovereign DRFI strategies this analysis must be considered in the context of other components of the sovereign DRFI Impact Appraisal Project where this assumption is relaxed.

References

- **Benson, C.** and **E. Clay**. 2004. *Understanding the Economic and Financial Impacts of Natural Disasters*. World Bank.
- **Bevan, D.** and **S. Cook**. 2014. "Public expenditure following disasters". SDRFI *Impact Appraisal Project*.
- **Clarke, D.** and **R. Hill**. 2013. "Cost-benefit analysis of the African risk capacity facility. Technical Report" 1292, *International Food Policy Research Institute*.
- **Clarke, D.** and **O. Mahul**. 2011. "Disaster Risk Financing and Contingent Credit: A Dynamic Analysis." *World Bank Policy Research Working Paper 5693*.
- **Clarke, D.** and **R. Poulter**. 2014. "A methodology for calculating the opportunity cost of layered sovereign DRFI strategies." *SDRFI Impact Appraisal Project*.
- **Dana, J.** and **S. von Dahlen**. 2014. "An overview of potential pathways to appraising impact of sovereign DRFI: Where should we be looking to assess benefits?" *SDRFI Impact Appraisal Project*.
- **de Janvry, A.** 2014. "Quantifying through ex-post assessments the micro-level impacts of sovereign disaster risk financing and insurance programs." *SDRFI Impact Appraisal Project*.
- **Freeman, P.**, **L. Martin**, **R. Mechler**, and **K. Warner**. 2002. "Catastrophes and development integrating natural catastrophes into development planning." *Technical report, World Bank*.
- **GFDRR and World Bank Group**. 2014. *Financial protection against disasters: an operational framework for disaster risk financing and insurance*. World Bank.
- **Goes, A.** and **J. Skees**. 2003. "Financing natural disaster risk using charity contributions and ex ante index insurance." American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association), 2003 Annual meeting, July 27-30, Montreal, Canada.
- **Gurenko, E.** and **O. Mahul**. 2003. "Combining insurance, contingent debt and self-retention an optimal corporate risk financing strategy." *World Bank Working Paper 3167*.
- **Grenham, D.** 2014. "Actuarial approaches to assumption setting." *SDRFI Impact Appraisal Project*.
- **Grenham, D.** and **N. Foster**. 2014. "Review, challenge and use of impact appraisals by decision makers." *SDRFI Impact Appraisal Project*.
- **Hallegatte, S.** 2014. "The indirect cost of natural disasters and an economic definition of macroeconomic resilience." *SDRFI Impact Appraisal Project*.
- **Hinds, R.** 2013. "Sovereign insurance and risk finance schemes for disaster management." *Technical Report 903, GSDRC University of Birmingham*.
- **Linnerooth-Bayer, J.** and **R. Mechler**. 2007. "Disaster safety nets for developing countries: Extending public-private partnerships." *Environmental Hazards*, 7:54–61.
- **Teh, T.** 2015. "Sovereign disaster risk financing and insurance (SDRFI) impact appraisal." *SDRFI Impact Appraisal Project*.

Impact evaluation of government interventions

Chapter 9

Insuring Growth: The Impact of Disaster Funds on Economic Development

ALAIN DE JANVRY
ALEJANDRO DEL VALLE
ELISABETH SADOULET

Abstract

While a recent stream of papers has shown that natural disasters in developing economies have negative and persistent effects on economic development, it is still unclear whether *ex ante* budgeting allocations for post-disaster reconstruction provide a cost effective way of mitigating these losses. By taking advantage of the sharp rules that govern the municipal level eligibility to infrastructure reconstruction funds in Mexico, this paper provides some of the first estimates of the impact of disaster funds on local economic activity. Our main finding is that access to disaster funding increases local economic activity by as much as 2.57% one year after damage from heavy rainfall has occurred. We also find that the average benefit cost ratio of Mexico's disaster fund is 1.3.

Introduction

While in developed economies there is considerable debate over the long run effects of natural disasters on economic performance (see Strobl (2011); Hsiang and Jina (2014)), in developing economies both micro and macro level empirical studies suggest that natural disasters can have particularly large and persistent effects on economic performance (see Anttila-Hughes and Hsiang (2013); Noy (2009)).

The estimated effects of natural disasters on economic performance are potentially large. At the top range of estimates, Hsiang and Jina (2014) argue that a percentile 90 hurricane can reduce per capita income by as much as 7.4%, and for as long as two decades. This loss is of considerable magnitude as it is roughly equivalent to undoing 3.7 years of average economic growth. Similarly, in a medium run scenario, Anttila-Hughes and Hsiang (2013) claim that the damage created by west pacific hurricanes one year after the event is 15 times larger than the immediate damages.

Given the scale of potential medium and long run losses in post-disaster economic outcomes, a key question is whether tools like national disaster funds provide developing economies with a cost effective way of mitigating the losses caused by natural disasters. Taking advantage of a unique natural experiment and dataset, this paper provides some of the first evidence on the causal impact of disaster funds on medium run economic development.

We circumvent endogeneity in the provision of rapid reconstruction funds by using a regression discontinuity design that exploits the sharp rules that determine whether a natural disaster has occurred in a Mexican municipality.[1] Since only officially affected municipalities can access disaster funds, we recover causal estimates of the impact of disaster funds on local economic activity by comparing municipalities that are just below and above the thresholds that define the occurrence of the disaster.

We measure changes in economic activity at the municipal level using high resolution satellite imagery that allows us to measure the intensity of light as observed from outer-space. Because our night light measure is strongly related to local economic activity we are able to track the differential economic performance created by the provision of rapid reconstruction funds.

Our main finding is that Mexico's disaster fund increased local economic activity by as much as 2.57%. Our point estimates are currently too noisy to precisely determine whether the program is cost effective. Nonetheless, taken at face value the estimates suggest that the benefit cost ratio of Mexico's disaster fund is 1.3.

The rest of the paper is organized as follows. Section 2 presents brief background information on the FONDEN disaster fund. Section 3 presents the identification strategy. Section 4 discusses the various datasets used. Section 5 presents the main results. Section 6 concludes.

Background

FONDEN is a fund setup by the Mexican government to manage the risk created by natural disasters. The program is funded by the government and through the placement of catastrophe bonds in the capital market. The program became operational in 1999 with the primary purpose of supporting the reconstruction of federal and state infrastructure destroyed by natural disasters. Over time the efforts of the federal government have evolved to finance interventions at all stages of the disaster risk management cycle. Currently, FONDEN funds short term emergency relief operations and the reconstruction of low-income housing and public infrastructure.

1. A municipality is a second level administrative unit in Mexico. There are currently 2461 municipalities.

Mechanisms to mitigate the impact of disasters

The bulk of FONDEN expenditures are related to reconstruction efforts. These efforts include the reconstruction of federal and state roads, the provision of funds to reconstruct low-income housing, and the rebuilding of hydraulic, health, and educational infrastructure. These expenditures can provide a double gain to economic development. First, by mitigating the losses created by natural disasters. Second, by enabling local governments and households to reallocate resources from inefficient low risk-low return productive activities to more risky-higher yielding activities.

Our current analysis estimates the impact of FONDEN one year after the occurrence of a natural disaster, and focuses on the 2004-2011 period when road expenditures accounted for the bulk of overall expenditures.[2] Accordingly, we expect FONDEN to affect economic activity primarily by enabling municipalities to quickly rebuild their road network following a disaster.

Empirical Strategy

In order to estimate the impact of FONDEN we will take advantage of sharp physical event thresholds that determine whether a natural disaster has occurred, and therefore whether a municipality is eligible for FONDEN funding. The funding process begins with a request from the state governor. This request contains a list of municipalities that are believed to have experienced damages as a result of a natural disaster. The request is verified by an independent technical agency who compares measurements of the intensity of the disaster to the thresholds set out on FONDEN operational guidelines. For example, in the case of heavy rainfall, the technical agency CONAGUA[3] compares the rainfall at the weather station representative of the requested municipality to the FONDEN heavy rain threshold, that is, rainfall greater or equal to the percentile 90 of historic rain recorded at that weather station. CONAGUA will then list the municipalities that pass the threshold, and a declaration of disaster will be issued for this set of municipalities. A declaration of disaster is a necessary condition to receive FONDEN funding.

We will focus on rainfall related events because they account for the bulk of FONDEN expenditures. These events include: heavy rain, tropical storms, hurricanes, areal flooding, riverine flooding, landslides, and hail storms. The threshold for heavy rain, and areal flooding is rainfall greater than the percentile 90 of historic rainfall. Tropical storms, hurricanes, riverine flooding, landslides, and hail storms have other additional thresholds. In spite of the sharp rules, we use a fuzzy regression discontinuity design because we are currently unable to perfectly distinguish between different types of events, and because we are unable to fully match municipalities to the set of weather stations used for verification. Because of data restrictions, as previously mentioned, we will restrict the sample to the 2004 to 2011 period.

In the fuzzy regression discontinuity design to estimate two causal effects: the effect of crossing the percentile 90 threshold on the probability of receiving FONDEN, and the effect of crossing the percentile 90 threshold on local economic activity. Specifically we run the following regressions:

$$f_{mt} = \gamma_0 + \gamma_1 z_{mt} + \gamma_2 g(r_{mt} - c_{mt}) + y_3 g(r_{mt} - c_{mt}) * z_{mt} + \theta_t + v_{mt} \quad (1)$$

2. The share of expenditure by category vary year by year depending on the the type of damages that have occurred. During the period of analysis road expenditures account for 56% of overall expenditures, and for more than 70% of expenditures in three of the eight years analyzed.

