

WEATHER RISK AND THE WORLD FOOD
PROGRAM

A THESIS
PRESENTED TO THE FACULTY
OF
THE FLETCHER SCHOOL OF LAW AND DIPLOMACY

BY

BENJAMIN DANIEL MAZZOTTA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE
DEGREE OF DOCTOR OF PHILOSOPHY

MAY 2011

DISSERTATION COMMITTEE

DANIEL W. DREZNER, CHAIR
JENNY C. AKER
PATRICK WEBB

Abstract

Weather risk management is a set of financial products including insurance, catastrophe bonds, and derivative contracts based on seasonal precipitation and temperature. International organizations have recently put their toes in the water to see whether insurance and weather derivatives can help them secure conditional access to necessary funds for predictable emergencies. Ethiopia is the epicenter of financial innovation for food security, first in the form of a pilot weather insurance program at World Food Program, and subsequently with a risk financing program in the Productive Safety Nets Program. Why did these organizations innovate in this way? Financial theory predicts that firms optimize a portfolio of hedged and unhedged cash flows to protect the organization from risk. Rational choice predicts that firms seek the greatest possible access to funds while preserving the greatest latitude for operational independence. I show that the safety net program seeks to improve foresight and transparency over its program objectives, rather than credibility with international creditors or even operational partners in the field. I analyze the decisions made by WFP and PSNP related to financial risk management, using process tracing and grounded theory. Applications of the research include contract design for international humanitarian assistance, and potentially a market opportunity for financial services in the international public sector.

Acknowledgments

This dissertation would not have been possible without the support of my family and especially my wife. I am deeply grateful.

Many organizations have provided financial means, administrative assistance and encouragement over the years. I gratefully acknowledge funding and institutional support from the Fletcher School and its various funds including the PhD Program Travel Assistance, the Institute for Human Security, the Dean's Discretionary Research Fund, the John Roche Memorial Fund, the Frank C. and Christel W. Nichols Scholarship Fund; and also the Tufts University Provost Research Fellowship. The Feinstein International Center graciously extended its hospitality, refined my ideas, and let me ride the coat tails of its sterling reputation during my visit to Addis Ababa in January 2010.

My thanks also to all of the various faculty and colleagues who have supported my work and provided invaluable criticism since I first applied to the Fletcher doctoral program: Daniel Drezner, Jenny Aker, Patrick Webb, Steven Block, Katrina Burgess, Kerry Chase, Matthew Kahn, Michael Klein, Margaret McMillan, William Moomaw, John Curtis Perry, Julie Schaffner, Anna Seleny, Peter Uvin, Peter Walker; Susan Banki, Melissa Birch, Scott Borgerson, Lauren Greenberg Brodsky, Susanna Campbell, Ethan Corbin, Joshua Gleis, Elke Jahns, Nick Kenney, Jeff Kubiak, Abi Linnington, Tom McCarthy, Patrick Meier, Ronnie Olesker, Courtney Richardson, Xanthe Scharff, Andrea Strimling, and Rockford Weitz. The Fletcher School staff, especially Dean Sheehan's office and Jenifer Burckett-Picker, provided crucial support at various stages.

BENJAMIN D. MAZZOTTA

EDUCATION

2011	Ph.D.	Fletcher School of Law and Diplomacy, Tufts University Medford, MA International Political Economy, Development Economics and International Monetary Theory and Policy Advisers Daniel W. Drezner (chair), Jenny C. Aker, and Patrick Webb <i>Weather Risk and the World Food Program</i>	
2003	M.A.L.D.	Fletcher School of Law and Diplomacy, Tufts University Medford, MA International Political Economy and Development Economics Certificate of International Development, Economic Analysis Track <i>Revealed Preferences in United States Bilateral Aid, 1960-2000</i>	
1998	B.A.	Yale University Political Science and Theater Studies	New Haven, CT

EXPERIENCE

2004-2011		US Cyber Consequences Unit Research Director for Economic Relationships	Cambridge, MA
2009-2010		Cultural Change Institute, Tufts University Research Fellow	Medford, MA
2009 (May)		Duhok Business School Visiting Lecturer	Duhok, Iraq
2008-2010		Space Policy Working Group, Tufts University Analyst	Medford, MA
2007-2009		Fletcher Graduate Writing Program, Tufts University Director	Medford, MA
2008-2009		Institute for Global Maritime Studies Research Fellow	Gloucester, MA
2003-2009		Tufts University Teaching Assistant for Departments of Economics, Political Science, and Fletcher School of Law and Diplomacy Courses: International Politics, International Trade and Investment, Econometrics, Empirical Topics in Development, Foreign Economic Policy of the United States, Development Economics, and Introduction to International Relations	Medford, MA
2000-2002		Peace Corps Senegal (United States Government) Environmental Education Extension Agent Manager, Thienaba Community Training Center	Ndoulo, Senegal

AWARDS

2008	Presidential Award for Citizenship and Public Service (1 of 12), Tufts University
2006-2007	Provost Fellow (1 of 17), Tufts University
2004	Robert B. Stewart Prize, Fletcher School, Tufts University Outstanding first-year student
1998	Master's Prize, Berkeley Residential College, Yale University

SERVICE

2008	Chair, Ph.D. Journal Club
2007	Founding Co-Chair, Fletcher Doctoral Conference
2007	Hiring Committee, Assistant Professor of Development Economics
2006	Chair, Ph.D. Forum (a student-coordinated speaker series)
2006	Hiring Committee, Director of Career Services
2006	Hiring Committee, Director of Ginn Library
2005	Student Committee Representative
2004	Library and IT Committee Student Representative

PUBLICATIONS

2008	Benjamin D. Mazzotta. "Bring short sea shipping to Providence," <i>Providence Journal</i> . March 21, 2008.
2008	John Curtis Perry, Scott Borgerson, Rockford Weitz, et al. <i>America's Deep Blue Highway: How Coastal Shipping Could Reduce Traffic Congestion, Lower Pollution, and Bolster National Security</i> . Gloucester, MA: Institute for Global Maritime Studies.

CONFERENCES

2011	Benjamin D. Mazzotta. <i>Prominence and polarity in international trade: A relational concept of power</i> . Paper presented to the Annual Convention of the International Studies Association, Montréal, QC, March 17, 2011.
2011	Benjamin D. Mazzotta. <i>Leverage in cyberspace, without deterrence</i> . Paper presented to the Annual Convention of the International Studies Association, Montréal, QC, March 19, 2011.
2010	Benjamin D. Mazzotta. <i>Seeing trade patterns: Trade cartograms permit data-driven teaching</i> . Paper presented to the International Studies Association Northeast Section, Baltimore, MD, November 4, 2010.
2010	Benjamin D. Mazzotta. <i>Trade cartograms: A method for visualizing dyadic datasets</i> . Paper presented to the UseR! 2010 conference, Gaithersburg, MD, July 23, 2010.

- 2010 Benjamin D. Mazzotta. *Weather risk management and the World Food Program*. Paper presented to The Future of Food and Nutrition, Friedman School of Nutrition, Boston, MA. April 10, 2010.
- 2008 Benjamin D. Mazzotta. *Preliminary findings of the Short Sea Shipping Study*. Paper presented to the Short Sea Shipping Symposium, University of Massachusetts at Dartmouth, Dartmouth, MA, March 26, 2008.

LECTURES

- 2010 Benjamin D. Mazzotta. *Cybersecurity in international relations*. Lecture for Boston College.
- 2009 Benjamin D. Mazzotta. *How to visualize dyadic datasets*. Lecture for the Ph.D. Colloquium, Fletcher School, Tufts University.
- 2008 Benjamin D. Mazzotta. *Weather risk management and the World Food Program*. Lecture for the Harvard Extension School, Harvard University.
- 2008 Benjamin D. Mazzotta. *Weather risk management and the World Food Program*. Lecture for the Ph.D. Colloquium, Fletcher School, Tufts University.
- 2008 Benjamin D. Mazzotta. *Cell phones in emerging markets*. Lecture for the Fletcher School, Tufts University.
- 2008 Benjamin D. Mazzotta. *Complexity science in international relations*. Lecture for the Fletcher School, Tufts University.

Contents

1	Introduction	1
1.1	Overview	2
1.2	WFP Drought Insurance	2
1.2.1	Risk Management for WFP	4
1.2.2	Weather Risk Management	4
1.3	Problem Statement	7
1.3.1	Puzzle	9
1.3.2	Research Question	12
1.4	Hypotheses	16
1.4.1	Coordination Problems	16
1.4.2	Funding Windows and Constraints	22
1.4.3	Transparency	25
1.4.4	External Conditions	27
1.5	Summary of Hypotheses	31
2	Literature Review	33
2.1	Overview	33
2.2	Weather Risk Management	34
2.2.1	Catastrophe Risk Markets	40
2.2.2	Weather Risk in Emerging Markets	42
2.2.3	Risk Management in the Public Sector	44
2.2.4	Poverty Traps	47
2.2.5	Global Public Goods	48
2.3	Index-Based Risk Transfer Products	49
2.3.1	Plain Vanilla Weather Derivatives	49
2.3.2	Trade Financing	51
2.3.3	Microinsurance	51
2.3.4	Price Hedges	54
2.3.5	Commodity Price Risk and Public Finance	56
2.4	Coordination Problems	57
2.4.1	Donor Harmonization	63
2.4.2	Food Security	66

3	Theory	74
3.1	Risk Management Decisions	74
3.2	Coordination Problems	77
3.3	Funding Constraints	81
3.4	Transparency	82
3.5	Financial Market Function	84
4	Methods	86
4.1	Introduction	86
4.2	Case Selection	87
4.3	Documents	90
4.3.1	Project Documents	90
4.3.2	Datasets	91
4.4	Interviews	91
4.4.1	Interview Method	91
4.4.2	Subjects	93
4.4.3	Narrative	94
5	Analysis	96
5.1	Project Background	96
5.1.1	Drought Insurance Pilot	97
5.1.2	Productive Safety Net Program	98
5.1.3	Food Aid in Ethiopia	103
5.1.4	Insurance Markets	106
5.2	Documents	110
5.2.1	WFP	110
5.2.2	USAID	115
5.2.3	Institutional Change	116
5.2.4	Technical Measures	119
5.2.5	Policy Frameworks	126
5.3	Financial Data	136
5.4	Stakeholder Interviews	141
5.4.1	Coordination Problems	141
5.4.2	Aid Frictions	144
5.4.3	Transparency	146
5.4.4	Financial Market Functions	149
6	Conclusions	150
6.1	Summary	150
6.2	Transparency	151
6.3	Coordination Problems	153
6.4	Funding Constraints	155
6.5	Theoretic Significance	157
6.6	Future Research	161

Bibliography	164
A Weather Derivative Valuation	174
B List of Interviews	178
C Water Requirement Satisfaction Index	179
D Livelihoods Early Assessment and Protection Index	181
E Funding Sufficiency Game	184
E.1 A Formalization of Aid Coordination	184
E.2 Definitions	184
E.3 Assumptions	186
E.4 Results	188
E.5 Significance	190

List of Figures

3.1	Drought insurance decision tree	75
5.1	Top recipients of the EU Food Facility	107
5.2	Top recipients of the World Bank Food Price Crisis Response Facility . . .	108
5.3	IRA movements worldwide 2004-2009.	113
5.4	WFP drought insurance pilot relationships	116
5.5	PSNP relationships	117
5.6	IPC coping scale	122
5.7	Food aid time by delivery source	129
5.8	Top recipients of US food aid in 2008	137
5.9	US and UK vs. world bilateral assistance to Ethiopia	139
5.10	Program shares of US bilateral aid to Ethiopia since 2000	140
5.11	Development Assistance Group members, programs and thematic areas . .	142
A.1	Value of a plain vanilla oil call option at maturity	174
A.2	Value of a seasonal precipitation put at maturity	175

List of Tables

2.1	Payoffs in canonical prisoner’s dilemma game.	58
2.2	Payoffs in canonical battle of the sexes game.	58
2.3	Payoffs to the El Farol game.	59
5.1	Stylized cash flows of WFP and PSNP	97
5.2	PSNP spending by donor.	100
5.3	PSNP budget by program	101
5.4	Top sources of funding for WFP Ethiopia in 2008	138
5.5	US humanitarian assistance to Ethiopia FY 2009	139
E.1	Payoff matrix for the funding sufficiency game	186

List of Acroynms

AUSAID Australia Agency for International Development	GoE Government of Ethiopia
CAT Catastrophe Bond	HABP Household Asset Building Program (Ethiopia)
CERF Central Emergency Response Fund	HEA Household Economy Approach
CIDA Canadian International Development Agency	IA Irish Aid
CME Chicago Mercantile Exchange	IBRD International Bank for Reconstruction and Development (World Bank)
DAG Donor Assistance Group	IBRTP Index-Based Risk Transfer Product
DCSF Direct Cost Support Facility	IDA International Development Association (World Bank)
DEV WFP Country Operation	IFAD International Fund for Agriculture and Development
DfID Department For International Development (UK)	IMF International Monetary Fund
DRMFSS Disaster Risk Management and Food Security Service (Ethiopia)	IO International Organization
DRR Disaster Risk Reduction	IRA Immediate Response Account
EC European Commission	LEAP Livelihood Early Assessment and Protection
ECHO Humanitarian Aid Department of the European Commission	LIU Livelihoods Integration Unit (USA)
EDI Ethiopia Drought Index	MoARD Ministry of Agriculture and Rural Development (Ethiopia)
EMOP WFP Emergency Operation	NGO Non-Governmental Organization
EU European Union	OECD Organization for Economic Cooperation and Development
FEWSNET Famine Early Warning Systems Network	OFDA Office of Foreign Disaster Assistance (USA)
FFP Food for Peace (USA)	

PASDEP Plan for Accelerated and Sustained Development to End Poverty	UN United Nations
PCA Project Cash Account	USA United States of America
PRRO WFP Protracted Relief and Recovery Operation	USAID United States Agency for International Development
PRSP Poverty Reduction Strategy Paper	USDA United States Department of Agriculture
PSNP Productive Safety Net Program	WCF Working Capital Fund
SDPRP Sustainable Development and Poverty Reduction Program	WFP World Food Program
SIDA Swedish International Development Agency	WRM Weather Risk Management
UK United Kingdom	WRSI Water Requirement Satisfaction Index

Chapter 1

Introduction

Weather risk management constitutes a set of new opportunities for organizations devoted to improving agricultural and pastoral livelihoods. Insurance, one common strategy for mitigating livelihood risk, requires costly observations of crop yields, livestock losses, food security, and other events. Weather indexes are cheap to measure, perhaps providing a better source of contingent funds with which to mitigate disaster risk. The proliferation of financial structures and the rapid growth of capital under management make it ever more likely that humanitarian organizations can execute previously unthinkable risk management strategies.

With this newfound opportunity comes the need to carefully describe the political and organizational consequences of novel financing models. Particularly, new financing models shift authority and change the type of resources that public organizations require. International organizations (IOs), donors, non-governmental organizations (NGOs), contractors and host country officials will require careful attention to the nuances of risk management decisions, in order to ensure that their own interests, and ultimately those of the beneficiaries, are well protected.

A complete study of weather risk management for the public sector requires models from several different disciplines. Political science analyzes the design of institutions in

the international public sector, the incentives facing different actors in the humanitarian system, and the consequences of various methods of decision making for humanitarian policy. Finance theory provides a model for how investors consider contingent claims to future cash flows under uncertainty. Both of these disciplines draw heavily on game theory and statistics to model the optimal behavior of households, firms, and governments. Public finance provides a rationale for government intervention in markets, and may even suggest a basis for which to identify markets that demand public intervention. Finally, development economics describes the conditions and institutions that lead to economic growth, and what happens when these institutions are absent.

1.1 Overview

The remainder of this chapter provides more background information about weather insurance and weather derivatives, describes how they have been used for humanitarian aid, and outlines key theoretic concepts. I specify the research question and enumerate hypotheses that could affect WFP's ability and propensity to innovate with respect to risk management. The next chapter is a literature review that describes existing work related to the hypotheses, and shows how my research contributes to political science. In the third chapter, I develop the theory underlying the three main hypotheses, and in the fourth I describe the methods for gathering data related to each hypothesis. Chapter five presents and analyzes the data, and chapter six contains findings and directions for future research.

1.2 WFP Drought Insurance

In 2006, WFP began a pilot project to obtain contingent financing for drought relief.¹ WFP Bought a drought insurance policy from a private insurance company, which took a pre-

¹World Food Program. *World's first humanitarian insurance policy issued | WFP | United Nations World Food Programme - the UN food aid agency*. Website. 2006. URL: <http://www.wfp.org/node/598>.

mium payment from the donor on WFP's behalf, in exchange for a commitment to repay a larger sum if Ethiopia's rains failed. The project was part of a campaign by WFP to adopt comprehensive risk management as both an organizational strategy and a principle of its approach to food security for beneficiaries in the field.²

Drought insurance for humanitarian aid represents a radical departure from WFP's traditional funding model. Typically emergency operations are funded by appeal. The prototypical crisis is a rapid-onset event, with little early warning. Following a sudden disaster, WFP raises funds from donors for emergency operations. This model requires an assessment of the disaster while initial relief efforts are underway. Internal funding sources provide some access to operating funds while donors deliberate; but generally emergency operations are funded by donations. The funding status of individual appeals is publicly reported on a UN website, ReliefWeb.³

WFP advance funding mechanisms provide somewhat greater flexibility in emergency response, but largely within the context of the appeals-based funding model. The five sources of advance funding for WFP operations as of 2008 were the Immediate Response Account, the Direct Cost Support Facility, Working Capital Facility, the Project Cash Account, and the Central Emergency Response Fund.⁴ The Direct Cost Support Facility and Immediate Response Account primarily function to resolve internal logistical and financial rigidities at WFP, rather than providing new funding streams for emergencies.⁵ IRA expenditures to avoid pipeline breaks are the last line of defense in a layer of policies to protect continuous access to WFP programs.⁶ The Central Emergency Response Fund ensured collaboration with other UN bodies for integrated crisis response; and the Working Capital

²World Food Program. *WFP Enterprise Risk Management Strategy*. Sept. 2005.

³United Nations. *ReliefWeb: Appeals and Funding*. Website. 2011. URL: <http://ocha.unog.ch/fts/pageloader.aspx>.

⁴World Food Program. *WFP Advance Funding Mechanisms: Review and Recommendations*. 2008.

⁵The *Review of Advance Funding Mechanisms* also mentions the Project Cash Accounts, but this is a centralized accounting mechanism and not a source of funds as such

⁶World Food Program. *Ethiopia - FAO/WFP Crop and Food Security Assessment Mission: Phase I*. Crop and Food Security Assessment Mission WFP179344. Jan. 2008. URL: <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp179344.pdf>.

Facility advanced the date of access to funds committed by donors. None of these funding instruments provided dedicated, incremental capacity to WFP emergency operations except through appeals to donors.

1.2.1 Risk Management for WFP

Emergency operations require action in the face of uncertainty as a food crisis unfolds. WFP has limited foresight over the extent of the crisis, which determine its program costs, and limited foresight over donor government appropriations, which are the basis of its program funds. The timeliness of donors' pledges and disbursement matters to WFP. Targeting, logistics, and efficacy of food aid interventions all suffer when disbursements lag crises. As time passes, seasonal opportunities for targeting (such as school feedings) and logistics (such as the quality of roads) can be lost.⁷ Higher cost of foodstuffs dilutes emergency budgets and the purchasing power of cash-for-work programs.⁸ Time also adds to the costs of coping strategies (such as meals foregone), asset destruction, and declining health status.

WFP's problem is effectively how to bring donor appeals to maturity faster. A private corporation could simply raise capital through debt or equity; but WFP might as well have an infinite cost of borrowing. Its advance funding mechanisms do not permit it to raise private capital to be repaid with donor funds. Rather than procuring funds at lowest financial cost, WFP seeks to procure funds at the earliest possible date.

1.2.2 Weather Risk Management

Financial approaches to risk management in the private sector include hedging and insurance. Firms in distress may find it costly to raise funds through debt and equity instruments, so securing prior access to contingent funds may be preferable. Financial derivatives permit

⁷World Food Program, *WFP Advance Funding Mechanisms: Review and Recommendations*.

⁸C. J. Jepma. *The tying of aid*. Development Centre of the Organisation for Economic Co-operation and Development, 1991.

firms to offset risks associated with price movements. Insurance contracts explicitly insure the firm's assets against adverse events, such as natural disasters and lawsuits.

Financial derivatives can be written against a bewildering variety of prices and types of price movements.⁹ The simplest of these contracts are familiar to all financial analysts: swaps, futures, calls and puts. Swaps and futures are agreements to exchange at a fixed price at a specified date in the future; each party reaps the benefit of certainty over the price, avoiding taking a loss from adverse price movements. Underwriters of puts and calls provide customers with the option to sell or buy a stock at a fixed price in the future, even if the future price of that stock has fallen or risen in the meantime. The fixed price, called a strike, determines whether the derivative has any value at maturity. If the market price is above the strike, then the call is worth the difference in price, and the put is worthless (and if the market price is below the strike, then vice versa). Essentially all of these contracts can be used to protect firms from adverse market conditions over which they have little control. Synthetic derivatives provide payments exactly equivalent to the derivative's value at maturity, rather than actual transfers of stocks, foreign exchange, or commodities. The underwriter simply collects the purchase price and makes payments for the composite return equivalent to the value of a traditional derivative. To limit the risk in the underwriter's portfolio, the underwriter can sell offsetting positions on either side of a weather event (though some weather risks may be inherently unbalanced), or reinsure the risks of the portfolio. Standardized synthetic derivatives are transferable, and markets for popular securities are highly liquid.

Weather derivatives replace the underlying asset price with an index of precipitation or temperature for a specific location and date.¹⁰ These securities can be sold over the counter

⁹Robert W Kolb and James A Overdahl. *Financial Derivatives: Pricing and Risk Management*. Hoboken, N.J: John Wiley & Sons, 2010. ISBN: 9780470499108; Robert E Whaley. *Derivatives: Markets, Valuation, and Risk Management*. Hoboken, N.J: Wiley, 2006. ISBN: 0471786322; Christopher L Culp. *Structured Finance and Insurance: The ART of Managing Capital and Risk*. Hoboken, N.J: Wiley, 2006. ISBN: 0471706310.

¹⁰M. E. Hellmuth et al. "Index insurance and climate risk: Prospects for development and disaster management." *International Research Institute for Climate and Society, Columbia University, New York* (2009). URL: http://mahider.ilri.org/bitstream/10568/932/1/Hellmut_

or traded on exchanges. The most intuitive weather derivative is a put option on precipitation.¹¹ If seasonal rainfall in a given city falls below a threshold, the underwriter pays the bearer a prearranged sum that rises parametrically with the rainfall deficit. The parallel to the financial derivative is straightforward. The strike of the put option is measured in terms of rainfall, and the value of the derivative scales linearly with rainfall below the strike. Exchange-traded weather derivatives provide the added benefit of liquidity to the bearer, permitting adequate flexibility to the bearer with greater price transparency and perhaps at lower cost.

There are two principal structures used in weather risk management. Weather risk products can use extreme events such as hurricanes for triggers, as in the case of catastrophic reinsurance and catastrophe bonds. Alternatively, they can pay out according to a function of some climate variable such as daily temperature or seasonal precipitation.¹² Weather derivatives are available both over the counter and as exchange-traded securities in OECD markets, and they are increasingly being used in the creation of micro-insurance projects in the developing world.¹³ The Chicago Mercantile Exchange trades daily contracts for temperature and precipitation in a large selection of cities across North America, Europe, Australia, and Japan.¹⁴

Weather derivatives go by many names in humanitarian circles: weather insurance, drought insurance, weather indexes, index-based risk transfer products (IBRTPs) and others. These names may refer to nuances of product design, or they may reinforce that the goal of these derivatives is to hedge risks, rather than to speculate in volatile financial markets. Instruments in use include both index-based insurance, where the bearer purchases

IndexClimateSocietyNo2.pdf.

¹¹Simple examples of weather derivatives are explained in Appendix A.

¹²Jerry R. Skees. "Opportunities for Improved Efficiency in Risk Sharing Using Capital Markets." *American Journal of Agricultural Economics* 81.5 (Dec. 1999), pp. 1228–1233. ISSN: 00029092. DOI: 10.2307/1244112. URL: <http://www.jstor.org/stable/1244112>.

¹³Ulrich Hess, Erin Bryla, and John Nash. *Rural Finance Innovations: Topics and Case Studies*. Tech. rep. Washington, DC: World Bank, 2005. URL: <http://www.worldbank.org/rural>.

¹⁴CME Group. *Weather Products Homepage*. Website. URL: <http://www.cmegroup.com/trading/weather/index.html>.

a conditional payment from the underwriter when rainfall is bad, and credit, where the bearer's interest rate depends on seasonal rainfall. What these instruments have in common is that they use weather-linked, conditional payments (or debt reductions) to offset liabilities in agricultural and pastoral livelihoods.

It is worth stating here that this dissertation is largely concerned with financial and not operational approaches to risk management. The large literature on disaster risk management incorporates both financial and operational approaches. An operational drought risk strategy could be, for a farmer, to plant drought-resistant seed or to irrigate fields. For some weather-exposed businesses, operational strategies may ultimately be more effective than financial strategies; and this is especially true when systemic risk threatens the creditworthiness of weather risk underwriters.

1.3 Problem Statement

Weather risk management originated as a strategy to reduce the transaction costs associated with pricing and monitoring reinsurance. Insurance firms can purchase reinsurance, either parametric or excess of loss insurance, to cover against large losses from a pool of insurance policies they have written.¹⁵ Assessing and monitoring the risk of a pool of insurance policies is costly for reinsurance companies, compared to forecasting the distribution of seasonal weather patterns. Weather-linked assets, such as catastrophe bonds, provide an alternative asset pool for reinsurance in the event of catastrophes.¹⁶

For a private firm, the difference between assets and liabilities determines operating profits. From operating profits, the firm pays taxes, debts, and equity (retained earnings and dividends). Private firms measure incremental access to capital against the firm's cost

¹⁵Joseph W. Glauber. "Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 86.5 (2004), pp. 1179–1195. DOI: 10.1111/j.0002-9092.2004.00663.x. URL: <http://dx.doi.org/10.1111/j.0002-9092.2004.00663.x>.

¹⁶Banu Ozcan. "Market Convergence, Catastrophe Risk and Sovereign Borrowing: An Empirical Analysis for Emerging Market Countries." PhD thesis. Fletcher School of Law and Diplomacy, 2005.

of debt and equity. The optimal decision is the one that provides the firm with the greatest future earnings at the lowest cost. WFP and the Government of Ethiopia (GoE) do not raise capital through debt or equity, and they do not retain earnings. WFP raises money through emergency appeals. It cannot use more funds than have been allocated to specific purposes. If WFP has uncertainty over the timing of future cash flows, the optimal decision is the one that provides the greatest contingent access to scarce working capital on the basis of its expectations about future states of the world. GoE safety nets similarly have no sink for surplus funds. For humanitarian aid, weather insurance holds the promise of permitting aid to arrive in time. It could permit WFP to act before, rather than after, households have sold precious assets and started to bear the burdens of disease, stunting and wasting.

Governments typically choose to bear the risk of highly correlated losses due to climate events, such as storms and floods, rather than use insurance or hedging strategies to manage their risks. In the case of large governments, the government has a low cost of borrowing. This encourages the government to bear disaster risk and borrow for emergency spending whenever a disaster strikes. Small governments typically do not have the same access to cheap emergency funds. WFP is constrained on two accounts: neither does it have perfect flexibility in allocating emergency relief, nor does it bear losses that would be sensible to reinsure.

Weather insurance might provide more timely contingent cash flows to poor governments and international organizations; but it is not clear that public organizations view risk management in the same way that companies do. Finance theory assumes that investors are principally concerned about the expected returns to investments and the variance of those returns.¹⁷ Firms' access to capital depends on the cost of new equity and debt instruments, and those are in turn determined by investors' claims on future income from the firm.¹⁸ All contingent claims on future cash flows can be valued as functions of the underlying cash

¹⁷R. C Merton. "An Analytic Derivation of the Efficient Portfolio Frontier." *Journal of Financial and Quantitative Analysis* 7.04 (1972), pp. 1851–1872.

¹⁸J. E Stiglitz. "A re-examination of the Modigliani-Miller theorem." *The American Economic Review* 59.5 (1969), pp. 784–793.

flows, subject to the likelihood of the claim's realizing a given value at maturity.¹⁹ Insurance is simply another case of a contingent claim, for which the same models and tools can be employed: a few simple assumptions about investors' valuation of returns, aversion to risk, and absence of arbitrage opportunities.²⁰

Governments, on the other hand, have different goals and different borrowing constraints from firms. In the broadest sense, national fiscal and monetary policy attempt to optimize aggregate demand for output, taking into consideration concerns about saving and investment behavior, inflationary expectations, debt service, and future tax policy.²¹ Food security policy is just one component of Ethiopian national economic policy; that is, the purpose of its enactment is not to smooth the business cycle. Mankiw's *Principles of Economics* gives three microeconomic reasons for government intervention in the economy: to compensate for externalities, to provide public goods, and to optimize tax design.²² Social safety nets are typically modeled as a public goods problem; although strictly speaking they are excludable and rival in consumption.²³ For the purposes of humanitarian aid, neither the private perspective of lowest-cost access to conditional funds, nor the public perspective of whether to pay for the safety nets through debt or new taxes, provides a complete picture to evaluate potential funding instruments for food security programs.

1.3.1 Puzzle

Weather risk management holds the potential to fix a large asset-liability mismatch for WFP's emergency aid programs. When droughts and extreme storms can be hedged or insured in private capital markets, contingent cash flows may be cheaper and more timely

¹⁹R. C Merton. "On the pricing of contingent claims and the Modigliani-Miller theorem* 1." *Journal of Financial Economics* 5.2 (1977), pp. 241–249.

²⁰R. C Merton. "An analytic derivation of the cost of deposit insurance and loan guarantees An application of modern option pricing theory." *Journal of Banking & Finance* 1.1 (1977), pp. 3–11.

²¹D. W Elmendorf and Gregory N. Mankiw. "Government debt." *Handbook of macroeconomics* 1 (1999), pp. 1615–1669.

²²N. Gregory Mankiw. *Principles of Economics*. Cengage Learning, Sept. 2008. ISBN: 9780324589979.

²³Elmendorf and Mankiw, "Government debt."

than donors' responses to flash appeals. What are the political factors that lead to uptake of these relatively new financial instruments? If weather risk management is so cheap and flexible, why don't all the multilateral organizations already use it?

Weather risk management is a new financing model for international organizations engaged in humanitarian relief efforts. The principal benefits of an index-based risk management strategy are lower transaction costs and improved incentives. Unlike private firms, public organizations have historically not used financial risk management strategies to anticipate and provide for relief efforts. This dissertation asks why WFP (and subsequently the Government of Ethiopia) were first among public humanitarian organizations to adopt this financial strategy, and whether finance theory successfully explains their behavior. If not, what features of public organizations distinguish them from private organizations, concerning their risk management decisions?

Finance theory holds that index-based risk transfer products, such as weather derivatives, have two principal advantages over insurance: lower transaction costs and improved incentives.²⁴ The former refers to the simplicity of writing contracts and observing outcomes. Index-based products provide contingent cash flows on the basis of an easily observed index correlated to the insured party's risk, rather than on an estimate of specific damages to insured parties. The latter describes the behavior of insured parties. Insured parties may take imprudent risks when insured against losses; or they may skimp on investment when the returns to investment are diluted by the insurance contract. Index-based products are most appropriate when transaction costs are high and the threat of moral hazard, asymmetric information and adverse selection are greatest.

Humanitarian assistance displays some features that suggest index-based insurance could be useful, but not all. First, the transaction costs of measuring a humanitarian disaster are enormous.²⁵ Measurement of access to food and food security is complex and

²⁴Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

²⁵Patrick Webb et al. "Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do." *J. Nutr.* 136.5 (May 2006), 1404S–1408. URL: <http://jn.nutrition.org.ezproxy.library.tufts.edu/cgi/content/abstract/136/5/1404S>.

difficult. The measurement process requires detailed knowledge of local economic and health conditions, in areas where reliable statistics are scarce.²⁶ Both assessment of current conditions and forecast of budget requirements for humanitarian response require time and effort. These high transaction costs constitute an opportunity to innovate. If weather derivatives provide an accurate and quick mechanism to allocate funding for humanitarian interventions, donors and aid organizations should prefer the lower-cost alternative.

As for moral hazard and adverse selection, there is less of a concern. The international organization does not appear to have the capacity to alter the underlying food security profile of the beneficiary population in order to trigger larger payouts; or at least, not substantially more so with traditional emergency financing appeals than with any other financing mechanisms. This would amount to deliberate, willful destruction of food security in order to obtain larger budgets. In the abstract, humanitarian organizations might be very happy to undermine food security in service of ever-larger emergency operations; but not even Dambisa Moyo, to my knowledge, has argued such an extreme case.²⁷

Adverse selection is not a concern in the particular case of humanitarian assistance. Humanitarian aid is not based on risk pooling; and aid organizations intentionally serve the very worst off, i.e., the type of clients that an insurance company would most wish to avoid. Adverse selection refers to a particular type of problem in insurance markets, where the people most likely to pay their premiums are the people who perceive they stand to gain more from the policy than they stand to lose. Insurance pools only work if the average policy holder expects to lose a bit of money every year (given a certain premium and an unlikely payout), but perceives a utility benefit from catastrophic loss protection. Traditional emergency appeals are rarely structured as formal reinsurance contracts, which would take the form of a threshold (excess of loss) or parametric cost sharing with the international organization. Instead, aid organizations engage in negotiations with donors as

²⁶IPC Partners. *Integrated food security and humanitarian phase classification*. Technical Manual 1.1. July 2008. URL: <ftp://ftp.fao.org/docrep/fao/010/i0275e/i0275e00.pdf>.

²⁷Dambisa Moyo. *Dead Aid: Why Aid Is Not Working and How There Is a Better Way for Africa*. Farrar, Straus and Giroux, Mar. 2010. ISBN: 0374532125.

the need arises. Furthermore, humanitarian organizations play the role of an insurer of last resort. Beneficiaries do not have another readily available source for assistance, and there are few serious competitors for role of providing emergency assistance.

Essentially, the puzzle is why the financial innovation occurred at WFP, and whether the typical model of an index-based reinsurance contract is a good fit for WFP's weather insurance (and subsequent risk financing for humanitarian aid). Does the financial theory of lower transaction costs and improved incentives tell the whole story? Or are there other explanations for the occurrence of this policy innovation?

1.3.2 Research Question

This dissertation is about policy innovation in the global public sector. It asks how and why WFP and its successors arrived at a decision to manage weather-related risks, when other public organizations do not. There are two classes of theory that I will use in fleshing out that question: first, risk management decisions in finance, and second, a class of principal-agent games in humanitarian assistance that describe funding decisions and delegation of authority. The objective is to evaluate existing theory and suggest improvements where it may be insufficient.

I will model humanitarian aid in Ethiopia as a two-stage decision problem. First, WFP negotiates its funding with donors. Second, it implements programs with the Government of Ethiopia and contractors. This is a stylized vision of WFP's role in Ethiopia. In reality, donors plan economic assistance through the Development Assistance Group (DAG), of which WFP is a member. WFP's programming decisions in Ethiopia take place in the context of multi-year planning processes, shared responsibilities, and changing conditions on the ground. Since the dissertation focuses on emergency programs that respond to drought, the picture of WFP as an independent organization pursuing funding for emergency appeals is reasonable. After the WFP drought insurance pilot, however, the situation became somewhat more complicated. DAG and GoE collaborate on humanitarian affairs through

the Productive Safety Net Program (PSNP), which is administered by GoE's Ministry of Agriculture and Rural Development (MoARD) and funded by DAG. Under the PSNP's risk financing program, the identities of the counterparties changed dramatically. PSNP is now the recipient of so-called risk financing, and the donors have the place of the insurance company. Among donors, USAID and the World Bank made a commitment to finance the Government's safety net in case of drought, using the next iteration of the weather algorithm developed at WFP.

The second stage of the decision, i.e., allocating funds for drought relief, is largely simultaneous with the first stage, the solicitation of funds. In the case of the weather insurance pilot, funds were allocated to WFP's Emergency Operation in Ethiopia. While the specific identities and locations of beneficiaries might not be possible to specify in advance, the types of operations and targeting criteria were well known at the time the weather insurance was purchased. Under the PSNP, the use of funds is similarly determined by the PSNP's strategy document. In the PSNP, the Ministry of Agriculture forecasts income shocks to households and identifies communities in the greatest need of funds. These communities then select the works projects (e.g., road building) and target households that should participate in the safety net programs. While authority over the programs is highly devolved, the funding for these programs is committed and cannot be shifted to other non-PSNP uses.

The specific tool chosen by WFP for the first stage of the problem is a risk management instrument: weather insurance. This suggests that WFP might have had similar motivations to a private firm using the same instrument. Risk management decisions are a common topic of study in finance. A simple model for hedging strategies is a portfolio selection problem for the firm: i.e., whether to choose unhedged or hedged future cash flows in order to maximize returns and minimize variance.²⁸ A hedged future cash flow is one that is protected from loss, through the use of a derivative contract. The simplest possible contracts are futures and swaps, which eliminate price variability for the firm. These contracts, in

²⁸Kenneth A. Froot and Paul G. J. O'Connell. "On the Pricing of Intermediated Risks: Theory and Application to Catastrophe Reinsurance." *Journal of Banking and Finance* (2007).

the abstract, permit farmers to know the price they will receive at harvest time, rather than suffering the uncertainty of price changes after planting. This model is sufficiently well understood that economists use it to estimate optimal hedging ratios (the proportion of future losses that should be hedged by a rational corporation) and as a benchmark for evidence of capital market imperfections.²⁹ Another widely used approach is cash flow analysis, which calculates hypothetical cash flows for a potential government or international organization hedging strategy under historical or simulated market conditions.³⁰ The cash flow approach, however, largely neglects a statistical approach to modeling weather and market data in favor of a simpler scenario calculation. Although the risk-return model of optimal hedging is somewhat more abstract than a scenario-based cash flow analysis, it has the advantage of accounting for the volatility and uncertainty in climate and market variables.

Neither corporate risk management nor public finance is a perfect model for the IO with respect to risk management. A private firm makes decisions primarily on the basis of risk-adjusted return, whereas the international organization has many special features. WFP has a mandate to provide humanitarian aid. As an IO, it faces earmarks and political constraints on the allocation of donor funds. It participates in a complex, iterative funding game with the donor governments for voluntary contributions, with costly information and opaque intentions on all sides. Governments share several of these features with WFP but with one notable exception: governments can violate fiscal balance. Fiscal deficits are not without cost to the government, but governments, to my knowledge, universally prefer fiscal deficits for emergency humanitarian operations, rather than tapping private capital markets for weather contingent cash flows. Sovereign borrowing implicitly involves tapping private capital markets for public outlays, but national emergency humanitarian

²⁹Kenneth A. Froot. "The market for catastrophe risk: a clinical examination." *Journal of Financial Economics* 60.2-3 (May 2001), pp. 529–571. ISSN: 0304-405X. DOI: 10.1016/S0304-405X(01)00052-6. URL: <http://www.sciencedirect.com/science/article/B6VBX-433W7FJ-B/2/6bae8b68e1731b994400191b9366df12>; R. Faruquee, J. R. Coleman, and T. Scott. "Managing Price Risk in the Pakistan Wheat Market." *The World Bank Economic Review* 11.2 (1997), pp. 263–292.

³⁰Julie Dana, Christopher L Gilbert, and Euna Shim. "Hedging Grain Price Risk in the SADC: Case Studies of Malawi and Zambia." *Food Policy* 31.4 (Aug. 2006), pp. 357–71. ISSN: 0306-9192.

operations rarely receive funding that is explicitly contingent on the rollover of sovereign debt.

WFP does not operate in the austere world of neoclassical markets, but rather in a complex web of relationships. These relationships constitute constraints and incentives that might cause deviation from the portfolio selection model to which I alluded above. International organizations' (IO) institutional setting partially determines the universe of policies available to them. Donors may have diverse preferences over IO behavior. Donors cannot costlessly assess the nature, motivations, and effects of IO programs. IOs are professional organizations that have specialized bureaucracies that evolve both expertise and norms in their subject areas, reinterpreting their mission as time passes.³¹ The specific mission of the international organization has consequences for optimum design of funding and oversight.³² Compared to the private sector, WFP is far from an early adopter of this financial innovation; however, among IOs, WFP is the first. This dissertation asks, what are the features of WFP that brought about (or hindered) this policy innovation? What objectives did the policy accomplish (or fail to accomplish)? What are the constraints on supply, donor financing, or WFP demand for these securities?

There are several features of the weather insurance program in Ethiopia that merit closer examination. The contract's design illuminates the intent of WFP and its various counterparts in pushing for the innovative program. It might also bear the imprint of the bureaucratic processes and negotiations that were required to approve that design. The design of the contract has not been at all stable, merely growing or shrinking over time. In subsequent years, every feature of the pilot program was changed in a fundamental way, including the weather algorithm that determines payouts, the types of programs funded under the project, and the identities of the underwriter and the policy holder. These changes to the program

³¹Michael N. Barnett and Martha Finnemore. *Rules for the World : International Organizations in Global Politics*. Ithaca, N.Y.: Cornell University Press, 2004. ISBN: 0801440904 9780801440908 0801488230 9780801488238.

³²Scott Barrett. *Why Cooperate?: The Incentive to Supply Global Public Goods*. Oxford: Oxford University Press, 2007. ISBN: 9780199211890.

can show us how the political context of humanitarian aid in Ethiopia assimilates and responds to a new financial technology.

1.4 Hypotheses

1.4.1 Coordination Problems

One set of explanations for the development of weather derivatives for humanitarian aid revolves around coordination problems. The first stage of the humanitarian aid process, funding, takes center stage in this view. Humanitarian aid is the product of complex decisions with many stakeholders. The interests of various governments and their executive agencies, electoral constituencies and their legislative representatives, private firms and non-profits, and both political and financial interests of large international organizations are at stake in decisions about humanitarian aid. These organizations and decision makers have strong incentives to protect their own interests, and weak foresight over each other's intended course of action. It may be optimal, either from the perspective of a single actor or globally, to coordinate stakeholders' expectations around a particular method of decision making for humanitarian aid decisions. Without the weather insurance, donors do not have a complete picture of fellow donors' capabilities and funding positions until the appeal is announced. Weather insurance requires donors to agree ahead of time on the design of contingent commitments for emergency action. A variety of channels by which weather insurance might coordinate donor's funding decisions, are developed below in detail.

Free riding

Humanitarian aid in Ethiopia is a shared endeavor. From the perspective of the donors, it is like a public good or a club good, in that the donors receive collective political credit for the success of the humanitarian endeavor. Public goods suffer from underinvestment because of a commons problem: unfettered access to the public good, regardless of the

individual's investment in the production of the good, dilutes the incentive of the individual to invest in its production.³³ The weather derivative might constitute an effort to avoid free riding among members of the donor group. When donations are funded by appeal, each donor independently decides, according to its own funding calendar, rules, and interests, how much to invest in aid. Since the political outcome, i.e., whether the aid is successful, is likely to be judged collectively, each individual donor may seek to minimize the investment necessary to preserve a successful outcome. Even if all the donors agree on the levels of expenditure and types of programs required for success, individual donors will still face incentives to shift the funding burden onto other donors.

Barrett differentiates three types of international public good, according to the production function of the public good: first best effort, aggregate effort, and weakest link.³⁴ Where barriers to entry and cooperation are high, production of a public good depends on the capability and effort of an individual state, e.g., the United States global positioning system (GPS) satellite constellation. Humanitarian aid requires an aggregate effort, meaning that all states have largely equivalent opportunities to participate in humanitarian aid, subject to budget constraints, political will, and institutional capacity. (Saving whales is a good example of a weakest link problem, where even a small state can effectively undermine the efforts of the international community.) Since WFP's humanitarian aid budget is determined by a large number of donor countries and private organizations, no one player holds veto power over all emergency operations; but donors could exhibit strategic behavior in their decisions to fund emergency aid programs. Coordination problems of this kind could also engender strategic attempts to influence WFP priorities by withholding funding, attaching conditions to participation in relief efforts, and withdrawing participation altogether.³⁵

³³D. Hawkins et al. "Delegation under anarchy: States, international organizations, and principal-agent theory." *Delegation and agency in international organizations*. 2006, pp. 3–38.

³⁴Barrett, *Why Cooperate?*

³⁵David Epstein and Sharyn O'Halloran. "Sovereignty and Delegation in International Organizations." *Law and Contemporary Problems* 71 (2008), p. 77. URL: <http://heinonline.org/HOL/Page?handle=hein.journals/lcp71&id=85&div=&collection=journals>.

Competing priorities

Competing priorities provide another motivation for gaming the humanitarian aid negotiation. Whereas free riding describes the donor's effort to shrink its share of the funding burden, donors may also strategically withhold support for less favored programs. Suppose that funding appeals are issued consecutively, rather than simultaneously, by WFP to the community of donors. Each donor knows its own funding capacity and priorities, but not the others'. The funding appeal is an opportunity to discern others' appetites for aid programs. By delaying, each may watch and wait to see who allocates funds and who does not. Keeping score is easy; current funding status of each appeal is updated on a rolling basis at ReliefWeb. Where donors have overlapping preferences, the best use of any single donors' funds would be to encourage another to fund shared priorities, leaving the donor's own funds free for idiosyncratic humanitarian operations. Each donor has an incentive to be the last to announce funding decisions. Weather derivatives improve on this situation by making all decisions simultaneous. They provides a single context in which all the donors decide their budget shares for future droughts, subject to the exhaustion of insurance coverage.

WFP is a UN organization, but its funding is based on appeals and not the regular UN budget.³⁶ The top 10 donors in 2008 were the United States, Saudi Arabia, Canada, European Commission, United Nations,³⁷ United Kingdom, Japan, private donors, Italy, and Germany, who together account for 85% of 2008 donations.³⁸ The operational priorities of donors in this group may be quite different, and each may attach conditions to the funds independently of the others. The size and timing of donations to WFP programs depends on domestic institutional funding authorities, who have their own rules and calendars for allocating funds. A large literature on the political economy of aid explores the conse-

³⁶World Food Program. *Operational priorities*. Website. 2008. URL: <http://www.wfp.org/operations/priorities>.

³⁷The United Nations funds emergency operations through the Central Emergency Relief Fund.

³⁸World Food Program. *WFP's Operational Requirements, Shortfalls, and Priorities for 2008*. Oct. 2008.

quences of differences between donor governments and aid recipients.³⁹ Legislative limits may determine which aspects of emergency operations are eligible for funding; and donors may disagree on the political benefits of funding particular operations. Diverse donor preferences increase the need for negotiation among donors; and these negotiations may be unripe until the time that an emergency arises.

Hawkins et al. differentiate between collective principals and multiple principals in principal-agent games. Agents negotiating with multiple principals must conduct a series of bilateral negotiations on individual issues; whereas the creation of an international organization permits the agent to write a single agenda that obtains a winning coalition of support. Without stretching the model too far, this hypothesis posits the ex ante funding negotiation is similar to the IO agenda of the collective principal. Experts either at WFP can structure the agenda of emergency operations funding around a plan constructed by technical experts, and obtain a winning coalition of support to fund that program, rather than letting chance dictate the order in which individual appeals are made. Under appeals financing, the donor with the most flexible preferences might exhaust its budget early in the process, leaving a more restrictive donor with greater control over marginal programs. Weather derivatives could present a package of emergency funding priorities for a vote before the nature of a crisis is known.

Confidence

International organizations such as the IMF consider power relationships carefully in lending decisions to sovereigns. In particular, IMF and World Bank lending programs face trade-offs between moral hazard and austerity. Generous concessional lending can reward countries for bad behavior, while punitive lending needlessly punishes citizens of the most

³⁹Alberto Alesina and David Dollar. "Who gives foreign aid to whom and why?" *Journal of Economic Growth* 5.1 (Mar. 2000), pp. 33–63. DOI: 10.1023/A:1009874203400. URL: <http://dx.doi.org/10.1023/A:1009874203400>.

vulnerable countries.⁴⁰ One approach to this trade-off is to specify strict eligibility rules for IMF loan assistance.⁴¹ This view holds that the IMF can specify what constitutes good or bad behavior before crises strike, and then provide assistance to countries that meet the standards of prudent policy. In practice, time inconsistency problems and politics can interfere with successful execution of the ex-ante eligibility strategy.

Humanitarian organizations face an altogether different problem of conditionality. Even when the safety and operational autonomy of humanitarian organizations can be guaranteed, the donor community may, at times, not have the political support of the beneficiary government. The beneficiary government, in the worst case, can wield beneficiaries as a bargaining chip in negotiation with IOs and NGOs. WFP's financing strategy takes place in the context of a complex relationship between the international community and the government of Ethiopia.

Spending donor funds on an insurance premium for emergency operations is a credible signal of intent to intervene in a class of droughts. The insurance commits WFP to intervene on the basis of causes, rather than symptoms. It also commits funds at regular, predictable intervals in exchange for contingent capital flows, which become available in the event of a whole class of potential crises. The early and costly WFP signal to beneficiary governments fundamentally shapes expectations on both sides of the negotiating table.

Timing of negotiations

Weather risk management amounts to a set of conditions, specified in advance, which donors can agree should trigger at least some type of emergency operations. Whether the donors make binding commitments to provide the funds themselves, or whether the contin-

⁴⁰Olivier Jeanne and Jeromin Zettelmeyer. "International bailouts, moral hazard and conditionality." *Economic Policy* 16.33 (2001), pp. 407–432. DOI: 10.1111/1468-0327.t01-1-00080. URL: <http://dx.doi.org/10.1111/1468-0327.t01-1-00080>.

⁴¹Stanley Fischer. "On the Need for an International Lender of Last Resort." *The Journal of Economic Perspectives* 13.4 (1999), pp. 85–104. ISSN: 08953309. DOI: 10.2307/2647014. URL: <http://www.jstor.org/stable/2647014>; Charles Calomiris. "The IMF's imprudent role as lender of last resort." *Cato Journal* 17.3 (1998), p. 275. ISSN: 02733072. URL: <http://proquest.umi.com/pqdweb?did=30273544&Fmt=7&clientId=28972&RQT=309&VName=PQD>.

gent financing is obtained through contracts with the private sector, the decision to manage weather related risk forces donors to conduct some of the negotiations over emergency priorities in advance.

This has a potential drawback, in that it locks donors into funding for a certain set of conditions that happen to be amenable to index-based instruments. Political problems, crop disease and pests can have just as serious impacts on food security; but they are less amenable to index-based risk management. Risk management could thus secure the first place in line for emergency funds for those crises that happen to lend themselves to indexes.

Several factors might mitigate the practical effect of earlier funding decisions. Contingent funds may not translate into project expenditures or better access to food for beneficiaries. Long lead times for donor promises are not unequivocally better. Donor commitments to fund more than a couple of years in advance could be subject to renegotiation, revision, or default.

By how much the funding decisions are actually moved forward is another question. If flash appeals are researched, written, and funded within days of the occurrence of an emergency, then the lag introduced by the appeals process might be trivial. The timing of seasonal weather observations could also affect certainty over funding with the ex ante strategy. If the drought index is front weighted, meaning most of the crop yield forecast depends on the early rain, then WFP would expect somewhat more funding even before the final state of the rains was known.

Finally, future index-based funding could be subjected to any type of escape clause or conditionality that donors can collectively dream up. The original WFP drought insurance project did not attach significant covenants to the conditional funding, but future instruments might differ in that respect.

1.4.2 Funding Windows and Constraints

WFP uses drought insurance to address the delay between the occurrence of drought and the arrival of donor funds. Both WFP's costs and the marginal benefit of donor funds to beneficiaries can suffer from delay in the appeals funding process. This set of hypotheses asks whether drought insurance fills a role that existing WFP advance funding mechanisms could not.

The specific expenditures funded at the outset of a drought are likely to be more cash-intensive than later in the relief cycle. Rapid needs assessment and emergency relief operations rely less on food commodities than do food-for-work programs. Of immediate concern are breaks in the pipeline of food aid, and accurate estimates of beneficiaries' need in response to any potential crop failure. WFP cannot use in-kind food aid for some of these first, emergency expenditures in times of drought. The WRM strategy (since it provides cash and not commodities) would provide useful resources for WFP's first response to a drought.

Advance funding mechanisms

Several advance funding mechanisms exist to address the delay in donors' funding decisions and disbursements. This hypothesis holds that the adoption of weather insurance specifically addressed a gap in the existing advance financing mechanisms. Constraints on advance funding mechanisms include conditions that must be satisfied before the funds can be drawn from internal sources, the timeline on which funds can be accessed, and the uses of funds from particular internal sources.

At PSNP Ethiopia, this hypothesis takes on a very different character. Rather than a multilateral organization with a dedicated international budget, PSNP obtains funds through the Development Assistance Group in a multi-year strategic framework. Therefore this hypothesis is primarily concerned with whether the constraints on advance funding mechanisms at WFP provided the impetus to create and sustain weather insurance.

Aid tying, earmarks, and food/cash ratios

The diversity of donor preferences finds bureaucratic expression in earmarks and aid tying. Quietly, donor governments attach conditions to the use of their aid. When the conditions involve restrictions on the nationality of vendors for aid programs, those programs are called aid tying. Jepma's review of aid tying estimates that aid tying generally reduces the real value of aid by approximately 15%-30%.⁴² Jepma calculates both direct costs associated with aid tying, meaning higher costs for goods and services that could be sourced locally, and indirect costs, meaning administrative expenses and delays due to the procedures of tied aid. Recipients may also suffer welfare losses when tying requires substituting second-best goods and services.

Cash payments from the private sector may evade legislative requirements from donors in any of several ways. The purchase of insurance services from donor country firms could satisfy the aid tying requirements, while permitting WFP to allocate project funds to locally available supplies and logistical services. The purchase of insurance might also raise the effective ceiling on cash contributions by pooling limits from emergency and non-emergency years. If for whatever reason cash is preferable to in-kind assistance during emergencies (e.g., the expense of pre-positioning supplies, or the economic inefficiency of dumping grain into the local market), then weather insurance can increase the efficiency and flexibility of donated funds.

Logistics

Weather risk management might be a method of improving the logistics of drought relief. A number of factors could affect the timing of the arrival of resources into the field, and donor decisions to fund appeals are only one of those strategies. According to this hypothesis, the issue is how different funding mechanisms affect aid delivery, rather than how different funding mechanisms affect donor decision making. It also differs from aid tying and the

⁴²Jepma, *The tying of aid*.

relative sizes of cash vs. non-cash aid budgets.

Imagine, for instance, that in-kind aid sits in port in Rotterdam until called upon for emergency operations. At the moment of funding, the ship leaves port and heads for its newly announced destination. Needless to say, the reality is more complicated, but the principle is the same. Once a donor funding decision occurs, compare the two courses of action for the donor. For in-kind aid, funding is released by the ship's leaving port. Pre-positioned aid does not completely eliminate the problem of moving resources to the field. It is easy to imagine other logistical issues, such as specific bagging and bag marking requirements may not be fulfilled until the time of use. For cash aid, a wholly different type of transfers must occur in order for funds to appear in project cash accounts. Namely, there must be some system of electronic transfers and ultimately cash distribution into field projects where the social safety net holds works projects and effects cash transfers. This hypothesis asks whether the WFP Ethiopia's logistical concerns drove the decision to undertake the drought insurance pilot.

Standing vs. emergency budgets

This hypothesis holds that emergency and non-emergency aid budgets are partially fungible; and therefore WFP can augment total emergency funding by tapping non-emergency budgets for contingent emergency financing. Emergency budgets are nominally separate from annual foreign aid budgets. In principle, emergency appeals are funded on an individual basis and from a different budget. In practice, context matters. The second humanitarian disaster of a fiscal year might not receive the same level of funding as the first did, all else equal. Foreign aid officials describe both natural disasters and war reconstruction pulling marginal funds away from other projects. In this picture, the donor taps standing budgets for risk management, rather than emergency drought relief budgets, for the weather insurance premium; thus devoting additional resources to drought relief.

1.4.3 Transparency

The transparency of donors' decisions about emergency aid funding is a third set of explanations. Weather derivatives provide a concise description of donors' and international organizations' plans for managing some humanitarian emergencies. Weather derivatives replace discretion with conditions, which permit other stakeholders to forecast donor's behavior as seasonal emergencies develop.

Explicit conditions

Drought insurance alters the donors' funding decision by changing the timing and the nature of the expenditure. Rather than responding to an emergency appeal after the crisis has occurred, it permits states to commit to drought relief funding before food shocks occur, contingent on the occurrence of a class of events that cause food shocks. Early donor commitment to an ex ante financing mechanism surrenders discretion over the disbursement, at least in principle. This represents a material commitment on the part of the donor to aid on specific objective grounds, rather than opportunistic political strategy.

It also signals the donor's endorsement of the quality of an aid regime. Committing the proceeds of the weather insurance is a statement of confidence in the quality of the recipient bureaucracy. To see this more clearly, imagine the removal of the same signal. If the norm were for donors to pay annual insurance premiums on behalf of food insecure governments, refusal to pay subsequent premiums might be a statement of no confidence following a political crisis or a corruption scandal.

Ownership

Drought insurance might also improve the partner government's ownership of the aid program. Donor harmonization has been a priority in Ethiopia in recent years. PSNP has brought together the government of Ethiopia, the World Bank, and many NGOs to address

asset protection and livelihoods improvement for chronically food insecure individuals.⁴³ The objective of predictable social transfers to food insecure households is to prevent farmers from selling crucial assets when harvests fail.⁴⁴ This is subtly different from hypothesis 3 (a), in that it focuses on the partner government's investment of effort in the program, rather than the political transaction between the donor community and the partner government.

Overhead

There are a number of reasons that weather derivatives might streamline administrative processes for the host government. Under the WFP pilot, weather derivatives had little or no impact on GOE programs, except in so far as WFP required Ethiopia's assistance to identify and reach beneficiaries. Under PSNP, however, weather derivatives directly support the safety net program. The safety net program is one-stop shopping for MoARD. Since everything goes through the PSNP, there are none of the incremental administrative requirements, such as costly needs assessments, monitoring and evaluation, or accounting that separate emergency programs would require. The net effect of streamlining administrative processes is to save overhead for the MoARD.

Contingent contracting

WFP works closely with donors and partners on the ground in order to ensure end-to-end distribution of food aid. Whether cash donations are used to procure food aid supplies in the region where beneficiaries are located, or whether in-kind donations must be moved across oceans, WFP is responsible for coordinating the delivery of, and in many cases serving as its own freight carrier across the ocean.

⁴³World Bank. *Africa — productive safety net project (PSNP)*. Website. 2011. URL: <http://go.worldbank.org/E4PE1DEGS0>.

⁴⁴United States Agency for International Development. *U.S. International Food Assistance Report 2008*. 2008. URL: http://www.usaid.gov/our_work/humanitarian_assistance/ffp/fy08_usifar.pdf.

At the other end of the pipeline, WFP coordinates extensively with NGO partners to identify beneficiaries and target individuals, when and where appropriate. For the immediate needs assessment operations, cash is required to carry out needs assessment, meaning market surveys, public health data, and household surveys. If drought insurance improves the speed of funding, this should improve the speed of needs assessment and aid delivery with partners. It is not clear to what extent WFP collaborates with official government agencies in its distribution of emergency aid. These operations should be similar to operations with NGOs.

The cash flows provided by drought insurance are more flexible than potentially tied or earmarked funding in response to specific appeals. Inertia is a primary determinant of WFP spending at the village scale.⁴⁵ Initial emergency spending is highly discretionary by nature: WFP's expertise and experience determine in large part where and when to assess needs, how best to preposition supplies, and what methods should be used to analyze livelihoods. It would be difficult for a diverse group of donors to agree ahead of time under what conditions WFP should conduct emergency needs assessment, given the geographic breadth of WFP's responsibilities and the diversity of potential causes for beneficiaries' lack of access to food.

1.4.4 External Conditions

Market opportunity

A central benefit of hedging over traditional insurance strategies and yield insurance is low transaction costs. In order for weather risk to have low transaction costs, a number of conditions need to hold true. The design of the weather index itself needs to be well understood. Writing the first over-the-counter weather derivative contract involves substantially greater investment of actuarial and legal expertise than subsequent contracts. In the same way,

⁴⁵Thomas S. Jayne et al. "Targeting of food aid in rural Ethiopia: chronic need or inertia?" *Journal of Development Economics*. *Journal of Development Economics* 68.2 (2002), pp. 247–288. URL: <http://ideas.repec.org/a/eee/deveco/v68y2002i2p247-288.html>.

securitized weather derivatives require no incremental financial design or due diligence, which should reduce the transaction costs for all parties.

A second condition is that satellite weather observation must be cheap, timely, and reliable. All parties require access to the data that underlie the index. Advances in satellite weather observations, or alternatively, a fall in the price of satellite weather data, could cross a threshold that makes weather derivative contracts cost effective.

Finally, weather risk management requires an underwriter for the instrument. It may be that underwriters do not have the capability to write sufficiently large contracts for weather risk at scale; although the size of the WFP pilot project was only a notional \$7 million of coverage. Froot has suggested that supply constraints may contribute to American companies' low utilization of catastrophic risk instruments.⁴⁶ By their nature, catastrophic risk contracts involve high volatility in cash flows for the reinsurance company; so it may be difficult for the reinsurer to amass a portfolio of uncorrelated weather risks that permit effective risk pooling. It is possible that the supply of weather risk instruments globally crossed a threshold around the time of the WFP pilot project that increased the supply of instruments available.

One further possible source of greater access to world markets for weather risk is the lowering of barriers to investment in Ethiopia. Ethiopia may have local ownership requirements, investment taxes, and foreign exchange restrictions that limit local access to external financial markets. Financial market deregulation could have led to a new opportunity for international organizations operating inside of Ethiopia to access innovations that were widely available elsewhere.

Financial interests' pressures

Donor interest groups may play a strong role in determining the nature of international policy. These interest groups could affect foreign policy priorities in several ways. Dias-

⁴⁶Froot, "The market for catastrophe risk."

pora groups could affect the geographic composition of aid, although this would only affect the selection of weather risk management if certain countries were unusually susceptible to indexable risks.⁴⁷ Ruttan has suggested that America's reliance on commodities rather than cash is self-interested, driven by the relatively low opportunity cost of allocating grain surplus, rather than budget dollars, for international aid.⁴⁸ Interest groups could also create pressure on the government to favor various aid tying strategies, notably America's heavy reliance on in-kind rather than cash aid grants. American farm interests have thwarted efforts to use agricultural trade and aid policies as tools of diplomacy.⁴⁹ It is possible that public reliance on private capital markets for contingent access to emergency funds resulted from similar industry pressure on aid agencies.

Forecast quality

Rainfall is only one weather risk among many that affects WFP operations. Drought can create food shocks; but so can storms, floods, earthquakes, extreme temperatures, and tsunamis. Catastrophe risk markets can trade in all of these types of weather. WFP's operational risks are different from private sector risks, in that they are essentially unlimited and highly variable with respect to aggregate weather events. A private reinsurer has a relatively well defined pool of assets at risk from hurricanes in a given zip code. WFP cannot limit the number of people that become beneficiaries due to a crisis. Its liabilities per capita, however, are relatively well defined, since WFP's mandate is to prevent acute malnutrition and such other goals as are outlined in the country strategy. WFP has invested in the creation of an index relating woreda-level rainfall patterns to farmer livelihoods in Ethiopia.⁵⁰ The uncertainty of WFP's liabilities in times of drought is very likely lower

⁴⁷John J Mearsheimer and Stephen M Walt. *The Israel Lobby and U.S. Foreign Policy*. 1st ed. New York: Farrar, Straus and Giroux, 2007. ISBN: 9780374177720.

⁴⁸V. W. Ruttan. *United States Development Assistance Policy: The Domestic Politics of Foreign Economic Aid*. Johns Hopkins University Press Baltimore, 1996.

⁴⁹Robert L Paarlberg. *Food Trade and Foreign Policy: India, the Soviet Union, and the United States*. Ithaca: Cornell University Press, 1985. ISBN: 0801493455.

⁵⁰Peter Hoefsloot. "LEAP version 1.2 for Ethiopia User Manual." May 2008. URL: <http://www.hoefsloot.com/downloads/LEAP.pdf>.

than that of extreme weather events and earthquakes. Given the relatively precise observations of rainfall and the relatively predictable relationship between drought and livelihoods, drought insurance is a good candidate for WFP programs.

The impact of disasters on livelihoods is contextual.⁵¹ Households have complex responses to disasters that depend greatly on market conditions, farmers' crop baskets, labor markets, household assets, informal insurance, and health status. FEWSNET projects livelihood impacts on the basis of satellite weather observations, market data, and field interviews with affected populations.⁵² In principle drought insurance can be increased to reflect asset drawdown, health status, and market conditions. The implementation of drought insurance requires participation of staff with timely information about beneficiaries' livelihoods and health.

Financial reform per se

In Ethiopia, WFP's emergency drought relief plays the role of an insurer of last resort. WFP Ethiopia estimates that 8 million people chronically lack access to food, and a further 7 million are at risk of hunger in times of drought.⁵³ The link between poverty and rural financial markets has been the subject of an enormous amount of study.⁵⁴ Vulnerability to poverty may force rural households to choose risk-return tradeoffs that limit the risk of acute food insecurity, at the expense of expected future income.⁵⁵ Informal insurance is a poor structure for managing small pools of highly correlated risk, such as drought risk.⁵⁶

⁵¹Webb et al., "Measuring Household Food Insecurity."

⁵²Famine Early Warning Systems Network. *Livelihoods and FEWSNET*. Website. 2009. URL: <http://www.fews.net/ml/en/info/Pages/livefn.aspx?l=en>.

⁵³World Food Program. *Pilot Development Project—Ethiopia Drought Insurance 10486.0*. WFP/EB.2/2005/8-A, 2005.

⁵⁴C.R. Udry and J.H. Conning. "Rural financial markets in developing countries." *Handbook of Agricultural Economics*. Ed. by Robert Evenson and Prabhu Pingali. Vol. 3. Handbooks in Economics. Elsevier, 2007. URL: http://www.econ.yale.edu/~cru2/pdf/Rural_Finance.pdf; J. E. Stiglitz. "Incentives and risk sharing in sharecropping." *The Review of Economic Studies* (1974), pp. 219–255; S. Dercon. *Insurance Against Poverty*. Oxford; New York: Oxford University Press, 2005.

⁵⁵B. J. Barnett, C. B. Barrett, and J. R. Skees. "Poverty traps and index-based risk transfer products." *World Development* (2008).

⁵⁶Jerry Skees et al. *Can Financial Markets be Tapped to Help Poor People Cope with Weather Risks?* Tech. rep. Washington, DC: World Bank, 2005, pp. 1–32.

Highly correlated risks can strike all the members of an informal insurance network at the same time, and force the simultaneous sale of assets used for prudential savings—shrinking the value of the asset pool at precisely the time that it is needed.

Kaul and Le Goulven describe social safety nets as a type of public good, best provided by governments.⁵⁷ Where governments lack capacity to provide these goods, international institutions may create structures to provide them. Chronic emergencies in Ethiopia require frequent and large infusions of emergency aid. Some combination of local and international actors may have recognized the special role that safety nets play in rural financial markets, and attempted to bolster systemic stability by encouraging WFP to reinsure its risk in the private sector.

1.5 Summary of Hypotheses

1. Coordination problems. Weather risk management provides a framework for coordinating donors' decisions about aid.
 - (a) Free riding. Weather derivatives limit free riding behavior by fixing the budget for emergency interventions and permitting states to negotiate their shares of that burden.
 - (b) Diverse preferences. Weather derivatives structure donors' decisions about aid into a single, large decision about the mixture of aid programs, rather than permitting states to act on individual appeals from the World Food Programme and the Government of Ethiopia.
 - (c) Credibility. Weather derivatives increase the credibility of donors' stated intentions to mitigate droughts.
 - (d) Timing of negotiations. Weather derivatives permit more timely intervention in a crisis, by negotiating the funding burden in advance of the date of the crisis.
2. Funding windows and constraints. Weather derivatives can circumvent some legal and budgetary obstacles to participation in humanitarian programs in Ethiopia.
 - (a) Advance funding mechanisms. The constraints on WFP's advance funding mechanisms created a gap that drought insurance was designed to fill.

⁵⁷Inge Kaul and Katell Le Goulven. "Financing Global Public Goods: A New Frontier of Public Finance." *Providing Global Public Goods*. Ed. by Inge Kaul et al. New York: Oxford University Press, Inc., 2003, pp. 329–370.

- (b) Tying, earmarking, and food/cash ratios. Weather insurance circumvented restrictions on project funds by source, type of aid, and geographic location.
 - (c) Logistics. Weather derivatives may improve logistics through prepositioning, storage, and timely transportation.
 - (d) Annual v. ad hoc budgets. Weather derivatives make it possible to finance variable expenditures on emergency relief through a stable, annual budget item.
3. Transparency. Weather derivatives increase the transparency of humanitarian decision making. Transparency itself has a number of effects that might benefit stakeholders.
- (a) Objective commitment. Weather derivatives permit donors to cede discretion over future drought relief funding.
 - (b) Ownership. Weather derivatives improve the incentives for partner country officials and beneficiaries to achieve self-sufficiency.
 - (c) Overhead. Weather derivatives permit WFP and subsequently the Development Assistance Group to reduce administrative costs for the host government.
 - (d) Contingent contracting. Foresight over emergency operations permit contingent access to logistical services for field operations.
4. External conditions. WFP and PSNP adopted weather risk strategies in response to changing conditions that do not fit into the three categories above.
- (a) Market opportunity. Globally, financial innovation dropped the cost of WFP's pilot program to a point where it became cost competitive with other funding sources. Locally, deregulation of Ethiopian financial markets created new capacity to underwrite weather insurance.
 - (b) Interest groups. Financial interests in the donor countries pushed for restructuring of official assistance financing.
 - (c) Forecast quality. Recent advances in climate and livelihood forecasting crossed a threshold that made a derivative strategy feasible.
 - (d) Financial reform per se. Weather derivatives constitute an effort by donor governments to remedy financial market incompleteness in Ethiopia.

Chapter 2

Literature Review

2.1 Overview

Weather risk management in Ethiopia is an innovation because of its application to public sector risk. Most weather risk management instruments have been designed to protect firms with weather-related profits and losses, often in insurance, agriculture, energy, and construction. Microfinance institutions seized on weather-related instruments as a method of providing improved financial services to households and small firms with heavily weather-correlated incomes. Ordinarily when the public sector becomes involved in insurance markets, it is in the capacity of a regulator or an underwriter. This is a new case: when a public, international organization uses weather derivatives to hedge out its own operational risks. Governments have experimented with commodity hedges to offset export revenue risks, but WFP's pilot was the first case where a public organization hedged its own weather risk.

Most scholarship on weather insurance, weather indices, and crop insurance focuses either on optimal hedging for private firms or micro-scale product design. Governments could regulate derivative sales, specifying standards for contracts, capital adequacy, markets, and settlement mechanisms, notwithstanding America's political controversy over derivatives regulation. These regulations provide largely the same services as other finan-

cial market regulations: enforcing contracts and policing fraud, collusion, and anticompetitive practices. Governments may also mandate participation in insurance markets, such as American crop insurance.¹

Underwriting weather risk products for the private sector is the most common form of public involvement in weather risk products.² Various risk instruments incorporate a weather index into the structure somewhere: either as a cash payout to farmers, or as an adjustment to the coupon on farm credit, or as a reinsurance strategy to mutual insurance cooperatives. By underwriting these weather index products where the private sector does not offer services, the state is an insurer of last resort. (Treyner discusses insurers of last resort in reference to the Pension Benefit Guaranty Company, as do Jaffee and Russell on catastrophe risk.³) In one sense the state cannot escape this role, since disaster relief efforts fall to the government when droughts, floods, and other catastrophes ruin harvests.

This chapter frames the research question in the context of finance theory and humanitarian aid. It explains the basics of weather risk management instruments and markets, and evaluates the role that similar instruments play in public finance. It then provides a general background on coordination problems in game theory, a quick sketch of donor harmonization and some of the major theoretic problems in assessing and measuring food security.

2.2 Weather Risk Management

Weather risk management, as outlined in the introduction, encompasses a set of financial strategies designed to transfer weather-related risks outside of the firm. Risk transfer permits greater investment, by narrowing the range of outcomes that can lead to losses. Many financial structures are available to that end, including insurance, reinsurance, index-based

¹Glauber, "Crop Insurance Reconsidered."

²Hellmuth et al., "Index insurance and climate risk."

³Jack L. Treyner. "The Principles of Corporate Pension Finance." *The Journal of Finance* 32.2 (May 1977), pp. 627–638. ISSN: 00221082. URL: <http://www.jstor.org.ezproxy.library.tufts.edu/stable/2326796>.

insurance, weather-linked bonds, catastrophe bonds, and derivative contracts.⁴ Reinsurance is often written directly against the specific pools of insurance liabilities. Reinsurance limits the damage that the portfolio of policies can do to anyone firm. Catastrophe bonds provide greater amounts of capital at the right tail of the loss distribution, where frequency of loss is smallest and dollar value of loss is greatest.⁵ When hurricanes and earthquakes strike at sufficient frequency and severity to trigger the policy, bondholders lose the coupon on their investment and often the principal as well, which is transferred instead to the firm facing catastrophic liabilities.⁶

What these strategies have in common is an attempt to provide conditional payments to the firm, in case adverse weather affects the firm's profits. The choice of instrument is a strategic decision for the firm, with consequences for cost, regulatory compliance, tax treatment and associated risks.⁷ Firms may be unwilling to disclose that they hold large derivative portfolios, given the current stigma associated with derivatives. Insurance overseers may require special licensing for underwriters. Over-the-counter derivatives may raise more concerns about counterparty risk than exchange-traded derivatives. The section that follows here explains how weather risk management came to be seen as part of agricultural safety nets and food security policy.