3. CONAGUA is an agency of the government of Mexico charged with water conservation.

$$y_{mt} = \beta_0 + \beta_1 z_{mt} + \beta_2 g(r_{mt} - c_{mt}) + \beta_3 g(r_{mt} - c_{mt}) * z_{mt} + \theta_t + \varepsilon_{mt} \quad (2)$$

$$\hat{\pi}_1 = \frac{\hat{\beta}_1}{\hat{\gamma}_1} \quad (3)$$

Equation 1, the first stage, is estimated by regressing a dummy that takes the value of one when municipality m in year t receives FONDEN, f_{mt}, on an indicator variable that takes the value of one when an observation falls above the threshold, z_{mt}. That is, $z_{mt} = \mathbb{1}(r_{mt} \geq c_{mt})$ where r_{mt} is the amount of rainfall on the day requested and c_{mt} is the percentile 90 threshold. The function $g(r_{mt} - c_{mt})$ represents the relationship between the outcome and the forcing variable, that is, millimeters of rainfall to the the percentile 90 threshold. We will consider various ways of modeling this relationship. First we will model $g(\cdot)$ as a flexible polynomial function on either side of the threshold and use the full sample to estimate it. Second, we will assume that $g(\cdot)$ is linear and use a sample that falls within an optimal bandwidth to estimate it. To determine the bandwidth we will use the methods proposed by Imbens and Kalyanaraman (2012) and Calonico et al. (2014b).

Equation 2, the reduced form, is derived by regressing our measure of local economic activity, y_{mt}, on z_{mt}. The estimation procedure is analogous to that of equation 1. Next, we derive the impact of FONDEN on local economic, π_1, by rescaling the reduced form coefficient of z_{mt} by its first stage coefficient.[4]

Data

For our analysis, we use data from several sources. We proxy changes in municipal level economic activity by using imagery from the DMSP-OLS satellite program. The imagery provided by NASA and NOAA is available in yearly frequency from 1992 to 2012. The digital number (DN) that can be derived from these images is a measure of the intensity of the light observed from outer-space. The DN is recorded at a spatial resolution of approximately one km square.[5] Given the high-resolution of these images we are able to construct meaningful measures of the change in economic activity at the subnational level. Specifically, we follow Henderson et al. (2011) and use as proxy the log of the sum of the DN over all pixels that fall within a municipality standardized by the area of the pixels. Consistent with past literature our own tests reveal that the change in log lights is a good predictor of changes in state level GDP, as well as other measures of economic activity at the municipal level.[6]

Data on historical rainfall at the weather station level, the rainfall thresholds used to verify the occurrence of a natural disaster, and the mapping between weather stations and municipalities is provided by CONAGUA. Data on FONDEN expenditures are provided by the Ministry of Finance. Data on municipal-level requests and approvals for disaster declarations are constructed from the archives of Mexico's official diary.

All in all, we have 7200 municipal disaster observation between 2004 and 2011. In our first pass at the data, we will restrict the sample to municipalities that experience a natural disaster related to heavy rain and for whom we have complete information. Table 1 below presents summary statistics of our key variables in this sample.

4. In order to derive standard errors for $\pi 1$ we will instead estimate the coefficient using 2SLS.
5. The actual spatial resolution is 30 arc seconds, that is, at the equator 0.86 km by 0.86 km grids.
6. See Henderson et al. (2011) for a discussion of using changes in night lights to predict changes in economic activity.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	P5	P95
Δ log light	1745	-.04	.28	-.43	.48
Fonden = 1	1745	.58	.49	0	1
Above threshold	1745	.36	.48	0	1
Rainfall mm to threshold	1745	-13.09	74.94	-116.1	120.8

Results

Figure 1a plots the mean probability of receiving FONDEN relative to rainfall millimeters (mm) to the threshold. The figure reveals a potential jump in the probability of receiving FONDEN. Moving from just below to just above the threshold increases the likelihood of receiving FONDEN from about 60% to 80%. In order to better visualize this jump, the figure additionally plots kernel-weighted local polynomial regression lines that are estimated separately on each side of the threshold. The figure further suggests that the underlying relationship between the probability of receiving FONDEN and mm to the threshold could be captured by a second or third order polynomial function of $g(\cdot)$.

Analogously, figure 1b plots the mean change in log lights between the year a disaster occurs and the following year. The figure reveals a clear jump in brightness at the threshold. Moving from just below to just above the threshold increases brightness by roughly 0.07 log points. As expected, the figure additionally reveals that in the absence of FONDEN, night lights become dimmer as the intensity of the disaster increases, that is, as the we move towards the threshold from the left. Interestingly, moving from the threshold to the right there appears to be no relationship between the brightness and the intensity of the disaster. These findings are consistent with the idea that our log lights proxy is in fact capable of measuring a reduction in economic activity caused by natural disasters, and that FONDEN is at least partly capable of mitigating the impact of natural disasters.

Table 2 presents the regression analog of figures 1a and 1b. Panel A present OLS estimates of equation 1. Panel B presents OLS estimates of equation 2, and 2SLS estimates of the impact of FONDEN on local economic activity π_1. Columns 1 to 4 present various specifications of the functions $g(\cdot)$. Specifically, in columns 1 and 2 we estimate using the full sample and assume that function $g(\cdot)$ is a second or a third order polynomial. In columns 3 and 4, we assume that $g(\cdot)$ is linear and restrict the sample to within 50.5 mm and 57.3 mm as determined by two optimal bandwidth calculations. Standard errors are clustered at the municipal level.

Consistent with figure 1a, the estimates of panel A reveal that crossing the threshold increases the probability of receiving FONDEN between 13% to 19% and that this jump is statistically significant in all cases. Similarly, the reduced form estimates of panel B reveal that municipalities above the threshold grew by roughy 0.04 log points more than municipalities below the threshold. Once we rescale these reduced form coefficients, we find that FONDEN led to an increase in the range of 0.196 to 0.37 log points. While these coefficients are only statistically significant at the margin, the estimated effect sizes are of considerable economic magnitude. In the last column of panel B we convert the changes in log light created by FONDEN to changes in economic activity using an elasticity of light to GDP of approximately 0.07.[7] These estimates of the impact of FONDEN suggest that the program could have increased local economic activity by as much as 2.57%.

Simulation

In order to get a better sense of the magnitude of the changes in economic activity generated by FONDEN, this section preforms a simple counterfactual simulation. The calculation is preformed in four steps. First, we approximate municipal GDP at baseline by calculating 2004 per capita GDP at the state level and then multiply this figure by the population of each municipality. Second, we convert the estimated change in log light to a change in economic activity using an estimated elasticity of light to state GDP. Specifically, we follow Henderson et al. (2011) and derive this elasticity by regressing the log of state level GDP on our log light proxy, year fixed effects, state fixed effects, and linear state trends. Third, we restrict the sample to municipalities that received FONDEN between 2004 and 2011, our sample period. Fourth we calculate the value of the economic activity generated by FONDEN by multiplying municipal GDP by the change in economic activity. The municipal figures are then summed up and converted to dollars using the current exchange rate.

To account for the uncertainty in the estimated regression parameters, we perform the calculation described in the previous paragraph, using coefficients drawn from a normal distribution with mean equal to the estimated coefficient and a standard deviation equal to the standard error. This procedure is then repeated 1000 times, using a random draw of the coefficients each time.

The resulting simulation suggests that the increase in economic activity had an average value of USD $6.38 billion with a standard deviation of USD $5.63 billion. Given that the cost of FONDEN during this period is USD $4.9 billion,[8] these figures suggest that the average benefitcost ratio is roughly 1.3. These figures seem to be of a reasonable magnitude, if we were to think of FONDEN as fiscal stimulus even when taking into account one standard deviation we would derive a Keynesian multiplier in the 0.15 to 2.45 range. When we replicate this simulation exercise for each year in our sample, we find that FONDEN provides an average increase in local economic activity of USD $1.69 billion, that in all years the multiplier is above one, and that the multiplier could be as large as 5.

All in all, while our estimates are too noisy to clearly pin-down the effect of FONDEN, they are still informative as they provide lower bounds of program impact. We are likely to be underestimating the impact of FONDEN. First, because, one year after a disaster occurs, municipalities without FONDEN funds are likely to have engaged in reconstruction efforts of their own. Second, because municipalities without FONDEN funds are likely to benefit indirectly from FONDEN reconstruction projects in neighboring municipalities. These spillover effects could be particularly important in the case of road reconstruction projects, which represent the bulk of FONDEN projects in our sample.

Conclusion

This paper exploits the sharp rules that govern eligibility to FONDEN funding, to derive some of the first estimates of the impact of disaster funds on local economic activity. On the whole, our results suggest that, in Mexico, FONDEN has provided cost-effective protection from the public service disruptions created by natural disasters. Given the scale of gains to local economic activity brought

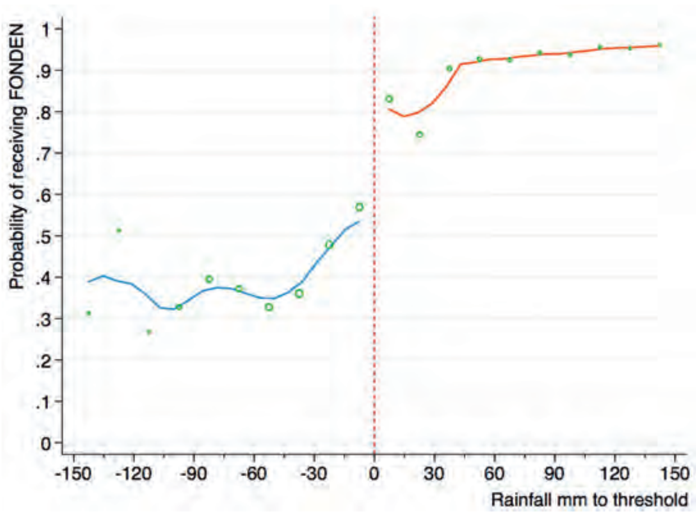
7. See the next section for details on this calculation.

8. This cost figure refers to the money spent by FONDEN in reconstruction projects. Note that in the absence of FONDEN these reconstruction projects are likely to be undertaken by other government agencies, albeit at higher administrative costs and longer waiting times. The additional benefits created by the more effective FONDEN administration are not been taken into account in this analysis.

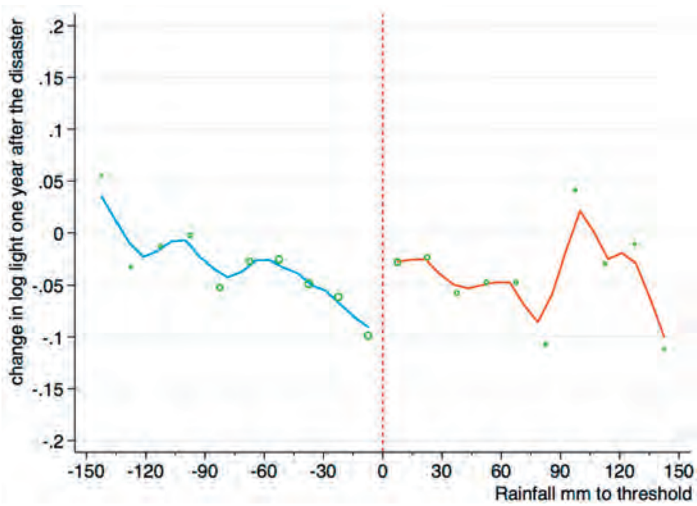
about by disaster funds, policy makers are encouraged to consider using disaster funds to extend their own response capabilities.

Figures and Tables

Figure 1: Probability of receiving FONDEN and change in lights by forcing variable



(a) First stage, twenty 15 mm bins



(b) Reduced form, twenty 15 mm bins

Note: The figures plot the local average of 15 mm bins, and triangular kernel-weighted local polynomial regression lines on each side of the threshold. The size of the markers is proportional to the number of observations used to estimate the local averages. The 15 mm bin width roughly corresponds to the optimal bin width derived when minimizing the integrated mean square error. See Calonico et al. (2014a) for details on deriving the optimal number of bins. The forcing variable is calculated by taking the difference between daily rainfall and the percentile 90 threshold, For disasters that span more than one day, the day with the maximum rainfall is used.

Table 2: The impact of FONDEN

	(1)	(2)	(3)	(4)
Panel A: First Stage				
Dep. Variable	Fonden=1	Fonden=1	Fonden=1	Fonden=1
Above threshold (γ_1)	0.194*** (0.042)	0.140*** (0.0510)	0.129** (0.0530)	0.157*** (0.0506)
Panel B: Reduced Form & 2SLS				
Dep. Variable	Δ log light	Δ log light	Δ log light	Δ log light
Above threshold (β_1)	0.038** (0.018)	0.0382 (0.0235)	0.0481** (0.0235)	0.0439** (0.0222)
$\widehat{\text{Fonden}}$ (π_1)	0.196* (0.104)	0.272 (0.199)	0.372 (0.238)	0.280* (0.167)
Impact on local GDP %	1.36	1.88	2.57	1.93
Observations	1,745	1,745	922	1,016
Specification	quadratic	cubic	linear	linear
Sample	Full	Full	Optimal bw IK: 50.5 mm	Optimal bw CCT: 57.3mm

Note: Standard errors clustered at the municipal level in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. All regressions include year fixed effects. Panel A presents OLS estimates of equation 1. Panel B presents OLS estimates of equation 2, and 2SLS estimates of the coefficient π_1. The label specification referrers to the polynomial order of the function $g(r_{mt} - c)$. In column 3, the optimal bandwidth was derived following Imbens and Kalyanaraman (2012). In column 4 the optimal bandwidth was derived following Calonico et al. (2014b). The impact on local GDP is derived by multiplying the 2SLS estimate by the elasticity of light to GDP, details on this calculation can be found in the simulation section.

References

- **Anttila-Hughes, J. K.** and **S. M. Hsiang**. 2013. "Destruction, disinvestment, and death: Economic and human losses following environmental disaster," *Available at SSRN 2220501*.
- **Calonico, S.**, **M. D. Cattaneo**, and **R. Titiunik**. 2014. *Optimal Data-Driven Regression Discontinuity Plots*
- **Calonico, S.**, **M. D. Cattaneo**, and **R. Titiunik**. 2014. "Robust Nonparametric Confidence Intervals for Regression-Discontinuity Designs," *Econometrica*. 82 (6): 2295–2326.
- **Henderson, J. V.**, **A. Storeygard**, and **D. N. Weil**. 2011. "A bright idea for measuring economic growth," *The American economic review*, 101 (3): 194.
- **Hsiang, S. M.** and **A. S. Jina**. 2014. "The causal effect of environmental catastrophe on long-run economic growth: evidence from 6,700 cyclones" Technical Report, National Bureau of Economic Research.
- **Imbens, G.** and **K. Kalyanaraman**. 2012. "Optimal Bandwidth Choice for the Regression Discontinuity Estimator." *Review of Economic Studies*, 79 (3).
- **Noy, I.** 2009. "The macroeconomic consequences of disasters," *Journal of Development Economics*, 88 (2): 221–231.
- **Strobl, E.** 2011. "The economic growth impact of hurricanes: evidence from US coastal counties," *Review of Economics and Statistics*, 93 (2): 575–589.

Chapter 10

Weather-indexed insurance and productivity of small-scale farmers: An impact evaluation of Mexico's CADENA program

Elizabeth Ramirez Ritchie

Abstract

Farmers in developing countries face substantial weather risk but often have few financial tools to deal with this risk. To address this issue, the Mexican government instituted a program in 2003 called CADENA that currently provides both agricultural and livestock insurance to small farmers. A large portion of the agricultural land that the program covers is insured via weather index insurance. This policy brief summarizes the preliminary results of an evaluation of CADENA's weather index insurance component. A regression discontinuity design using insurance thresholds allows us to determine the impact of receiving payment in the case of a weather shock among the set of insured municipalities. We find that payment results in an increase in the log hectares of maize sowed relative to the previous year. We also find evidence of positive effects on income and expenditure per capita in rural localities, particularly those where a large percentage of agricultural land is controlled by eligible producers. We hope to refine and expand this analysis with additional data in the future.

1. I would like to thank Alan Fuchs at the World Bank and Artemio Coutiño at the Mexican Ministry of Agriculture (SAGARPA) for providing valuable information about the CADENA program and facilitating access to data.

Introduction and program background

Weather shocks are a major source of income fluctuations among rural populations in developing countries, and they can have catastrophic impacts on vulnerable populations. With a rural population of approximately 27 million and two-thirds of the country's poor living in rural localities (CONAPO, INEGI), weather risk is an important issue for poverty reduction efforts in Mexico. To address this issue the Mexican Ministry of Agriculture (SAGARPA) began an index insurance program named CADENA in 2003, offering weather index insurance (WII) to small maize farmers in one state in Mexico. As of 2013, CADENA had almost nationwide coverage insuring more than 6 million hectares (FAO, 2014). The program currently offers WII to farmers growing staple crops on less than 20 hectares of rainfed land (SAGARPA, 2014). The insurance provides coverage during three pre-determined phases that cover sowing through harvesting. If precipitation falls below (or above in the case flood insurance) the threshold in any of the three phases, the farmers receive indemnity payments. By having the state or federal governments instead of individual farmers pay the insurance premiums, the CADENA program has been able to achieve widespread coverage. Evaluating an existing program with national coverage is an important contribution to the literature on index insurance in developing countries, since much of evidence regarding the effectiveness of WII comes from smaller scale projects. The CADENA program has been previously evaluated in Fuchs and Wolff (2010), which uses the rollout of the program to estimate impacts on income and agricultural yields. Fuchs and Wolff find that the program increases maize yields and rural per capita expenditure and income, but not the area devoted to planting insured crops. The goal of this evaluation is to take advantage of additional data as the program has expanded in geographic scope and has now been in existence for over a decade. Furthermore, we hope to disentangle the direct effects of insurance payments and the effects of changes in investment behavior induced by the insurance. This evaluation focuses on a regression discontinuity design to analyze the effect of payment. The preliminary results suggest that insurance payments increase per capita income and expenditures in rural localities, echoing the findings in Fuchs and Wolff (2010). However, unlike Fuchs and Wolff, we find that insurance payments increase the land area devoted to insured crops, but not the yield of said crops.

Preliminary analysis

Providing insurance to previously uninsured farmers has two distinct, although interrelated, effects. Insurance has the direct effect of payment in case of a bad weather realization, which can help smooth consumption or ensure sufficient resources for production in subsequent seasons. The risk reduction that this entails can have indirect effects on economic outcomes by altering farmers' investment decisions; for example, encouraging them to adopt riskier but more profitable investments during the planting stage. We begin our evaluation of the CADENA program by focusing on the direct effect of providing payment. To identify this effect we limit our sample to municipalities that were insured through index insurance policies between the years of 2005 and 2012 and focus for the time being on drought events only. Using weather data provided by the National Water Commission (CONAGUA), we match policies to their corresponding weather stations and calculate deviations from the threshold specified in the policy for each of the three phases. In a regression discontinuity design, we use the minimum deviation from the threshold over the three phases as our running variable. A municipality should receive payment if its deviation from the drought threshold is negative in any of the three phases. This strategy allows us to estimate the impact of payment by comparing insured municipalities with very similar weather realizations, such that any difference in outcomes can plausibly be attributed solely to insurance payments.