Weather risk markets grew rapidly with financial innovation in the last twenty years.⁸ Crop insurance dates to 1917 in the United States; but index-based risk weather instruments were not developed until the 1980s.⁹ Historically, transaction costs and asymmetric information have prevented private provision of crop insurance in the United States. Insurance companies cannot easily assess the quality of farmers' land, microclimate, expertise,

⁴U. Hess et al. "Managing Agricultural Production Risk: Innovations in Developing Countries." *The World Bank, Agriculture and Rural Development Department, Report* (2005).

⁵U. Hess, W. Wiseman, and T. Robertson. "Ethiopia: integrated risk financing to protect livelihoods and foster development." *WFP Discussion Paper* (2006).

⁶Ozcan, "Market Convergence, Catastrophe Risk and Sovereign Borrowing."

⁷Andrea S. Kramer. "Critical Distinctions between Weather Derivatives and Insurance." *Structured Finance and Insurance: The ART of Managing Capital and Risk*. New Jersey: John Wiley & Sons, 2006.

⁸Joseph Glauber and Keith Collins. "Crop Insurance, Disaster Assistance, and the Role of the Federal Government in Providing Catastrophic Risk Protection." *Agricultural Finance Review* (2002), p. 81.

⁹Glauber, "Crop Insurance Reconsidered."

or annual effort. Since the 1980s the United States has mandated that farmers of four major crops carry insurance, which the United States then subsidizes.¹⁰ Critics of the US crop insurance scheme note that federal subsidies of domestic crop insurance programs created conditions where farmers and insurers both faced positive expected incomes for the purchase of the programs. The inference is that crop insurance is a disguised farm subsidy.

Jerry Skees began writing about the problems of moral hazard and asymmetric information in agricultural financial markets in the early 1990s. He was among the first to point out the potential of index-based risk transfer products, such as weather derivatives, as a viable alternative to yield-based insurance contracts. Together with Peter Hazell and Mario Miranda, Skees suggested that American crop insurance suffered fatally from asymmetric information; as it was essentially impossible to observe sufficient information about agricultural production at reasonable cost.¹¹ Furthermore, they argued that existing crop insurance programs failed to achieve sufficient diversification of risk in policy pools. Area-based index products would be cheaper for all concerned and improve the insurer's ability to identify and hedge out the risk of the portfolio.

Weather derivatives, both over the counter and exchange traded, improve the incentives facing the policy holder. Crop insurance, when yields are close to the threshold for a payout, weakens the farmer's incentive to maximize the harvest. It is trivial to show that the farmer's marginal return to investment is the same when uninsured or using a rainfall derivative, but lower under insurance. This is the same incentive facing a bad baseball team near the end of the season: the more remaining games they lose, the higher their pick in the following draft. Weather derivatives solve this problem by basing the payout on a weather index, such as rainfall, rather than the crop yield itself. The weather derivative pays out based on the rain, so there is no incentive for the farmer to reduce investment or effort.

Here are some extremely simple profit functions for a farm household, from which first-

¹⁰Glauber and Collins, "Crop Insurance, Disaster Assistance, and the Role of the Federal Government in Providing Catastrophic Risk Protection."

¹¹Jerry Skees, P. B. R. Hazell, and Mario Miranda. *New approaches to crop yield insurance in developing countries*. 1999. URL: <http://ideas.repec.org/p/fpr/eptddp/55.html>.

order conditions can be derived by inspection. Equation (2.1) shows the farmer's returns without insurance. The farmer's objective is to maximize profits over the expected value of rain. An alternative assumption is that the farmer minimizes the expected losses from agriculture.

$$\Pi = PQ - C \quad (2.1)$$

$$Q = f(w, C) \quad (2.2)$$

where

Pi: profit

P: price

C: cost

Q: yield

w: rainfall

f: yield function

Crop insurance dilutes the farmer's incentive to produce as much as possible, by compensating for losses below the reference point. Under the alternative assumption of loss-minimizing utility functions, the farmer may be willing risk a greater initial investment, C, due to the reduction in expected losses. Investment decisions on labor late in the season will still suffer from dilution.

$$\Pi = PQ - C + g(Q' - Q) \quad (2.3)$$

where

Q': reference yield

g: insurance algorithm

Equation (2.3) shows how insurance affects the farmer's profits, and Equation (2.4) shows how the rainfall index does. Index insurance does not affect the investment incentive, since there is no marginal compensation for reduced yield.

$$\Pi = PQ - C + h(w) \quad (2.4)$$

where

h: drought insurance algorithm

Weather derivatives, one example of an index-based contract, are useful when incentives are likely to be a problem, when information on the insured party's true risk (e.g., the farmer's yield, or WFP's need for emergency program funds) is costly to obtain. Weather derivatives trade basis risk for the incentive problems created by traditional insurance. Basis risk describes the difference between the risk facing the insured party and the weather index. A high degree of correlation results in low basis risk, and a low degree of correlation results in high basis risk. Both traditional insurance and hedging strategies carry counterparty risk, which is the risk that the insurance firm will default on its obligation when the policy triggers.

Doherty and Richter cover the tradeoffs between moral hazard and basis risk extensively. Their paper solves the expected wealth and variance for the insured party under a variety of reinsurance contracts, beginning with indemnity contracts.¹² Indemnity contracts are a reinsurance instrument based exactly on the insurer's liabilities, which are passed on directly to the reinsurer. This indemnification introduces moral hazard into the insurer's business: since the firm is indemnified against losses, it has less incentive to screen out risky clients, or to audit clients for compliance with the terms of the insurance policy. Indemnity contracts have higher moral hazard and lower basis risk than index-based contracts, which scale the payout to an index over which the insurer does not have control. The index contract leaves the insurer with the same marginal exposure to each client, but it alleviates the risk of exhausting the insurer's capital to cover losses. Since the index has an imperfect correlation with the insurer's liabilities, there will often be a gap between the optimal coverage and what the index provides. Doherty and Richter show that if the index contract is truly costless, then insurers can do better by purchasing an index contract with a traditional reinsurance policy to cover the gap introduced by basis risk, as opposed to either a pure insurance strategy or a pure index-based strategy.

¹²Neil A. Doherty and Andreas Richter. "Moral Hazard, Basis Risk, and Gap Insurance." *The Journal of Risk and Insurance* 69.1 (Mar. 2002), pp. 9–24. ISSN: 00224367. URL: <http://www.jstor.org/stable/1558637>.

Formal trading in weather risk, according to the Weather Risk Management Association, began in 1997, and weather securities began trading on the Chicago Mercantile Exchange in 2001.¹³ These contracts are derivatives where the strike is based on an index, such as temperature or precipitation in a major city, on the day of maturity, rather than the price of a stock or a commodity. Examples include heating degree days (HDD), whose strikes are expressed as a reference temperature on a winter day, and cooling degree days (CDD), whose strikes are expressed as a reference temperature in summer. Colder than expected weather in winter drives up demand for oil, resulting in potentially costly purchase for energy companies and consumers. Hotter than expected weather in summer drives up the spot price of electricity and the marginal cost of electricity generation. The growth of synthetic securities such as this is limited mainly by financial creativity, market thickness, and counterparty risk.

Weather derivatives, like all derivatives, can be used either to hedge risks or to speculate. Hedging risks involves de-levering operating risks, by eliminating asset and liability mismatches. Speculation involves increasing exposure to operating risks, seeking to profit from the divergence in asset and liability prices.

Weather risk markets tipped from OTC contracts with large reinsurance firms to exchange-traded products in 2004. Between 2004 and 2006, the notional value of contracts traded on the CME increased seventeen-fold.¹⁴ This trend has been borne out in the major financial centers of the world. Where capital markets are thick, exchange-traded derivative securities provide customization and price competitiveness, while lowering transaction costs. Where markets are thin, weather derivative securities may suffer market failures or simply not exist.

¹³Weather Risk Management Association. *History of the Weather Market*. Website. 2007. URL: http://www.wrma.org/risk_history.html.

¹⁴Ron Panko. "Doing Something About the Weather." *Best's Review* (Apr. 2006).

2.2.1 Catastrophe Risk Markets

Hess and Syroka show how catastrophic risks turn to securitization when the size of low-frequency events exhausts the capital adequacy of traditional reinsurance.¹⁵ They show a frequency distribution of losses. Above some market-determined cutoff, weather securities enable reinsurance companies to distribute manageable tranches of risk. Catastrophic risk products thereby expand the market's ability to distribute outside risks; and weather indices are one of a set of structures for catastrophic risk instruments.

A simple model of demand for catastrophe coverage is presented in Froot (2001), following Arrow 1965.¹⁶ The model assumes that reinsurance contracts have the following four parameters: r for the retention or deductible, l for the limit or cap on payouts, the exceedance (probability of a shock greater than r), and exhaustion (probability of a shock greater than l). The firm's wealth, P , depends on initial wealth, ω , as governed by Equation (2.5) in the presence of a shock, ε .

$$\omega(\varepsilon) = \varepsilon \int_{r-l}^r (r - \varepsilon) dF(\varepsilon) + \int_{-\infty}^{r-l} l dF(\varepsilon) + |(r - \varepsilon)(r - l < \varepsilon < r) + l(\varepsilon < r - l)| \quad (2.5)$$

where

r : retention

l : limit

ω : wealth

ε : shock

The firm maximizes the wealth equation subject to a budget constraint (2.6), which, when differentiated and solved, yields the proposition (2.7) that firms have the greatest incentive to hedge the lowest-probability, highest-loss events.

$$\int_{r-l}^r r - \varepsilon dF(\varepsilon) + \int_{-\infty}^{r-l} l dF(\varepsilon) \leq B \quad (2.6)$$

¹⁵U. Hess and J. Syroka. "Weather-Based Insurance in Southern Africa: The Case of Malawi." *Agriculture and Rural Development (ARD) Discussion Paper 13* (2005).

¹⁶Froot, "The market for catastrophe risk"; Kenneth Joseph Arrow. *Aspects of the Theory of Risk-Bearing*. Helsinki: Unknown, 1965.

where

B: budget

$$\int_{-\infty}^{r-l} P_{\omega}(\omega(r-l)) dF(\varepsilon) = \int_{-\infty}^{r-l} P_{\omega}(\omega(\varepsilon)) dF(\varepsilon) \quad (2.7)$$

where

r: retention

l: limit

ω : wealth

ε : shock

In reality, firms' behavior substantially deviates from this model, in that firms do not seek coverage for the highest possible tranches of risk. Rather, they seek coverage against losses for which there is some observed history of loss. Froot presents eight hypotheses that could explain the deviation from theory: insufficient capital, oligopoly, corporate form of reinsurance underwriters, high frictions, moral hazard and adverse selection, implicit government guarantees, managers' incentives, and behavioral incentives.

Three of Froot's factors seem likely to matter to WFP: high frictions, incentives, and behavioral incentives. Several features of WFP could lead to higher costs for the insurance company: a lack of comparable clients in the past, the jurisdiction of transactions with a multilateral, and the exotic location of the precipitation. Managers' incentives might portray the funding situation as fundamentally outside of managers' control, and therefore not reward them for securing contingent funding. Behavioral incentives might lead WFP executives to focus on what has been most successful in the past, i.e., securing rapid access to appeals and ignoring ex ante funding strategies. In addition, the novelty of formal risk management in humanitarian affairs may require humanitarian organizations to assess whether their mandates permit them to purchase financial services, and in which office that authority should reside. A case could also be made for implicit donor guarantees: when WFP's funding runs out and risk to beneficiaries is sufficiently high, WFP can be fairly sure that donors will step into the breach. The other conditions seem unlikely to obtain: thin capacity, moral hazard, adverse selection, market power of insurers, and the corporate

form of underwriters.

2.2.2 Weather Risk in Emerging Markets

Hess, Skees, Stoppa, Barnett, and Nash give a thorough review of theory and policy for rural financial markets in developing countries.¹⁷ They compare weather risk to price risk and other risks facing rural households. They survey both public and private instruments, including explicit weather derivative contracts and other types of loans, reinsurance and social safety nets that combine a simple weather derivative with other assets and government programs. Hess, Bryla and Nash (2005) discuss a number of recent for-profit and non-profit experiences with agricultural production risk management.¹⁸ The strategies in their work include commodity price risk management, crop yield insurance, and weather risk management instruments. The cases detailed there include DrumNet (Kenya), Clark Cotton (Zambia), BASIX (India), SudAgroServ (Tajikistan), Indian Tobacco Company (India), Fondos (Mexico), CDRB Ltd (Tanzania), Cedula de Produto Rural (Brazil), and Nacional Financiera, SNC (Mexico). Hess and Syroka give an extensive explanation of a proposed weather-linked household-scale farm loan in Malawi.¹⁹ Hess (2003) explains how to structure a micro-level insurance program in India could overcome marketing barriers, notably the communication of index-based risk instruments to innumerate farmers.²⁰

The same volume covers disaster risk instruments in Mexico, Vietnam and the Caribbean, where storms and floods threaten both agricultural production and household assets. The Mexican model provides public, index-based insurance to state governments for agricultural relief. Mexican state and federal governments jointly purchase index-based insurance from private reinsurers in exchange for agricultural relief due to drought or flood in Mex-

¹⁷Hess et al., "Managing Agricultural Production Risk"

¹⁸Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

¹⁹Hess and Syroka, "Weather-Based Insurance in Southern Africa."

²⁰Ulrich Hess, *Innovative Financial Services for Rural India: Monsoon-Indexed Lending and Insurance for Smallholders*. 2003. URL: <http://www.itf-commodityrisk.org/documents/indiafinsvc.pdf>.

ico.²¹ The Vietnam Bank of Agriculture and Rural Development insures losses on an agricultural loan portfolio using private, weather-indexed insurance.²² This is the closest case to Ethiopia's contingent financing for PSNP, except that VBARD is a national organization, and its assets are not a pool of door funds.

Malawi's national weather insurance instrument is the closest to WFP drought insurance. Various sources have described the structure of the instrument.²³ According to Bryla and Syroka, Malawi has bought a seasonal rainfall put on the private market.²⁴ The proceeds from this put, should it pay out, will be used to stabilize grain prices. The advantage of this strategy, say Bryla and Syroka, is two months' advance access to funds. The drought index settles in April, and harvest assessments are not completed until June.

Hazell, Anderson, Balzer, Clemmenson, Hess, and Rispoli completed a review of index-based insurance projects for IFAD and WFP in 2010.²⁵ They outlined eight principles for success gleaned from existing IBRTPs: integration into a package of financial services; education for stakeholders; client awareness; integration with existing delivery channels; access to international risk markets; quality of weather data; quality of legal and regulatory frameworks; and monitoring and evaluation. Some of these items amount to good management: capacity building, product design, marketing, monitoring and evaluation. Good legal and regulatory frameworks are near-universal requirements for financial products. Two of them are particularly insightful: access to international reinsurance, and integration with existing delivery channels.

²¹Jesus Scamilla et al. "Disaster Relief in Mexico." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.

²²Jason Hartell and Jerry Skees. "Vietnam: Flood Insurance in the Mekong Delta." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.

²³Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

²⁴Erin Bryla and Joanna Syroka. "Unlocking Development Potential in Malawi." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.

²⁵Peter Hazell et al. *The Potential for Scale and Sustainability in Weather Index Insurance for Agriculture and Rural Livelihoods*. International Fund for Agricultural Development and World Food Program, Mar. 2010. URL: <http://www.ifad.org/ruralfinance/pub/weather.pdf>.

2.2.3 Risk Management in the Public Sector

Several sources recognize the growing prevalence of weather insurance in agricultural risk management programs, but relate somewhat scarcer data on the use of weather risk management for humanitarian aid and official disaster relief efforts.²⁶ Both private micro-finance and state-owned agricultural businesses have implemented index-based products with households, but rarely have states and intergovernmental agencies themselves purchased, rather than writing, the index-based weather risk instruments.

Disaster relief is most often the province of national governments. Kunreuther and Linnerooth-Bayer approach the problem of disaster relief through the lens of insurance.²⁷ They estimate the costs of different financing instruments for disaster relief, using the example of a Polish flood in 1997. Estimated costs include both private property losses and rebuilding of infrastructure, and figure the benefits of private insurance against these losses and expenses. They examine the incentives for proactive risk mitigation under a variety of financial structures, including prudential savings, ex post bond issues, insurance policies, and ex ante CAT bonds. They find that ex ante risk management strategies contain price signals which can encourage governments to prepare for the most likely disaster scenarios, and to mitigate the risk of physical damage to valuable infrastructure. This finding substantiates the link between financial and operational strategies: meaning that well designed, transparent financial mechanisms can improve the performance of risk-bearing public entities.

Banu Ozcan's 2005 dissertation at the Fletcher School examines markets for sovereign borrowing.²⁸ Specifically, she asks whether and how sovereign spreads rise in response to natural disasters. Her dataset looks at floods, landslides, earthquakes, extreme temper-

²⁶Hess et al., "Managing Agricultural Production Risk"; Barnett, Barrett, and Skees, "Poverty traps and index-based risk transfer products."

²⁷Howard C. Kunreuther and Joanne Linnerooth-Bayer. "The Financial Management of Catastrophic Flood Risks in Emerging-Economy Countries." *Risk Analysis* 23.3 (2003), pp. 627–639. DOI: 10.1111/1539-6924.00342. URL: <http://dx.doi.org/10.1111/1539-6924.00342>.

²⁸Ozcan, "Market Convergence, Catastrophe Risk and Sovereign Borrowing."

atures, volcanic eruptions, and one tidal wave. The countries in the sample are largely middle income countries: Algeria, Argentina, Brazil, Bulgaria, Chile, Colombia, Croatia, Ecuador, Egypt, Guatemala, Indonesia, Jordan, Mexico, Morocco, Nigeria, Peru, Philippines, Poland, Russia, South Africa, South Korea, Thailand, Turkey, Venezuela, and Viet Nam. Her findings demonstrate a close relationship between sovereign debt spreads and disaster occurrence, within a range of approximately two weeks. The effect is stronger for lower-income countries, suggesting that the perceived risk of default rises more for these countries following disasters. Rather than indicating the quality of humanitarian assistance provided, the risk of sovereign default reflects the general state of sovereign finances and the political will to adhere to debt repayment schedules. Disasters could cause the national fiscal position deteriorate either through lost revenue or greater expenditures; and it could shift fiscal priorities away from budget balance and debt service toward other more pressing matters. Neither the prevalence of insurance within the country nor the pre-crisis rating of the bond affected the size of market response to the disasters. Countries with higher GDP per capita and higher frequencies of natural disasters suffered less volatility in sovereign spreads immediately following crises.

Ethiopia differs from the countries in the Ozcan dataset in two important ways. First, Ethiopia essentially does not have the capacity to issue sovereign debt (in its own currency on private markets). Rather, the vast majority of Ethiopian external financing is provided through multilateral institutions and at concessional rates. Ethiopia completed the Highly Indebted Poor Country (HIPC) initiative in 2004 and has participated in the Multilateral Debt Reduction Initiative (MDRI) ever since. Under these programs, Ethiopia has dramatically reduced its debt service payments. The purpose of writing down Ethiopia's debt under the HIPC and MDRI initiatives is to substitute social spending for debt service in the national budget. Ethiopia's debt relief has largely accomplished that goal. Debt service payments shrank from 20% of exports prior to joining HIPC to between 1% and 3% since

completing the HIPC program.²⁹ Poverty-reducing expenditures meanwhile, have climbed from 9% of GDP to nearly 12% of GDP (slightly over 100% of government revenues) during the same period.³⁰

The second major difference is that the international community takes extraordinary responsibility for humanitarian assistance in Ethiopia. Middle- and upper-income countries would be loathe to accept such public assistance except in the most extreme circumstances. Chronic food insecurity and international assistance is the norm, rather than a temporary symptom of an acute crisis. Strategic planning, needs assessment, and implementation are shared responsibilities across a slew of international donors, specialized international organizations, Ethiopian government and civil society.

WFP functions as an insurer of last resort against disasters. There is an extensive private sector literature on catastrophe risk financing (notably Froot and coauthors).³¹ Catastrophe risk refers to outlier events in private insurance markets, i.e., catastrophic losses reported on a pool of insured assets. Catastrophe risk and super-cat risk are efforts by reinsurance companies to provide tranches of coverage or parametric coverage to insurers that could be wiped by catastrophic events if uninsured. Where market constraints prevent reinsurers from amassing sufficient capital to provide catastrophic coverage, derivative securities such as catastrophe bonds may provide a solution to private catastrophe risk problems.

Limits on private firms ability to provide catastrophic risk coverage, in this literature, stem from the threat of takeovers of firms hoarding cash for potential catastrophic payouts. The threat of corporate takeover is a very poor model of the constraints facing WFPs use of emergency financing instruments, detailed below. Note that this table of costs and benefits is different from the list presented in Rural Finance Innovations, which focuses

²⁹International Development Association and International Monetary Fund. *Highly Indebted Poor Country (HIPC) Initiative and Multilateral Debt Relief Initiative (MDRI) Status of Implementation*. World Bank, Sept. 2009. URL: <http://go.worldbank.org/85B908KVE0>.

³⁰Ibid.

³¹K. Froot. *The Financing of Catastrophe Risk*. University Of Chicago Press, 1999; Froot, "The market for catastrophe risk"; Froot and O'Connell, "On the pricing of intermediated risks."

predominantly on the efficiency and scalability of the WRM instruments.³²

2.2.4 Poverty Traps

Stephen Dercon traces a long literature explaining the links between credit market imperfections and rural poverty.³³ Specifically, the inability to insure against losses forces families at risk of poverty to choose low-risk strategies over high-yield strategies. Whereas a farmer with access to savings and insurance can reap a higher expected yield over a period of years by planting high-yield crop varieties, farmers at risk of poverty must protect against losses much more aggressively. Drought resistant varieties, farming without fertilizer and irrigation, and other choices can reduce downside risks, but often at the expense of expected yield.

Barnett, Barrett and Skees recently reviewed the literature on weather risk management.³⁴ They document how rural financial market failures create poverty traps, particularly through the channel of asset destruction when income falls below some poverty threshold. The causes of insurance market failure include covariate risks, asymmetric information and high transaction costs. The available strategies for households with only access to traditional financial markets are prudential savings, mutual insurance, and asset smoothing. Saving may be substantially more uncertain and costly in the absence of functioning financial institutions. Mutual insurance is even less robust to locally covariate risks, such as drought, than is formal insurance. Livestock are a preferred asset for saving in Ethiopia, but they are vulnerable to drought. Livestock require access to food and water in times of food insecurity; and livestock prices suffer from procyclic panics. Index-based risk transfer products can resolve a number of these problems, depending on the institutional form that the risk-transfer products take, at the expense of introducing basis risk, i.e., the occurrence of uninsured shocks to income. Udry and Conning summarize salient characteristics of

³²Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

³³Dercon, *Insurance Against Poverty*.

³⁴Barnett, Barrett, and Skees, "Poverty traps and index-based risk transfer products."

rural financial markets, empirical strategies to test market completeness, the efficiency of risk sharing, and the role of rural financial intermediaries.³⁵

WFP considers the impact of its livelihood programs to be of fundamental importance to a true cost-benefit analysis of the weather insurance program. WFP emergency programs are designed to protect the livelihoods of rural households during times of acute stress. Hess explicitly states that he hopes to prevent households from falling into poverty as a result of the expanded emergency livelihoods assistance.³⁶

A substantial literature assesses completeness of credit markets. The existence, nature, and completeness of rural credit markets are of particular concern to financial theorists. Conning, Kevane and Dercon note the dearth of financial institutions both historically and presently in rural Africa.³⁷ They cite social conventions for mutual insurance across household as the basis for a theoretic barrier to market entry. Side contracts among households can, depending on the information sets available to rural households and to the firm, either cause houses to crowd into formal insurance markets, or to crowd firms out.

2.2.5 Global Public Goods

Two strands of literature address the problem of how the international community can provide insurance against acute food insecurity in cases of extreme drought. Hawkins, Lake, Nielson and Tierney explain the decision to delegate authority to an international organization as a function of the degree of cooperation among the states neighbors, with specific benefits and costs following on delegation.³⁸ International institutions provide specialization, credibility, policy lock-in, collective decision making and dispute resolution, at the expense of the states control over the nuances of policy and the certainty of the states back-

³⁵Udry and Conning, "Rural financial markets in developing countries."

³⁶Hess et al., "Managing Agricultural Production Risk."

³⁷Jonathan Conning, Michael Kevane, and Stefan Dercon. "Why Is There Not More Financial Intermediation in Developing Countries?" *Insurance Against Poverty*. Oxford: Oxford University Press, 2005, pp. 330–357.

³⁸Hawkins et al., "Delegation under anarchy."

ing of that policy.

Kaul and Le Goulven describe a broad typology of institutional forms for providing global public goods.³⁹ They advocate for institutions that are results oriented, responsive to feedback from technical personnel, and also closely coordinated with national legislative and policy making organizations. They see three categories of international organizations: those that create norms and standards (e.g., WHO, FAO), those that provide aid (e.g., WFP, UNICEF, IFAD), and global service providers (e.g., IMF, WIPO).

2.3 Index-Based Risk Transfer Products

2.3.1 Plain Vanilla Weather Derivatives

A weather derivative takes its name from financial derivative securities. The simplest financial derivatives are often called plain vanilla derivatives: futures, swaps, calls, and puts. Futures contracts are standardized, exchange-traded contracts that commit the buyer to a future purchase by pre-agreed date, quantity and price. Futures can be written against nearly any type of security: commodities, foreign exchange, stocks, bonds, and other financial assets. Swaps are closely related to futures, except that a second asset is promised as payment for the first, instead of cash. If the quantities are correct, two parties can enter into a swap without any money changing hands today. The contract is settled by arranging for the payment of an invoice equivalent to the difference between the financial returns on the two promised assets. Call options are the right but not the obligation to buy at a pre-specified price called a strike price. If the spot market price at maturity is below the strike, the call option becomes worthless; otherwise its value is equal to the difference. Put options are the option to sell at a given strike; meaning that they are worthless if the spot price rises above the strike at maturity. The underlying asset's price determines the value of the derivative, e.g., the price of a stock, the euro-dollar exchange rate, the price of an ounce of gold, or the

³⁹Kaul and Goulven, "Financing Global Public Goods: A New Frontier of Public Finance."

LIBOR interest rate. Weather derivatives are similar to plain vanilla options, except that they replace the underlying asset price with a weather-related index.⁴⁰

Weather derivative securities were first created in the Cayman Islands in 1999, and subsequently replicated across the OECD.⁴¹ Typically the securities are created through a special purpose vehicle that issues weather-linked debt securities. Investors' capital is repaid at a premium interest rate if the index does not trigger. The SPV then also writes weather derivative securities that can be purchased at issue or on the run, which provide cash flows to the bearer contingent on the performance of the weather index. Structures may also involve credit enhancement and insurance of the SPV's obligations, and swaps against various interest and currency exchange rates. Typical underlying weather indices are the frequency of storms, seasonal precipitation, and seasonal heat (or cold) in excess of (or below) a reference temperature. Exchange-traded derivatives are available for standardized indices and periods of time, theoretically promising more efficient pricing than for a comparable over-the-counter derivative contract.

Weather derivatives are ideal for companies exposed to spot market conditions that are tightly correlated with daily weather indices. For example, spot prices for electricity vary closely with temperature. High summer temperatures give rise to the name of the CME's temperature instrument, the cooling degree day (CDD). Each degree above the reference temperature predicts demand for cooling services in the summer, which translate instantaneously into demand for electricity on the spot market. Similar pressures on energy prices in the winter occur due to the tight daily correlation between temperature and energy demand. The name for the winter energy derivative is a heating degree day.

Seasonal weather derivatives are harder to write for agriculture than for power and energy traders, due to the complex relationship of precipitation to yield. All rain days are not equal in the life of the crop. Substantially more complex formulas are required to capture

⁴⁰See Appendix A for simple examples.

⁴¹Jan Job de Vries Robbé and Paul A. U. Ali. *Securitisation of derivatives and alternative asset classes: yearbook 2005*. Kluwer Law International, June 2005. ISBN: 9789041123756.

these conditional statements about patterns of rainfall, such as “sufficient rainfall, without flooding, and without any stretch of dry days lasting longer than two weeks.” Appendix C explains the basics of the FAO model that predicts crop yields from rainfall patterns. Appendix D shows how WFP and its partners forecast beneficiary counts from the FAO yield model.

2.3.2 Trade Financing

Trade financing provides loans for operating expenses collateralized by future sales or accounts receivable. Sellers borrow money from a bank for expenses, e.g., seeds and fertilizer during the planting season. Collateralizing loans against future receipts is one strategy for lowering the cost of the loans. Where forward contracts can be written with a specific buyer, the bank can take ownership of the forward contract from the seller as collateral for a loan. When the buyer pays for the product, the cash goes to the bank, who then credits it as a repayment of the loan from the seller. The balance on the account at this point may be positive or negative, depending on the creditworthiness of the seller.

A weather indexed strategy for trade financing would link the interest rate paid on trade financing to a weather index. In years with bad rainfall, the loan would be cheaper than in years with good rainfall. Weather indexed trade financing ordinarily does not affect the principal of the loan, meaning that in bad years the farmer takes a loss on capital invested. Where insurance or weather derivatives exist, the bank can partially or fully offset its liabilities on a weather-linked pools of debt.

2.3.3 Microinsurance

Insuring farmers’ livelihoods directly has been a much more common strategy than scaling social safety nets to livelihood shocks. Two approaches to household insurance are most common: yield insurance and index-based insurance. With yield-based insurance, the insurance company offers to compensate farmers facing low yields, which creates two

problems. First, the firm has to assess the farmer's claim, which can be costly (or invite abuse). Second, the farmer has reduced incentive to invest capital and effort into the field if his losses are partially covered by insurance.

Index-based insurance does not suffer from moral hazard, provided farmers cannot change the index's weather observations. The return to the farmer's effort is the same in marginal terms regardless of the size of the payment. (One could imagine a payment large enough to dilute the farmer's incentive to continue working in the fields, but none of the policies that have been tried so far can make the farmers rich enough for that.) If anything, the index payment should reassure the farmer that it is safe to take risks in search of high returns. For example, when a farmer faces a tradeoff between high-yield and drought-resistant varieties, drought insurance should tilt the farmer's incentives slightly toward the high-yield variety.

Index-based insurance exists in the private sector, in state-owned enterprises, and as a specific project of international organizations. Private enterprises operate with different levels of direct subsidy, technical assistance. At one end of the spectrum is BASIX India, which sells index-based insurance without public subsidy.⁴² BASIX provides integrated financial services to farm households, including savings, lending, and insurance. One of the instruments they provides is a weather-indexed insurance policy, and another combines that insurance with agricultural credit. This loan-with-insurance scheme is a common format for targeting farmers that already use financial services in their business. Such farmers are more likely to see the benefits of offsetting precipitation risk, and more likely to have confidence in contracts signed with a bank as a counterparty. Combining products was a response to low demand for a standalone weather insurance product.

Index-based insurance schemes at microscale are often packaged with other products to improve uptake. Smallholder agriculture worldwide is slow to adopt innovations, until they have a track record of local success. Weather index policies are abstract, and al-

⁴²Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

though pricing may be transparent, it may be difficult for farmers to evaluate whether a policy is both cost effective and utility improving because they have no reference points for competing products. One innovative solution in Kenya through Syngenta Foundation has been to package microinsurance policies with bags of fertilizer.⁴³ Combining the insurance purchase with farm inputs has several advantages. Targeting the fertilizer market selects farmers who already invest in their fields. Combining the purchase with a physical good frames the insurance decision as an added service to complement farm inputs. Small increments of insurance, scaled to inputs, help farmers choose an appropriate amount of insurance for their operations, whether they are testing the waters or choosing to insure an entire farm. The insurance cards issued to farmers integrate with mobile phones, a familiar platform for small financial transactions in Kenya.

Crop insurance in Mexico achieves a structure much closer to what WFP, PSNP, and catastrophe insurance providers use. Fondos are agricultural insurance cooperatives, which can obtain weather-indexed reinsurance from FONDEN, the national government's disaster risk management agency.⁴⁴ Risk pooling provides protection against idiosyncratic losses. Weather indexes provide efficient reinsurance, at price that the government can choose whether it operates at a subsidy or a loss.

Weather indices introduce significant basis risk for individual farmers, due to the covariance of microclimate, i.e., rainfall on the farmer's plot, and the climate, i.e., rainfall at the regional scale. Any plan to introduce weather index products at microscale should include a basis risk insurance policy to protect the household from basis risk. If the farmer suffers a yield shock and the policy fails to pay out, the farmer is the worse off for having purchased the index-based microinsurance product. A basis risk insurance policy could provide reimbursement (or better, a bit of yield insurance) for farmers who fall into that category. This combination of an index-based hedge and an insurance policy on the basis

⁴³Syngenta Foundation. *Fact Sheet: Kilimo Salama*. URL: http://www.syngentafoundation.org/__temp/Kilimo_Salama_Fact_sheet_FINAL.pdf.

⁴⁴Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

risk is exactly comparable to what Lu and Neftci recommend in their article on innovative sovereign hedging strategies for commodity risk.⁴⁵ Hybrid policies, which use insurance to mitigate the basis risk from index insurance, often refer to the insurance portion as “gap insurance.”

2.3.4 Price Hedges

Price hedging instruments take a global approach to price risk rather than adjusting payments to yields. The simplest price risk instrument would be a forward contract, struck at a fixed price at the start of the growing season between the farmer and the counterparty. This is the canonical example of how derivative contracts can benefit both the farmer and the baker, without introducing speculation or leverage into the financial system. Both the farmer and the baker, in theory, are happier with a guaranteed small profit, rather than a small chance for a larger profit and a small chance to realize a loss. Provided there is some overlap in the prices at which each can expect to turn a profit at the time the contract is struck, they can agree ahead of time a quantity of the farmer’s grain which the baker will offtake at a certain price.

Price hedge instruments rely on the enforceability of contracts. No matter which direction the price moves from the strike price, one of the parties will have an incentive to default on the contract. If the price is high, the farmer has an incentive to sell on the spot market, rather than deliver on the strike price. Likewise, if the baker can obtain cheaper grain on the spot market, he may not arrive to claim his grain at the strike price. Early payment for the future contract provides insulation only on one side of the contract, i.e., it prevents the baker from defaulting but not the farmer. The value of the forward contract relies on some countervailing incentives for contract enforcement, which in the formal sector could be a threat of litigation or reporting to a credit agency; and in the informal sector might include

⁴⁵S. N. Neftci and Y. Lu. “Financial Instruments to Hedge Commodity Price Risk for Developing Countries.” *IMF Working Papers* 8006.200 (2008), pp. 1–20.

reputation costs, damaged relationships, and the shadow of the future.

Alternatives to the forward contract are futures. If for whatever reason it is difficult or costly to find a counterparty to the forward contract, the farmer can instead sell future contracts of standardized value for the date at which he expects to harvest. The clearinghouse for the futures market finds a suitable set of counterparties willing to take delivery at the strike price in the future. Entry into the futures market requires a margin payment, and is thought to reduce counterparty risk.

A pure financial strategy would be to sell the farmer a payment equivalent to holding the futures contract, called a synthetic future. Suppose the strike price of the synthetic future is \$10 reflecting market expectations about what the price of grain will be. Due to some unforeseen circumstances, the spot price at maturity rises \$12. The return to the synthetic future is \$−2, wiping out the farmer's windfall profit. If instead the price dips at maturity to \$8, the synthetic future instead pays \$2, protecting the farmer from \$2 worth of loss. The synthetic future requires no physical exchange of commodities, providing contingent payments of equivalent value. This strategy can be more efficient where financial transaction costs are lower than the cost of taking delivery of commodities.

Brazil's Cedula de Produto Rural (CPR) used a future contract as one of a menu of options. The forward contract paid farmers in exchange for bonded offtake of the farmer's output. The total value of contracts over 10 years to 2005 was \$2.5 billion, for 130,000 contracts, giving a mean contract size of nearly \$20,000. Synthetic futures were also available and increased uptake of the instruments.⁴⁶ Tanzania's national agriculture board, CRDB, uses financial hedges on export commodities to protect itself against unwelcome price volatility in American and European markets.⁴⁷

⁴⁶Hess, Bryla, and Nash, *Rural Finance Innovations: Topics and Case Studies*.

⁴⁷Ibid.