Following Card and Lee (2008), we use the entire range of data but control for the conditional expectation of the outcome as a function of the running variable using a quadratic polynomial. Specifically, we estimate the following equations:

$$Pay_{mct} = \alpha + \beta Z_{mct} + \gamma f(X_{mct}) + \pi f(X_{mct}) \cdot Z_{mct} + \delta_c + \varepsilon_{mct} \quad (1)$$

$$y_{mct}+1 = \tilde{\alpha} + \tilde{\beta}\widehat{Pay}_{mct} + \tilde{\gamma} f(X_{mct}) + \tilde{\pi} f(X_{mct}) \cdot Z_{mct} + \delta_c + \tilde{\varepsilon}_{mct} \quad (2)$$

Pay_{mct} is an indicator for payment in municipality m for crop c, and year t, which is instrumented with X_{mct} in equation 2, and y_{mct+1} is our outcome of interest in the following year. X_{mct} is the minimum deviation from the threshold over the three phases ($X_{mct} = min_s \{Rain_{mst} - Threshold_{mcst}\}$ where s indexes phases), and Z_{mct} is an indicator for rainfall falling below the threshold in at least one phase $\mathbf{1}\{X_{mct} < 0\}$. The function $f(X_{mct})$ in our case is a quadratic polynomial in X_{mct}. Lastly, δ_c is a crop fixed effect. We restrict ourselves to the insured crops, which are rainfed corn, sorghum, barley, and beans.

Panel b of figure 1 (see page 86) illustrates the graphical equivalent of equation (1), which is the first stage of our regression discontinuity. In theory, all observations with a negative deviation from the threshold should receive payment, while none of those with a positive deviation should receive payment. However, this is not always the case given our data limitations. First of all, the weather stations used to determine if rainfall has fallen below the threshold are sometimes missing data. Secondly, we do not have data for outcome variables for any units smaller than a municipality. However, policies are assigned at the level of the weather station, and there may be multiple weather stations per municipality. To deal with this limitation, any observation within a municipality that receives payment (from any of its policies) is considered treated. This assumption results in some observations being designated as treated despite having rainfall that falls above the thresholds. However, this assumption is reasonable given that program directors have some discretion in allocating funds. Despite this limitation, we observe a strong first stage, as evidenced by the sharp decline in the probability of treatment for observations to the right of the threshold in panel b of figure 1.

In figure 2 (see page 87), we see the corresponding discontinuities in log maize yields in t+1 and the change in log hectares of insured crops sowed from t to t+1 (Δ log hectares sowed). We see a drop in Δ log hectares sowed to the right of the threshold but not so for yield. Considering that municipalities to the right of the threshold are less likely to receive payment, this implies that payment results in an increase in the area sowed for insured crops. This finding is reflected in the regression results reported in table 1, where we find no significant effect of payment on yield, but an increase of approximately .19 log points in the number of hectares sowed with insured crops.

Turning to the economic outcomes, panels a and b of figure 3 (see page 88) show the discontinuities in log total income per capita and log total expenditures per capita. The data for this analysis come from the Mexican Income and Expenditure Survey (ENIGH), and the sample is restricted to rural localities as defined in the survey. We see a sharp decline in both outcomes of interest at the threshold, implying that insurance payment increases income and expenditure per capita. Table 2 reports the regression equivalent of the discontinuity seen in figure 3. The two-stage least squares estimation shows effects of similar magnitude on expenditure and income per capita, around 27%. However, the estimates are somewhat noisy and the effect of payment is only significant for income (at the 10% level).

We further explore the effect of insurance payment, by testing heterogeneity with respect to the percentage of land that is farmed by eligible producers (as mentioned above, those farming corn, barley, beans or sorghum on rainfed land on less than 20 hectares). We would expect the effect of insurance to be proportional to the percentage of land that is farmed by those who are eligible for the program, since they should be the only individuals receiving payment in the case where the insurance is triggered. These results are reported in table 3. Interestingly, when looking at the change in hectares planted, the interaction term (Payment x % eligible) is not significant, while the main effect, Payment, remains significant and of the same magnitude. This implies that the effect of payment does not appear to vary according to the percentage of eligible land. The same is true for yield. However, when we look at economic outcomes, the interaction term is highly significant in both the case of log income and expenditure per capita. Moreover, once the interaction term is included, the main effect is no longer significant, implying that for municipalities with very low percentages of eligible land the effect of payment is almost null. The mean value of % eligible is approximately 50%. Thus, receiving payment increases expenditure and income per capita by approximately 45% and 37%, respectively, for the mean insured municipality. The pattern observed in these results in somewhat puzzling in that we would expect similar results for both the agricultural and economic outcomes. We hope that further analysis will help us elucidate the discrepancy between these results.

Discussion of Results

While this is a preliminary analysis, the results suggest that the insurance payments provided by CADENA increase the amount of land devoted to insured crops, but have no effect on yield. We also find some evidence that payments increase income and expenditure per capita in rural areas, particularly in those with a large number of beneficiaries. One reason why our results could differ from those of Fuchs and Wolff (2010) would be if the increase in yields observed in Fuchs and Wolff is due to changes in investment choices, such as increased fertilizer user at planting, prompted by the reduction in risk for insured producers. We should observe this effect primarily when comparing insured and uninsured municipalities as they do, instead of when the sample is limited to insured municipalities as is the case for this analysis. One caveat with this explanation is that if farmers are credit constrained, we may still find that receipt of insurance payments impacts investment decisions, and consequently yield. Another potential explanation could arise from the fact that the insurance payments provided by CADENA are not sufficient to cover one hundred percent of the planting costs. Thus, they might not provide a strong incentive to increase investment. The government notes that the goal of the insurance is to provide a safety net so that farmers are able to plant the year following a bad weather shock. Insurance payments then allow producers to plant land they may have otherwise left fallow for lack of funds. This proposed mechanism would explain the observed increase in hectares sowed for municipalities that receive payment. We plan to continue this analysis in order to better understand the mechanisms through which insurance impacts agricultural productivity and economic outcomes, which should also help clarify differences between the results of this analysis and those in Fuchs and Wolff (2010). Furthermore, we plan to estimate the impact of insurance on the volatility of state budgets, since one of the aims of CADENA is to insure state governments against large unforeseen expenditures in the case of weather shocks.

Tables

Table 1. Agricultural outcomes, Subsequent year

	(1) First Stage: Payment	(2) Reduced form: Δ log ha sowed	(3) Reduced form: log yield	(4) 2SLS: Δ log ha sowed	(5) 2SLS: log yield
Payment				0.189**	0.144
				(0.0784)	(0.0938)
Below threshold	0.531***	0.0996**	0.0762		
	(0.0526)	(0.0398)	(0.0470)		
Years insured		0.00545	0.0134	0.00559	0.0135
		(0.00480)	(0.00865)	(0.00486)	(0.00864)
N	5152	5152	5152	5152	5152
F-statistic	100.11				

Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Hectares sowed and yield is for rainfed insured crops only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2. Economic outcomes, Subsequent year

	(1) First Stage: Payment	(2) Reduced form: Expenditure p.c.	(3) Reduced form: Income p.c.	(4) 2SLS: Expenditure p.c.	(5) 2SLS: Income p.c.
Payment				0.270	0.269*
				(0.165)	(0.159)
Below threshold	0.887***	0.240	0.238		
	(0.153)	(0.158)	(0.159)		
Years insured		0.0948**	0.0929**	0.0939**	0.0920**
		(0.0405)	(0.0430)	(0.0398)	(0.0422)
N	5021	5021	5021	5021	5021
F-statistic	33.91				

Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Dependent variables in (2)-(5) are in logs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

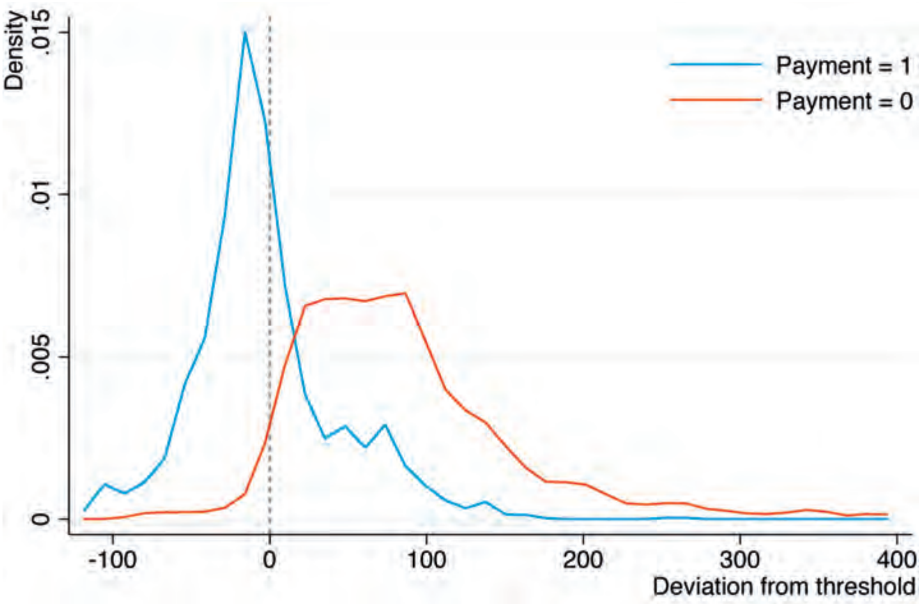
Table 3. Heterogeneity by % eligible

	(1) 2SLS: Δ log ha sowed	(2) 2SLS: log yield	(3) 2SLS: Expenditure p.c.	(4) 2SLS: Income p.c.
Payment	0.274**	0.117	-0.124	-0.0585
	(0.133)	(0.143)	(0.177)	(0.191)
Payment × % eligible	-0.177	0.0580	0.889***	0.744**
	(0.189)	(0.246)	(0.329)	(0.354)
% eligible	0.0500	-0.0275	-0.739***	-0.800***
	(0.0396)	(0.0768)	(0.140)	(0.146)
Years insured	0.00586	0.0134	0.0675*	0.0588
	(0.00487)	(0.00878)	(0.0396)	(0.0407)
N	5152	5152	5021	5021

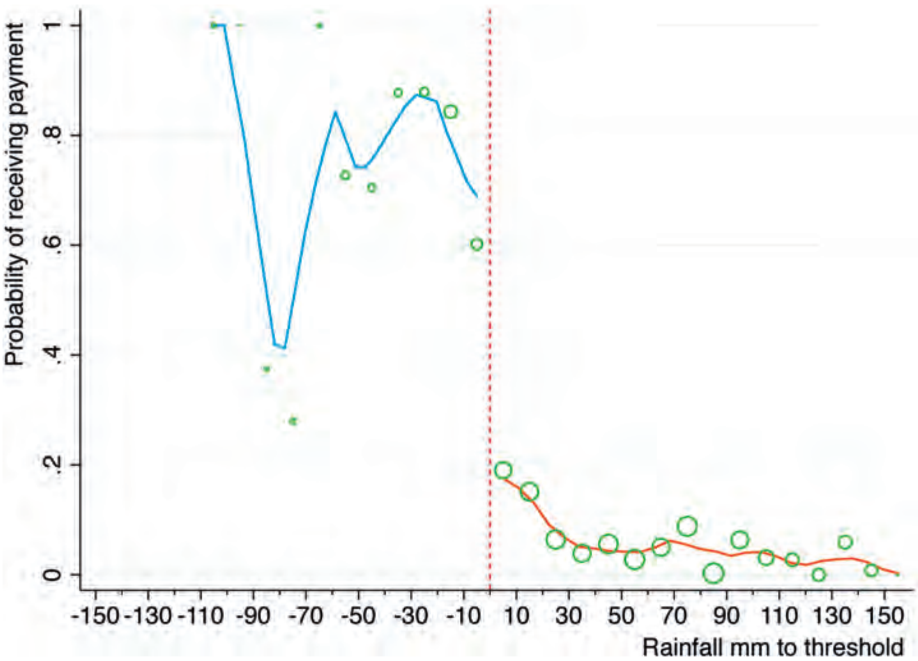
Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Dependent variables in (3)-(4) are in logs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figures

Figure 1: Probability of payment status by deviations from threshold

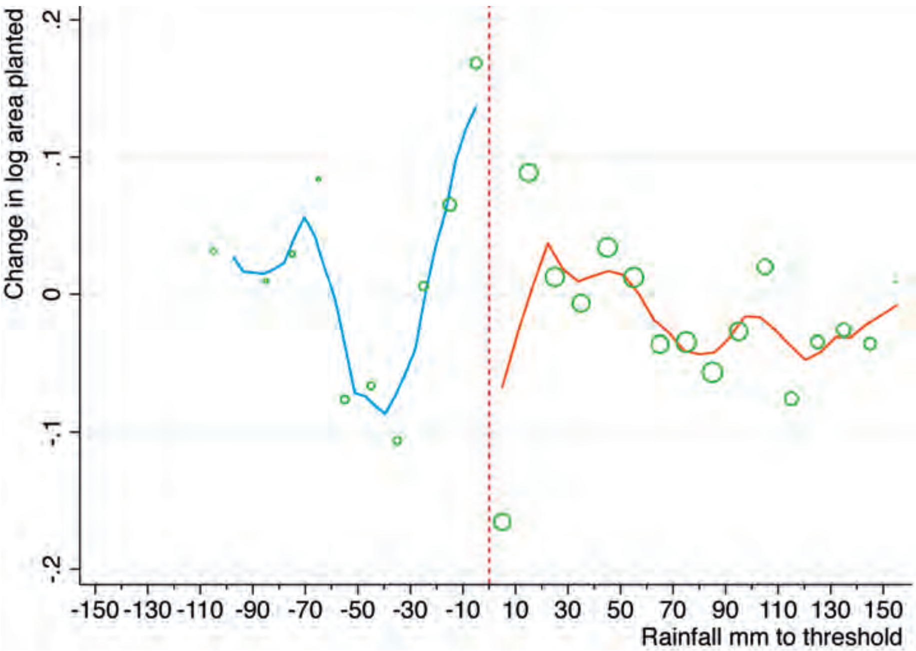


(a) Distribution of deviations from threshold

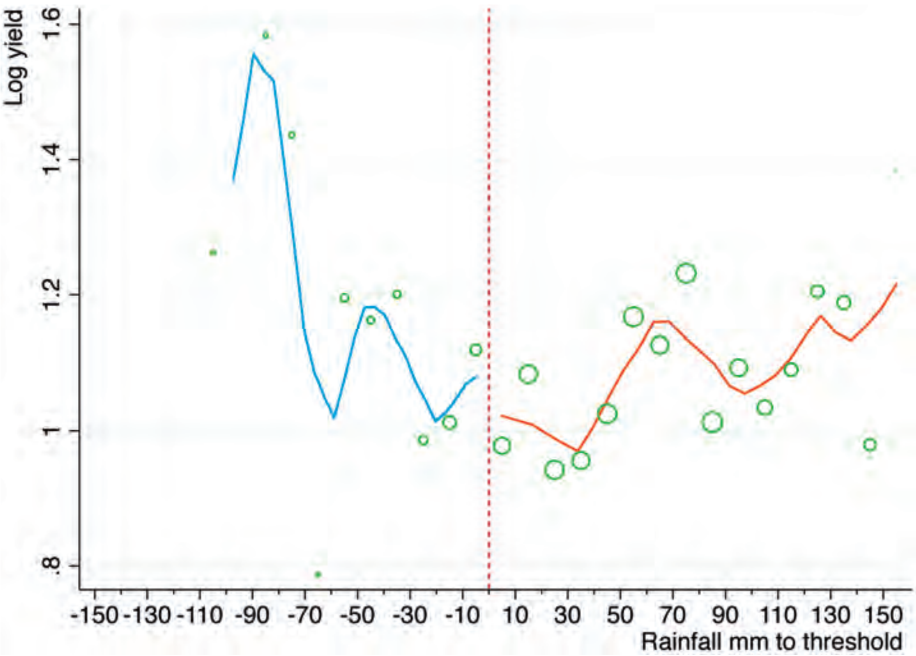


(b) Probability of payment

Figure 2: Discontinuity in agricultural outcomes at payment threshold

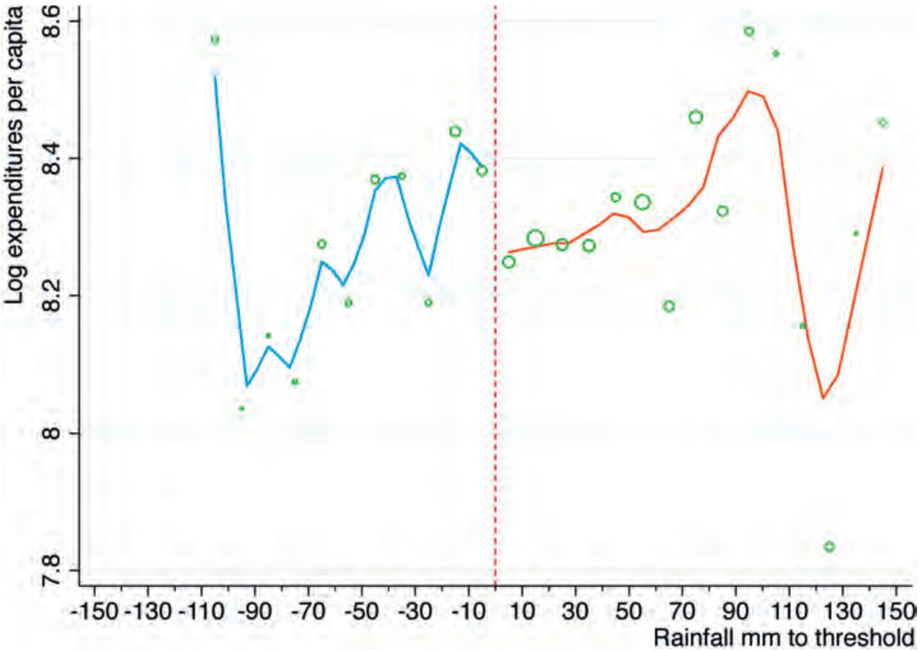


(a) Δ log maize sowed (ha) in t+1

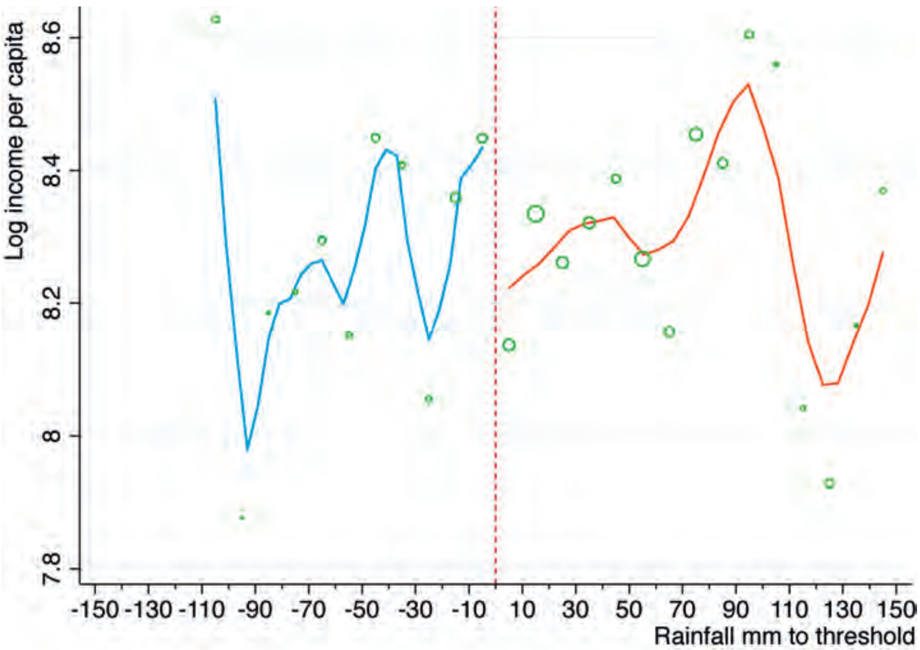


(c) Log maize yield in t+1

Figure 3: Discontinuity in economic outcomes at payment threshold



(a) Log total income per capita in t+1



(b) Log expenditures per capita in t+1

Political Economy of disater relief

Chapter 11

Voters Response to Natural Disasters Aid: Quasi-Experimental Evidence from Drought Relief Payment in Mexico

Alan Fuchs
Lourdes Rodriguez-Chamussy

Abstract

We estimate the effect of a government climatic contingency transfer allocated through the recently introduced rainfall indexed insurance on Presidential election returns in Mexico. Using the discontinuity in payment based on rainfall accumulation measured on local weather stations that slightly deviate from a pre-established threshold, we show that voters reward the incumbent presidential party for delivering drought relief compensation. We find that receiving indemnity payments leads to a significant average electoral support for the incumbent party of approximately 7.6 percentage points. Our analysis suggests that the incumbent party is rewarded by disaster aid recipients and punished by non-recipients. This paper provides evidence that voters evaluate government actions and respond to disaster spending contributing to the literature on retrospective voting.