2.3.5 Commodity Price Risk and Public Finance

Weather risk contracts are often referred to as quantity risk, rather than price risk instruments. In energy, agriculture, and other industries where their use is common, the quantity of goods and services demanded at any given prices shifts dramatically with the weather. Commodity prices provide another set of indices on which hedging strategies can be based; and in some ways the options are more intuitive. The food price crisis of 2008 generated substantial interest in governments' exposure to commodity prices. High food prices generated pressure on public food subsidies and created turmoil even for seasoned humanitarian organizations. Given the steady rise of food prices, beneficiaries that had traditionally preferred cash to commodity transfers changed their tune and clamored for physical supplies of food. The World Bank created a separate financing facility in response to the food price crisis.⁴⁸

Commodity price derivatives and foreign exchange derivatives have also been proposed for hedging government risks. Lu and Neftci of the IMF outlined a novel bond structure for developing countries in the same year, 2008. They discuss a hybrid instrument to smooth borrowing costs, composed of an external bond, a commodity derivative, and a credit default swap.⁴⁹ The bond is denominated in foreign currency, which leads to greater default risk. Since fiscal and monetary pressures will increase on the developing country if its export commodity prices suffer, the developing country holds a put option on commodity prices. The cost of the put option is decreased through a special feature called a knock-in, meaning that only particularly severe price drops will trigger the option.⁵⁰ Instead of a cash payment, the sovereign takes a credit default swap as payment, which is held on its behalf by an issuing bank, and written by a third party insurer. If the commodity price takes a

⁴⁸World Bank. *News & broadcast—World Bank launches \$1.2 billion fast-track facility for food crisis*. Web page. URL: <http://go.worldbank.org/2VMOHRKEY0>.

⁴⁹Neftci and Lu, "Financial Instruments to Hedge Commodity Price Risk for Developing Countries."

⁵⁰Tecnically, the knock-in feature is a trigger. On a knock-in put, the knock-in price is below the strike price of the put option. If the price at any time dips below the knock-in level, then the option has the same value as a European put with identical maturity and strike. If the price at no time dips below the knock-in, the option expires worthless.

steep dive, the bondholders receive a guarantee on the bonds from an insurance company.

On the other hand, inept public sector purchases of derivative securities can result in serious financial costs (an illustrative list from the mid-1990s in Becker and Yoon includes many municipalities and pension funds).⁵¹ The largest public sector derivative losses in the United States have run from tens of millions to over a billion dollars, resulting in significant political turmoil.⁵² Political debate on derivatives regulation tends to center on accounting standards and capital requirements, rather than controls on public purchases of derivative securities.⁵³

2.4 Coordination Problems

Coordination problems are a class of game theory problems where the expectations of the players in the game have crucial role in determining the equilibrium of the game. Coordination refers to the players' ability to infer expectations about other players' behavior, absent the existence of a dominant strategy. Consider two canonical examples, the prisoner's dilemma (PD) and the battle of the sexes (BS). (For an introduction to game theory, von Neumann and Morgenstern's classic is the essential work.⁵⁴) PD has only one stable equilibrium, where BS has two. In a one-shot PD game, the defection strategy dominates cooperation, no matter what either player thinks of the opponent's likely course of action. Contrast that with the optimal strategy of the BS game, where both players are just as well

⁵¹Brandon Becker and Jennifer Yoon. "Derivative Financial Losses." *Journal of Corporation Law* 21 (1995), p. 215. URL: <http://heinonline.org/HOL/Page?handle=hein.journals/jcorl21&id=225&div=&collection=journals>.

⁵²Merton H. Miller. "The social costs of some recent derivatives disasters." *Pacific-Basin Finance Journal* 4.2-3 (July 1996), pp. 113-127. ISSN: 0927-538X. DOI: 10.1016/0927-538X(96)00007-8. URL: <http://www.sciencedirect.com.ezproxy.library.tufts.edu/science/article/B6VFF-3VW90G6-8/2/b6b149ef7f1de7eab710a86e2d77d106>.

⁵³Sebastian Mallaby. *More Money Than God: Hedge Funds and the Making of a New Elite*. 2nd Printing. Penguin Press, June 2010. ISBN: 1594202559; Simon Johnson and James Kwak. *13 Bankers: The Wall Street Takeover and the Next Financial Meltdown*. Random House, Inc., Mar. 2010. ISBN: 9780307379054; Pablo Triana. *Lecturing birds on flying: can mathematical theories destroy the financial markets?* John Wiley and Sons, June 2009. ISBN: 9780470406755.

⁵⁴John Von Neumann and Oskar Morgenstern. *Theory of games and economic behavior*. Princeton Univ. Press, 1947.

off with either strategy, provided they agree on the same alternative. In a one-shot game, there is no optimal solution; each player should arrive at a mixed-equilibrium strategy expressed as a probability of choosing opera or football.

There is an important difference between the games in repetitive play. PD strategy revolves around communicating each player's willingness to choose a non-dominant strategy. One of the most effective strategies, tit-for-tat, makes no assumptions at all about the likelihood of the opponent's defection. BS strategy, however, changes drastically if either player can infer the other's intentions; each player has a strong incentive to follow suit. If the two players can coordinate their expectations in some manner (always opera, always football, take turns, etc.) they can both adjust their strategies to reflect this expectation. This is a simple illustration of the principle of coordination, meaning the setting of expectations ahead of time in favor of any of a number of alternatives.

		PLAYER 1	
		Cooperate	Defect
PLAYER 2	Cooperate	(3,3)	(1,4)
	Defect	(4,1)	(1,1)

Table 2.1: Payoffs in canonical prisoner's dilemma game.

		PLAYER 1	
		Cooperate	Defect
PLAYER 2	Cooperate	(3,2)	(1,1)
	Defect	(1,1)	(2,3)

Table 2.2: Payoffs in canonical battle of the sexes game.

Coordination can have a much larger role in other game theory settings, such as the El Farol game, where players only enjoy going to a bar when it is not too crowded.⁵⁵ In the El Farol game, a town has one bar, and the players' enjoyment of the bar depends on its not being too full. When more than 60% of the people attend the bar, it becomes crowded and

⁵⁵W. Brian Arthur. "Inductive reasoning and bounded rationality." *The American Economic Review* 84.2 (May 1994), pp. 406–411. ISSN: 00028282. URL: <http://www.jstor.org.ezproxy.library.tufts.edu/stable/2117868>.

everyone has a bad time. With pure strategies (go / don't go), the game is degenerate. Each player's decision as to whether to attend the bar depends crucially on whether he or she expects the other players to attend. With no information about the likelihood of the bar's being crowded, the best strategy is to go to the bar which leads inevitably to a crowded bar. Probabilistic strategies offer one way out of the logjam, leading players to attend the bar only the fraction of the time that the bar is expected to be uncrowded. A better solution, were it possible, would be to forecast the likelihood that the bar is crowded tonight. Most forecasting algorithms are based on recent attendance; but the performance of any of these forecasting algorithms hinges on the algorithms being used by the other players. The El Farol game demonstrates infinite regress of expectations. A trustworthy signal of forecast attendance cannot be available to all players; or else its value will be destroyed.

	Crowded	Not crowded
Go to the bar	0	1
Stay home	1	0

Table 2.3: Payoffs to the El Farol game.

Coordination also plays a crucial role in financial crises, where market expectations of future currency exchange rates (and other variables) have an overweening effect on the spot market exchange rates and other derivatives. Under some circumstances, government policy can wipe out the incentives for bank runs and currency collapses, largely by coordinating the expectations of investors and financial institutions around the promise that their interests will be protected in an orderly unwinding of bad debts and asset positions.⁵⁶ When investors are reassured, they refrain from destructive (but self-interested) reactions, such as withdrawing deposits and selling risky sovereign debt, that tend to worsen the effect of the original crisis.

The negotiations among donors over the size, programs, and conditions of humanitarian aid programs involve a great deal of coordination. Donors negotiate over the total size of

⁵⁶Kenneth Rogoff. "International Institutions for Reducing Global Financial Instability." *Journal of Economic Perspectives* 13.4 (1999). Fall 1999, pp. 21–42. ISSN: 0895-3309.

humanitarian programs, the individual shares of the funding burden each will bear, and the specific features of humanitarian programs, such as program objectives, project design, financial arrangements, targeting, monitoring, and evaluation. The behavior of individual donors depends on the sequence of decisions (whether the decisions are simultaneous or sequential); the donor's place in the sequence of decisions; and crucially, what each donor expects are the others' funding constraints and priorities. The donors that have the most limited discretion over project funds and the earliest place in the decision sequence create strong expectations, and thus play a great role in coordinating outcomes. The largest donors also have a greater role over the total portfolio of humanitarian projects, because their choices about funding matter the most.

The political economy of multilateral humanitarian projects is a principal-agent game. In a typical single-principal setting, the game involves a principal who has an agenda and a budget. The agent has an agenda of its own, and the two organizations bargain over the allocation of funds to various projects.

Principal-agent problems deal with the ways a principal, such as an electorate, or a legislature, or shareholders, can elicit desired behavior from the party to whom it has delegated some authority. Principal-agent problems are a fairly general class of problems in political science literature. Pollack's 2002 review article describes several classes of problems and critically evaluates the empirical strategies associated with each of these.⁵⁷ Pollack points out that both case studies and large-n studies have been tried with success. Within the case study approach, the two issues that are hardest to address methodologically are selection bias and rational anticipation. Rational anticipation here means the degree to which the agent adjusts its behavior in anticipation of sanctions (or rewards) by the principal. A study designed to compare the oversight of a regulatory body might find very few specific reactions by the principal to actions taken by the agent, if the agent is politically savvy enough to avoid or postpone sensitive decisions that it fears will incur costs of oversight.

⁵⁷M. A. Pollack. "Learning from the Americanists (Again): Theory and Method in the Study of Delegation." *West European Politics* 25.1 (2002), pp. 200–219.

Hawkins et. al describe compare multi-principal and collective principal games in the opening chapter of *Delegation and Agency in International Relations*.⁵⁸ In a multi-principal setting, the choice of bargaining forum determines how much influence the principals have over the agent. When donors vote on independent policies of the principal in implementing a policy (e.g., the size of a budget on a numeric interval) the agent's optimal strategy is well defined. Given any two proposals, the one that will win a majority of support from the principals is the one closest to the median value of the principals' preferences. The agent's strategy should be to assess the value of its own preferences and the value of the principals' preferences, and then propose a budget that maximizes its own preferences subject to the constraint that the policy must be closer to the median than the next best competing policy on the table. In the collective-principal setting, donors can band together to link issues up for negotiation. Combinations of policies need only a winning coalition of support, rather than a median strategy for each. Whoever sets the bargaining agenda (principals or agent) can fashion strategies that combine issues to create winning coalitions, rather than requiring a simple majority of support for each issue individually.

Devarajan, Rajkumar, and Swaroop (DRS) describe a related principal-agent game in which the donor funds a partner government.⁵⁹ The partner government's policy preferences are weighted toward security expenditures, rather than humanitarian expenditures. The economists demonstrate a theoretic case for suspecting that humanitarian aid projects end up supporting increased security expenditures in the recipient government, partly due to the fungibility of national budget resources, no matter what their source. While the empirical results of the paper emphasize the low aid elasticity of tax receipts and the high proportion of African fiscal budgets spent on debt service, these results are of limited use in understanding Ethiopia's case. The parameter that determines the degree to which aid is fungible in the DRS model is the chance that future aid will be curtailed, as a function of

⁵⁸Hawkins et al., "Delegation under anarchy."

⁵⁹Shantayanan Devarajan, Andrew Sunil Rajkumar, and Vinaya Swaroop. "What Does Aid to Africa Finance?" *World Bank Policy Research Working Paper WPS 2092* (Jan. 1999). URL: <http://go.worldbank.org/B4BWUDZ7J0>.

the recipient's fiscal behavior. The greater the diversion of national finances to compensate for donor priorities, the greater the prospect of future sanctions.

Hawkins et al. give six reasons for delegation of power to international organizations: specialization, policy externalities, collective decision making, dispute resolution, policy credibility, and policy lock-in.⁶⁰ WFP in this case has demonstrated considerable specialization in the development of rainfall indices relevant to local agriculture; but that is instrumental to the development of weather derivatives, and not causal. It plays less of a role with regard to policy externalities, policy coordination, and dispute resolution. Weather insurance boosts the policy credibility of WFP's emergency relief programs, to the extent that the promptness and certainty of private sector insurance payments is preferred to traditional appeals-based funding. Finally, there is the potential that ex ante emergency financing can create policy lock-in, shifting future discretion over emergency aid away from donors and toward WFP. WFP's weather insurance will not have evidence on that question for years to come. So from the perspective of policy delegation to an international organization, the main function of WFP weather insurance is to promote credibility that WFP will swing into action at the first possible moment.

Domestic interest groups can also affect foreign policy choices. Paarlberg's work on food policy during the Cold War demonstrates that domestic agricultural interests frequently trump geopolitical strategy, when those objectives compete.⁶¹ His work examines the failure of the United States to exercise food aid as a tool of foreign policy: i.e., why food aid was not withheld to coerce foreign powers during the Cold War. Here, the substitution of fungible insurance claims for more frequently tied or in-kind aid appears to contradict the Paarlberg model. Financial interests of the donors might perhaps trump the agricultural interest groups, particularly prior to the market crash of 2008, but the advent of the weather insurance is correlated with a rise in securitization of weather derivatives, and not the advent of the weather insurance market itself.

⁶⁰Hawkins et al., "Delegation under anarchy."

⁶¹Paarlberg, *Food Trade and Foreign Policy*.

Epstein and O'Halloran document a complex signaling between legislative principals and their executive agents that may be instructive.⁶² Their empirical strategy, however, does not have a clear analogy in this case. They show how American executive branch policy items responded to bills introduced in Congress. Threats of legislation color the way that executive branch authorities use powers delegated from Congress. Here, WFP's emergency funding forecasts do not begin until months after the payment of the weather insurance is complete.

2.4.1 Donor Harmonization

Donor harmonization is one major element of a broad OECD plan to improve the effectiveness of aid. In the narrowest sense, it refers to the streamlining and rationalizing of development institutions for improved transparency and efficacy.⁶³ Donors work together in common organizations, rather than duplicating one another's efforts. Donors collaborate (with one another and with the recipient country) on finances, strategic planning, and reporting. Donors simplify reporting requirements and focus on improved incentives for good results, rather than pervasive controls over contractors and recipient governments.

In a broader sense, harmonization is the byword for all of the other specific objectives in the OECD's DAC negotiations on aid effectiveness. It is a philosophy of aid efficacy with the following components: ownership, harmonization, alignment, results, and accountability.⁶⁴ DAC literature documents the agreement of aid donors and recipients (or partners, in the parlance of the DAC) to adopt these five principles in order to address the worst shortcomings of global development assistance. Each of these principles applies to various processes of development institutions, from needs assessment and strategic planning,

⁶²David Epstein and Sharyn O'Halloran. *Delegating Powers: A Transaction Cost Politics Approach to Policy Making Under Separate Powers*. Political economy of institutions and decisions. Cambridge, U.K: Cambridge University Press, 1999. ISBN: 0521660203.

⁶³Development Assistance Committee. *Paris declaration on aid effectiveness and Accra agenda for action*. Organization for Economic Cooperation and Development. Mar. 2005, p. 6.

⁶⁴*Ibid.*, p. 1.

to financial arrangements and organizational design, to monitoring and evaluation. Unless otherwise specified, I will use the word harmonization in this broader sense, to refer to the general set of principles for aid effectiveness, from the Paris and Rome Declarations to the DAC Guidelines on effective aid delivery.⁶⁵

Rather than an academic treatise on the effects of aid, the DAC guidelines are institutional documents that outline a political approach to aid design and implementation. They discuss the objectives of development, and specific means for achieving those goals. Both in 2003 and in 2006, DAC released specific performance objectives for global development efforts, under the title “Indicators of Progress.”⁶⁶ The specific list of guidelines from 2006 is as follows.

1. 75% of partner countries have development strategies.
2. Half of partner countries move up at least one measure (0.5 points) on the PFM / CPIA scale of assessment.
3. One-third of partner countries move up at least one measure on the four-point scale used to assess performance for this indicator.
4. Halve the proportion of aid flows to government sector not reported on the government’s budget(s), with at least 85% reported on the budget.
5. Half of technical cooperation flows are implemented through coordinated programs consistent with national development strategies.
6. All donors use partners’ public financial management systems.
7. All donors use partners’ procurement systems.
8. Reduce parallel project implementation units by two-thirds.
9. Halve the proportion of aid not disbursed within the fiscal year for which it was scheduled.
10. Untie aid.
11. Two-thirds of aid flows are provided in the context of program-based approaches.

⁶⁵Development Assistance Committee. *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2003; Development Assistance Committee, *Paris declaration on aid effectiveness and Accra agenda for action*; Development Assistance Committee. *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2006.

⁶⁶Development Assistance Committee, *Harmonising Donor Practices for Effective Aid Delivery*.

12. 40% of donor missions in the field are joint.
13. 66% of country analysis is joint.
14. Reduce the proportion of countries without transparent and monitorable performance assessment frameworks by one-third.
15. All partner countries have mutual assessment reviews in place.

The point of introducing the whole list of progress indicators is to specify what might be otherwise unmanageably abstract principles. Some of the abstract principles are nearly impossible to disagree with: who could disfavor transparency or results in the provision of economic and social development assistance? Even with achievable objectives in mind, some still sound disarmingly naïve: e.g., that donor governments will be content to conduct accounting through partner government financial structures, or that partner governments will have transparent and feasible monitoring strategies with accountability to those strategies.

The OECD meetings were extremely well attended by donor countries. All of the top 10 donors to WFP signed the Paris Declaration. Ethiopia was among a large group of African countries signing the declaration, including Botswana, Cameroon, Egypt, Kenya, Morocco, Senegal, South Africa, Tanzania, and Zambia. The Paris Declaration represents a good faith negotiation between influential majorities of both donor and partner countries. All of the principal multilateral and regional organizations related to humanitarian assistance and specifically Ethiopia signed onto the Paris Declaration, as well as a number of civil society organizations.

While the Accra Agenda of 2008 changed the emphasis of the donor harmonization agenda, the headlines were the same: partner country ownership, capacity building, partner country financial and procurement systems, eliminate duplication, untying, accountability, South-South cooperation and increased NGO participation enjoyed somewhat greater focus at the Accra meeting than it had at Paris and Rome. The Accra Agenda also pushed for greater willingness to work in fragile states, and for closer collaboration with private civil

society.

2.4.2 Food Security

The final section of the chapter deals with the specific purpose of WFP and PSNP operations in Ethiopia. The safety net operations are necessary because beneficiaries do not have access to food. Chronic food insecurity affects one in ten Ethiopians, meaning that WFP estimates 10% of the population will fall below the IPC's survival threshold. The PRRO budget document lists a variety of risks to food security: population growth, drought, health concerns, and political events.⁶⁷

Simon Maxwell differentiates three basic approaches to food security in a lengthy catalogue of official and academic definitions of food security.^{68,69} National approaches focused on the supply of grains and other foods at harvest, controlling for international market movements and transfers. Household measures analyzed the household's risk of suffering periods without access to food, taking account of livelihoods, asset stocks, and wage labor markets. These measures reflected much better the constraints facing households and sometimes also the distribution of food within the household; but did not adequately reflect choices that households made to forego food in service of other investment goals. Subjective measures, the third school, attempted to circumvent these problems and also the problems of baseline measurement, nutritional adequacy, and food quality.

The United States Department of Agriculture (USDA) calculates food availability with an accounting identity (2.8).⁷⁰ The USDA measure computes quantities of commodities

⁶⁷World Food Program. *Budget Increases to Protracted Relief and Recovery Operation Ethiopia 10665.0*. Protracted Relief and Recovery Operation WFP/EB.2/2007/9-C/5. WFP/EB.2/2007/9-C/5, Sept. 2007.

⁶⁸Simon Maxwell. "Evolution of Thinking about Food Security." *Food Security in Sub-Saharan Africa*. Ed. by Stephen Devereux and Simon Maxwell. Institute of Development Studies, 2001.

⁶⁹Maxwell catalogued definitions from the UN, Reutlinger and Knapp, Kracht, Valdes and Konandreas, FAO, Oshaung, Eide, Heald and Lipton, World Bank, Zipperer, Barraclough and Utting, Falcon, World Food Council, Reardon and Matlon, Sarris, Phillips and Taylor, Staatz, Kennes, UNICEF, Mellor, Gillespie and Mason, von Braun, Weber and Jayne, Jonsson and Toole, ACC/SCN, Alamgir and Arora, and Frankenberger and Goldstein

⁷⁰Jean Buzby and Hodan Farah Wells. *Food Availability (Per Capita) Data System: Food Availability Documentation*. Economic Research Service. United States Department of Agriculture. Mar. 2010. URL:

available on local markets by counting the sources and sinks of those commodities: local production, non-food sinks, and gains and losses through trade. This measure largely does not address issues of purchasing power or subjective access to food detailed below; and USDA does not intend it as a measure of livelihood or household food sufficiency.

$$A = P + I - N - X \quad (2.8)$$

where

- A: Available food
- P: Production
- I: Imports
- N: Nonfood uses
- X: Exports

Economic and political studies of famine unequivocally separate declines in agricultural production, as for example droughts could cause through lowered yields, as only one among many possible causes of food insecurity. One of Amartya Sen's seminal contributions to economics is his study debunking agricultural yield shocks as an explanation for the Great Bengal famine.⁷¹ He proposes a simple economic exchange model whereby adverse terms of trade shifts can shrink the value of household consumption budgets below the threshold of food security. With inelastic demand for food commodities and speculative behavior by commodity traders, price dynamics can impose severe shocks on household consumption.

Declining terms of trade are by no means the only or the primary cause of food insecurity. De Waal explains that in mid-1980s Sudan, neither destitution nor malnutrition was the primary cause of excess mortality; rather diseases spread as a result of economic and social conditions resulting from the famine.⁷² Webb and von Braun cite alternative taxonomies of the causes of food insecurity in Jeliffe and Jeliffe's initial, aggravating and ameliorating factors; Downing's baseline vs. current framework; Swift's proximate and intermediary

<http://www.ers.usda.gov/Data/FoodConsumption/FoodAvailDoc.htm>

⁷¹A. K. Sen. *Poverty and famines*. Oxford University Press New York, 1981.

⁷²Alex de Waal. "Famine Mortality: A Case Study of Darfur, Sudan 1984-5." *Population Studies* 43.1 (Mar. 1989), pp. 5-24. ISSN: 00324728. URL: <http://www.jstor.org/stable/2174235>.

factors; and Kates and Millman's underlying, immediate, and direct causes.⁷³

Webb and von Braun's conceptual framework derives food security and famine as end states that result from complex interactions among a number of primary factors.⁷⁴ Resources are the basis of production, which provides income for consumption and ultimately nutrition. Households require complementary natural, physical, and human resources for combinations of both farm and non-farm activities, permitting consumption of both food and nonfood goods. Food security arises from adequate food availability, access, and appropriate use of food (i.e., stable food intake, evenly distributed within the household). Famine can result from failures of any of basic processes from resource acquisition to nutrition. Absences of adequate resources, production, income, consumption, and nutrition result in degradation of resources, social and economic dislocation, and excess mortality (as from preventable diseases, poor sanitation, and lack of complementary non-food consumption goods).

Webb and von Braun entitle Chapter 3 of *Famine and Food Security in Ethiopia* "The Labyrinth of Famine Causality."⁷⁵ Ethiopia's history of civil war and Eritrean secession exacerbated food insecurity; and the consequences of the famines since 1970 were deeply political. Webb and von Braun document withholding of food aid as a weapon of war; diversion of food aid to feed troops; conscription of civilians away from productive rural enterprises; ineffective land reforms; the grossly inefficient agricultural policy of the Derg regime; and unintended economic consequences of food aid itself. Webb and von Braun cite estimates of Ethiopia's war dead that are well in excess of half a million, and

⁷³D.C. Jelliffe and E.F.P. Jelliffe. "The effects of starvation on the function of family and society." *Famine. A symposium dealing with nutrition and food operations in time of disaster*. Ed. by G. Blix, Y. Hofvander, and B. Valquist. Swedish Nutrition Foundation, Symposium IX. Upsalla: Alquist and Wiksells, 1971; T. E. Downing. *Assessing socioeconomic vulnerability to famine: Frameworks, concepts, and applications*. Alan Shawn Feinstein World Hunger Program, Brown University, 1991. ISBN: 0944960081; J. Swift. "Why are rural people vulnerable to famine?" *IDS bulletin* 20.2 (1989), 815. ISSN: 1759-5436; S. Millman and R. W. Kates. "Toward understanding hunger." *Hunger in History: Food Shortage, Poverty, and Deprivation* (1990), pp. 3–24.

⁷⁴Patrick Webb and Joachim Von Braun. *Famine and Food Security in Ethiopia: Lessons for Africa*. Chichester: John Wiley, 1994. ISBN: 0471948217.

⁷⁵Ibid.

approximately 80% civilian, without counting disabled survivors and excess mortality from nonviolent causes. The war, Derg-era agricultural policies, and aid policies all introduced deep disruptions of fragile rural economies, which compounded falling means and rising variance of seasonal rainfall.

Weather risk and food shocks

Weather risk is only one source of food shocks among many. Lautze et al. discuss the three principal sources of food shocks in detail. “Plagues and pests have been equally important [as droughts] historically.⁷⁶” They point also to Pankhurst’s discussion of many social causes of famines, including land tenure, tax policy, agricultural technology and war.⁷⁷

No simple correlation exists between rainfall and yields. Still following Webb and von Braun’s history: in Ethiopia, cereal production has fallen and the volatility of production rose steadily from the early 1960s through the late 1980s. The variance of crop yields has been higher than the variance of rainfall during that period of time. Webb and von Braun estimated the supply response to high prices, and found a supply elasticity of price 1.4.

IBRTPs are remarkably well suited to easily observed climate conditions, such as daily and seasonal rainfall. IBRTPs cannot cope with some of the other principal risk factors. While in theory it would be possible to track epidemics of diseases associated with famine, to my knowledge no reliable reporting system exists for those data; and if there were, politicians might be reluctant to tie the provision of aid directly to the outbreak of human and animal disease.

No suitable, objective indicators are immediately available for describing failed agricultural policy, ineffective land reforms, or the intensity of recent political violence. Linking

⁷⁶S. Lautze et al. “Risk and Vulnerability in Ethiopia: Learning from the Past, Responding to the Present.” *Preparing for the Future. Report for the US Agency for International Development, Feinstein Famine Center, Tufts University, Medford* (2003).

⁷⁷Richard Pankhurst. *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*. Addis Ababa: Relief and Rehabilitation Commission, 1990.

aid directly to observations of refugee movements, violent conflict, or bad Ethiopian policy could poison political relationships between the donor community and the Government of Ethiopia. Rudimentary efforts to use mock financial markets to predict terrorist attacks in the United States met with widespread opprobrium and were rapidly abandoned once the media discovered them. IBRTPs are thus restricted to a relatively narrow class of problems where simple, objective indicators have a reasonably strong association with one of the main risk factors for rising beneficiary counts.

Famine early warning systems track a multitude of indicators. Lautze et al. detail meteorologic patterns, market conditions, migration patterns, and human health indicators (among others) used by many different institutions to track food security conditions. These institutions include the national government, NGOs, multilaterals, and donor governments.⁷⁸ WFP's Country Office Food Security Update for Ethiopia focuses specifically on three types of indicators: production forecasts, public health data, and market prices.⁷⁹ Famine Early Warning Systems (FEWSNET), a product of USAID, focuses on weather data, market data, and livelihood analysis to forecast food security.⁸⁰

Because weather risk is only one among a group of risks that threaten livelihoods, weather risk management has a limited role in emergency food assistance financing. Weather instruments introduce basis risk into WFP programs, because food shocks and droughts do not perfectly coincide. WFP's program costs rise quickly whenever livelihoods worsen and access to food worsens. It is an insurer of last resort for households. An ideal financing tool would provide funds to WFP whenever access to food worsened; but food security assessment is costly in terms of human resources, money, and time.

⁷⁸Lautze et al., "Risk and Vulnerability in Ethiopia," 47 et seq.

⁷⁹World Food Program. *Ethiopia Country Office Food Security Update*. Feb. 2009. URL: <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp198785.pdf>.

⁸⁰Famine Early Warning Systems Network, *Livelihoods and FEWSNET*.

Measures of food security

A sizable literature seeks to model vulnerability to poverty. The measures proposed calculate vulnerability as the probability of future household consumption falling below a poverty line, typically the dollar-a-day standard. Counts of vulnerable households and vulnerable populations are frequently expressed as the count of households more than 50% likely to be poor in the next period of the economic model. A number of papers estimate the determinants of vulnerability, including Christiaensen and Boisvert,⁷⁹ Christiaensen and Subbarao,⁸⁰ Kamanou and Morduch.⁸¹ Chaudhuri, Jalan and Suryahadi both provide a conceptual overview of determinants of vulnerability, and also describes how the sets of households currently poor and currently vulnerable to future poverty are overlapping but non-nesting sets.⁸² Jalan and Ravallion provide a simple microeconomic model with a production function and an unstable lower equilibrium, indicating that household consumption falls rapidly when present-period consumption decreases below a threshold.⁸³

Food security comprises more than simple income poverty. Webb et al. point out several fundamental criticisms of food availability measures.⁸⁴ Simple measures of caloric intake and availability of food miss important aspects of the social and cultural aspects of food access. They argue instead for models of access to food that incorporate several other dimensions of access to food, notably: uncertainty over future access to food, behavioral evidence of poor food access, and subjective experience of food security. They argue that subjective measures can and should comprise part of a comprehensive measure of food

⁸¹L. J. Christiaensen and R. N. Boisvert. *On Measuring Household Food Vulnerability: Case Evidence from Northern Mali*. Dept. of Agricultural, Resource, and Managerial Economics; College of Agriculture and Life Sciences. 2000; L. Christiaensen and K. Subbarao. "Towards an Understanding of Household Vulnerability in Rural Kenya." *Journal of African Economies* 14.4 (2005), pp. 520–558; Gisele Kamanou and Jonathan Morduch. "Measuring Vulnerability to Poverty." *Insurance Against Poverty*. Ed. by Stefan Dercon. Oxford: Oxford University Press, 2005, pp. 155–175.

⁸²S. Chaudhuri, J. Jalan, and A. Suryahadi. "Assessing Household Vulnerability to Poverty from Cross-sectional Data: A Methodology and Estimates from Indonesia." *Unpublished Manuscript* (2001).

⁸³Jyotsna Jalan and Martin Ravallion. "Household Income Dynamics in Rural China." *Insurance Against Poverty*. Ed. by Stefan Dercon. Oxford: Oxford University Press, 2005, pp. 107–123.

⁸⁴P. Webb et al. "Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do." *Journal of Nutrition* 136.5 (2006), 1404S. URL: <http://jn.nutrition.org/cgi/content/abstract/136/5/1404S>.

security. Coates et al., in a related paper, explain that the method of obtaining access to food must be socially acceptable. They compare measures from the United States and a variety of other countries, and show the importance of social and subjective measures in good measures of food security.⁸⁵

Donor policies

Food security interventions have themselves evolved considerably in recent years. Long-standing criticism of the problem of aid tying, i.e., national purchasing and service requirements for donors such as the United States, failed to effect much change despite well argued economic analyses of the resulting inefficiencies.⁸⁶ Since about 2005 practitioners have argued for greater local and regional purchases of food aid.⁸⁷ This position rises in part from the greater aggregate efficiency of cash aid delivery, both in terms of time and of cost.⁸⁸ Barrett, Bell, Lentz, and Maxwell argue that food may remain preferable to cash under certain circumstances: when markets are distant or out of season; when local supplies are tight; when nutrition is the priority and not beneficiaries' choice; when intra-household distribution is an issue; when the risk of food theft is greater than the risk of cash theft; and when cash transfer systems are limited.⁸⁹

Contribution to the literature

The use of private capital markets to finance international organizations is, to my knowledge, a relatively new subject of inquiry. While a fair literature exists on catastrophic

⁸⁵J. Coates et al. "Commonalities in the Experience of Household Food Insecurity across Cultures: What Are Measures Missing?" *Journal of Nutrition* 136.5 (2006), 1438S.

⁸⁶Jepma, *The tying of aid*.

⁸⁷Christopher B. Barrett et al. "Poverty traps and climate risk: limitations and opportunities of index-based risk financing." *Policy Roundtable on Climate Risk, Poverty Traps and Index-Based Financing, hosted by the International Research Institute for Climate and Society, Columbia University* (Sept. 2007).

⁸⁸C. E Hanrahan. *Local and Regional Procurement for US International Emergency Food Aid*. Report for Congress R40759. Congressional Research Service, 2009.

⁸⁹Christopher B. Barrett et al. "Market information and food insecurity response analysis." *Food Security* 1.2 (2009), pp. 151–168. ISSN: 1876-4517. DOI: 10.1007/s12571-009-0021-3. URL: <http://www.springerlink.com/content/20t80w3656428335/>.

reinsurance and catastrophe bonds, to my knowledge these bonds have not been used to pay for international relief efforts. If such a literature existed, it might provide the tools to evaluate different instruments for obtaining contingent cash flows from capital markets.

The literature on the government as insurer of last resort for food security is another missing area in the academic literature. Last-resort function literature tends to focus on financial markets and the lender of last resort, or on catastrophic events, such as terrorism and floods. Lender of last resort functions are designed for problems too different from food security to be of much use. As for terrorism and flood risks, while these events are similar to droughts in the scale of destruction created, but they create a much simpler basis for identifying affected geographic areas, assets, and livelihoods. The food security community does not agree on a standard definition of a famine, or of the area in which a famine occurs, or of exactly whom a famine affects.⁹⁰

Finally, this dissertation shows the relationship between funding structures and the delegation of authority for international humanitarian efforts. This research will demonstrate whether Hawkins et al.'s prediction about collective principals delegating to international bodies is sufficiently strong to trump Paarlberg's vision of domestic interest groups dominating the foreign policy process. Delegation to an international organization can take few forms more sincere and committed than ex ante payment of a humanitarian insurance premium.

Underwriters of public sector products also stand to benefit from a clear understanding of how their customers view the decision to hedge or insure operational risks. Underwriters should be able to use this knowledge to design instruments that are most beneficial to the specific institutional situations and operating environments of public organizations. Governments and international organizations, such as the World Food Program (WFP), will reap the benefits of improved product design.

⁹⁰Webb et al., "Measuring Household Food Insecurity."

Chapter 3

Theory

This chapter gives some supporting theory for hypotheses as necessary. Recall the problem statement: this dissertation attempts to explain the role that weather risk management plays in WFP decisions. The crucial decisions fall into three realms: coordination problems for donors, constraints on the use of committed funds, and implementation and management of development programs. The three main hypotheses are that weather derivatives coordinate the behavior of stakeholders; that they solve a technical and administrative gap in funding constraints and conditions; and that weather derivatives are a vehicle to achieve a broad set of objectives related to transparency and harmonization.

3.1 Risk Management Decisions

Figure 3.1 is an extended tree diagram of the international organization's decision to obtain drought insurance. In the first stage of the decision tree, the IO decides whether or not to manage its weather risks. Following that, the state of the rains is observed; and following that, the state of the beneficiaries is observed. With high rains, the probability of a humanitarian emergency is markedly reduced. With low rains, the probability of a humanitarian emergency rises. Payouts from the insurance company are predetermined by the weather index as a function of rainfall. Donors then undertake funding decisions in light of the

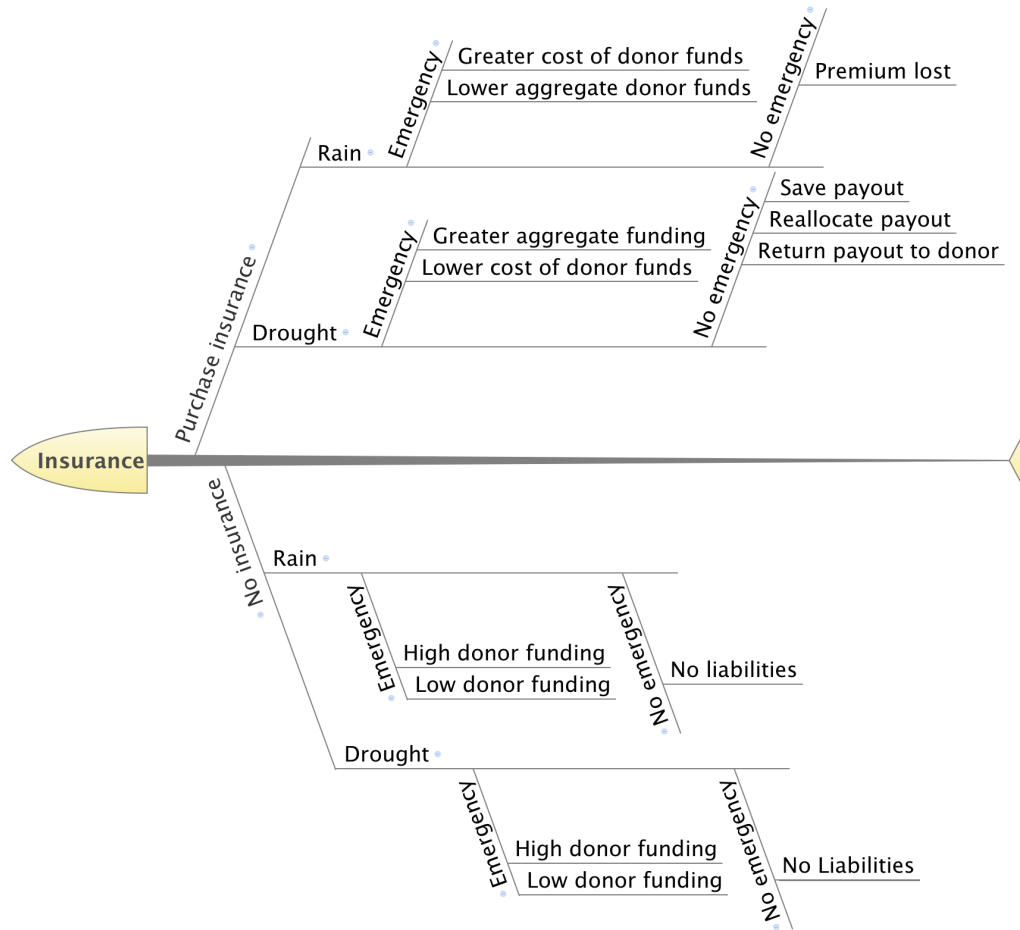


Figure 3.1: Drought insurance decision tree

state of the emergency, premium payments and payouts from insurance. Finally, in the rare instance that the weather index pays out without a serious humanitarian crisis, the IO must decide whether to save, reallocate, or return the funds to the donors.