Are there electoral returns to government disaster aid? This is a central question in terms of political accountability in democratic societies and has recently attracted scholarly attention in political economy.

Identifying the effect of government transfer policies --such as disaster relief-- on individual political behavior is a challenging task. A set of growing literature provides empirical evidence of a positive electoral effect of government provision of economic benefits (Manacorda, Miguel and Vigorito 2010; Pop-Eleches and Pop-Eleches 2009; Litschig and Morrison 2009; Rodriguez-Chamussy 2009). However, assessing voter's response to compensation received after a natural contingency imposes additional difficulties. In effect, empirical studies trying to test voter responsiveness to disaster aid face at least three types of problems. First, the targeting of relief action and resources may not be exogenous as politicians might target public resources towards swing voters or channel resources to core supporters as a reward to their loyalty. Second, even when the natural shock producing adverse effects for the population may be exogenous, the extent of the damages and losses is potentially endogenous as vulnerability to natural catastrophes may differ among localities and populations. Finally, there are several confounding factors interacting with government disaster spending (media coverage, actions of NGOs and volunteer aid, etc.) and some of these may cancel out estimates of a potential effect of relief transfers.

In this paper we use a quasi-experimental approach to provide evidence on the electoral effect of government economic transfers as compensation for the damage caused by a natural shock: severe drought on rain-fed agricultural regions. Exploiting the discontinuity in payment of a government funded climatic contingency aid program in Mexico, we show that voters reward the incumbent presidential party for delivering drought relief compensation. In 2005, after a severe drought the Mexican Federal Government delivered for the first time drought compensation payments under the Weather Index Insurance program. Provided that the Weather Index Insurance program was designed to allocate indemnity payments according to a strictly defined pre-established rainfall cutoff, we employ a regression discontinuity (RD) design to compare outcomes across electoral sections that were covered during 2005 by the insurance program and had similar levels of rainfall but differed in whether they experienced government aid in the form of a monetary transfer or not. This enables us to address the possibility of omitted variable bias between recipients of relief compensation and their counterparts who experienced a drought but did not qualify for compensation.

The basic regression model used through the analysis is given by equation (1):

$$Vote_i = \delta BelowCutoff_i + f(rainfall_i) + \beta X_i + \varepsilon_i$$

where $Vote_i$ represents the electoral outcome of interest – the share of votes for the incumbent party – in the electoral unit i.
$BelowCutoff_i$ is an indicator variable equal to 1 if the accumulated rainfall during the sowing season is less than the minimum cutoff for the program, and 0 otherwise. The main coefficient of interest in the analysis is δ, which indicates the effect of being in an area that corresponds to receiving government aid after a drought on the relevant outcome. The term $f(rainfall_i)$ denotes a smooth function of rainfall, which is the forcing variable in the context of this regression discontinuity design.

Finally, X_i includes a set of control variables such as a dummy for each state, municipality average per capita income, average temperature measured by weather station, distance from the electoral section to the weather station, distance to the nearest river and distance to the *cabecera*.[1] Although units on each side of the discontinuity experienced similar rainfall levels, it is important to include these control variables since they are not necessarily geographically located next to each other. Table 1 shows that units in which payments were disbursed are located in wealthier municipalities but all other characteristics do not appear to be statistically different for electoral sections below and above the cutoff. Particularly, the average share of votes for the Presidential incumbent in the previous election – year 2000 – is not statistically different for the two groups.

To get a sense of the way in which observations distribute on each side of the discontinuity we consider Figure 1 (see page 96), which plots the level of rainfall normalized to the defined threshold in each electoral section and the corresponding share of votes for the incumbent in the 2006 Presidential elections. The non-parametric regression line jumps down at the discontinuity suggesting an effect of the drought compensation payment on voting behavior. In order to explore the significance and magnitude of this apparent effect we first specify a linear model of $f(rainfall_i)$ and we allow it to vary on either side of the discontinuity.

Table 2 shows the results of estimating Equation (1) using OLS. Column (1) presents the results when no controls are used in the estimation. The coefficient for *cutoff* remains positive and stable as we add co-ntrols. Column (2) shows the estimates when we include a set of dummy variables for each state. Column (3) presents the results when we include also controls at the electoral section level such as altitude, distance from the weather station, distance to the nearest river and distance to the "cabecera". Finally, Column (4) presents the estimates when controls at the municipal level are introduced. These specifications indicate a statistically significant effect of government disaster spending on the share of votes for the Presidential incumbent party. The magnitude of the coefficient decreases slightly once we control for the state and the characteristics of the electoral units and municipalities. With the full set of controls, our estimate suggests that receiving drought compensation had an effect of approximately 7.6 percentage points increase in the share of votes for the incumbent party.

Our study builds on the empirical literature about electoral accountability and retrospective voting by providing at least two key contributions. First, we analyze a specific policy that provides indemnity payments to small-scale farmers if the amount of accumulated rainfall within a specific time period falls below an exogenous and pre-established threshold. This allows the use of a quasi-experimental approach – using regression discontinuity design – to credibly identify causal effects of government transfers on electoral results. Moreover, studying the case of the Mexican Weather Indexed Insurance (WII) allows us to compare voter response in areas that have similar and comparable levels of vulnerability. Second, we collected, constructed and use electoral data at the lowest aggregation level: the electoral section. Multiple confounding factors potentially make difficult to identify an effect of disaster spending even with the use of panel data; in our setting these are minimized as we use small units of analysis and compare electoral outcomes of a single election. To the best of

1. "Cabecera" refers to the Municipal seat. It generally corresponds to the biggest town in the municipality and the better connected in terms of transportation and information.

our knowledge, this is the first study that exploits the key features of a weather-indexed insurance scheme using GIS methods to produce a complete dataset allowing the empirical test of voter's response to government disaster spending. Evidence in the context of developing countries is very limited with the exception of India (Cole, Healy and Werker, 2009). Our findings complement the existing literature and are consistent with the results in previous studies for the US context (Healy and Malhotra 2009, Chen 2009, Chen 2008) and Germany (Bechel and Hainmueller, 2010).

Table 1. Descriptive Statistics, electoral sections with insurance coverage in 2005

	Units WITH compensation	Units WITHOUT compensation
Altitude (meters)	1442.75 (43.48)	1554.19 (23.39)
Distance from weather station (meters)	1088.12 (30.66)	1042.5 (23.11)
Distance to cabecera (meters)	1792.98 (96.73)	1771.4 (123.10)
Distance to nearest river (meters)	526.2 (35.68)	582.88 (27.05)
Municipal infant Mortality	21.97 (0.12)	25.33 (0.13)
Municipal income per capita (pesos)	1821.82 (26.97)***	1233.51 (12.7)***
Number of votes, 2006	617.84 (23.06)	677.99 (11.75)
Share of votes for incumbent 2000	32.35 (1.08)	32.22 (0.48)
Number of votes, 2000	619.05 (19.69)	651.2 (9.08)
Observations	305	733

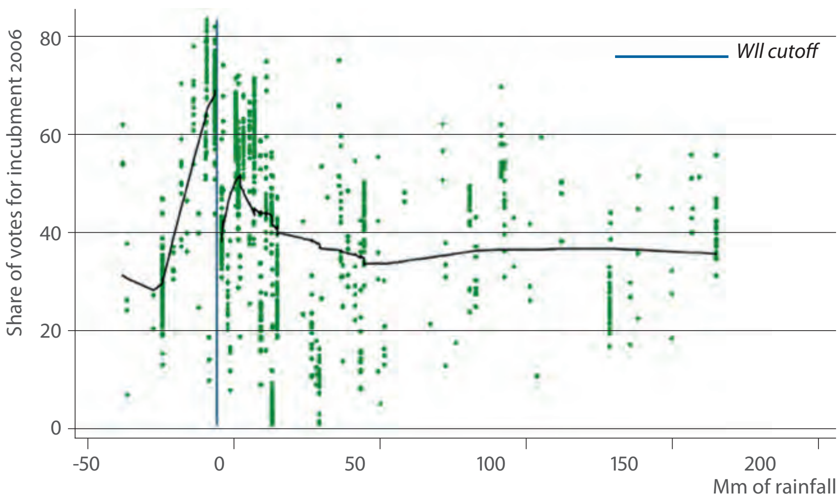
Standard errors for the t-test in parenthesis. Null hypothesis is average characteristic is equal for the two groups. *** Indicates the null is rejected at 1% confidence level.