Donors’ ex post funding decisions will more than likely reflect the outcomes of the drought insurance policy. In the state of the world without drought insurance payments, donors have some baseline response to a given emergency. For simplicity I have used a binary distribution; but in principle the beneficiary count B could be a random variable with any nonnegative support. Donors’ response to appeals (3.1) is partially determined by the beneficiary count, and partly by the prior decisions to spend a premium p_1 in order to receive the payout p_2 in case of drought.

$$D = f(B, P) \quad (3.1)$$

$$D_0 = f(B_1, 0) \quad (3.2)$$

$$D_1 = f(B_1, -p_1) \quad (3.3)$$

$$D_2 = f(B_1, p_2 - p_1) \quad (3.4)$$

where

D: donor ex post funding

B: beneficiaries

$$B \in \{0, B_1\}$$

P: insurance value

$$P \in \{-p, 0, p_2 - p_1\}$$

p_1 : premium

p_2 : payout, $p_2 > p_1$

Drought insurance may affect donors' response to emergency appeals in two ways: as a function of donor costs, and as a function of donors' forecast of IO liabilities. Donor costs (3.5) reflect both the sunk cost of the premium, p_1 , and the marginal cost of relief, D . Donors may treat the total budget for relief as fixed or not; they may debit premiums paid against future relief at any marginal rate between zero and one. Donors may also discount IO funding needs based on the payout from the drought insurance policy. Again, the donor may count dollars from the insurance payout on a one-to-one basis, or fractionally, or not at all. This model elides the role of appeal design for the sake of clarity. In reality, the IO would alter its appeal to reflect the receipt of drought insurance funds. The model is simply here to illustrate the role that donors' knowledge of the drought insurance program has on appeals response.

$$C \equiv \begin{cases} p_1 + D & \text{with insurance} \\ D & \text{without insurance} \end{cases} \quad (3.5)$$

where

C: cost

p_1 : premium

D: donor ex post funding

This analysis yields the following boundary conditions (3.6) on the donors' ex post response to appeals (3.8), the total cost function for donors (3.9), and the total funds available for drought relief (3.10).

$$D_0 - p_2 \leq D_2 \leq D_0 \quad (3.6)$$

$$D_0 - p_1 \leq D_1 \leq D_0 \quad (3.7)$$

$$\begin{cases} D_0 & \leq C \leq D_0 + p_1 & \text{non-drought years} \\ D_0 - p_2 + p_2 & \leq C \leq D_0 & \text{drought years} \end{cases} \quad (3.8)$$

$$\begin{cases} D_0 - p_1 & \leq F \leq D_0 & \text{non-drought years} \\ D_0 & \leq F \leq D_0 + p_2 & \text{drought years} \end{cases} \quad (3.9)$$

$$\text{and } F \equiv \begin{cases} D + P_2 & \text{with insurance payout} \\ D & \text{without payout} \end{cases} \quad (3.10)$$

where

F: funds available

Thus drought insurance can have the effect in rainy years of either raising donors' marginal costs or shrinking the funding that reaches IO programs. In drought years, it is the opposite: drought insurance can either lower donor costs or increase the total funds available for relief.

3.2 Coordination Problems

This section aims to develop a theoretic setting for coordination problems at WFP and PSNP. Prior to the development of drought insurance at WFP Ethiopia, the international organization had a set of annual liabilities of unknown size. Good knowledge of the crops

under cultivation and the mixture of agricultural, pastoral, and nonfarm income in rural areas permits accretion of knowledge about the likelihood and scale of food insecurity. Closer to the end of the rainy season, the population of beneficiaries can be forecast somewhat better with a combination of meteorological observations, social surveys, and economic data. These datasets are the basis of appeals-based funding.

WFP takes funding from individual donors for specific appeals. WFP strategy and appeals are integrated with other UN organizations as described in the Development Assistance Framework.¹ Several independent donors review appeals simultaneously, either with or without mutual consultation. The theoretic case for free riding is strong. Simple assumptions about the scarcity of budgets and various donor's degree of knowledge about one another's priorities and true capacity lead to inefficient outcomes. My simple game theoretic model (Appendix E) shows that donors with diverse preferences have an incentive to move last, so that they can ensure that they have the best chance conserve resources and ensure that favorite programs receive funding. The political benefits of drought relief accrue to all donors in the group, which dilutes each donor's incentive to contribute resources to the effort.

Reasons for donors' differences abound. Donors have a multitude of available targets, such as the diverse collection embodied in the Millennium Development Goals. Donors may prioritize their efforts differently, depending how they perceive the values of spending on food security, infrastructure, education, and gender equality. Some donors may be motivated by crises that dominate the news, while others may respond more to geopolitical concerns. Amartya Sen begins Chapter 3 of *Development as Freedom* with a parable about Dinu, Bishanno, and Rogini, each of whom merits first crack at a job on somewhat different grounds: Dinu, because he is the poorest; Bishanno, because he suffers the greatest disutility from newfound poverty; and Rogini, because she could use the money to heal a

¹United Nations Development Program. *United Nations Development Assistance Framework in Ethiopia 2007-2011*. 2007. URL: http://www.et.undp.org/index.php?option=com_docman&task=doc_download&gid=10.

chronic ailment once and for all.² The lesson is that donors can honestly disagree over the best way to spend humanitarian funds.

Under Ethiopia's Plan for Accelerated and Sustainable Development to End Poverty (PASDEP), donor contributions are mediated by the Development Assistance Group.³ Created in response to Ethiopia's request in 2001, the DAG is a quintessential coordination body. It transforms the group of donors into a collective body that can negotiate a development assistance plan with the Government of Ethiopia.

Helen Milner suggests two political motivations for funneling aid through international organizations, rather than allocating bilaterally.⁴ The advantages of international organizations concern project design and reporting. First, IOs protect the donor from a skeptical public's cynicism about the goals and uses of aid budgets. As long as the public perceives WFP to be relatively better at choosing aid policies on the merits, the US State Department can mitigate concerns about the purity of its motives by allocating aid budgets to WFP. The use of *ex ante* conditions to commit to foreign aid decisions would tend to further expose donors' decisions to external review. If such a motivation was present in the WFP pilot, however, it made no appearance in any of the interviews I held with the staff of any stakeholder organizations. Neither a mention of corruption, nor a mention of undue American influence over Ethiopian policy (e.g., regional security concerns in Somalia, Kenya, Sudan, or Eritrea) occurred in my interviews with various stakeholders.

Milner's second point is that multilateral donors might have better access to information about the uses of donors' money than the donors themselves. This could occur either as a result of the international organization's magnified influence (negotiating on behalf of a number of donors), or as a result of efficiencies gained from a single reporting mechanism.

²Amartya Sen. *Development as Freedom*. 1st. ed. New York: Knopf, 1999. ISBN: 0375406190.

³Government of Ethiopia. *Ethiopia: Building on Progress A Plan for Accelerated and Sustained Development to End Poverty (PASDEP)*. Sept. 2006. URL: http://www.et.undp.org/index.php?option=com_docman&task=doc_download&gid=8.

⁴Helen Milner. "Why Multilateralism? Foreign Aid and Domestic Principal-Agent Problems." *Delegation and Agency in International Relations*. Ed. by Darren G. Hawkins et al. New York, NY: Cambridge University Press, 2006.

The Paris and Rome Declarations made extensive reference to the burdens of partner countries' efforts to satisfy bilateral reporting and monitoring requirements. A single, unified reporting and monitoring structure could provide a higher quality of information, although a single reporting channel is not unambiguously preferable to multiple channels. For example, a single reporting channel might be easier to distort for political purposes in the partner country. WFP may also have greater longevity in the partner country, better political access to information, or greater access to field staff. Any number of conditions could explain Milner's suggestion that WFP would be better placed than a typical bilateral aid agency.

Another reason for using a multilateral donor group might be to enhance the credibility of donor commitments for drought relief. To this way of thinking, confidence in donors' promises for future emergency aid is an issue. WFP and GoE uncertainty over donor promised aid might lead them to devise commitment devices for aid delivery. Sourcing index-based insurance from a global reinsurance firm might be one way to obtain early commitments from donors. Once they have paid the premium on a drought insurance policy and contractually committed the proceeds to WFP, donors have little recourse to recover the capital invested. Similarly, description of an explicit, easily observed index on which contingent funds greatly reduces the donors' wiggle room when droughts occur. Rather than a soft commitment in case of need, the index specifies the amounts, whether of cash or of commodities, that donors commit to provide. Ultimately the index-based pledge is less effective as a commitment device than third-party drought insurance; but it still carries the donors' implicit endorsement of the recipient. Once made, a commitment is more difficult to rescind.

3.3 Funding Constraints

The second hypothesis about the purpose of weather risk management is legalistic and narrow. Rather than transforming relationships among donors or helping organizations minimize uncertainty, on this view risk management is a technical financial means to match donors' intents with existing budgets and authority. This set of hypotheses is, collectively, a necessary condition for weather risk management to achieve implementation. If weather risk management didn't match programs with available budgets, it would have remained an academic possibility. Since it has achieved implementation, we can safely assume it was a feasible solution to some financing problem at WFP and MoARD. The hypothesis has more to do with a failure of existing advance funding mechanisms led to the creation of the drought insurance.

One factor that could have led to the failure of existing financial mechanisms is the sufficiency of donor budgets for appeals funding. Assessing the exhaustion of donor budgets is difficult for a number of reasons. First, donors' budgets are difficult to observe. Aid agencies frequently have global mandates with considerable discretion to allocate resources across countries in line evolving needs and political commitments. Second, donors can increase their budgets markedly in response to domestic politics, international commitments, and medical coverage of disasters. Third, donors' calendars for appropriations are not synchronized. While it might seem sensible to assess the order in which various UN appeals are funded, or the time lags between appeals and pledges (or disbursements), the timing of donor commitments might suffer from overwhelming domestic constraints. So while we might suspect that aid budgets have an implicit ceiling, or that even without a proper ceiling, a large commitment of funds to (for example) a tsunami might make it more difficult to find funds for a small earthquake elsewhere in the same year. Unpacking the relationships among many donor commitments remains a serious empirical problem.

The narrower issue of which budgets can be used to pay for what, as opposed to exhaustion of donors' willingness to pay, may provide something of an entering wedge. For

example, American cash aid budgets are much smaller than food aid commitments. (Specific constraints on American Public Law 480 Title II, or Food for Peace, aid commitments are detailed in Chapter 5.) Since annual ceilings on cash commitments are low, financial services might be a way to transform low annual cash expenditures into larger budgets in exactly those years when specific crises, such as drought, strike. Provided that any funds received from drought insurance went to local and regional purchases of aid, the drought insurance might permit satisfy the law and permit greater cash assistance for emergency response. In practice most constraints on the uses of aid are both more complex than this stark example of American sourcing and shipping requirements for food aid. Constraints are also more likely to be political and less likely to be explicit.

3.4 Transparency

The third set of hypotheses revolves around the role that transparency played in the design of WFP and subsequent PSNP risk management decisions. Transparency is the inevitable result of a formal risk management decision. Humanitarian aid's appeals funding mechanism requires no particular transparency on the part of donors about their systematic goals or motivations for funding one program and not another. Bilateral aid is a political transaction between a donor state and a partner state, which places the humanitarian decision in the context of a political relationship between two governments, rather than an aid agency and a vulnerable population. Although reasons of state rarely manage to govern specific aid decisions, the appeals mechanism itself makes the donor's motivation opaque. An early, public commitment to provide contingent funding for drought relief, whether sourced through the private sector or directly from donors' budgets, can effectively settle the question of the immediate trigger for aid programs.

Discretion over donor aid is a potential stumbling block to effective collaboration for development. Donors and partner countries might have markedly different interpretations

of one another's motivations and plans for humanitarian programs. Explicit conditions, rather than discretionary donations, remove the incentives for parties to treat humanitarian aid as a political negotiation. Without explicit conditions, the Government of Ethiopia might take a wait-and-see approach to fuzzy donor commitments in support of the safety nets, rather than planning effectively to expand the safety nets in response to drought. Explicit conditions are the mirror image of monitoring and accountability: they provide the partner government with standards to judge what has been promised, rather than what has been delivered.

Country ownership is a key principle in the Paris and Rome Declarations on aid effectiveness. The Paris Declaration commits signatories to partner country leadership in developing broad and consultative strategies for both emergency and development assistance.⁵ There can be no sustainable coordination of complex multi-donor development efforts without the leadership of the host country. The partner country's strategy papers for poverty reduction must be accompanied by a firm commitment of funds, if they are to engender serious participation from stakeholders. Donor discretion over aid commitments works against the leadership of the partner country. So, donors must find a way to delegate authority to the multilateral aid process under the leadership of the partner country, without compromising the intent of the funds. Explicit triggers for contingent funds are a mechanism to achieve just that.

Partner country administrative costs, a third component of aid harmonization, are relatively straightforward. Partner countries generally have smaller staff, budgets, and resources than donor countries and IOs. Partner countries also face different accounting, monitoring and evaluation standards in different donor countries. In the Paris Declaration, countries committed to working through the public financial management and results assessment systems of partner countries.⁶ Rather than ask the partner countries to learn the administrative systems of multiple donors, donors must learn the systems of the coun-

⁵Development Assistance Committee, *Paris declaration on aid effectiveness and Accra agenda for action*.

⁶Ibid.

tries where they operate. Donors secured a reciprocal commitment to improve the partner countries' systems themselves, bringing them in line with international quality standards. Although it remains to be seen how effective these reforms will be, the result should be lower administrative costs and higher administrative quality.

Finally, there is the question of whether transparent commitments for conditional funding permit early allocation of resources: e.g., human resources, needs assessments, works project selection and the like. As the drought develops, the likelihood of the contingent fund's trigger should increase. If the structure of the IBRTP is known to all stakeholders and weather observations are widely available, then even rural stakeholders can update their beliefs about the likelihood of drought relief funds. This should enable them to adjust their participation in labor markets, their planning for additional works programs, and to begin the difficult work of targeting households for the PSNP. All of that work requires time and effort. There is no return on detailed planning for drought relief in a rainy year. Without the index, drought relief is conditional on a political deal to secure funding. When the index replaces donor discretion, the volatility of expected drought relief flows should drop, leading to increased incentives for rural MoARD staff to plan for the works projects.

3.5 Financial Market Function

When financial markets function well, they allocate investment to farms that are likely to produce valuable outputs. Following shocks to output or assets, formal financial services permit farmers to rebuild productive asset stocks. During times of difficulty, asset stocks can be drawn down in order to preserve a necessary consumption for sustained productivity.

PSNP and WFP before it had ambivalent function as financial institutions. PSNP was not the main insurance vehicle for farm output. In one sense, it did provide farmers some insurance, simply by virtue of the safety net's existence. Consider a farmer with the ability to spend a bit of savings on fertilizer that costs money but could increase the productivity of

his field. Without the safety net, he might be reluctant to draw down savings for marginal investment. If the likelihood of drought is high, he might be reluctant to sink liquid assets into the field, since the marginal impact of fertilizer on a drought-stricken field is nearly zero. Liquid savings could determine how many weeks his food budget will last during a drought.

Safety nets mitigate the farmer's need to hold onto savings by providing ready access to cash and food if a drought occurs. The predictability of these safety nets, and the timing of cash payments for works projects, are of enormous significance in the farmer's decisions about risky agricultural investments. Even if the fertilizer is certain to raise expected incomes, it is not certain that the farmer's optimal decision is to invest in fertilizer with rain-fed agriculture.

PSNP's next program for households with more assets is the HABP. Consider now a better-off farmer, who has enough assets to invest some in productive capital and preserve a bit left over for her family, in case of drought. She faces different risks by dropping her capital into the field. If the harvest is bad, she loses productive capital. Rather than facing hunger this year, she faces permanently lower income from the loss of a draft animal or a few head of livestock.

The safety nets function as a way of mitigating downside risk if farmers trust that works projects will supply cash for consumption in hard times. PSNP monitors the timeliness and reliability of payments to workers in the safety nets programs. Without timely and reliable payments, the edifice of higher investment, higher incomes, and sustainability crumbles.

Chapter 4

Methods

4.1 Introduction

This study is a single, inferential case study. The primary sources of information are project documents and interviews with decision makers on the project. The track record of implementation is too short to shed light on any but the most basic outcomes of either WFP and PSNP.

The major barrier to study of the WFP drought insurance pilot was the absence of a payout; which made it impossible to search for effects of the financing decision on implementation and project outcomes. It effectively limits inference to questions of designers' intent, rather than pragmatic effects on drought relief.

PSNP gives the first opportunity to judge project performance against the criteria set out in the project design. And since this risk financing approach has only been implemented in Ethiopia, it will not always be possible to distinguish between the idiosyncrasies of PSNP Ethiopia and the impact of risk financing on project outcomes. For example, the history of humanitarian operations in Ethiopia, the unique relationships between the Ethiopian government and the international community, and simple path dependence (policy inertia) could all play a role in PSNP design, PSNP institutional capacity, and project outcomes.

Since data about project outcomes are so thin, I have placed substantial weight on interviews with project stakeholders. These interviews are designed to provide data on the mental models that project managers have with regard to project design. They explain how managers understand their organization's interests in risk financing decisions. They explain how managers' decisions are constrained by financing decisions. They also illuminate the evolution of project design over a short period of years. In an ideal setting, these perceptions could be evaluated against a long track record of project outcomes; but without that track record, I can only draw inferences based on project evaluation documents and interviews.

4.2 Case Selection

Only the World Food Program's drought insurance pilot, at the time I submitted the proposal, had successfully reviewed bids and sourced private insurance for humanitarian risks indexed to seasonal weather. Although a variety of other models had been implemented, they were relatively remote parallels for WFP drought insurance. Micro-scale index-based insurance products offered farmers the opportunity to offset their risks directly. The underwriters for these projects were, variously, state agencies, state-owned enterprises, private enterprises, and special collaborations between donors and states. A few states had hedged weather and commodity risks on private markets. These states did not source their budgets from donors, as did WFP and subsequently PSNP. Only the Ethiopian case involved an international group of donors and a partner country hedging (or insuring) the weather-related risk of emergency humanitarian operations.

In the language of George and Bennett, this is a heuristic case study.¹ It identifies an outlier, i.e., the only case where a multilateral organization has opted to adopt weather risk management as the basis on which to arrange for drought relief funding. The purpose of

¹Alexander L George and Andrew Bennett. *Case Studies and Theory Development in the Social Sciences*. BCSIA studies in international security. Cambridge, Mass: MIT Press, 2005. ISBN: 0262072572.

such a case is to discover causal mechanisms. Only the weakest form of hypothesis testing, the rejection of necessary conditions for the specified outcome, is possible.

Heuristic case studies use process tracing to assess several steps in a causal chain. Where statistical methods may only measure the inputs and outputs of a political process or institution, rich detail from a case study provides three other inferential methods: inductive reasoning from similar cases, Bayesian inference based on prior expectations, and assessment of equifinality. These methods all rely on a careful picture of the causal chain for each hypothesis. In this case the progression from vulnerability analysis and mapping, to WFP drought insurance pilot, to PSNP risk financing provides a measure of insight into the goals and interests of various players in the study. Interviews with various stakeholders and careful reading of project documents and evaluation provide that detail.

Munck describes a five-stage process for case study research.² His method entails defining the universe of cases, selecting cases for study, adopting and executing a measurement strategy, and iterative hypothesis development and research. Munck cautions that social science observations are often theory-laden; therefore hypothesis construction and the empirical strategy embed assumptions about the causal dynamics at play in the study. The observer's choice of negative cases, meaning relevant cases where the outcome are conditioned on expectations about what makes the case relevant.

The reason that I chose a single case study for this topic is exactly that: without knowing what aspect of Ethiopian food assistance drives the international community to adopt weather risk management, any of the available comparisons might introduce spurious comparisons. Other available comparisons include private sector reinsurance, non-agricultural applications of weather derivatives, catastrophe bonds, state-underwritten index-based reinsurance to local governments and coops, micro-scale index-based insurance, and privately sourced index-based insurance. It is not clear that risk management decisions at the WFP or PSNP have anything to do with those for private reinsurance, or for national agricultural

²G. L. Munck. "Tools for qualitative research." *Rethinking social inquiry: Diverse tools, shared standards* (2004), pp. 105–21.

policy, or for microfinance product design and implementation.

For illustrative purposes only, consider a reframing of the same research topic, i.e., the reason for innovation in weather derivatives in Ethiopia. The Disaster Preparedness and Prevention Agency (DPPA) that oversees PSNP originally collaborated with the Vulnerability Analysis and Mapping office (VAM) of WFP, the Disaster Risk Reduction (DRR) group of the World Bank, and two disaster management groups of USAID, OFDA and FEWSNET. Contingent funding for DPPA could be considered one of a spectrum of disaster risk management strategies. Weather derivatives could be analyzed in the context of the Hyogo protocol and all of its intended priorities, rather than through the lens of financial markets. The crucial features then would be the performance of the project on the Hyogo protocol's five main points: political support for risk management, risk assessment, institutional capacity for risk awareness, prospective risk reduction, and disaster preparedness. This lens of analysis would lead to a completely different set of hypotheses and cases for comparing weather risk management. The judgment about which countries could have implemented weather derivatives but did not is deeply informed by the investigator's claims about the reasons for the innovation. First, this study of Ethiopia's weather risk management should validate the understanding that all parties have of the roles of insurance, contingent financing, and vulnerability analysis. Subsequent studies can assess the performance of the specific assets designed to mitigate safety net risks in the context of appropriate comparators of which there are surprisingly few. The process described by Munck is what I have sought to enact here: document analysis and interviews with decision makers to inform my hypotheses about the reason for adopting this risk management strategy; followed by iterative adjustments to the hypotheses as new features of the model come to light.

4.3 Documents

4.3.1 Project Documents

WFP provided me with access to project documents from Ethiopia's Country Program, Protracted Relief and Recovery Operation, and other simultaneous operations in Ethiopia. In addition, they shared an internal report comparing advance funding mechanisms of the WFP.

The World Bank is the chair of the Donor Assistance Group for Ethiopia, which oversees the collaboration with MoARD on the PSNP and other donor-funded programs in Ethiopia. The World Bank's staff shared with me an internal review of the PSNP dated September 2009, which describes completely the organizational relationships, financial arrangements and status, project goals, and monitoring documentation of the project.

Papers by key figures in the WFP, World Bank, and DFID disaster risk management community provided both theoretical insight and focused comparisons to aspects of the WFP drought insurance. Ulrich Hess, Tim Robertson, Joanna Syroka, Will Wiseman, and Richard Wilcox have all written discussion papers, reports, and academic papers explaining how risk management benefits various functions of governments and multilaterals in response to natural disaster.

Industry assessments showed how conditions in local and global markets could have affected the choices available to WFP, the Government of Ethiopia, and various other stakeholders. Chief among these were the ILO report on Ethiopian insurance and the PricewaterhouseCooper annual assessments of the global weather risk market for the Weather Risk Management Association.

Sandro Calmanti also shared with me his preliminary results on the second generation LEAP index, which forecasts beneficiaries from precipitation data in Ethiopia. These forecasts are the inputs to the risk financing agreements structured by the World Bank and the Donor Assistance Group for incremental drought forecasts.

4.3.2 Datasets

A number of publicly available datasets on economic development and humanitarian aid further contributed to the analysis. USAID publishes annual funding streams for bilateral foreign assistance, including the separate titles of Public Law 480 food aid, maternal-child health, and HIV programs, in the Green Book.³ Separately, it publishes the funding position of complex emergencies at its website.⁴ Donor funding levels for PSNP are taken from the World Bank's interim report on the PSNP in 2009.⁵ Funding positions of UN appeals are available at ReliefWeb.⁶

4.4 Interviews

4.4.1 Interview Method

I based my interview strategy on grounded theory.⁷ Grounded theory attempts to discover the mental models that the subject uses to analyze an experience or a case. Developed for psychology and sociology, it is also an appropriate tool for analysis of managers' decision frames.

³Inc. DevTech Systems and United States Agency For International Development. *U.S. Overseas Loans and Grants*. Dataset. June 2009. URL: <http://gbk.eads.usaidallnet.gov/>.

⁴Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 2. United States Agency for International Development, May 2008; Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 6. United States Agency for International Development, Apr. 2009; Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 8. United States Agency for International Development, June 2009; Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 7. United States Agency for International Development, May 2009; Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 5. United States Agency for International Development, Mar. 2009; Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia-Complex Emergency*. Situation Report 9. United States Agency for International Development, July 2009; Bureau for Democracy Conflict and Humanitarian Assistance, *Ethiopia-Complex Emergency*.

⁵World Bank. *Project appraisal document*. Report 48633-ET. World Bank, Sept. 2009.

⁶ReliefWeb. *Ethiopia: Multi-Sectoral contingency plan, january to june 2010 – joint government and humanitarian partners' national contingency plan*. Dec. 2009. URL: <http://www.reliefweb.int/rw/rwb.nsf/db900sid/AMMF-7YRS3C?OpenDocument&rc=1&cc=eth>.

⁷B. G Glaser and A. L Strauss. *The discovery of grounded theory*. Aldine Chicago, 1968; K. Charmaz. "Grounded theory." *Strategies of qualitative inquiry*. Ed. by J. F Gubrium and James A Holstein. 2003, p. 249.

Grounded theory interviews consist of five stages. The researcher prepares for the interview with a list of topics he or she hopes to discuss with the subject. In my case, this preparation included a review of the research hypotheses and the specific project authority held by the interview subject. During the interview, I hoped to learn information about relevant decisions, interests, and experiences for my research.

Second, the interview begins with open-ended questions. These questions elicit the subject's impressions of the project under study. Open-ended questions identify concrete and abstract topics the subject believes are related to the project in question. Third, the interviewer raises a topic of theoretic interest, such as decisions under uncertainty or the substitutability of various funding windows. The questions remain open-ended, but the topic is much more specific and placed in context of the researcher's model. Fourth, the researcher asks evaluative questions. Evaluative questions ask the subject to discuss the importance, relevance, or accuracy of assumptions and inferences of the researcher's model. These questions are somewhat more closed in form than the first two categories, but ideally they should give the subject an opportunity to endorse, augment, clarify, dispute, alter, and otherwise alter the researcher's analysis of the project.

Finally, the researcher should transcribe the interview and review project notes personally before discussing the interview with other researchers. The researcher's fresh notes provide a unique opportunity to capture the subject's comments, vocabulary, assumptions, and inferences about a problem. When conversations with other researchers precede this step, there is a danger that the researcher will tend to privilege assumptions shared with other researchers, interpreting interview transcripts in that context.

Interviews were conducted exclusively on the actions and opinions of subjects in their professional capacity. No effort was made to discern any personal information about them outside the office. Interviews were recorded whenever technology permitted and subjects consented. When subjects did not consent, I relied instead on handwritten notes from the interview. Subjects uniformly preferred not to be quoted directly from the interview,

although I am free to discuss the interviews in the dissertation.

4.4.2 Subjects

I sought interviews with five classes of organizations. Both WFP and PSNP had individuals responsible for the program direction and for vulnerability analysis. At WFP, I needed to interview several departments of the Rome staff, concerning business risk, Ethiopia projects, logistics, and donor forecasting. I also met with the vulnerability analysis and mapping staff in Addis Ababa, as well as a number of their partners at FAO, OFDA, and MoARD. At PSNP, I interviewed two key officials within the MoARD who head the household asset building program and food security assessments. It was not possible to meet with the head of disaster risk management (DRMFSS) despite several entreaties from partners on the ground. It was not possible to meet with Ministry of Finance officials during the visit; but the finance ministry is essentially a conduit for PSNP funds. It does not have control over allocation of funds, targeting, or the selection of projects for works programs.

On the donor side, I interviewed representatives of the World Bank, USAID, and DFID. I met with contractors to both PSNP and USAID. These interviews were conducted over a period of two years, including both site visits and phone conversations. I decided against meeting with any beneficiaries for a variety of reasons. First, logistical barriers (time, expense, language) were prohibitive. Second, beneficiaries were not directly affected by the financing decisions of the WFP or the PSNP. The project outcomes are of course determined by impact on beneficiaries' lives, so ultimately their experience is the one that truly matters. However, I did not see evidence of a direct beneficiary interaction with either WFP drought insurance or the negotiation of risk financing for PSNP.

At every stage of the interview process, the key was to ascertain whether the incentives and mental models used by managers of the various stakeholders matched the theoretic predictions and project literature. The primary purported benefits of contingent funding instruments are rapid settlement, transparent donor decisions, and early planning for dis-

aster response. Interviews show whether managers share financier's beliefs about these purported benefits, and what other political incentives might have affected decisions to participate in the program.

PSNP's overarching strategic goal is to support sustainable rural development in Ethiopia. The Government of Ethiopia and the donors have a strategy for improving rural livelihoods, with the ultimate objective of reducing the population of beneficiaries facing chronic food insecurity. PSNP is one element in a layered approach to improving productivity, managing agricultural and pastoral risks, and providing social safety nets for those who cannot cope with poor soils, rising population density, adverse market conditions, and natural disasters.

4.4.3 Narrative

During the fall of 2007, I studied the theoretical background for the WFP drought insurance in the context of humanitarian assistance. The use of weather derivatives was clearly innovative in the global public sector, but it was old news to American firms. Weather derivatives had clearly been used to reinsure crop yield risk in the United States, but it turned out that the market was dominated by energy, power, and construction companies. Why, if so many industries in the United States had access to these financial instruments, did governments eschew them? One answer revolved around the deep pockets of rich countries: why insure when you can simply borrow from the public at the risk-free rate? Another answer revolved around the limited resources of poor countries: why insure risk when perennial disasters outstrip your budget? The UN system fit neither of these models: its funding depended on the political will and financial resources of donors, both public and private. It was not clear from the outside what financial tools the WFP had at its disposal to smooth donations for emergency relief; or what the benefits of such a strategy would be.

I contacted the WFP headquarters in early 2008, and received an invitation from Ulrich Hess, the chief of business risk for WFP, to visit his Rome office. He and his staff briefed me on the purpose and outcomes of the project. They provided me with contextual informa-

tion about WFP financial strategies, including donor relations and emergency procedures. Their 2005 review of advance funding mechanisms turned out to be a key document. It detailed the sizes and purpose of various advance funding mechanisms, and the strategic concerns of WFP related to each one.

Development of the LEAP algorithm continued under the direction of the Vulnerability Analysis and Mapping department after the drought insurance pilot wound down. Hess's office encouraged me to learn more about the LEAP algorithm's development and its application to livelihoods risk for other donors in Ethiopia. LEAP was to be instrumental in the assessment of donors' contingent commitments to the PSNP, which had been ongoing since 2005.

As I sought funding for a trip to Ethiopia to learn more about the PSNP, I read what I could about the project from Boston. There were some impact assessments that contained useful reviews of specific project dimensions, but obtaining a clear picture of the project turned out to be less than straightforward. PSNP's lead agency is the Ethiopian government's Disaster Risk Management and Food Security Service, but its website is maintained under its former name, Disaster Preparedness and Prevention Agency. My efforts to contact Ethiopian offices of various partners, even with introductions from WFP's Rome office, proved ineffective. In the meantime I interviewed senior managers and technical experts from WFP, DFID, and the World Bank.

Once the dissertation proposal had been approved in October of 2009, I made arrangements to visit Ethiopia. Due to funding constraints the only visits I would be able to make were to offices in Addis Ababa. In two weeks of January-February 2010, I visited MoARD, WFP, USAID, USAID/OFDA, CARE, Save the Children (US), Nyala Insurance, and FAO.

Chapter 5

Analysis

5.1 Project Background

WFP's main project in Ethiopia is Protracted Relief and Recovery Operation (PRRO) 10665.0, titled Responding to Humanitarian Crises and Enhancing Food Security.¹ The PRRO is a nationwide program for Ethiopia, although relief operations are regionally concentrated where the impact of drought is greatest, as in Afar, Amhara, Gambella, Oromiya, Tigray, SNNPR, and Somali regions. A separate but concurrent emergency operation handles the influx of Somali refugees. PRRO 10665.0 has four major programs in Ethiopia: safety nets, relief operations, targeted supplementary food, and urban HIV/AIDS. Both safety nets and relief operations address acute food insecurity. The size of the PRRO in 2007 was forecast at \$561 million over three years, of which \$275 million was food, to cover 3.8 million beneficiaries annually.² The PRRO is explicitly designed to assist the Government of Ethiopia's antipoverty campaign and safety net, respectively termed Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) and Productive Safety Net Program (PSNP).

Money spent on food security programs represents a liability for both WFP and PSNP.

¹World Food Program, *PRRO 10665.0*.

²Ibid.

WFP			PSNP		
ASSETS		LIABILITIES	ASSETS		LIABILITIES
PRRO funding from donors		Development programs and PRRO	Donor funds via MDTF		Cash and food for safety nets
Emergency appeals		Needs assessment and emergency operations	Bilateral donor funds		Livelihoods assessments
Internal financing mechanisms		Repayment of internal financing mechanisms			Beneficiary forecasts
(Drought insurance payout)		Drought insurance premium	(Risk financing)		(Incremental cash and food for safety nets)

Parentheses indicate weather-dependent cash flows.

Table 5.1: Stylized cash flows of WFP and PSNP

Under PSNP, which identifies its program expenditures somewhat more clearly than did WFP, any contingent funds promised for drought relief would constitute an expansion of the safety nets program, meaning a combination of works programs and cash transfers to households. Emergency operations at WFP are highly variable, occurring whenever drought and other events push beneficiaries below the threshold of food security. PSNP shares the same commitment to reach beneficiaries falling below a livelihoods threshold, since the safety net contains provisions for incremental expansion as the drought index predicts a greater number of beneficiaries. Each organization's uncertain liabilities result directly from a political commitment to provide assistance to beneficiaries that face food insecurity. Each organization's uncertain assets result from donors' commitments, implicit or explicit, to provide funds for those programs.

5.1.1 Drought Insurance Pilot

Drought insurance was originally a strategy for WFP to provide early access to contingent capital in 2006. Internal reviews of financial mechanisms had pointed out limits to the availability of funds for crises. Though the worst emergencies could occasionally elicit

surpluses of funds, WFP could not predict in advance which emergency appeals would be funded and when. Risk management provided a proactive way to leverage donor funds for emergency access.

WFP elected to use a custom drought insurance strategy. The weather insurance pilot required the participation of a number of partners. USAID paid the premium on behalf of WFP to a French reinsurance company, Axa Reinsurance. Nine bids were received, of which six were evaluated and Axa Reinsurance's was selected.³ The identities of the other companies that submitted proposals were not made public. The weather insurance WFP obtained in 2006 was structured as follows.⁴ The value of the policy was determined by seasonal rainfall in Ethiopia, measured by 26 weather stations throughout the country. WFP obtained parametric coverage for livelihoods assistance, worth up to \$7 million for the 2006 rainy season. The funds were sufficient to offset a crop failure affecting up to 310,000 farmers. The baseline forecast for food insecure populations at WFP Ethiopia was 8 million; and severe droughts can double that number.

5.1.2 Productive Safety Net Program

Following the end of the pilot drought insurance project, pilot's weather index algorithm was folded into the omnibus rural livelihoods project in Ethiopia, the Plan for Accelerated and Sustainable Development to End Poverty. PASDEP is the second phase of Ethiopia's Poverty Reduction Strategy, following the Sustainable Development and Poverty Reduction Program that ended in 2005.⁵ The largest element of the PASDEP Food Security Program is the Productive Safety Net Program (PSNP), and development workers casually refer to the entire Food Security Program by the name PSNP. PSNP supplements incomes

³World Food Program. *Final Report on the Ethiopia Drought Insurance Pilot Project*. Executive Board Documents WPF/EB.1/2007. 2007. URL: <http://one.wfp.org/eb/docs/2007/wfp113643~1.pdf>.

⁴Ibid.

⁵Government of Ethiopia, *Ethiopia: Building on Progress A Plan for Accelerated and Sustained Development to End Poverty (PASDEP)*.

for food-insecure rural households with jobs programs and direct transfers. It is administered through the Ministry of Agriculture and Rural Development. Using funds from the Development Assistance Group (DAG), MoARD's woreda and kebele boards select works projects and target specific households. MoARD has both woreda and kebele level organizations that are responsible for carrying out the day to day activities of the PSNP, contributing analysis to the beneficiary forecasts, and targeting.