Table 2. Effect of Drought Relief Compensation on Share of Votes for the Incumbent, Main Results

	Dependent variable: Share of votes for incumbent in 2006			
	(1)	(2)	(3)	(4)
Below Cutoff	10.395 (1.421)***	8.211 (1.040)***	8.332 (1.219)***	7.69 (1.000)***
Rain Deviation	-0.078 (0.012)***	0.057 (0.015)***	0.045 (0.018)**	0.03 (0.018)*
Constant	45.188 (0.845)***	14.38 (3.574)***	-13.398 (10.258)	7.255 (9.071)
Observations	1038	1038	1038	1038
R-squared	0.12	0.78	0.79	0.82
State controls	No	Yes	Yes	Yes
Controls at electoral section level	No	No	Yes	Yes
Controls at municipal level	No	No	No	Yes
Mean of dependent variable	45.37	45.37	45.37	45.37

Robust standard errors in parentheses.
State controls are dummy variables for each state. Controls at the electoral sections include altitude, distance from the weather station, distance to the nearest river and distance to the "cabecera". Controls at the municipal level include municipal income per capita for the year 2000.
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1. Non-parametric graphic analysis, share of votes for the incumbent in electoral sections with insurance coverage in 2005



References

- **Achen, C. H.** and **L. M. Bartels**. 2002. "Blind Retrospection: Electoral Responses to Drought, Flu and Shark Attacks". Paper presented at the annual meeting of the American Political Science Association, Boston.
- **Agroasemex**. 2006. "La Experiencia Mexicana en el Desarrollo y Operación de Seguros Paramétricos Orientados a la Agricultura." Working Paper, April 19, 2006. http://www.agroasemex.gob.mx
- **Bechtel, M.** and **J. Hainmueller**. 2011. "How Lasting is voter Gratitude: An Analysis of the Short-term and Long-term Electoral Returns to Beneficial Policy". *American Journal of Political Science*, 55(4): 852-868.
- **Chen, J.** 2013. "Voter Partisanship and the Effect of Distributive Spending on Political Participation". *American Journal of Political Science*. 57(1): 200-217.
- **Cole, S.**, **A. Healy** and **E. Werker**. 2012. "Do Voters Demand Responsive Governments? Evidence from Indian Disaster Relief". *Journal of Development Economics*. 97(2012) 167-181.
- **De La O, A. L.** 2013. "Do Conditional Cash Transfers Affect Electoral Behavior? Evidence from a Randomized Experiment in Mexico". *American Journal of Political Science*, 57(1): 1-14.
- **Fiorina, M. P.** 1978. "Economic Retrospective Voting in American National Elections: A Micro-Analysis", *American Journal of Political Science,* 22(2): 426–443.
- **Fuchs, A.** and **H. Wolff.** 2011. "Concept and Unintended Consequences of Weather Index Insurance: The Case of Mexico." *American Journal of Agricultural Economics*, 93(2): 505-511.
- **Fuchs, A.** and **H. Wolff.** 2011. "Drought and Retribution: Evidence from a large scale Rainfall Indexed Insurance Program in Mexico", *University of California Berkeley Working Paper*.
- **Hazell, P.**, **J. Anderson**, **N. Balzar**, **A. Hastrup Clemmensen**, **U. Hess** and **F. Rispoli.** 2010. *Potential for scale and sustainability in weather index insurance for agriculture and rural livelihoods*. International Fund for Agricultural Development and World Food Programme. Rome

- **Healy, A.** and **N. Malhotra.** 2009. "Myopic Voters and Natural Disaster Policy", *American Political Science Review,* 103(3): 357–406.
- **Healy, A.** and **N. Malhotra.** 2010. "Random Events, Economic Losses, and Retrospective Voting: Implications for Democratic Competence", *Quarterly Journal of Political Science*, 5(2).
- **Lay, C. J.** 2009. "Race, Retrospective Voting, and Disasters: The Re-Election of C. Ray Nagin after Hurricane Katrina", *Urban Affairs Review,* 44(5): 645–662.
- **Litschig, S.** and **K. Morrison.** 2012. "Government Spending and Re-election: Quasi-Experimental Evidence from Brazilian Municipalities". *Barcelona GSE Working Paper Series* nº 515.
- **Manacorda, M.**, **E. Miguel** and **A. Vigorito.** 2011. "Government Transfers and Political Support". *American Economic Journal: Applied Economics*, 3(3): 1-28
- **Pop-Eleches, C.** and **G. Pop-Eleches**. 2009. "Government Spending and Pocketbook Voting: Quasi-Experimental Evidence from Romania".
- **Rodriguez-Chamussy, L.** 2014. "Local Electoral Rewards from Centralized Social Programs: Are Mayors Getting the Credit?" *IDB Working paper* n°555
- **Sobel, R.** and **P. Leeson.** 2006. "Government's Response to Hurricane Katrina: A Public Choice Analysis", *Public Choice,* 127(1): 55–73.

Chapter 12

Discipline and disasters: The political economy of Mexico's Sovereign Disaster Risk Financing Program

Laura Boudreau

Abstract

Evidence suggests that voters punish politicians for the occurrence of natural disasters but reward them for the allocation of post-disaster aid. These behaviors create incentives for politicians to overspend on post-disaster aid, in particular in election years. Advocates of Sovereign Disaster Risk Financing and Insurance (SDRFI) Programs claim that these programs help to eliminate these incentives through transparent rules that govern politicians' behavior (Dana and Von Dahlen, 2014). This note examines voters' behavior and these claims in the context of Mexico, where the Federal Government has adopted a SDRFI strategy. It finds that voters punish incumbent political parties for the occurrence of natural disasters. It also finds that the Mexican governors are more likely to request, and the Federal Government is more likely to declare, natural disasters during election years. Finally, it finds that while using parametric thresholds to determine natural disaster declarations may help to discipline politicians in election years, the fact that some types of events do not use thresholds may erode parametric thresholds' disciplining value.

Introduction

Discipline and accountability are important pathways to impact for Sovereign Disaster Risk Financing and Insurance (SDRFI) Programs (Dana and Von Dahlen, 2014). In particular, SDRFI Programs that feature objective mechanisms, such as parametric event thresholds to determine access to funding, limit politicians' discretion following natural disasters, when they may face incentives to overspend on disaster relief (Healy and Malhotra, 2009). Rules and transparency also compel the government to commit to behave in a certain way or to face punishment by voters (Ferraz and Finan, 2011). But SDRFI Programs must be politically viable, and evidence suggests that voters demand overly responsive governments before elections (Cole et al., 2012). This policy note provides an early analysis of the effectiveness of one SDRFI Program, Mexico's Natural Disaster Fund (FONDEN), at disciplining politicians in light of potentially suboptimal incentives provided by voters.

Research questions

This research note analyzes two streams of questions related to the political economy of SDRFI:

i. *Voter behavior*: Do Mexican voters punish politicians for the occurrence of natural disasters? [1]
ii. *FONDEN effectiveness*: Do Governors of Mexican States request more natural disaster declarations during election years? Does the Federal Government grant more natural disaster declarations during election years? Does the FONDEN help to discipline politicians in light of potentially suboptimal incentives provided by voters?

Related literature

Previous research shows that voters punish politicians for the occurrence of natural disasters in the run-up to elections (Achen and Bartels, 2004; Cole et al., 2012). But politicians can partially offset these effects, and sometimes even gain voteshare, by providing reconstruction funding (Cole et al., 2012; Healy and Malhotra, 2009). These results highlight the adverse incentives generated for politicians around elections. Consistent with these incentives, Gasper and Reeves (2012) and Reeves (2011) find that in the United States, governors up for reelection request more disaster declarations in election years, and correspondingly, presidents grant more disaster declarations in election years.

These findings suggest a potentially important role for SDRFI Programs to tie politicians' hands and to increase transparency. To the author's knowledge, however, there are no empirical studies of SDRFI Programs' effectiveness at disciplining politicians. This research note provides preliminary evidence of one aspect of FONDEN's effectiveness at disciplining politicians in election years. The next stage of this research will deepen this analysis, which is the primary contribution of this research to the existing literature.

Context

Politics in Mexico

Mexico is a federal presidential representative democratic republic consisting of 31 states and one federal district. Although a multi-party system, Mexico's political scene was long dominated by a

1. A related, important question is whether voters reward politicians for the delivery of post-disaster aid; due to data limitations, this question is not addressed in this note but will be added to the analysis in the next stage of research.

single party, which won every Presidential election from 1929 until 2000. The 2000 Presidential election was a landmark change of power, and since then the Presidency has been highly contended by several parties. Presidential elections are held every six years and feature single-term limits.

State governors are elected once every six years and also face single-term limits. The timing of governors' elections varies across states. Since 2000, there has been significant variation in gubernatorial leadership at the state level. In the majority of states, party control of the governorship has changed at least once since 2000. Coalitions and local political parties are very prevalent in state politics; many elections are won through multi-party coalitions, and it is often difficult to identify an incumbent party. The data on state elections collected for this research include over 100 different political parties and coalitions across 112 elections.

El Fondo de Desastres Naturales (FONDEN)

In 1996, the Federal Government of Mexico (FGM) established FONDEN to ensure that adequate financial resources were available to finance post-disaster reconstruction of public infrastructure and low-income housing without compromising existing budgetary plans and public programs. Although the FGM did not list the discipline of politicians among its goals in establishing FONDEN, the government considers accountability and transparency as important features of the FONDEN system (World Bank and Government of Mexico, 2012).

FONDEN utilizes a two-stage process to determine a municipality's eligibility for reconstruction funds. First, a governor requests for one of three technical agencies, which are responsible for different types of events, to evaluate the presence of a hazard in one or more municipalities that experienced an event. For certain types of hazards, FONDEN uses pre-determined thresholds based on physical event parameters (e.g., millimeters of rainfall) to determine municipalities' eligibility (Table 1). The FONDEN's use of thresholds based on physical event parameters is particularly interesting and an important feature of this study. The technical agency assesses which municipalities qualify and sends this information to the FGM, which declares a natural disaster in these municipalities. Municipalities that are declared enter the second stage of the FONDEN process, a damage assessment, where the amount of reconstruction funding is determined.

Table 1: Threshold and non-threshold events covered by FONDEN

Threshold event	Non-threshold event
Extreme rainfall	Flooding*
Drought	Hurricane/tropical storm*
Frost	Earthquake/tsunami
Hail	Landslide
Snow	Tornado
Forest fire	Avalanche

* *De facto*, for flooding classified as "flooding due to rainfall" and for most storm events, the rainfall threshold is used. For storms, this is because the government does not have the technical capability to determine wind speed at the municipal level. Source: *Las Reglas de Operación del Fondo de Desastres Naturales* (versions 3/31/1999, 2/29/2000, and 10/22/2004.)