PASDEP's strategy is to graduate participants from the program after a period of participation. Through a combination of temporary assistance, education, and asset building, the program prepares households to provide for themselves in the future. Households in the program aim to build up sufficient assets that they can both (1) improve productivity and (2) absorb losses from bad harvests, without having to sell off vital productive assets.

PSNP's donors are USAID (USA), the World Bank, DFID (UK), CIDA (Canada), IA (Ireland), EC (Europe), RNE (Netherlands), WFP, and SIDA (Sweden). Major NGOs implement bid for contracts under PSNP, including various aspects of early warning, works programs, household assets programs, monitoring and evaluation. The weather contingency comes principally from the United States and the World Bank (see 5.2). These are also the two largest PSNP donors excluding the risk financing, together accounting for more than half of safety net funds.

Risk financing instrument

Starting in 2008 PSNP incorporated a risk financing element. This part of the project laid out explicit conditions under which PSNP would expand in years of bad rain. Risk financing expands the budgets for the safety net portion of the PSNP, specifically works programs and direct transfers. PSNP risk financing used the LEAP algorithm to calculate the size of annual increases to the PSNP. WFP's Vulnerability Analysis and Mapping (VAM) department created the original EDI that underlay the drought insurance and adapted it for use in Ethiopia as the LEAP index. The algorithm forecasts the number of food insecure house-

Program	CIDA	DFID	EC	IDA	IA	RNE	SIDA	USAID	WFP	TOTAL
Safety net grants	68.0	218.8	73.2	398.5	68.8	66.3	21.5	457.0	50.0	1422.1
Risk financing	0.0	31.5	0.0	50.0	0.0	0.0	0.0	73.9	0.0	155.4
Support to PSNP	13.8	32.0	5.5	14.0	5.0	5.0	1.5	0.0	0.0	76.8
Support to HABP	0.0	41.8	0.0	17.5	0.0	0.0	0.0	0.0	0.0	59.3
Total	81.8	324.1	78.7	480.0	73.8	71.3	23.0	530.9	50.0	1713.6

Source: World Bank

Table 5.2: PSNP spending by donor.

holds based on daily rainfall observations.

Three tranches of increased PSNP funding are available to compensate for drought. The tranches are triggered based on the MoARD beneficiary forecast, which is an aggregate of estimates of beneficiaries at the woreda (county) and kebele (village) levels. MoARD creates the baseline forecast annually prior to the beginning of the main (meher) rainy season. MoARD uses the current iteration of the LEAP algorithm. At the midpoint of the meher rains and the end of the meher rains, MoARD updates the beneficiary forecasts. At the end of the meher rains, risk financing tranches are triggered if the beneficiary counts rise by 50%, 100%, and 150%.⁶

Activities

The vast majority of PSNP funds support public works projects and cash transfers, with remaining funds going toward capital budgets, administrative support, and annualized costs of contingency programs related to the same objectives.⁷ Neglecting administrative expenses and multi-year contingencies, the ratio of public works to direct support (food and cash transfers) is about four to one.

The major activities of the PSNP fall into three categories. The largest category of PSNP operations, accounting for 73% of funds, is the safety net program. Safety nets include both works projects and direct support. Works projects employ households that are at risk of food insecurity to product community assets, meaning infrastructure. Households

⁶IDL Group Risk Financing Mechanism. *Final Guidelines for the PSNP Risk Financing Mechanism in Ethiopia*. World Bank. Apr. 2009.

⁷World Bank, *Project appraisal document*.

Program	Cost	Percent
Safety Net Grants	1098.3	77.40%
Drought Risk Financing	160	11.28%
Support to PSNP	77.4	5.45%
Support to HABP	83.3	5.87%
Total	1419	100.00%

Source: World Bank

Table 5.3: PSNP budget by program

that cannot participate in the works projects may receive direct support, i.e., transfers of cash or food.

Safety net activities are targeted at families that are at risk of falling below a survival threshold, which is a consumption measure accounting for caloric sufficiency, water, and cooking fuel. Procedures for sampling and calculating household income are detailed in manuals from the Livelihoods Integration Unit (LIU), a collaboration of USAID and the Government of Ethiopia's Disaster Risk Management and Food Security Service (DRMFSS) (formerly Disaster Prevention and Preparedness Agency, DPPA).⁸ PSNP's drought contingency does not target the poorest of the poor, who face chronic, annual food shortages. The population targeted are those on the brink of self-sufficiency, who are at high risk of losing or liquidating those assets during the onset of the crisis.

Safety nets are implemented through woreda offices of the MoARD. Village councils decide the list of households to be targeted for direct support and works projects. They also decide the priority of community needs for works projects.⁹ The financial and project offices are separated; and procurement of materials and services occurs through competitive bidding processes detailed in the World Bank's procedures and Ethiopian law.¹⁰ According to the World Bank's project documents, the line of financial transfers occurs through the hierarchy of the Ministry of Finance; and reporting on project activities occurs in parallel

⁸Livelihoods Integration Unit and Disaster Risk Management and Food Security Service. *Seasonal Assessment Manual*. United States Agency for International Development and Government of Ethiopia. Sept. 2009.

⁹World Bank, *Project appraisal document*, p. 94.

¹⁰Ibid., p. 110.

through the hierarchy of the Ministry of Agriculture.¹¹ Each procurement contract must have plans, bids, and bid evaluations proposed and approved by separate authorities.

The second major portion of PSNP is the household asset building program (HABP). HABP provides financing, education, market linkages, and other services to households in danger of falling below the livelihoods sufficiency threshold. The livelihoods sufficiency threshold is a level of income above which households have access to sufficient consumption goods that they can afford to invest in productive assets for the future. The objective of HABP is to improve the productivity of small businesses and to diversify household income. Market linkages, subsidized inputs, financial services, and education all have a role to play in HABP. This strategy improves the chances that households can build up assets and eventually graduate from the PSNP. HABP is the linchpin of the PSNP's approach to sustainability. Without it the chances of household graduation are slim.

The third broad category of programmatic expenditure is the PSNP's institutional support for MoARD. Donors and MoARD agree that Ethiopian institutional capacity is crucial to the success of the PSNP. Donors assist MoARD in improving administrative and financial processes related to PSNP, to improve the efficiency of the program and ensure that MoARD achieves its policy objectives.

Outcomes

PSNP has delivered positive outcomes, though somewhat smaller than might have been expected. Gilligan, Hoddinott, Kumar, and Tafesse, in a 2006 impact evaluation, report positive effects on food security (measured in months), growth in livestock holdings, and ability to obtain cash in an emergency.¹² Together with non-PSNP programs (OFSP, for Other Food Security Programs) beneficiaries receiving the highest quantity of assistance in a panel survey managed to improve food security by half of a month, and to improve

¹¹World Food Program, *Ethiopia Country Office Food Security Update*, p. 106.

¹²Daniel O. Gilligan et al. *An Impact of Ethiopia's Productive Safety Nets Program*. Washington, D.C., June 2009.

the value of livestock holdings by 14%. On a different measure of food availability, caloric acquisition, PSNP performed even better, providing 30% improvement compared with non-beneficiaries.

Gilligan et al. also report an absence of perverse incentives. Beneficiaries are just as likely to own businesses and participate in private labor markets. Safety nets do crowd out private transfers occurs, as might be expected, but they also crowd in private transfers when safety net payments are irregular suggesting that beneficiaries are better able to draw on informal mutual insurance when expectations of future income rise. PSNP has not been able to ensure timely payments to workers. While the problem has improved between 2006 and 2008, some households had received only one payment despite working for five months.

Sustainability has been an issue for the project. While evaluators largely agree that community assets have value, the project had lofty goals for graduating half of participants in ten years. While there has been significant churn among beneficiaries (meaning that households exit the program and others enter), formal graduation has occurred only rarely. Food price spikes since 2006 have contributed to the difficulty of graduation, forcing households to allocate higher earnings to food budgets and away from asset growth. USAID created its own program, PSNP-PLUS, outside of the HABP, to provide specific financial and business services aimed at increasing graduation rates in 2008.¹³

5.1.3 Food Aid in Ethiopia

Food security in Ethiopia has been a major political issue both through the centuries and especially since the 1960s. Food aid in Ethiopia predates the Productive Safety Net Program, the current government, the Development Assistance Group, the World Food Program, USAID, essentially the entire cast of the current drama. Webb and von Braun explicitly

¹³United States Agency for International Development. *USAID, CARE Launch PSNP PLUS to Improve Micro-Finance and Market Linkages*. Website. Mar. 2009. URL: <http://ethiopia.usembassy.gov/pr1209.html>.

link the famine of the 1970s to the fall of the monarchy to the Derg regime; and that of the 1980s to the fall of the Derg in their turn.¹⁴ And politics has important feedbacks to food security. Many Derg policies crippled agricultural and pastoral livelihoods: to name a few, land reform, forced settlement of pastoralists, prohibitions on internal movements of food commodities, crop quotas for rural zones, and the loss of crucial inputs such as draft animals and skilled workers. Clay and Holcomb even claim that food aid has facilitated government control over the population: through facilitation of population displacement and forced settlement policies; through increased government access to remote and formerly autonomous areas; and through the economic power it affords a politically powerful minority.¹⁵ They wrote in 1986, “The provision of ‘humanitarian’ aid with no questions asked helps the Ethiopian government get away with murder.¹⁶”

WFP was founded in 1961 in order to coordinate donors’ food aid for development and emergency relief.¹⁷ Large grain surpluses in donor countries were a cheap source of donor aid. Contributions from member states began and remain voluntary; although the proportion of cash aid has grown significantly since the 1960s. WFP focused on delivery of donors’ food aid to partner countries, and it remains the largest single transporter of international food aid commodities. At the time of its founding, WFP was a means to ensure voluntary participation in a coordinated, international mechanism for the distribution of food aid. In the intervening decades, many donors (but notably not the United States) refocused food aid away from international shipments of food commodities and onto cash supports for food security programs.

Borchgrevink’s review of donor conditionality in Ethiopia contains a useful summary of donors’ attempts to influence Ethiopian politics via aid programs and the withholding

¹⁴Webb and Braun, *Famine and Food Security in Ethiopia*, p. 42.

¹⁵Jason W Clay and Bonnie K Holcomb. *Politics and the Ethiopian Famine, 1984-1985*. Rev. ed. Cambridge, MA (11 Divinity Ave., Cambridge 02138): Cultural Survival, 1986. ISBN: 0939521342, p. 192.

¹⁶Ibid., p. 193.

¹⁷Mitchel B Wallerstein. *Food for War-Food for Peace: United States Food Aid in Aglobal Context*. Cambridge, Mass: MIT Press, 1980. ISBN: 0262231069, p. 85.

thereof.¹⁸ In rough terms, aid levels halved during following the collapse of the Derg regime in 1991, which coincided with the end of the Cold War. Aid levels rose rapidly between 1998 and 2005, the last year of Borchgrevink's study, although total aid rose much faster than humanitarian aid during this time. During this time, successive droughts in 2003 and 2005 brought large interventions, and Borchgrevink points to the role of Ethiopia as a bulwark of regional stability.

In sum, then, in the years 2000 to 2005, Ethiopia experienced a strong increase in international aid. This increase may be explained by the end of the war with Eritrea, Ethiopian relief needs, the country's strategic importance in the war on terror, and donor support for the PRSP processes.¹⁹

Debt relief partially explains the rapid rise in aid volumes. Ethiopian debt relief under Highly Indebted Poor Countries (HIPC) and Multilateral Debt Relief Initiatives (MDRI) totaled \$6.6 billion through 2008.²⁰ Between 2001 and 2008, annual debt service fell from \$196 million to \$37 million (or 2.5% to 0.1% of GDP), and poverty reducing expenditures rose from \$0.7 billion to \$2.5 billion (9% to 13% of GDP). Debt forgiveness and food aid are lumped together under official development assistance, meaning that the debt cancellation can introduce a spike in ODA when food aid and other programs on the ground continue smoothly. Ethiopia reached its HIPC completion point in 2004, just between the droughts of 2003 and 2005. Although aid to Ethiopia rose steadily during the early 2000s, the headline ODA number masks marked variation in the constituent food aid and debt cancellation figures.

¹⁸Axel Borchgrevink. "Limits to Donor Influence: Ethiopia, Aid and Conditionality." *Forum for Development Studies* 35.2 (2008).

¹⁹Ibid., p. 210.

²⁰International Development Association and International Monetary Fund, *HIPC and MDRI Status of Implementation*, p. 39.

5.1.4 Insurance Markets

The evidence points against WFP or PSNP taking advantage of a market opportunity in procuring weather insurance. There is no evidence that weather insurance lowered the average cost of funds for WFP or PSNP, and there is no evidence of a rapid supply shock for index-based risk transfer products for Ethiopia. Rather than the market driving WFP or PSNP decisions, the reverse is clearly the case. WFP's investment in weather risk represented a foray into private markets exactly for the purpose of price discovery (which was found to be too high). The limited Ethiopian market for private weather risk draws heavily on international organizations' expertise. Ethiopian private weather insurance trials began after PSNP's began using WFP income shock forecasts. The primary concern for Ethiopia's private insurers is whether they can generate demand for the products they are selling.

The Chicago Mercantile Exchange (CME) first listed weather derivatives in 1999, and the securitized market for weather risk grew aggressively.²¹ PricewaterhouseCooper's 2006 survey indicated the weather risk market rose from \$2.5 billion in 2001 to \$45 billion in 2006.²² The mean contract value in the survey is roughly \$1 million. Total trades outside of the United States, Europe and Asia accounted for under 1% of the weather risk market. Since 2006, the US market has crashed by two-thirds, although there has been some modest global growth in weather derivatives (not in Ethiopia).²³

The majority of weather risk contracts are not used in agriculture.²⁴ While weather risk products are useful for agricultural reinsurance, farmers generally cannot tolerate the high level of basis risk introduced by microclimatic variation. A few degrees and a few inches of rain can make a large difference in crop yields; but weather station data often differs systematically from farmers' microclimates. Larger tracts of farmland suffer less covari-

²¹Calum G. Turvey. "The Pricing of Degree-Day Weather Options." *Agricultural Finance Review* 65.1 (2005), pp. 59–85.

²²PricewaterhouseCoopers. *Weather Risk Management Association Survey Results*. June 2006. URL: <http://www.wrma.org/wrma/library/PwCResultsJune222006.ppt>.

²³Storm. "News Analysis: Weather Derivatives Volume Plummetts." *Storm* 43 (June 2009). URL: <http://www.wrma.org/pdf/weatherderivativesvolumeplummetts.pdf>.

²⁴PricewaterhouseCoopers, *Weather Risk Management Association Survey Results*.

ance with reference temperature and precipitation data series. Energy markets, electrical power and construction all transacted larger shares of weather derivatives, which include temperature and precipitation.

The sequence of risk financing decisions in Ethiopia does not fit with a story about market opportunities. Although the original drought insurance pilot was placed for competitive bid, the PSNP risk financing program was not. PSNP apparently did not have either the means or the interest to obtain private financing for the safety net, and instead obtained conditional commitments for public funds from the United States, the United Kingdom, and the World Bank. If a global market opportunity had existed, supply for these contracts should have been relatively easy to obtain. If capital to insure these contracts were scarce, insurers should have been able to charge premium rates for the service and set triggers closer to catastrophic risk levels, as they did in the original WFP contract.

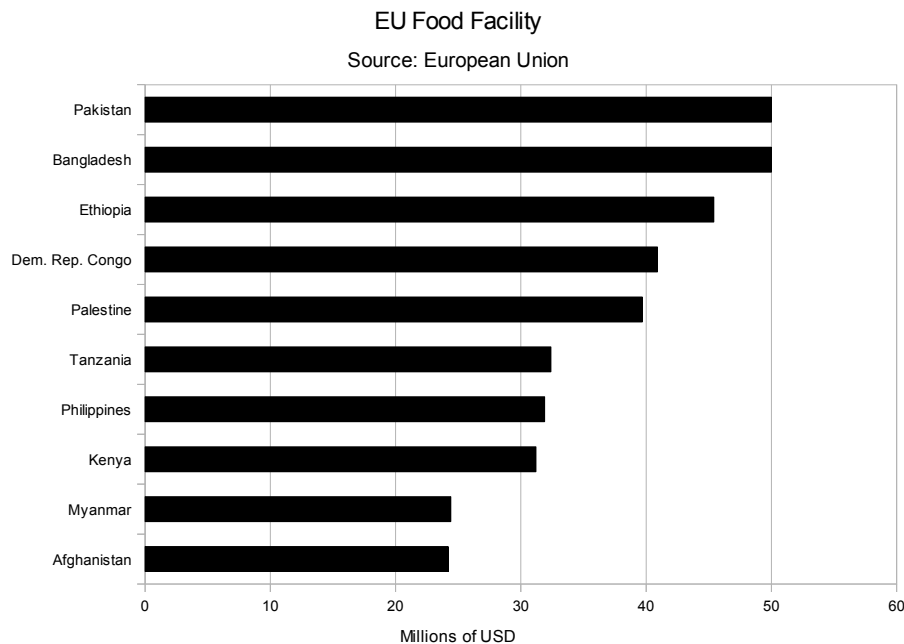


Figure 5.1: Top recipients of the EU Food Facility

The other major market trend at the time of the 2008 PSNP risk financing payout was the food price crisis. Sharp rises in world food prices contributed to riots in several coun-

tries across Africa and South Asia. The World Bank, the EU, and the United States each launched a separate facility for response to the food price crisis. Ethiopia was among the top five recipients of the Bank's and the EU's facilities for the food price crises. Ethiopia alone accounted for more than one-fifth of the Bank funds available, and more than 5% of global EU funds.²⁵

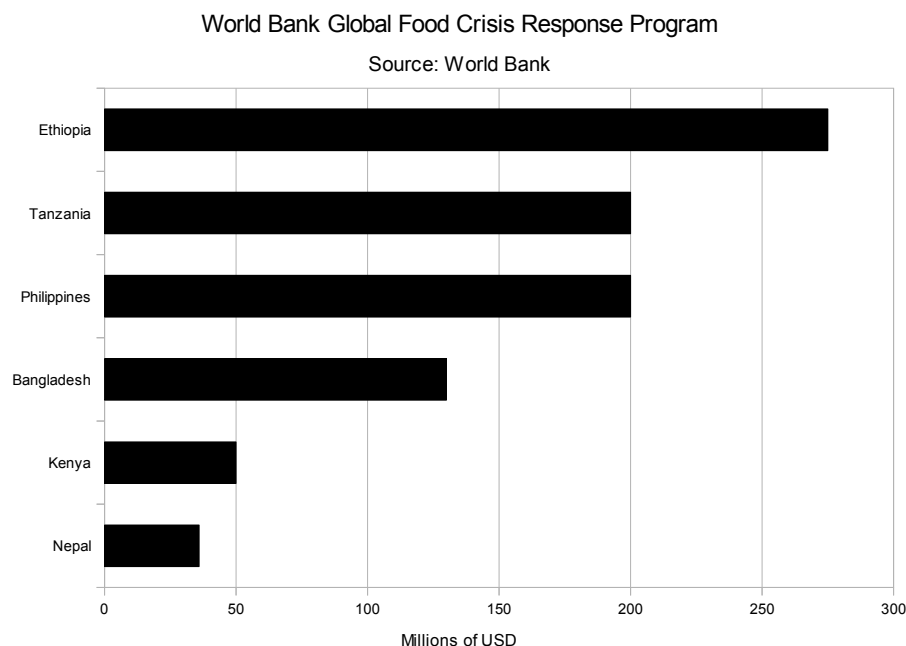


Figure 5.2: Top recipients of the World Bank Food Price Crisis Response Facility

There is no evidence to indicate that a local market opportunity drove the WFP and subsequently PSNP to adopt weather risk management for their operations. A comprehensive review of the Ethiopian insurance market from October 2009 describes a country with a tiny market for formal insurance, no domestic reinsurance industry, high barriers to entry, little access to foreign insurance services, and no weather derivative securities.²⁶ Foreign insurers are prohibited from owning Ethiopian subsidiaries. The insurance indus-

²⁵European Commission. *Food facility: EU rapid response to soaring food prices in developing countries*. Website. 2010. URL: http://ec.europa.eu/europeaid/how/finance/food-facility_en.htm; World Bank. *Global Food Crisis Response Program Project Status*. Dec. 2009. URL: <http://www.worldbank.org/foodcrisis/pdf/GFRPProjectStatus.pdf>.

²⁶World Bank, *Global Food Crisis Response Program Project Status*.

try was nationalized from the 1970s until the 1990s. The Central Bank is responsible for the regulation of insurance companies. Fewer than 1% of Ethiopians have any formal access to insurance. Reinsurance is a relatively bright spot in the local industry. Minimum reinsurance thresholds are set by the Bank of Ethiopia. Access to external reinsurance is permitted; which suggests that for local insurance companies, designing weather derivative contracts with external partners could be feasible. As of the present writing, however, no external partners apart from the World Bank have participated in the development of any weather index strategies; and none of these strategies have taken the form of reinsurance.

WFP assisted a local, private insurance company with the creation of two insurance products for smallholders. Nyala offered since 2007 an index-based drought insurance pilot and a multi-peril crop insurance program. These products are micro-scale, permitting farmers to insure either against a weather index or against the total yield of their plots. Not surprisingly, as the multi-peril insurance provides greater coverage and lower basis risk, it has garnered the greater market share of the two. Oxfam indicates that the cost of the drought risk policy is 25-30% of the maximum payout. Households that cannot afford the program have access to NGO funds and works programs to enable them to participate.²⁷ Participation in the IBRTP exceeded targets, which NGO reports attributed in part to the ability to pay the premium in labor.²⁸ Evidently this requires a strategy to monetize the policyholders' labor, currently provided by Oxfam America. A Nyala report on the insurance pilot was due out in March 2010. Both of these plans received political support from the Ethiopian government and technical assistance from WFP. Rather than the market driving political decisions about risk management, this was quite the reverse: political decisions about risk management drove the market instead.

²⁷IRIN. *Taking the Disaster out of Drought*. Addis Ababa, Ethiopia, Nov. 2010. URL: <http://www.irinnews.org/Report.aspx?ReportID=91176>.

²⁸Oxfam America. *HARITA project report: Nov 2007 - Dec 2009*. Rural Resilience Series. Aug. 2010. URL: <http://www.oxfamamerica.org/publications/harita-project-report-nov07-dec09>.

5.2 Documents

5.2.1 WFP

WFP has four major types of projects, organized by country of operations. Country Operations take place over several years, in consultation with the partner government and other donors. Country Operations have the designation DEV, which indicates a development strategy for food security. Emergency Operations are immediate responses to natural disasters, political events and other acute crises with rapid onset. Emergency Operations that are not resolved within a period of six months transition to Protracted Relief and Recovery Operations. PRROs can last up to three years. Special Operations provide supplemental logistical support, e.g., repairing roads to permit distribution of food and supplies. It is possible to have more than one concurrent operation in a country, depending on the specific situation(s) requiring international response.

WFP has a variety of operations in Ethiopia, responding to specific and distinct emergencies. The longstanding Country Operation has the current designation 10430.0. Since 2003, WFP has focused on the declining sustainability of agriculture in Ethiopia, which it sought to bolster through the MERET program since 2003.²⁹ The current Protracted Relief and Recovery Operation began in 2008, which was ongoing at the time of PSNP, and following the period when WFP's drought insurance pilot was underway.³⁰ The PRRO was slated to end in 2010, returning food security operations to the Country Program. PSNP is one of four food security programs in the PRRO.

WFP stated its objectives in the project document for executive board approval. The project objectives were:

- to reduce acute malnutrition

²⁹World Food Program. *Country Programme–Ethiopia 1430.0 (2007–2011)*. Country Programmes WFP/EB.2/2006/8/8. Aug. 2006. URL: http://one.wfp.org/operations/current_operations/project_docs/104300.pdf.

³⁰World Food Program. *Protracted relief and recovery operation Ethiopia 10665.0*. Protracted Relief and Recovery Operations WFP/EB.A/2009/9–C. May 2009.

- to increase the ability of beneficiaries to manage future shocks without assistance,
- to rehabilitate and educate specially targeted populations (children under 5, lactating women, and people with HIV/AIDS),
- to increase the rate of school attendance among orphans and vulnerable children, and
- to improve the capacity of government, particularly at local levels, regarding needs assessment, disaster risk reduction, and hunger.

Each WFP project is funded by appeal. Regular appeals are released on an annual calendar, but emergencies can be funded through a separate process. Flash appeals are released in partnership with other UN agencies. WFP and partners prepare these in a matter of days following the onset of a crisis, for immediate review by donors. The UN's Central Emergency Response Fund is a donor to flash appeals. CERF is a prudential account that holds money for immediate emergency response by whichever UN organizations are working on the ground. CERF does not provide comprehensive funding; rather it is designed to provide temporary funding while national donors mobilize funds, equipment and personnel in the field.

WFP conducted a review of business operations in 2005 that explicitly evaluated advance funding mechanisms. The findings of this program had more to do with the financial organization of WFP's transactions, rather than its external relationships with donors or the sizes and sources of funding for various programs.³¹ The Immediate Response Account (IRA) amounted to \$70 million globally in 2005. Its use is restricted to unforeseen, emergency expenditures. A fund of this size is not adequate to scale up emergency responses to acute crises, or seasonal variation in large programs such as the Ethiopia PRRO. For comparison: the \$7 million drought insurance pilot would have provided assistance for fewer than half a million households, had it triggered. Its use is largely restricted to avoiding pipeline breaks, meaning logistical obstacles to delivery of food aid under existing project accounts.

³¹World Food Program. *Business Process Review: Working Capital Financing*. Executive Board Documents WFP/EB.1/2005/5-C. Jan. 2005.

The Working Capital Facility (WCF) provides early access to funds that WFP reasonably anticipates donors will provide. The total global size of the facility is \$180 million, and the annual ceiling for write-downs is \$20 million. Limits on project access are determined by the amount and the certainty of appeals-based funding. WFP does not pay interest for the use of funds from this project, but projects must collateralize 100% of borrowing from this account. Collateral is calculated as the product of the future donation (in dollars) and the certainty of the donor's funding the appeal (25%, 50%, 75%).³² Thus a forecast donation of \$10 million with 25% certainty would permit \$2.5 million on WCF funds to be drawn for a project, to be repaid on receipt. No internal interest is charged; but the size of the facility is finite. WCF is the principal source of project funds waiting for donor appeals to arrive; but the loans must be repaid out of donations, meaning that can only change the timing, and not the amount, of expenditures.

Two other facilities, the Direct Support Cost Advance Facility (DSCAF) and Project Cash Account (PCA) provide methods of transferring expenditures among accounts at WFP. The DSCAF permitted the transfer of up to \$60 million of expenditures among various WFP accounts during the 2004-05 biennium. Neither of these accounts provide incremental capacity to PRROs or EMOPs from outside of WFP.

Finally, there is the Central Emergency Relief Fund, a shared UN-wide facility that addresses large emergencies, often with many collaborating organizations across the UN system. This facility is largely outside of WFP control. It is an adequate facility for large, unpredictable emergencies; but it is not well suited to managing annual variation in PRROs.

During the same period as the drought insurance pilot, use of the IRA expanded considerably. The 2008 review of advance funding mechanisms focused on the limited application of IRA and WCF funds.³³ At the time, IRA funds were largely limited in application to pipeline breaks and prepositioning of food. This is no longer the case.³⁴ IRA

³²World Food Program, *Business Process Review: Working Capital Financing*.

³³World Food Program, *WFP Advance Funding Mechanisms: Review and Recommendations*.

³⁴World Food Program. *Overview of Operations in 2009*. 2008. URL: http://www.wfp.org/appeals/Projected_needs.

funds can now be used for new emergencies and unforeseen expansions of EMOPs. As of 2007, allocations had nearly doubled, and new contributions to the IRA have more than kept pace (see Figure 5.3). Donors appear happy to fund continued expansion of the IRA. Ethiopia received IRA funds for both PRRO 10665.0 and the emergency operation for Somali refugees, amounting to \$15 million in 2009 (combined allocated and revolved funds, more than 90% of which went to PRRO 10665.0).³⁵ The amount of this funding, however, is considerably smaller than PSNP risk financing, which has a \$160 million budget over five years. Despite rapid recent growth in IRA revolved funds, even a single drought year's notional risk financing of \$80 million would consume more than half of total global allocations from the IRA.

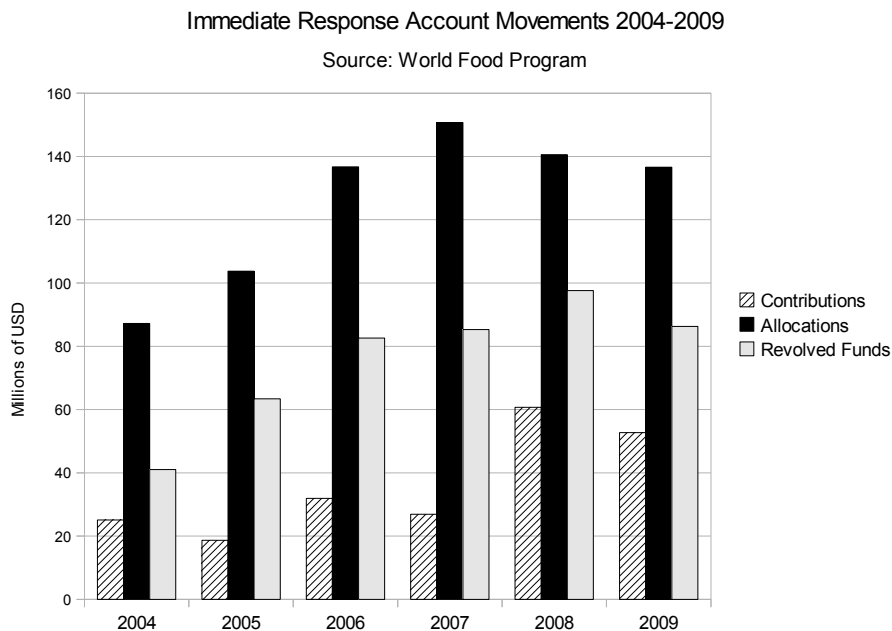


Figure 5.3: IRA movements worldwide 2004-2009.

WCF requirements have not substantially changed in the same period of time. WCF funds can only be released as fully collateralized, interest-free internal loans, with certainty-

³⁵World Food Program. *Report on the use of the immediate response account (1 January–31 December 2009)*. Executive Board Documents WFP/EB.A/2010/11-D. Rome: World Food Program, Apr. 2010. URL: <http://documents.wfp.org/stellent/groups/public/documents/eb/wfp219203.pdf>.

adjusted donation forecasts used as collateral for specific appeals. In 2008 a new subsidiary program called the Forward Special Purpose Account provided a means to source food from local markets. The revolving \$60 million fund claims to have shortened lead times and reduced costs of goods purchased. The main findings of the WFP review concerned the size and frequency of transactions. The authors sought to optimize financial operations for cost and timeliness, rather than assessing potential linkages between financial structures and project outcomes. Essentially only IRA provides incremental funding for WFP projects, and its use is tightly circumscribed.

PSNP, by contrast, has no corresponding set of advance funding mechanisms against which the risk financing tranches can be compared. The argument would have to be that emergency appeals cannot be used for safety nets for some reason which is, to the contrary, exactly what the risk financing accomplishes. Neither does MoARD have an alternative mechanism for obtaining funds, nor does the transparency affect in any marginal way the date at which MoARD ultimately draws on particular funding sources. Incremental financing would have to come from the Government of Ethiopia, meaning the Ministry of Finance, rather than the donor community, unless donors had indicated a willingness to create a rainy day fund for MoARD. PSNP's risk financing does not provide a source of temporary working capital for MoARD. The transparency of MoARD's risk financing provides early information to all parties and scales donors' commitment to the anticipated need for those program goals.

Risk management is a core approach to WFP activities. The executive board planning document lists natural hazards, market risks, political violence, and administrative problems in the aid pipeline as risks to the WFP program. Predictability of project aid received special attention in the strategy document. Some of these risks describe risks to Ethiopians' food security, which translate into increases in WFP beneficiary counts, and some of these risks describe donors' relationships with implementing agencies. Risk assessment in WFP parlance describes risks to the food security operation itself, not (primarily) the risks to

agricultural and pastoral livelihoods.

5.2.2 USAID

One of the central issues for USAID participation in the WFP pilot project and subsequently PSNP risk financing is through what program the funds could be committed. USAID's conditional commitment for drought relief to PSNP covers food aid, not cash aid. Food aid grants are ordinarily committed through USAID's Food for Peace Program (FFP), or Title II of Public Law 480.³⁶ American food aid is far more concentrated in commodities (as opposed to cash) than other donors' aid.³⁷ In any given year, American food aid comprises more than half the global total.³⁸ Food aid is also the main modality of American WFP contributions, totaling over \$2 billion worth in 2008.³⁹ While a risk management program at USAID exists in the Office of Foreign Disaster Assistance (OFDA), it was not sufficient to underwrite the scale of food (see Figure 5.3). American law requires that 75% of Title II grants must be commodity food aid, and overhead expenditures are statutorily limited to between 7 and 13% of food aid by value.⁴⁰

Substantial changes to US food aid occurred in 2008, but these ultimately did not have an impact on the mixture of food to cash promised under PSNP risk financing.⁴¹ Changes to the US farm bill occurred too late to have an impact on the design of the PSNP risk financing element, for one thing. The Bush Administration had sought annual changes to FFP appropriations since 2003 in order to raise the ceilings on cash appropriations without success. The 2008 Farm Bill did increase food for local purchase by \$500 million worldwide; which would have been enough, in principle, to purchase food aid for the PSNP risk financing contingency locally. At the time the risk financing element was drawn up, however, this

³⁶C. E Hanrahan. *International Food Aid Provisions of the 2008 Farm Bill*. Report for Congress RS22900. Congressional Research Service, 2008.

³⁷Barrett et al., "Market information and food insecurity response analysis."

³⁸Ibid.

³⁹Hanrahan, *Local and Regional Procurement for US International Emergency Food Aid*.

⁴⁰Ibid.

⁴¹Hanrahan, *International Food Aid Provisions of the 2008 Farm Bill*.

additional funding was not in place. It would also represent a fairly concentrated appropriation of that purchasing program. Further, it might not satisfy Barrett et al.'s criteria for local and regional purchasing, such as the food targeting issue, the location and seasonality of rural grain markets, oversight systems for cash accounting, and the quality of the rural payments networks in Ethiopia.⁴² The subsequent Roadmap Act of 2009, which called for \$7.4 billion over five years in local and regional procurement of food aid, occurred long after USAID committed food aid to the risk financing structure of PSNP.⁴³

5.2.3 Institutional Change

Two main features of the weather risk financing program changed between the WFP pilot and PSNP's adoption of risk financing. The first significant change was the identity of the underwriter, and the second was the approach to integration with PSNP. The specific expenditures that would have been funded remain essentially unchanged: the social safety nets in Ethiopia, meaning works projects and cash transfers to households.

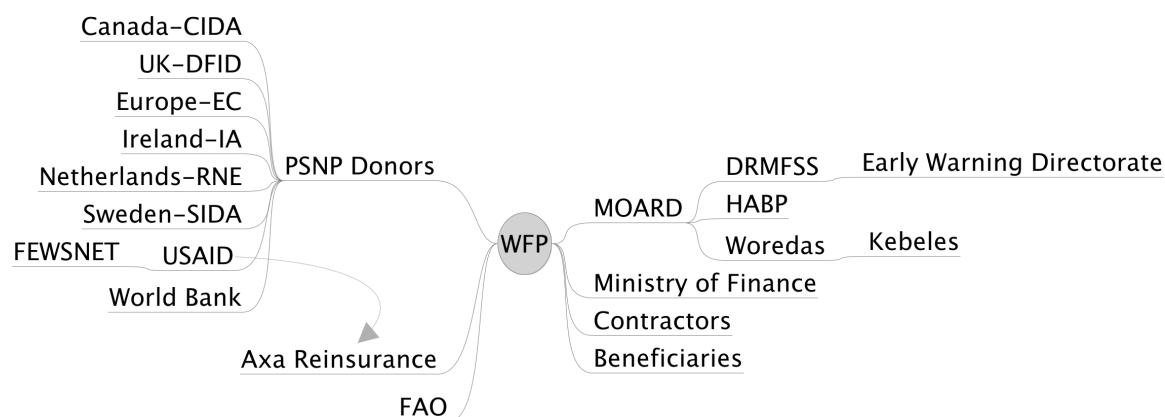


Figure 5.4: WFP drought insurance pilot relationships

The drought insurance premium in the WFP pilot was paid by USAID. USAID funds went directly to the private reinsurance company. This is markedly different from the risk

⁴²Barrett et al., "Market information and food insecurity response analysis."

⁴³Hanrahan, *Local and Regional Procurement for US International Emergency Food Aid*.

financing element of PSNP, where GoE pays no premium to DAG in exchange for the promise of conditional funding. USAID and the World Bank have together changed from consumers of risk management services to underwriters of that service. That tends to discount Hypothesis 2.(d), which holds that weather risk management is a way for donors to improve their total budgets for drought relief by tapping standing as well as emergency budgets. Rather than reinsure its variable pool of insured liabilities, USAID fired the reinsurance company after the pilot phase of the project and underwrote PSNP's marginal risks itself.

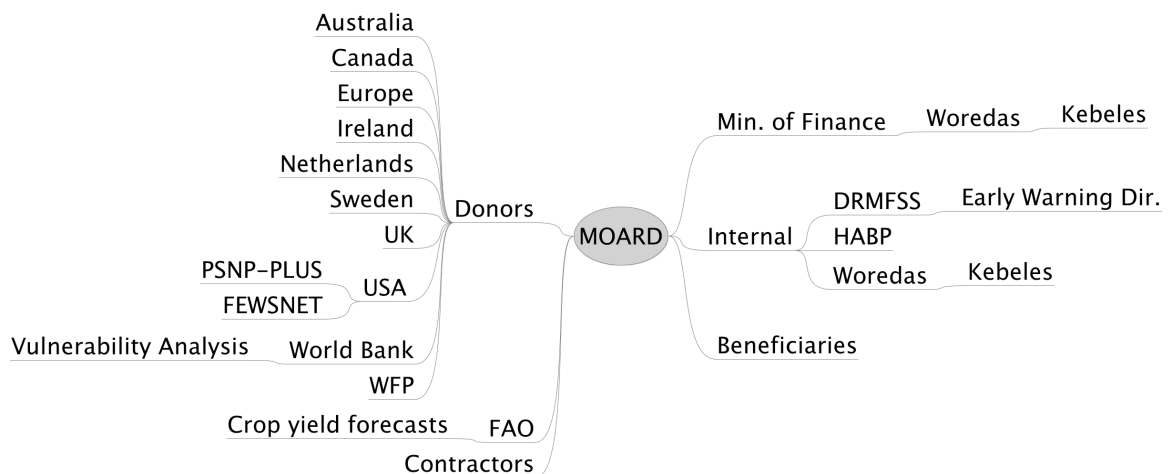


Figure 5.5: PSNP relationships

The second change was the nature of integration with PSNP. Whereas the original WFP insurance would have provided WFP cash to augment works programs and cash transfers, the second iteration incorporated risk financing directly into PSNP. USAID and the World Bank promised to increase their contributions to specific PSNP activities, working through the project selection and management structures of MoARD. The contributions were also larger, as described below, and designed to handle a much larger increase in beneficiary populations.

Weather-contingent funds were largely allocated to the same types of activities as would have existed without them. Donor concerns about targeting, corruption, and transparent

project selection do not appear to play a central role in either WFP or PSNP selection of index-based funding mechanisms. Authority over the PSNP projects funded by risk financing accrues to the same bodies that would otherwise have governed the safety net. What changes with weather indexed financing is the amount of the flows, not the basis on which it is allocated.

Around the same time as the inclusion of weather-linked financing in PSNP, USAID created a supplemental project, PSNP-PLUS, for Ethiopia. This was both an additional commitment of resources to the PSNP agenda, and it focused specifically on the area where PSNP has struggled. Graduation rates are far below projected totals. Best-case scenarios showed 80% of beneficiaries graduating from chronic food insecurity within a decade; and the most-likely forecast was in excess of 50%.⁴⁴ In practice the realized rate as of January 2010 was under 5%, due to a significant shortage of rainfall in the 2009 meher rains. In order to address the shortfall, USAID has invested in microfinance and market linkages in order to address the shortfall of household asset building. Without household asset growth, it is unlikely there will be savings to cushion household incomes during tough seasons and dry years. The PSNP-PLUS program is an NGO-led effort to improve households' progress toward graduation. USAID participation in PSNP has not suffered as a result of this expenditure; but the move signals a lack of confidence the the MoARD programs are on track to achieve long-run food stability for households.

In its new role as underwriter, USAID's commitment under the risk financing structure is for contingent food aid and not cash. The precise ratios of food and cash assistance depend on the size of the weather contingency when invoked. American contributions to the weather contingency are 100% food aid, rather than cash aid, and budgeted at half of the project size. The notional value of American risk financing is more than one hundred times greater than what was committed to WFP drought insurance. While OFDA might have been able to cover small risk management premiums in any given year, underwriting

⁴⁴World Bank, *Project appraisal document*.

catastrophic food security risk for millions of beneficiaries is not within the scope of OFDA funding.

5.2.4 Technical Measures

The primary technical forecasts used for PSNP forecasting are the Water Requirement Sufficiency Index and the Household Economy Approach. WRSI estimates crop yields on the basis of rainfall data, and is explained in somewhat greater detail in Appendix C. HEA is an integrated estimate of farm livelihoods based on market conditions and income baskets that are diversified between agriculture, pasture, and commercial activities. The Household Economy Approach (HEA), which underlies the evaluations in the livelihoods classifications and beneficiaries forecasts, is the product of extensive collaboration among major national donors and international organizations. The HEA is explicitly incorporated in PSNP design, and MoARD is now working with donors to train woreda committees on implementation.

HEA analyzes risk through the lens of livelihoods and assets. Households have income, and they have asset stocks. These assets prepare them more or less well to cope with shocks from various types of hazards. The emphasis of the HEA is on natural hazards, such as droughts, floods, and earthquakes. Within each geographic zone, MoARD and various international organizations sample households to give a baseline study of livelihoods and assets. Based on these studies of livelihoods and assets, forecasters model the impact of various natural disasters on both livelihoods and asset stocks, taking into account local coping strategies for these natural disasters.⁴⁵ This is the main method of analysis that provides estimates of beneficiary numbers under the PSNP algorithm. It combines satellite data with market and agricultural data to estimate the sizes of populations that will fall below reference consumption poverty lines. The poverty lines correspond to levels of food

⁴⁵Livelihoods Integration Unit and Disaster Risk Management and Food Security Service, *Seasonal Assessment Manual*.

insecurity in the IPC, which Brown described as major milestone and an innovation.⁴⁶

The quality of livelihood forecasts has increased dramatically since 1970, but there was no discrete advance that suddenly permitted risk financing on the basis of livelihoods forecasts. Livelihoods forecasts are essential to the design of the PSNP weather contingency. That is largely a result of PSNP's goals in enacting the weather contingency, i.e., to scale safety nets explicitly to Ethiopia's population of beneficiaries. They are a necessary condition for donors to commit meaningful amounts of money to risk financing, but not the inciting event.

Livelihoods classification

LIU divides Ethiopia into livelihoods zones, which are geographic zones that share a common pattern of livelihoods. Using decennial household surveys, LIU estimates the wealth and income distribution for each zone. Using these baseline forecasts of household income, LIU models the impact of shocks such as droughts against the income distribution to forecast the resulting rise in food insecurity. LIU models include estimates of household asset stocks and the impact of coping strategies. Low cost strategies include drawing down reserve crops and cutting back on pleasure items, such as cigarettes. Medium cost strategies involve herd reductions, looking for extra work, asking for remittances and cash from neighbors, and drawing down savings or nonproductive assets, such as jewelry. High cost strategies include skipping meals, pulling children out of school, selling productive assets, selling land, selling homes, permanent reductions in herd size, and migration.⁴⁷ Generally, the higher cost coping strategies are also irreversible, and more likely to compromise future livelihoods.

The livelihoods assessment system used in the PSNP is the Integrated Food Security

⁴⁶Molly E. Brown. *Famine Early Warning Systems and Remote Sensing Data*. Springer, 2008. ISBN: 9783540753674. URL: <http://dx.doi.org/10.1007/978-3-540-75369-8>.

⁴⁷Livelihoods Integration Unit and Disaster Risk Management and Food Security Service, *Seasonal Assessment Manual*.

Phase Classification system (IPC) [sic].⁴⁸ The IPC provides both a conceptual framework and a technical approach to measuring food insecurity. The technical approach was developed principally (though not exclusively) in East Africa, where agricultural, pastoral, and urban livelihoods experience shocks from climate, market conditions, and political events. Participating countries are Burundi, Côte d'Ivoire, Kenya, Nepal, Somalia and Sudan. The technical manual claims that as of 2009 other countries were implementing the IPC for food security assessment.

Political support for the IPC is strong. The IPC carries direct sponsorship from WFP, FAO, Oxfam, FEWSNET, Save the Children, Care, and European Community Joint Research Centre (JRC). Funds come from a wide variety of donors, including the Netherlands, EC/FAO, ECHO, Canada, United Kingdom, Australia, and Sweden. Despite the participation of FEWSNET, the website and materials do not carry the logo of either USAID or USDA.

The IPC overview summarizes twelve categories of information for analysis of food security that yield a color-coded scale of danger. Because the scale corresponds to directly observable human statistics for mortality and economic hardship, this color-coded scale contains hard information that policy makers can use to compare emergencies in disparate geographic and social contexts. The categories of information are:

1. gross mortality rates,
2. acute malnutrition,
3. stunting,
4. disease
5. food access and availability,
6. dietary diversity,
7. water access,
8. hazards,

⁴⁸IPC Partners, *IPC Technical Manual 1.1*.

9. coping mechanisms,
10. destitution / displacement,
11. civil security, and
12. livelihood assets.

I have omitted the category structural, which originally referred to a perennial lack of access to sufficient food when the scale included a chronic level of food insecurity. Since then, the chronic level has been removed, resulting in an acuity scale ranging from generally secure (green) to catastrophic (maroon), shown in Figure 5.6. Since structural only appears in the category formerly titled chronic, it does not distinguish analytically among levels of acuity of food insecurity. Rather, the structural food insecurity perspective belongs to comparative assessment of baseline food security levels, rather than an assessment of emergency acuity.

Phase Classification	
1A	Generally Food Secure
1B	Generally Food Secur
2	Moderately / Borderline Food Insecure
3	Acute Food and Livelihood Crisis
4	Humanitarian Emergency
5	Famine / Humanitarian Catastrophe

Figure 5.6: IPC coping scale

The IPC goes a long way toward incorporating Webb, Coates, and other's ideas in measuring food security. Although it still includes objective data such as calorie counts, income measures, and upper arm circumference, the IPC method augments this data with food variety, coping behaviors, and the economic tradeoffs facing food insecure families. Furthermore, the broader consequences of poor access to food, such as epidemiology and gross mortality, are explicitly included in the IPC measure.

LEAP Index

WFP's weather index provides two numerical outputs for any given geographic area. The first of these is a water requirements sufficiency index (WRSI). WRSI models water balance in the soil, based on precipitation, the soil's capacity to hold water, and evaporation rates.⁴⁹ Each crop has a growing season and a water requirement calculated on the basis of 10-day periods throughout the season. If the water is below crop requirements during any of these periods, the yield coefficient describes the impact of that water shortage on reference yields. The WRSI forecasts crop yields based on the rainfall observed at 10-day intervals.

The Ethiopia Drought Index (EDI), precursor to the LEAP index, was the indicator of impact on beneficiaries. The Ethiopia Drought Index (EDI) reflected a forecast value of yield shocks on 17 million farmers' crops.⁵⁰ Parametric coverage was provided to the WFP as a fraction of the shortfall. If the EDI exceeded \$55 million in forecast crop losses, then the insurance policy scaled parametrically with the losses up to a maximum value of \$7 million for WFP operations. Since rains were good in 2006, aggregate losses were forecast at under \$25 million, less than half the amount required to trigger a payout.

Academic trials of the WRSI model in Southern Africa in 2002 and Ethiopia in 2003 were promising. Correlations of between 80% and 92% had been achieved for using satel-

⁴⁹James Verdin and Robert Klaver. "Grid-cell-based crop water accounting for the famine early warning system." *Hydrological Processes* 16.8 (2002), pp. 1617–1630. DOI: 10.1002/hyp.1025. URL: <http://dx.doi.org/10.1002/hyp.1025>.

⁵⁰World Food Program, *Final Report on the Ethiopia Drought Insurance Pilot Project*.

lite rainfall data to predict yields.⁵¹ Agricultural experts from FAO and the Ethiopian Ministry of Agriculture and Rural Development provided information about crop water requirements and historical yields from woredas throughout Ethiopia. FEWSNET provided American satellite weather observations, also on a historical basis, that could be correlated with historical crop yields as a training dataset for the LEAP algorithm. The satellite data, provided at concessional rates, provides national coverage with minimal incremental expenditure. At the insistence of local partners, WFP is currently expanding a set of 24 weather stations throughout the country. Initial trials with manual weather stations indicate a mean variance of 2% from satellite observations; but farmers distrust data that they essentially cannot audit.

The LEAP index also produces a beneficiary forecast at the woreda level. Each woreda reports the composition of livelihoods by crop basket and non-agricultural income in a typical farm household. Using the crop yield forecasts, each woreda forecasts the shock to household income using the specific WRSIs for each crop in the income basket. Using a known distribution of household income from the baseline study and the forecast shock to household incomes, each woreda estimates the number of beneficiaries who cannot meet the requirements for food security based on the IPC food security phase classification.

Using local weather observations, even from automated and supposedly tamper-proof weather stations, will somewhat increase the cost of measuring the rainfall that underlies both the WRSI and the beneficiary forecast. Given the broad participation in the PSNP, which measures many millions of beneficiaries, even relatively expensive weather observations should not greatly affect the transaction costs of the program as a whole.

FAO has been studying the correlation between rainfall and crop yields since the 1970s. NASA had the technical capability to produce maps of African vegetation on economically meaningful time scales and spatial resolutions.⁵² By the 1990s annual forecasts of crop

⁵¹G. B. Senay and J. Verdin. "Characterization of yield reduction in Ethiopia using a GIS-based crop water balance model." *Can. J. Remote Sensing* 29.6 (2003), 687-692.

⁵²Brown, *Famine Early Warning Systems and Remote Sensing Data*, p. 12.

yields enabled year-on-year comparisons and differentiation between crop and non-crop vegetation. Reference precipitation data series have since been created stretching back to 1960 for most of Africa, enabling FEWSNET to analyze long-run patterns in agricultural productivity where crop yield, market, and population data are available.⁵³ Even with all the progress that has been made, annual discrepancies in yield data of 20-25% are common.⁵⁴ Isolated instances of accurate drought prediction on a horizon of about 90 days have been achieved.⁵⁵ Seasonal climate forecasts may never provide the lead time or the specificity required for annual risk financing contracts.

Continued efforts by WFP to refine the analysis have provided measurable improvements to the beneficiary forecast model. The current model predicts beneficiaries as a logarithmic function of rain shortfall, with the support of the WRSI bounded by a floor (beneath which crops are a total loss) and a ceiling (maximum yield), as in (5.1).⁵⁶

$$N = K \log \left(\frac{100 - F}{WRSI - F} \right) N_0 \quad (5.1)$$

where

- F: minimum value of WRSI below which yields are negligible
- K: numerical constant estimated from training data
- N: number of beneficiaries
- N₀: numerical constant estimated from training data

Calmanti's forecasts for five regions have achieved a precision of between 10% and 50%, depending on the region. The results are quite good, for a couple of fairly technical reasons. First, the pattern of variation in beneficiary needs is more volatile than the predictions based on rainfall alone. We know that precipitation is only one part of the risk facing households, so it would be troubling if the model predicted wild gyrations in the number

⁵³Ibid., p. 77.

⁵⁴Ibid., p. 145.

⁵⁵Ibid., p. 253.

⁵⁶Sandro Calmanti. *Calibration of a Log Model for Drought Related Livelihood Assistance in Ethiopia*. Mar. 2010.

of beneficiaries that did not in fact come to pass. Second, the model's volatility over different regions varies quite widely. This also sits well with the story that rainfall is only one of a menu of shocks that might hit regional livelihoods. In areas that experienced few non-precipitation shocks during the period of the training data, the gap between minimum and maximum beneficiary forecasts is absolutely and relatively smaller than in areas where other shocks occurred. Furthermore, the model performs best in pastoral regions where livelihoods are more tightly linked to annual rainfall, and less well where livelihoods are more diversified.

The issue of climate change has been used fairly exhaustively by all sides in the debate over beneficiary forecasting. Among the points of view argued: climate change is responsible for a drying trend in Ethiopia and therefore higher beneficiary counts; climate change is responsible for rising variance in precipitation over time, raising the cost of hedging weather risk; climate change is a cynical narrative exploited humanitarian organizations to increase their budgets. The only long-run trend that appears in Brown's outstanding case study on Ethiopia is a secular drying trend on a 15-year scale.⁵⁷ During the same time period, population pressures have diluted rural livelihoods, and markets have been tough on Ethiopian exports, such as coffee. It would be impossible to blame only one factor, such as climate, for the decline in the proportion of households that have access to food year-round in Ethiopia.

5.2.5 Policy Frameworks

Timing

The timing of drought relief decisions is of crucial importance is well documented in project literature. FEWSNET quarterly food security assessments include a calendar that marks out annual variations in precipitation and food stocks. LIU documents estimate a

⁵⁷Brown, *Famine Early Warning Systems and Remote Sensing Data*.

benefit of 3 months with risk financing, as compared to traditional appeals funding.⁵⁸

Ex ante funding decisions, logically, must occur earlier than ex post, except in the most unusual of circumstances. Regardless of the negotiations required to secure an ex ante funding decision, the decision is resolved well in advance of the start of the crisis. By comparison, the ex post funding instrument requires needs assessment, distribution of the appeal, and funding decisions to occur after the fund begins. Only ex ante mechanisms that relied on the most onerous calculations could delay valuation of the instrument for days (or weeks, in theory) after the onset of the crisis.

Since the performance of the precipitation inputs to the LEAP algorithm can be tracked over the course of the growing season, WFP officers can forecast risk financing as soon as precipitation data are in. Drought forecast would have provided WFP officers with the ability to draw from the Working Capital Facility (WCF), had there been a need to roll out drought relief before the Axa Reinsurance contract could be settled; but as it turned out the program was short-lived. Concerning PSNP, disbursement mechanisms do not differ substantially in Ethiopia with or without risk financing. Incremental tranches of cash and food for the PSNP from USAID and other donors are delivered via the same mechanisms. The crucial difference is that the drought relief appeal has effectively been written and agreed before the growing season starts.

A notional calendar of emergency assistance appeals and funding appears in the April 2009 risk financing guidelines for the PSNP.⁵⁹ IDL's risk financing guidelines for the PSNP, the reference document for stakeholders in Addis Ababa, points out a savings of approximately three months, as compared to appeals financing. The reasons for the time savings, IDL argues, is that risk financing triggers automatically at the same time in the calendar when needs assessment, funding decisions, and disbursement would occur under appeals-based financing.

⁵⁸Livelihoods Integration Unit and Disaster Risk Management and Food Security Service, *Seasonal Assessment Manual*.

⁵⁹IDL Group Risk Financing Mechanism, *Risk Financing Guidelines*.

Delivery times for food and cash aid can also differ markedly. Depending on the structure of the index, IBRTPs may alter the mixture of food and cash aid in drought relief projects. Recall that the WFP insurance pilot would have sourced cash from a European insurance company. Settlement times for exchange-traded weather derivatives are measured in days, not months; but the OTC product WFP purchased was not securitized, meaning it would have been subject to bilateral settlement arrangements. PSNP appears not to have altered the type of contributions of individual donors; as USAID made conditional food aid commitments to the risk financing program.

Delivery times and costs for internationally sourced food aid can be substantially greater than for locally purchased food aid. An American GAO report in 2009 found that mean delivery times were 147 days for food aid, against 37 days for local and 41 for regional procurement (see Figure 5.7).⁶⁰ Cost savings were less dramatic, on the order of one fourth of the cost of US food aid. These figures may differ from Ethiopian drought relief, however, in that they average out the effects of prepositioning and local geography. A finding of 90 days' time saved here may not be equivalent to a finding of 90 days' time saved in appeals funding decisions. Due to the necessarily slow onset of drought, prepositioning food aid may greatly cut the time required. These figures do not address the costs of logistics and oversight for food aid and cash within Ethiopia.

The efficacy of safety net grants and household asset building programs (HABP) are sensitive to the timing of payments. Safety nets are intended to reach household before they resort to destructive coping behaviors, such as skipping meals, pulling children out of school, and consuming or trading productive assets, such as seed and draft animals. The timing of a safety net program crucially affects whether families can manage an income shock without resorting to destructive coping strategies.

Monitoring and evaluation reports on the PSNP track the timeliness of payments to

⁶⁰Thomas Melito. *International Food Assistance: Local and Regional Procurement Can Enhance the Efficiency of US Food Aid, But Challenges May Constrain Its Implementation*. GAO-09-570. Government Accountability Office, 2009. ISBN: 1437917941. URL: <http://www.gao.gov/products/GAO-09-570>.

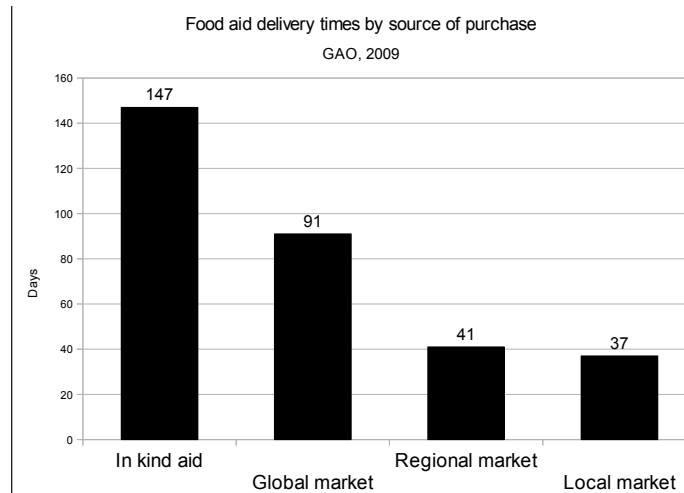


Figure 5.7: Food aid time by delivery source

households in the works programs and direct transfers. These reports do not break out results for households reached under the risk financing tranche of the PSNP and the remainder of the PSNP. Incremental PSNP works projects and direct transfers are selected by local boards, rather than the national office of MoARD. The history of PSNP monitoring for payment timeliness is not designed to compare risk-financed to non-risk-financed years. The history of PSNP payments is short and the study does not differentiate whether households benefit from risk financing.

Predictability of transfers appears to be the criterion of greatest concern to the Bank in particular and to donors in general, regarding the impact of risk financing on donor harmonization. Risk financing openly commits resources to PSNP's needs. In project documents, the language of predictability is used both at the level of international transfers to the PSNP and PSNP transfers to households. Predictability of transfers is explicitly measured in the IFPRI reviews of PSNP impact. Project managers understand that the development objectives of PSNP, meaning farmers' decisions to invest in higher-return agricultural and pastoral activities, depends very much on their ability to mitigate the higher associated risks. USAID and project documents focus explicitly on faster emergency funding decisions, more credible advance notice of transfers to beneficiaries, and more timely payments

to households.

Advance funding mechanisms

Interviews and WFP documents point clearly to the importance of advance funding mechanisms in the years leading up to the original WFP drought insurance project. The timing of disbursements for emergency operations is an explicit concern in the WFP pilot project document. It also features clearly in the training materials on the Household Economy Approach created by USAID for the PSNP.

At that time WFP first obtained drought insurance, the existing advance funding mechanisms were constrained by their scope, as with the Immediate Response Account, or the certainty of donor funding, as with the Working Capital Facility. Drought insurance appeared to provide incremental capacity, and with greater foresight. By obtaining a transparent commitment for timely disbursement from the private sector, WFP enjoyed both earlier funding decisions and a more predictable commitment. As the seasonal rainfall occurred WFP could objectively forecast the likelihood that the rainfall index EDI would trigger a payout; which provides a quantitative basis for access to the WCF. WFP's study of advance funding mechanisms cites logistical opportunities as the major source of savings achieved when disbursements can be accelerated.⁶¹ They suggest that changes to local roads, bridges, and other distribution networks are the main source of cost savings. Prepositioning supplies can shorten the final leg of the journey that supplies must travel. The port of Djibouti is the nearest location where WFP stockpiles supplies for Ethiopia. In WFP parlance, prepositioning of supplies and emergency expenditures can prevent breaks in the aid pipeline, using a variety of program accounts. Particularly, the IRA described above is a large and growing pool of advance funds available to managers at various levels designed to ensure aid arrives on time.

⁶¹World Food Program, *Business Process Review: Working Capital Financing*.

Program authority

Ethiopian authority over the triggers for risk financing for the PSNP necessitates a transparent commitment from the Development Assistance Group. Without an explicit trigger, Ethiopian authority over the program would constitute a complete grant of discretion from the donors to the Government of Ethiopia. IBRTPs could themselves be a means to further ownership and capacity building in the partner country. This is rarely mentioned as an explicit goal in the design of weather risk management strategies. Reviews of index-based risk transfer products are quick to point out microfinance applications of the technology, but rarely discuss the importance of having explicit targets as a means to achieve the Hyogo framework.

Coordinating donor programs appears to be one of the highest priorities in PSNP design. The PSNP describes a five-year strategy for achieving durable results in food security. It delineates one single approach that will meet a variety of measures important to different donors. The funding of the PSNP has been both more timely and more certain than the track record of appeals for Ethiopia. The PSNP involves capacity building at both national and local levels for many areas of the MoARD.

PSNP's weather contingency coordinates donor participation by transforming incremental commitments for emergency programs. It does away with ad hoc appeals for participation at the last moment, and replaces them with technical discussions in a multilateral framework before a crisis begins. While donors may still game the negotiations over conditional commitments to some extent, the basis for decisions is technocratic and objective to the greatest extent possible. This coordinates expectations in the discussion of funding levels around known projects, and reduces donors' uncertainty as to the quality of information that they may receive in emergency appeals. WFP's drought insurance strategy may have been intended to coordinate participation in the same way; but it is hard to establish that on the basis of such a small project. With only one donor involved, there was not sufficient scope to alter the funding model for emergency programs even in Ethiopia, let alone

a global context.

Working through the PSNP constitutes an effort by USAID to promote disaster risk reduction, a framework for action adopted at Hyogo in 2005. The Hyogo framework calls for comprehensive efforts to forecast disaster risks, build capacity for risk analysis and response, and manage risks through a spectrum of financial and operational risk management techniques.⁶² Even attempts to supplement the PSNP with bilateral US assistance are couched in terms of the PSNP project goals and targets, rather than lifted straight out of American strategy documents.

Risk financing itself, however, appears not to make an enormous difference in smoothing out differences among donors. Risk financing is a contingency for the PSNP. PSNP's philosophy is that household assets are the key to building food security. Households at the lowest level of classification in the IPC, meaning the most food insecure, are included in the baseline calculations for food security, not the drought contingency. Drought contingency funds are used at the middle of the food security scale, where households are at marginal risk of food insecurity. Households that are in danger of losing assets to coping behaviors, food price spikes, or other costs associated with drought conditions might be in danger of losing the few assets they have built as a result of the project's works projects and financial education. Drought contingency provides a simple, predictable way to scale up the existing PSNP programs, but it does not fundamentally alter the geographic or programmatic focus of the PSNP.

There is strong evidence that donor harmonization is a paramount goal of PSNP design; and some evidence to support the claim that PSNP's weather contingency plays a similar role. PSNP implements many of the principles of donor harmonization as outlined in the Paris and Rome Declarations.⁶³ Those principles are ownership, alignment, harmonization,

⁶²United Nations. "Hyogo Framework for Action 2005-2010: Building the Resilience of Nations and Communities to Disasters." Kobe, Kyogo, Japan: United Nations International Strategy for Disaster Reduction, Jan. 2005. URL: <http://www.unisdr.org/en/hfa/hfa.htm>.

⁶³Development Assistance Committee. *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2005.

management, and accountability. In practice, these principles dictate that Ethiopian agencies must be responsible for needs assessment, planning, early warning, implementation, monitoring and evaluation. Donors must work with Ethiopian financial and procurement systems, and must to the greatest extent possible adopt common structures for project design and evaluation. On paper at least, PSNP appears to have pushed this institutional design as far as it will go. What remains to be seen is the extent to which donors will continue to participate in this process.

MoARD is responsible for many stages of the PSNP. Strategic plans originate from collaborative planning with donors and the World Bank. PSNP program objectives, such as household asset building, early warning systems, and disaster risk management, have specific agencies within MoARD that are responsible for coordinating program activities and delivering mission critical information. MoARD, crucially, forecasts the number of beneficiaries independently from donor and international organization estimates. MoARD bases these estimates on analysis from the woreda and kebele level.⁶⁴ Trainings in the Household Economy Approach are ongoing with international assistance.⁶⁵ The numbers from MoARD are ultimately determine the trigger for risk financing element of PSNP.

Another rationale for donor harmonization is to streamline administrative processes, financial controls, and reporting requirements for the host government. The DAC guidelines on donor harmonization argue forcefully in favor of national (rather than donor-oriented) administrative systems, meaning financial reporting, purchasing, and reporting. The objective of national reporting is to permit unified reporting for projects, thereby reducing the burden on partner country resources. There is little support for this hypothesis in any of the documents I read or interviews I conducted, other than as an instrumental goal for lowering overhead on the project as a whole.

There is no reason to suspect that the international community or individual donors are

⁶⁴World Food Program, *Ethiopia Country Office Food Security Update*.

⁶⁵Livelihoods Integration Unit and Disaster Risk Management and Food Security Service, *Seasonal Assessment Manual*, 91 et seq.

opposed to lowering administrative costs for MoARD. In the World Bank's 2009 review of the PSNP, the only two specific targets mentioned in reference to donor harmonization are (1) to lower transaction costs and (2) to improve reporting.⁶⁶ This is a small subset of the larger list from the Paris and Rome declarations, viz., to improve planning frameworks, to align aid, to improve capacity, to manage for results, to hold projects accountable, to eliminate duplication, to rationalize expenditures, to increase cost efficacy, to simplify procedures, to define standards and measures, to stabilize development objectives, to delegate authority to field staff, and to reduce corruption. Since the Bank's comprehensive review of the PSNP fails to describe project elements that so clearly strive toward a number of these goals, I can only conclude that the lens of donor harmonization is incidental to the Bank's performance on these objectives.

With the possible exceptions of accountability and corruption, nearly all of these objectives are met with PSNP design; the same cannot be said for WFP's drought insurance pilot. WFP's objectives had more to do with proof of concept and market assessment. The fate of the PRRO would be only slightly affected by the triggering of the drought index. Recall that the payout would have provided coverage for fewer than half a million households, where 4 million are chronic beneficiaries and the lowest trigger for incremental tranches of PSNP funding is a 50% increase in household-months of safety nets.

WFP drought insurance provided essentially no impact, either positive or negative, on Ethiopia's administrative systems. WFP's PRRO was part of the PSNP, but the livelihoods analysis that underpinned the original Ethiopia Drought Index required little of the local livelihoods analysis that the current LEAP algorithm does. WFP's original weather insurance index was settled on the basis of rainfall observations alone, which minimized transaction costs for all parties. WFP invested a great deal of expertise in the policy design, but once the policy had been written it was possible to assess performance on 20 years of historic satellite data observations. The same calculation would be impossible with today's

⁶⁶World Food Program, *Ethiopia Country Office Food Security Update*, p. 22.

LEAP index because it requires social surveys for the HEA.

Concerning PSNP, it is difficult to argue that the current risk financing measure reduces the administrative burden on MoARD. MoARD and its local counterparts are required to submit the livelihoods analysis on which beneficiary forecasts are based. Implementing this new livelihoods analysis required extensive trainings at the local level on the household economy approach and risk analysis. The impact on MoARD costs increases, rather than decreasing, with PSNP risk financing. PSNP, by contrast, relies on a highly distributed calculation of beneficiary forecasts, incorporating data from around Ethiopia.

PSNP succeeds categorically in improving capacity and devolving authority to the field staff. It explicitly provides training to woreda and kebele staff to calculate livelihoods and shocks at the local level. The national strategic plan is a long-run, integrated framework. Targeting, project selection, procurement, and project management are devolved at least on paper in accordance with donor harmonization guidelines. Careful monitoring and evaluation studies are in place for the PSNP relative to non-PSNP food security projects in Ethiopia. Procurement, again at least on paper, appears to occur through the partner government's channels using partner government accounting. Even the United States, which is Congressionally forbidden to pool assistance funds through the PSNP, participates in the Development Assistance Group and commits funds to the risk financing measure of the PSNP.

Financial market quality

Only the weakest form of the pure financial market remedy hypothesis might be satisfied by the design of PASDEP for rural household finances. The HABP program's mere existence demonstrates that PASDEP did provide financial services. HABP mainly provides advisory services, rather than identifying and supporting rural financial institutions. No component of the PSNP specifically targets the Ethiopian financial sector, or its presence in rural woredas. PSNP funds small infrastructure projects through works programs. Al-

though the HABP seeks to encourage household asset growth, it is largely not concerned with the size and performance of formal financial institutions in rural Ethiopia.

The timeliness of both PSNP funds and HABP funds was an explicit monitoring and evaluation indicator. PSNP and HABP do not resemble a policy to remedy weak, thin, or absent financial markets for beneficiaries. It does not appear that the risk financing element of PSNP was designed specifically with financial services for the poor in mind. Rather, as designed, HABP would have generated confidence that the PSNP would not run out of funds for works programs and direct support in times of need.

5.3 Financial Data

Ethiopia is the top recipient of United States food aid, and one of only five countries to receive more than \$1 billion in total economic and military assistance in 2008. Ethiopia has consistently been among the top recipients of US food aid for 20 years, regularly accounting for one-tenth of total economic assistance to sub-Saharan Africa.⁶⁷

The top sources of funding for WFP Ethiopia in 2008 are listed in Table 5.4.⁶⁸ Worldwide, private donations are (collectively) the seventh largest donor of funds to WFP, but few of those funds apparently are earmarked for the PRRO in Ethiopia. The United States was the sole donor for the WFP drought insurance pilot.

Financial flows are not consistent with the hypothesis that PSNP's risk financing evolved as a solution to donors' haggling over program priorities or burden sharing. In Figure 5.9 I have broken out funding by the United States, United Kingdom, and rest of the world's bilateral official development assistance (ODA) to Ethiopia.⁶⁹ If free riding were a problem that PSNP were designed to fix, the American share of bilateral ODA should creep up in

⁶⁷DevTech Systems and United States Agency For International Development, *U.S. Overseas Loans and Grants*.

⁶⁸World Food Program. *Resourcing Update*. Feb. 2010.

⁶⁹World Bank. *World Development Indicators Online*. Dataset. 2010. URL: <http://databank.worldbank.org/>.

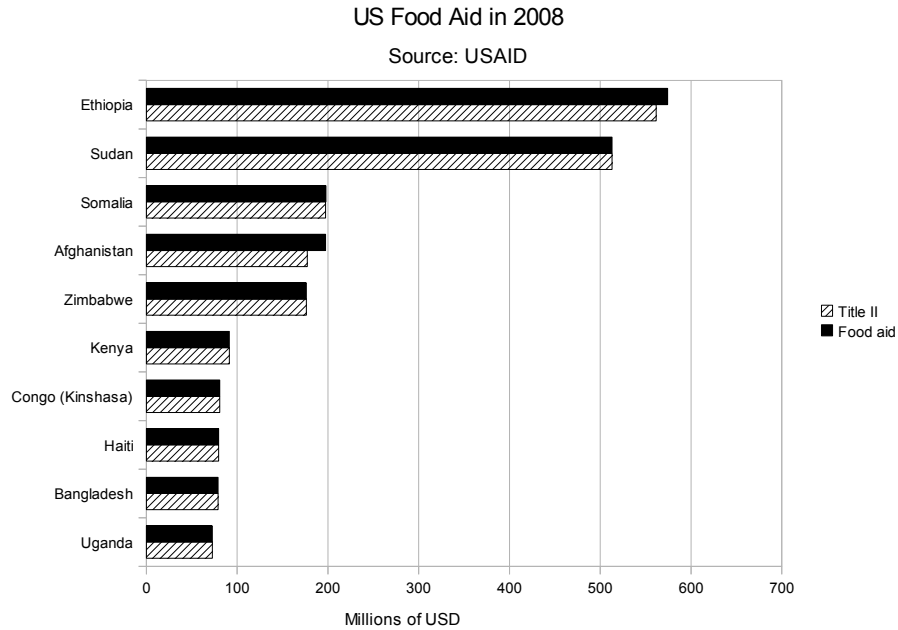


Figure 5.8: Top recipients of US food aid in 2008

the early 2000s, and then revert to a historical norm once the PSNP was enacted. Instead, American funding levels have varied according to political priorities.

Similarly, American food aid assistance to Ethiopia already varied largely in response to drought conditions before the advent of PSNP's risk financing program. In Figure 5.3, American non-food economic assistance to Ethiopia appears relatively constant.⁷⁰ Food aid spiked in 2003 in response to a drought, and remained high for the poor rains of 2004-5. Despite falling off somewhat in 2006-7, food aid rose again in 2008 due in part to a drought. The non-food portions of aid spending that rose during this period were the product of American policy priorities, such as maternal and child health and AIDS, rather than social safety nets and works programs. This admittedly rough measure shows little evidence that the largest donor in the PSNP experienced the type of free riding that risk financing could have alleviated.

My second hypothesis holds that weather derivatives are designed to circumvent some

⁷⁰DevTech Systems and United States Agency For International Development, *U.S. Overseas Loans and Grants*.