Data

Natural disaster and weather data

This research avails of an original dataset, developed by the author, of natural disaster declarations published in Mexico's *Diario Oficial de la Federación* from 1999-2013. The declarations contain information including the list of municipalities requested by the governor, the list of municipalities declared by the FGM, the event type, and the event dates. In total, there were 547 unique natural disaster declarations from 1999 through 2013, of these, 320 occurred after the October 22, 2004 update to the FONDEN operating guidelines (see Table 2 for summary statistics).[2] Most of the declarations – 61.3% of all municipalities declared since the 2004 rule change – are for threshold events.

Political data

This analysis uses presidential election results from the Federal Election Institute (IFE) of Mexico at the municipality level for 2006 and 2012. It also uses state-level gubernatorial election results between 2000 and 2011. Panel B of Table 2 reports summary statistics for federal and gubernatorial elections.

Table 2: Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
Panel A					
State: Year (2005-2013)					
Annual # Munis Req	288	29.1	77.5	0	642
Annual # Munis Dec	288	16	40.85	0	323
Annual # Threshold Munis Dec	288	9.8	26.3	0	212
Municipality: Full period (2001-2013)					
# Requests	2275	4.587	3.7369	0	19
# Decs	2275	2.644	2.3858	0	23
Panel B					
Federal Election Results					
Incumbent voteshare (state)	64	0.30	0.12	0.04	0.59
Incumbent voteshare (municipality)	4885	0.26	0.14	0	0.72
State Election Results					
Incumbent voteshare (state)	57	0.449	0.114	0.025	0.620

2. One limitation of the data is that it necessarily only includes published declarations, and so misses any governors' requests that are completely denied. According to the former head of FONDEN, however, it is very rare for requests to be completely denied.

Empirical strategy and results

Voter behavior

Evidence from India and the United States shows that voters punish politicians for the occurrence of natural disasters but reward them for delivering post disaster aid (Cole et al., 2012; Healy and Malhotra, 2009). This analysis first analyzes whether Mexican voters who experience abnormally high numbers of natural disasters in an election year punishes the incumbent party. Due to current data limitations, the question of whether they also reward post-disaster aid is left to the next stage of this analysis. I estimate:

$$IncumVote_{it} = \alpha + \beta DisDec_{it-1} + \gamma_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where $IncumVote_{it}$ is voteshare in entity i of the incumbent political party in election year t. $DisDec_{it\text{-}1}$ is the standard score of disaster declarations entity i in the year leading up to the election; γ_i and λ_i are entity and election fixed effects, respectively, and ε_{it} is the residual. Standard errors are clustered at the entity level in all regressions.

Table 3 Column (1) shows that a one standard deviation increase in the number of natural disasters experienced by a municipality in the year prior to the election decreases the incumbent presidential party's voteshare in that municipality by 2.4%; this result is consistent with Cole et al. (2012), who estimate that a one standard deviation decline in rainfall decreases the incumbent party's voteshare by 2.6% at a comparable administrative division in India. The effect is still detectable at the state level, where a one standard deviation increase in disaster declarations decreases the incumbent presidential party's voteshare by 1.3%. This decrease is politically important – in 25% of observations, the gap between winning and losing parties is 2.7% or less. Finally, Column (2) shows that while the sign and magnitude of the point estimate for gubernatorial elections is consistent with that of presidential elections, large standard errors render it insignificant – this result is not surprising considering the important role of coalitions, which makes it difficult to identify one incumbent party in the data.

Table 3: Voter response to natural disasters

	Presidential party incumbent voteshare (1)	Gubernatorial party incumbent voteshare (2)
State-level analysis		
$DisDec_{it-1}$	-0.013* (0.007)	-0.012 (0.031)
N	62	61
Municipal-level analysis		
$DisDec_{it-1}$	-0.024* (0.013)	
N	4885	

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
* Significant at the 10 percent level.

FONDEN effectiveness

Evidently, Mexican voters punish incumbent political parties when they experience natural disasters. If they also reward incumbent parties who allocate post-disaster reconstruction funding, consistent with voter behavior in other contexts, then we would expect to see Mexican political parties overly responding with reconstruction funding in election years. FONDEN's use of thresholds for certain events, however, should tie the state and federal governments' hands in election years, making it more difficult to channel funds to municipalities that experience less extreme events.

First, I determine whether state governors are more likely to request natural disaster declarations in election years.[3] Then, I analyze whether the FGM is more likely to declare more municipalities in election years; importantly, I examine these effects separately for threshold and non-threshold events. Due to space constraints, I omit results for gubernatorial election years, which consistent with the results above, are not significant. Also, to ensure comparability of results, I confine the analysis to the period following the 2004 rule change. I estimate two specifications:

$$Re\, q_{st} = \alpha + \beta\, ElectYr_t + \gamma_s + \varepsilon_{it} \quad (2)$$

$$\begin{aligned} NumDec_{sdt} = \\ \alpha + \beta_1\, NonThresh_{sdt} + \beta_2\, ElectYr_{st} \\ + \beta_3\, ElectYr_{st} * NonThresh_{sdt} \\ + \delta\, NumReq_{std} + \gamma_s + \lambda_t + \varepsilon_{sdt} \quad (3) \end{aligned}$$

In equation (2), I first estimate linear probability, probit, and conditional logit models of the likelihood of a governor requesting a natural disaster declaration during an election year. Req_{st} is an indicator equal to 1 if a governor of state s requests a natural disaster declaration during year t, γ_s is a state fixed effect, and ε_{st} is the residual. Standard errors are clustered at the state level in all regressions in this section. I also check the frequency of declaration requests in election versus nonelection years using a negative binomial and a linear model with a count variable for Req_{st}.[4]
In equation (3), $NumDec_{sdt}$ is the number of municipalities declared by the FGM in state s in declaration d at time t. $NonThresh_{sdt}$ is an indicator if a declaration is for one of the non-threshold events listed in Table 1, $ElectYr_t$ is an indicator for whether a declaration is made in a presidential election year, and $NumReq_{sdt}$ controls for the number of municipalities requested by the governor. γ_s and λ_t are entity and election fixed effects, respectively, and ε_{sdt} is the residual.

Table 4 shows the results of estimating (2); it includes the estimate for from each specification mentioned above. The estimates show that governors are significantly more likely to request at least one disaster declaration in presidential election years than in nonelection years (estimates suggest 10-15% more likely). In addition, they are significantly more likely to request more disaster declarations in presidential election years. The IRR from the negative binomial model and the estimate from the linear regression model suggest request counts increase 25% in presidential election years (all results significant at the 5% level).

3. The next stage of this analysis will analyze whether governors request more municipalities for non-threshold verus threshold events in election years.
4. I use a negative binomial model due to overdispersion of the data. Negative binomial result is reported as the Incidence Rate Ratio (IRR).

Table 4: Governors' Disaster Declaration Requests During Federal Election Years

	Federal Election Year
Request declaration in year ({0,1})	
Linear Probability Model	0.1094** (0.047)
Probit M.E.	0.153** (0.062)
Conditional Logit M. E.	0.143** (0.056)
Number of requests in year (count variable)	
Linear model	0.2552** (0.123)
Negative binomial model (Incidence Rate Ratio reported)	1.254** (0.118)
State FE	Y
N	256

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
* Significant at the 10 percent level.

Turning to the FGM's disaster declarations, Table 5 Column 2 shows the results of estimating (3). Starting with β_1, the estimate shows that, controlling for the number of municipalities requested, the FGM declares an average of 3 more municipalities for non-threshold events than for threshold events in nonelection years (significant at the 10% level). β_2 shows that the FGM declares more municipalities for threshold events in presidential election years than in nonelection years. But the most interesting coefficient is β_3, which shows that the effect of a presidential election on the number of municipalities declared for non-threshold events (sum of β_2 and β_3) is much greater than for threshold events (β_2 and β_3 both significant at the 5% level).

Table 5: Federal Government Declarations during Federal Election Years

	Number declared (1)	Number declared (2)
$Non\text{-}threshold_{sdt}$		2.933* (1.669)
$Fed\ Elect_t$	14.061* (7.167)	10.315** (4.694)
$Fed\ Elect_t$* $Non\text{-}threshold_{sdt}$		11.395** (4.511)
$NumReq_{sdt}$	0.460*** (0.033)	0.457*** (0.034)
State FE Year FE	Y Y	Y Y
N	320	320

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
* Significant at the 10 percent level.

Edited by:

- Daniel CLARKE is a Senior Disaster Risk Financing and Insurance (DRFI) Specialist, Finance and Markets Global Practice of the World Bank Group.

- Alain de JANVRY is a Professor of Agricultural & Resource Economics at the UC Berkeley. He is a Senior Fellow at the Ferdi.

- Elisabeth SADOULET is a Professor of Agricultural and Resource Economics at the UC Berkeley. She is a Senior Fellow at the Ferdi.

- Emmanuel SKOUFIAS is a Lead Economist at the Poverty Reduction Group of the World Bank.

with the authors :

Danamona Andrianarimanana • Laura Boudreau • Daniel Clarke • Stefan Dercon • Alan Fuchs • Ruth Hill • Alain de Janvry • Olivier Mahul • Craig McIntosh • Francesca de Nicola • Richard Odoom • Bazoumana. Ouattara • Catherine Porter • Richard Poulter • Felix Povel • Elizabeth Ramirez Ritchie • Lourdes Rodriguez-Chamussy • Elisabeth Sadoulet • Emmanuel Skoufias • Eric Strobl • Tse-Ling Teh • Alejandro del Valle • Jan Vermeiren • Emily White • Stacia Yearwood

Cover illustration: From *Siné Saloum, Sénégal* – Painting by Aude Guirauden

ISBN : 978-2-9550779-1-7

9 782955 077917

FERDI

63, boulevard François-Mitterrand
63000 Clermont-Ferrand
www.ferdi.fr
+33 (0)4 73 17 75 30