Donor	Amount	Share
United States	652.6	55.98%
Canada	89.3	7.66%
United Kingdom	79.3	6.80%
Spain	61.0	5.23%
European Commission	48.0	4.12%
Germany	29.0	2.49%
CERF	19.3	1.66%
Japan	16.0	1.37%
Australia	10.3	0.88%
WCF Advances	4.3	0.37%
IRA Advances	21.0	1.80%
Total committed	1,165.7	100.00%
Shortfall	421.4	36.15%

Millions of USD

Percentages do not sum to 1

Source: World Food Program

Table 5.4: Top sources of funding for WFP Ethiopia in 2008

long-standing conditions attached to humanitarian aid budgets. This might have appeared to obtain with respect to the WFP drought insurance project. WFP's PRRO in Ethiopia involved a mixture of cash and in-kind assistance. WFP is the primary logistical channel for American in-kind assistance, which makes up the bulk of grants to Ethiopia.

One primary use of derivatives is to transform a steady and predictable stream of small expenditures into a much larger, infrequent sum for a specified purpose. In theory, if food emergencies are rare and very expensive, weather derivatives might be a way to smooth out Title II expenditures on food despite the volatility in beneficiary populations. Weather derivatives with a small probability of payout could result in occasional payments larger than USAID would normally muster from Title II money. There is a separate program within USAID for disaster assistance, the Office of Foreign Disaster Assistance (OFDA) which manages large disasters from a different budget (see Table 5.5).⁷¹

The Office of Foreign Disaster Assistance (OFDA), an office within USAID, is respon-

⁷¹Bureau for Democracy Conflict and Humanitarian Assistance, *Ethiopia-Complex Emergency*.

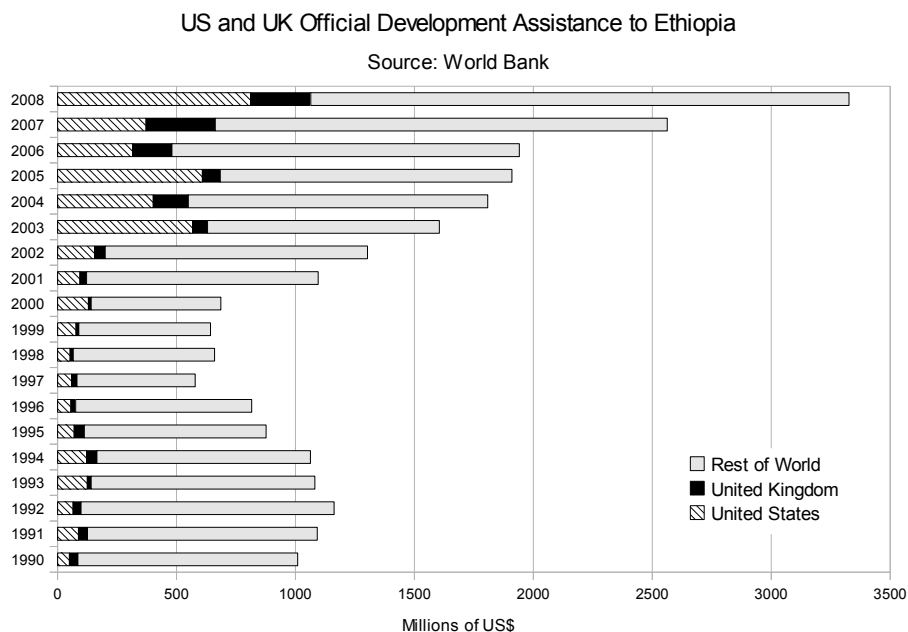


Figure 5.9: US and UK vs. world bilateral assistance to Ethiopia

Program	Budget	Percent
Office of Foreign Disaster Assistance (OFDA)	38.85	19.36%
Food for Peace (FFP)	154.22	76.84%
Population, Refugees and Migration (PRM)	7.62	3.80%
TOTAL	200.69	100.00 %

Millions of US dollars

Table 5.5: US humanitarian assistance to Ethiopia FY 2009

sible for disaster risk mitigation. Its budget in 2008 was 5% of the total USAID budget.⁷² Droughts accounted for just 3 of more than 50 disasters worldwide in that year. Risk reduction comprises just 3% of OFDA's budget. OFDA manages large crisis response operations for the American government, such as the Indonesia tsunami and the Haiti earthquake. Its budget is insufficient to provide an annualized \$32 million in costs for drought risk management in Ethiopia. With a high frequency of drought and high annualized costs of related relief efforts, USAID needs a structure more suited to chronic than emergency operations.

⁷²Office of Foreign Disaster Assistance. *USAID Disaster Assistance: Annual Reports Index*. Website. 2010. URL: http://www.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/publications/annual_reports/index.html.

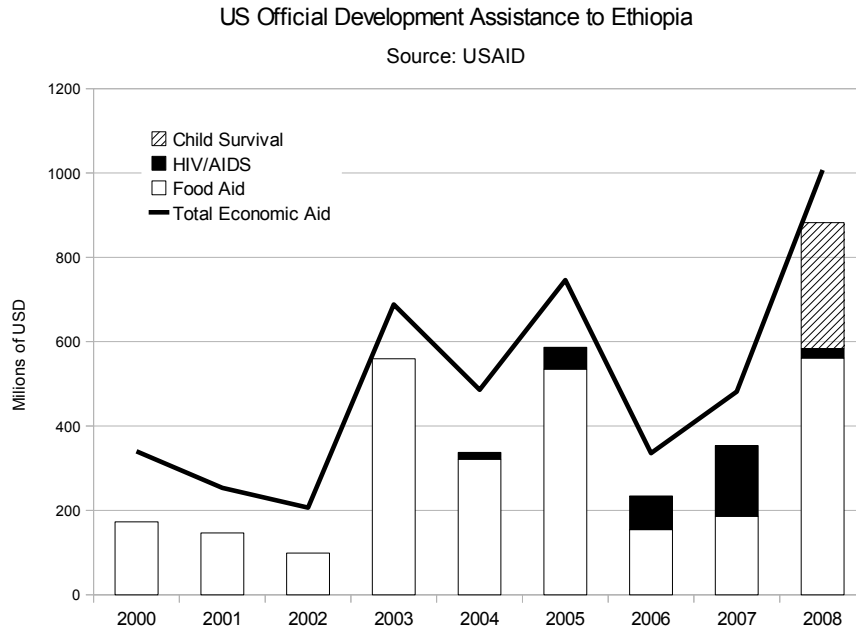


Figure 5.10: Program shares of US bilateral aid to Ethiopia since 2000

It is entirely possible that USAID has difficulty managing volatile aid flows for drought relief outside of OFDA.

Ethiopia is already one of the top recipients of US assistance under this program for its complex emergency budget. In 2009-2010, large natural disasters in Haiti and elsewhere will limit the availability of emergency funds for chronic crises like Ethiopia's.⁷³ OFDA's 2008 statistics on global disaster risk reduction included a line item for the Ethiopian livelihoods analysis project (among more than 70 projects worldwide), but did not specify its share of the global \$70 million budget.

HABP targets productivity and the robustness of productivity to adverse market conditions. It works through a combination of loans, diversification, education, and marketing. These programs are targeted at a higher point on the IPC food security classification. Because the households at this level of the IPC have modest assets to invest in small business,

⁷³Refugees International. *Haitian Disaster Spotlights Funding Gaps for Humanitarian Crises*. <http://www.reliefweb.int/rw/rwb.nsf/db900sid/MYAI-82C47P?OpenDocument>. Feb. 2010. URL: <http://www.reliefweb.int/rw/rwb.nsf/db900sid/MYAI-82C47P?OpenDocument>.

these assets are cushions against livelihood shocks. These households also have more to lose and therefore perhaps they face greater financial losses as a result of delays to HABP implementation. To my knowledge no formal evaluation of the relative time sensitivity of PSNP's safety nets and household asset building programs, i.e., the relationship between timing of safety net payments and destructive coping behaviors.

Risk financing is slanted toward the safety nets. It is designed to enlarge the safety net when households slip down the IPC, down from the level where HABP is appropriate toward a condition of greater risk for food insecurity. By including these families in the social safety nets, PSNP aims to prevent these households from permanently slipping below the level of assets required to increase productivity, diversify income, and amass sufficient assets to graduate from the pool of beneficiaries.

5.4 Stakeholder Interviews

5.4.1 Coordination Problems

Interviews revealed surprisingly little discord among donors. Donor coordination problems could involve disagreements over project goals; over the geographic and demographic distribution of aid flows; over perceived free riding; or over implementation strategies. Perhaps out of mutual deference no donors made reference to issues related even anecdotally to these types of differences. Donors' approach to food security in Ethiopia is dominated by the effort to coordinate with the Development Assistance Group. The technical processes of beneficiary estimation by the donors and MoARD carries great political weight, as it largely determines the course of annual food security interventions.

Technical managers tended to view risk management strategies through the lens of early warning, rather than a means to settling differences among donors. Prices of seed, animal feed, and livestock are indicators of food scarcity. NGOs actively monitor the terms of trade among rural vs. urban markets and agricultural vs. pastoral livelihoods. One man-

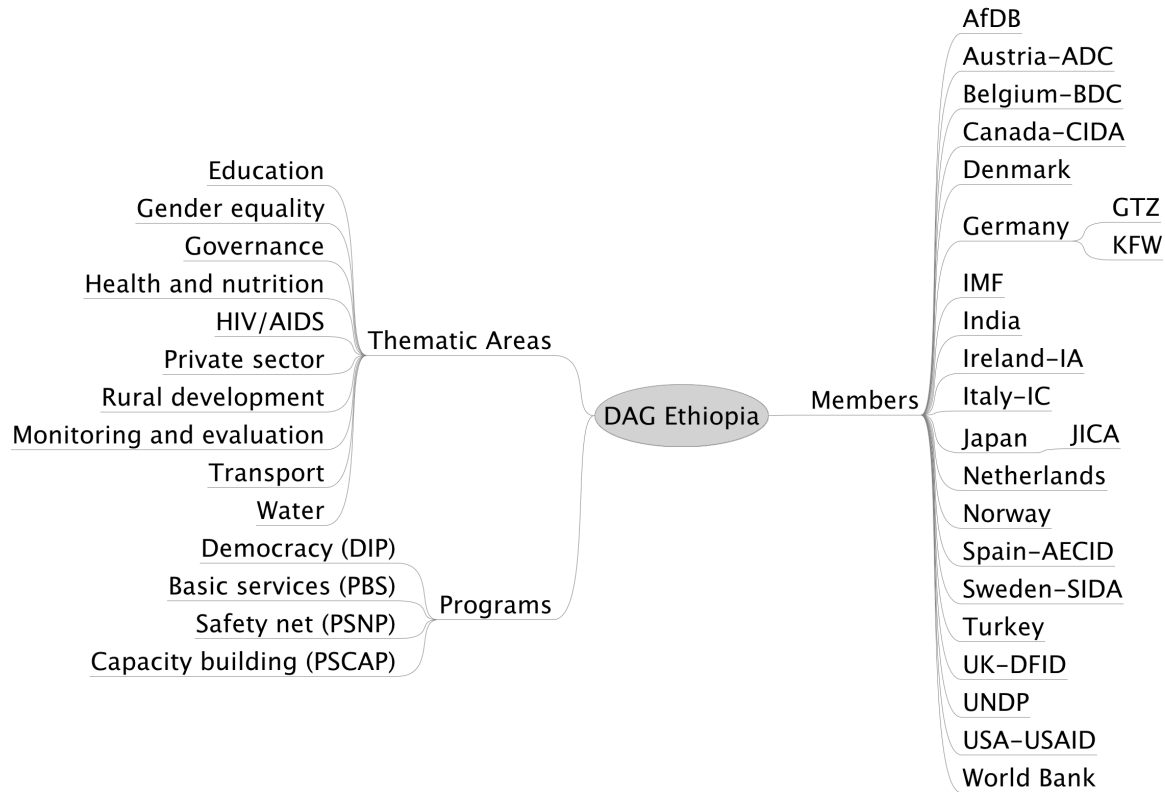


Figure 5.11: Development Assistance Group members, programs and thematic areas

ager even went so far as to organize market visits for urban traders in order to encourage arbitrage during periods of acute scarcity. But none of the managers with whom I spoke considered seriously the impact of weather risk management on their own businesses or their negotiations with other stakeholders.

Stakeholders reacted skeptically to the idea that donors suffered from a lack of credibility with the partner government. Rather, the perennial tussle revolved around access to beneficiaries. Forecasts of beneficiaries were controversial for precisely the opposite reason: GoE refused to accept proffered assistance from the international community.

According to rational choice, MoARD should pursue policies that maximize its income from donors, while minimizing associated costs (e.g., costs of administration, oversight and implementation; opportunity cost of other projects foregone). Since the beneficiary forecasts using LEAP are the basis for incremental tranches of drought funding, theory predicts

that MoARD should prefer higher beneficiary forecasts, biasing estimates in favor of more severe drought. The size of the weather contingency depends on woreda calculations of beneficiaries. Local calculations of the beneficiary forecast do not match FAO and donor calculations. These calculations differ by more than 50% of the baseline forecast, approximately 4 million beneficiaries. Donors consistently forecast more beneficiaries than does MoARD. A difference of this magnitude is sufficient to decide the triggering of the risk financing mechanism.

The puzzle engenders speculation about the source of the discrepancy, although hard evidence is difficult to come by. One theory is that the historic yield estimates used for the algorithm's training data were inflated. If this were true, and if the approximate form of the model corresponded to Equation (5.2) below, the bias should be the opposite. Systematically inflated yields in dry years should shrink the positive coefficient estimate for WRSI. Conversely, if beneficiary counts are systematically shrunk in dry years, then the negative coefficient estimate for WRSI should also shrink. Of course, if the data are simply inaccurate (and not systematically inflated) errors could crop up in either direction.

$$Y = \beta WRSI + \vec{\gamma} \vec{Z} + \epsilon \quad (5.2)$$

$$P = \beta WRSI + \vec{\gamma} \vec{Z} + \epsilon \quad (5.3)$$

where

- Y: yield
- WRSI: water requirement satisfaction index
- \vec{Z} : controls
- P: beneficiaries

Political motives for the discrepancy fall broadly into three categories. The first is simple pride, or nationalism. Ethiopia's MoARD may wish to demonstrate success and independence from the international community. It may have an inflated estimate of the efficacy of its own programs. A second set of motives has to do with MoARD's anticipation of donors' review of PSNP. PSNP has already demonstrated difficulty achieving gradua-

tion rates specified in the strategic plan. Since PSNP has succeeded in the past with the HIPC and other donor conditionality programs, it may have a strong incentive to preserve donor relationships by inflating its performance record or lowballing its current beneficiary estimates. In an effort to improve graduation, MoARD may even have built in strong incentives for all woredas to report improved graduation rates, ultimately producing inflated estimates, like the children of Lake Wobegone. A final, less often discussed political motivation could be the collective error of the donor community in overstating the number of beneficiaries. Perhaps the national MoARD office is able to access something closer to the truth in reporting from woreda boards, while the donor community in general suffers from systematic attempts by local staff to overstate food insecurity. Given the level of technical effort and cooperation in livelihoods measurement, this would only appear to be possible if the beneficiary forecast models were deeply flawed. I have no evidence for any of these three guesses as to the source of the discrepancy between MoARD and donor estimates of beneficiaries in 2010.

On the question of whether the donors sought to reassure either WFP or MoARD about the certainty of promised drought relief funds, there is absolutely no evidence that the eventual provision of emergency humanitarian aid to Ethiopia was in question. Bilateral official development assistance, food aid, and the PSNP were all increasing during the time that WFP created the drought insurance pilot; and again during the years when PSNP ramped up. Donors have been more aggressive than MoARD in their willingness to use risk financing for supplemental safety net programs.

5.4.2 Aid Frictions

The USAID managers to whom I spoke were concerned at the high cost of funds for the WFP drought insurance pilot. Based on their comments, I calculated the IRR of funds for that project, which worked out to 14%. This number must seem high to USAID managers. US government's cost of capital is extremely low. Ethiopian currency has consistently lost

value to the US dollar over long time horizons. USAID's budget calculations most likely do not account for time-value-of-money calculations. Therefore a notional expenditure of 14% for contingent access to financing must seem like an exorbitant rate to a USAID manager, even if the Government of Ethiopia might face a higher cost of funds on the open market.

The speed and cost of aid delivery was another sensitive issue for managers in Ethiopia. Interviews with both multilateral and national donors revealed a high degree of certainty that existing appeals mechanisms were too slow. Appeals writing began once crises had broken out, meaning early warning indicators from both meteorologic and market systems indicated a crisis was already underway. WFP managers believed that IBRTPs would avoid costly and damaging coping behaviors. This is essentially the same strategy that USAID followed in supplanting HABP with its independent PSNP-PLUS. Both programs aimed to supply cash and food prior substantially earlier and thereby preserve household asset stocks for future investment.

There was surprisingly little data available to document the timeliness and cost of aid delivery via PSNP as compared to other channels. Managers held convictions that delivering cash to the field was simpler, faster and cheaper than delivering Title II aid or monetizing in-kind food assistance, but there were no sources by which I could document the logistical efficiency.

The regional port for food distribution to Ethiopia is Djibouti. The road from Djibouti to Addis Ababa is approximately 900km.⁷⁴ Food aid stocks can be prepositioned in Djibouti for distribution to any of the regions within Ethiopia. Djibouti is also the main port for Ethiopian exports.

Managers also complained about the inefficiency of aid monetization, meaning the sale of American grain for project cash accounts. Monetization not only transfers wealth from local producers to consumers; it also introduces frictions into the aid pipeline. Managers

⁷⁴Google Maps. *Djibouti to Addis Abeba, Ethiopia*. <http://maps.google.com/>. 2010. URL: <http://maps.google.com/>.

claim they could provide more than 50% lower costs for service delivery by using cash, rather than monetizing aid for the same cash.

Unrestricted funds are the most highly prized assets of managers of American projects. These funds are not likely to be used for quotidian logistics and procurement contracts. When managers have the luxury of receiving unrestricted funds (fewer than 5% of the total budget, according to one contractor) they are more likely to use them to examine their own best practices and strategy. Unrestricted funds provide the sole opportunity to put staff time against problems that the contractors need solved for themselves. In order to put capital against the type of incremental project expenditures associated with risk financing mechanisms, project managers would require conditional commitments to execute those contracts. To my knowledge, such conditional commitments have not been passed on either by donors or by the MoARD and its local counterparts. Neither global nor local contractors have been able to bid for conditional contracts on the expectation of future risk financed safety nets. The added foresight provided by early, conditional commitments of donors is not passed through to village councils, bidders, and contractors.

5.4.3 Transparency

Interviews with contractors, MoARD, and donors indicated that contingent contracts are essentially impossible in the current business climate in Addis Ababa. These contracts might provide for capital equipment, human resources, logistical services, and other components of project expenditures that are difficult to order on short notice in Ethiopia. Contingent access to capital could permit PSNP operations to have priority access to scarce assets during crises, or to extend offers of employment to key staff conditional on the approval of key staff. This does not mean that contingent funding commitments from donors are without value; rather that the conditional funding commitment cannot be passed through from a donor to contractors or human resources. Managerial decisions that contractors and MoARD staff make on the basis of risk financing must be treated with some uncertainty.

While managers can position their businesses to vie for contracts that come available under risk financing, they cannot secure priority access to those contracts, and they cannot collateralize other obligations with the expected project funds. Contract design and enforcement is too weak to permit formal agreements on the basis of contingent assets.

A number of other issues related to contract design surfaced during interviews on this topic. The American portion of PSNP cannot be funded through the common accounts of the PSNP and MoARD. Contracts for safety nets programs under American funding must go out for competitive bid according to US procedures. Contractors indicate that lags inherent in the US bidding and contracting system are a major hindrance to optimal staff and capital allocation. Work in Ethiopia for external contractors requires relationships; so it is in the interests of managers to be ever-present on the ground in villages. Competition for the best Ethiopian staff is intense, and contract work cannot be charged outside of the contract period. Managers manage the instability in staffing levels for contract staff by passing opportunities for temporary work on to even their best staff, which they claim puts them at a competitive disadvantage.

Due to GOE concerns about the accuracy of FEWSNET weather data, WFP rolled out a network of ground-based weather stations. These weather stations will require ongoing expenses to corroborate precipitation data that FEWSNET provides free of charge to the Ethiopian government. Initial estimates of the difference between ground-based weather observations and the satellite data provided by FEWSNET are in the range of 2%. The cost of maintaining 24 weather stations, while significant, is minimal considering the size of the territory and population covered by the PSNP. At present, WFP maintains the network of weather stations. The cost of improved weather data is also vastly smaller than would be required to provide yield-based farm insurance to smallholders. Should the ground-based weather stations continue to corroborate satellite observations, farmers' and MoARD's confidence in the accuracy of precipitation data will likely rise. It is not clear what inferences various stakeholders will draw from systematic differences in the weather data.

In response to direct questions about the extent to which managers would be able to write contingent bids and contracts based on conditional safety net projects, managers replied that there were no formal mechanisms for any procurement, logistics, or other services. Relationships were more important than formal contracts; and to some extent managers might be able to allocate staff time and resources better with advance knowledge of contracts. It is not possible, however, to write a conditional contract for access to goods or services, and expect that the contract carries the full faith and credit of the counterparty.

The only serious interest group pressure story that appeared anywhere in the literature on American foreign aid is the pressure of agricultural interests. Federal commitments to purchase American grain in service of price stabilization greatly lower the opportunity cost of sending in-kind, rather than cash, assistance abroad. When this aid arrives in country, it is often monetized by contractors as a method of distribution: meaning that the contractors sell the grain on local markets, and retain the proceeds for operational funds. Contractors in Ethiopia have come out against continuing monetization of food aid, and subsequently USAID followed suit there, but this decision had nothing to do with weather risk management and has not been executed on a global scale. Monetization was perceived as an American agricultural interest issue, since the end of monetization calls in to question the use of American grain reserves for food aid under PL480.

At no time during my conversations with practitioners at any level did financial interests garner any mention at all; except in the context of the Ethiopian insurance company currently in trials with weather indexed insurance products. American aid tying laws are not convoluted or opaque. They clearly bar USAID from exceeding well specified thresholds for cash aid and non-American contracting. USAID managers in country immediately associated the work that I did with risk analysis, risk mitigation and disaster relief. They suggested that I track down American OFDA officers and consult the Hyogo Framework for Action. Specifically, OFDA focuses on capacity building for risk assessment and disaster response planning.

5.4.4 Financial Market Functions

Scaling the PSNP to predictable changes in the size of the beneficiary pool goes part of the way toward mitigating farmers' downside risks. Marginal funds from risk financing, however, were earmarked for an expansion of the safety net. The triggers for risk financing also have to do with the size and duration of safety net projects, but not the household asset building agenda.

The triggers might depend on the safety nets for reasons of simplicity. Simply conducting baseline forecasts and updates after the meher rains requires a large investment of effort from MoARD. Attempts to measure the performance of household assets affected by HABP would be significantly more difficult for a variety of reasons: fluctuations of asset values, reluctance to report true asset stocks, and choice of mark-to-market strategies. Thus it might be pragmatic to scale PSNP to the safety net program, the largest and simplest aspect of the program, rather than attempting to scale each program component separately.

To my knowledge HABP only provides rural financial services. HABP does not make an effort to regulate, stimulate, or otherwise influence either formal or informal financial services for agriculture and pastoralists. Market monitoring is a crucial feature of early warning, so there may be efforts to monitor price movements for assets, inputs, and outputs from all of these markets. In particular, adverse terms of trade for pastoralists are actively monitored; and some NGOs have even coordinated open market operations by traders to arbitrage away price differentials. Anecdotally, these programs are thought to have mitigated price spirals in affected markets, where supply and demand were out of balance.

Chapter 6

Conclusions

6.1 Summary

The evidence favors transparency as a principal goal of weather risk management in Ethiopia. An early experiment with private sector vendors was replaced by a multilateral commitment from donors. In it, donors committed to scale humanitarian aid to observable and objective criteria, rather than deferring judgment until after a crisis develops. Although weather derivatives might be an effective tool of coordination in multilateral aid settings, little in this case indicates such a motivation. Donors' views on the needed level of food aid were largely in accord, but they diverged sharply from the Ethiopian government's estimate. And while privately sourced weather insurance might change the composition of aid, donor commitments themselves are still largely subject to the same limits and conditions when promised on a conditional basis.

A slew of market-based and interest group hypotheses proved unrelated to the project. There was essentially no market for weather derivatives in Ethiopia prior to the development of the WFP drought insurance instrument. By the time PSNP adopted the algorithm developed for WFP, no substantial world markets for Ethiopian weather risk had developed. The advent of Ethiopian drought insurance came at the suggestion of WFP. The

most serious challenge faced by early entrants into the index-based insurance market was how to generate demand for the product. Neither the American financial industry, which was entirely uninvolved in the WFP tender and the risk financing element of PSNP, nor the Ethiopian, had anything to do with these forays into humanitarian risk structuring. Not even the weaker argument that incomplete financial markets could have been an impediment to asset creation, risk taking, and rural productivity appears to have been an impetus for WFP and PSNP's risk financing decision.

6.2 Transparency

Transparency, in the sense of specifying an objective for donor policy in Ethiopia, is the hypothesis that best explains the present form of Ethiopia risk financing. The replacement of donor discretion with objective weather observations is an important transfer of political authority from the donors to the PSNP. While different organizations may not ultimately agree on the supposedly objective criteria (i.e., forecast beneficiary counts), at least the space for negotiation has been greatly narrowed. Ethiopia agrees to accept money which the donors agree to provide in a well-specified set of emergency conditions.

Hypothesis 3(a), which addresses the observability of conditions for incremental drought relief, is all the more important in light of Ethiopia's contentious history with the donors. At various times, factions and the Government have been accused of holding the population hostage and intensifying humanitarian crises. Donors have tried iterations of control over Ethiopia's economic and political policies, such as influencing its external alliances during the Cold War, structural adjustment lending, political conditionality for program aid, debt forgiveness, and poverty reduction strategies. When the donors and Ethiopia can agree on objective criteria for future humanitarian aid, the politics of aid can recede a little.

Predictability of transfers at the household level was evident in the planning and evaluation documents for PSNP. The predictability of transfers is seen as a channel to improve

household investment and risk appetites. When safety nets protect households from the worst poverty, households can feel safer investing scarce capital in risky agriculture. Unfortunately, the short record of the program provides limited information about the timeliness of promised payments to households in the safety nets, rather than the effect of risk-financed vs. non-risk-financed households in the PSNP.

Partner country ownership of the humanitarian operation appears to be a project goal for PSNP, but the link from *ex ante* risk management strategy to country ownership is not especially direct. The design of this risk management instrument aligns well with several principles of the Paris and Rome Declarations and the Hyogo Framework, such as the preference for local accounting and procurement systems, and the development of integrated risk assessment and management capacity in the partner country; but again, this risk financing instrument is relatively new and untested.

Host country costs were not minimized in the PSNP risk financing model. The simplest possible contract, from the point of view of settling the contract, computes the payout from the security as a function of rainfall. This transformation of mm of daily rainfall into dollars or tons of food, can in principle be computed at negligible cost using satellite data. Instead, PSNP chose to supplement satellite data with ground weather stations around Ethiopia. It also chose to tailor the weather index to mimic yield shocks to households, resulting in a calculation of expected numbers of beneficiaries in a given year, rather than a plain vanilla weather derivative (such as a put on a weighted average of daily rainfall during the growing season). The PSNP approach entailed training rural officials to calculate woreda-specific household income baskets, and made the national beneficiary estimates contingent on the completion of rural agriculture boards' calculations. So one of the primary benefits of index-based risk transfer products, the low cost of assessment and settling, was sacrificed in favor of improved basis risk and partner country ownership. Capacity building, and not optimizing costs, was the priority in risk financing.

One additional consequence of the derivative structure is its unsuitability for securi-

tization on global markets. OECD weather derivatives follow simple daily exposures to temperature and precipitation. Complex beneficiary forecasts make it harder to model and audit the index value; witness the 2010 controversy over beneficiary counts. If the ultimate objective were to achieve a thick market for securities similar to OECD weather derivatives, the index as designed is too complex and too specific.

The issue of contingent contracting, which I had supposed would be a primary motivation for a risk financing strategy, exists only in a very weak form in Ethiopia. Contractors manage uncertainty and risk through relationships, rather than legal or contractual instruments. When work is scarce, contractors can only smooth human resource usage by providing temporary work from non-project funds. Managers of private companies can neither write contracts for contingent access to trucks and other equipment, nor can they draw down company resources on the basis of anticipated contracts. The projects PSNP funds today through risk financing provide little work for contractors; as these funds are largely food and cash for transfers to households.

6.3 Coordination Problems

Risk financing does not substantially alter the policy targets of the PSNP (or WFP's PRRO before it). Risk financing specifies policy targets and matches predictably required funds to those policy targets, rather than passing the hat once budgets have been exhausted. Nothing about the financial vehicles, either drought insurance or weather contingent finance, changed donors' definitions of beneficiary status or the type of assistance to be provided. There is no evidence from interviews, project documents, DAG documents, or PSNP documents that indicates risk financing itself altered the choices that donors made in allocating funding across various programs related to poverty, access to basic social goods, public health, and other goals of the DAG.

Donors' preferences in the case of Ethiopia are considerably more technocratic than

might be expected. Given the longevity of global efforts to achieve food security in Ethiopia, I would have expected greater diversity of views on the strategy and sustainability of food aid. The multidonor effort is managed to a great extent by the DAG process and the work of technical experts. Other institutional structures preceded weather risk management with reasonable success. Inclusion of risk management in the PSNP design was more of a technical decision to ensure completeness of these institutions, rather than a strategy to eliminate divisive negotiations among donors. And although USAID has separated PSNP-PLUS from the existing HABP, it remains the leader in committed funds to the PSNP risk financing program. It is hard to argue that PSNP was a strategy to fold wayward USAID policy into the larger PSNP program. There was no specific evidence that donors' discord over burden sharing or the composition of food security programs led to the creation of the risk financing program.

Evidence from funding streams provides only weak evidence about burden sharing and free riding. Comparison of funding levels suffers from equifinality, both in international and intertemporal dimensions. Donors' legislative calendars and funding deadlines are not globally aligned. Political relationships with the government of Ethiopia and the intensity of food insecurity both appear to trump free riding behaviors within the donor group. So while there is no direct evidence that free riding behaviors are the specific impetus for the weather insurance, that point of view is consistent with the existing mechanisms for coordinating donor activities.

Hypothesis 1(c), that the DAG used risk financing as a stronger commitment device, is clearly refuted in documents and interviews. Uniformly, humanitarian professionals in Addis Ababa expressed dismay that the Government's estimates of beneficiaries' need were too low to trigger risk financing tranches. Given the opportunity to increase the funds for PSNP, the Government essentially refused emergency aid from the international community. Commitment to food security programs was not a problem the donors faced.

Time-sensitivity is a common feature of PSNP works programs and transfers during

poor harvests. PSNP's long-run strategy for sustainability rests on household asset accumulation. Without the works projects to provide temporary cash income, yield shocks would force households to draw down any asset stocks built up during the preceding years. Coping mechanisms, such as culling herds and selling livestock at low prices, undermine the HABP and threaten the success of the PNSP.

The improved speed of donors' funding decisions was largely assumed in the project literature. Since the conditional commitments to drought insurance and risk financing were enacted long before the growing season was complete, the donors' decisions occurred much earlier in the project cycle. It was not clear, however, that the rainfall index could be valued and settled significantly earlier in the calendar than traditional early warning measures, such as anthropometric indicators and market prices. Due to the decentralization of beneficiary calculations, significant delays in computation and reconciliation of competing estimates limits the speed of settlement of the risk financing program.

6.4 Funding Constraints

Under WFP's drought insurance, project documents at the time clearly identified limits to the availability of competing advance funding mechanisms. Without concerns about the timing and sufficiency of WFP advance funding mechanisms, there would have been no point in searching for additional ways to bring donor commitments forward in time.

In the PSNP, a similar situation existed where the Government of Ethiopia did not have ready access to standby funds for the expansion of works projects and cash transfers. In accordance with the project's focus on risk management and building household assets, securing an advance commitment for extra tranches of funding was responsible. The well-vetted LEAP algorithm for calculating beneficiaries' need from rainfall patterns, developed under the auspices of WFP's Vulnerability Analysis and Mapping group, was a natural fit for structuring that commitment.

There is anecdotal evidence that emergency funds become scarce when outside emergencies, such as the Haiti earthquake and Indonesia tsunami, or war reconstruction efforts, such as Iraq and Afghanistan, strain donor budgets. It seems impossible that weather risk management would be a primary strategy for addressing scarce emergency budgets, since such an effort would require early expectations of the budget scarcity itself. In other words, the humanitarian community would have to have advance warning of an outside emergency that was likely to soak up all discretionary funds. The most likely candidate in such a scenario would be a multi-year disaster or reconstruction effort; in which case, legislative increases could relieve budget scarcity. Nonetheless, nothing in the data specifically contradicts this hypothesis, and several of the interviews raised the issue of American reconstruction efforts.

Neither WFP drought insurance nor PSNP risk financing delivered significant change to existing aid budget rigidities. The WFP pilot was a price discovery exercise. It would have provided significant but not sufficient funds to offset the severity of drought for which it triggered. Despite models suggesting that the price was close to actuarially fair, USAID officers viewed the project as an expensive failure. PSNP, even more so, worked within existing donor constraints, rather than bringing funds in from a different budget or substituting cash for food. Where PSNP goals did not match American priorities, USAID circumvented the DAG rather than its own policies.

Rigidities in aid budgets, at the outset of the WFP pilot, appeared to be a central problem that risk financing should surmount; and yet this goal was not achieved in implementation. While evidence suggests that the WFP abandoned drought insurance about the same time that it expanded the use of the IRA and WCF to cover unforeseen project expenses, drought insurance could not fundamentally free donor funds from restrictions as the strongest form of this hypothesis suggested. The outcome of PSNP was not to transform USAID's in-kind donations into unrestricted project cash. It simply structured USAID's contingent commitment to provide that aid, with normal conditions, under circumstances specified in

advance.

6.5 Theoretic Significance

The result of the study is, unfortunately, not a concise and elegant mathematical model of international organizations' financial decisions, comparable to portfolio theory or the capital asset pricing model. The absence of a profit motive for the international organization makes it hard to characterize the utility function succinctly. This proved to be an insurmountable obstacle in generating a unitary measure of institutional performance. Instead, the institution evaluates many stated and implicit goals separately, and no unique, self-evident algorithm exists to compare performance on these various axes.

The primary finding for the political science literature is that a principal-agent model from rational choice theory requires convoluted adjustments in order to fit the data. Whereas simple models of aid allocation predict that the partner government should attempt to maximize contributions from the donors, in practice this is not the case. Why should frequent requests for extra aid not benefit the partner government? Perhaps stringent conditions have been attached to the delivery of aid; but the conditionality literature suggests just the opposite. Perhaps interest group politics drive the partner government to seek policies that benefit an urban population or an empowered party that does not benefit from food security policy. Perhaps the shadow of future sanctions looms large, and the government rationally seeks to overstate its performance with existing aid budgets, rather than invite criticism by augmenting the funds. Perhaps the partner government buys into an economic model whereby food aid undercuts the rural sector, and is more sanguine about the prospects for rising agricultural and pastoral productivity. These theoretic alternatives to the agent's budget-maximizing strategy lead mostly away from a picture of the agent as a unitary rational actor. Instead, to unpack the agent's behavior requires a more sophisticated model of the agent's structure, interests, or ideas.

Similarly, existing institutional forms aside from risk management were sufficient to prevent free riding and strategic delay by humanitarian donors. The multidonor process administered by the World Bank Group clearly delineated policy for food security. USAID's only significant attempt to circumvent this institution was a small supplemental program designed to improve graduation rates. USAID apparently pulled out of the HABP strategy for long-run improvements to household income, but it did not withdraw commitments for the much larger safety net cash and food transfers. PSNP decentralized control over the locations and identities of beneficiaries to the the lowest possible levels. Within food security projects, the diversity of donor positions had already been managed before risk financing occurred. Risk financing simply defined observable criteria by which the existing programs could be scaled up to meet demand, and precisely by estimating the number of additional beneficiaries for the safety net.

Instead the implementation of the risk financing at PSNP places predictability at a premium. The central theoretic question is why this should be so: whether the impact of cash transfers on beneficiaries' asset stocks (and ultimate graduation) depends on this predictability; or whether the predictability is an end unto itself in the risk management framework of the Hyogo Protocol; or whether one or several of the donors (or the Government of Ethiopia) adopted this position for other reasons.

It remains an open question to what extent credibility passes through from the financial design of the safety net program to household income and investment decisions. There are strong reasons to suspect that the risk of extreme poverty forces smallholders to avoid risks, thereby limiting their returns and diluting the incentive to invest. Also open is the question whether the promise of a wage labor market, in the form of a safety net, can provide sufficient income during droughts to promote household risk taking, investment and asset accumulation. Nyala Insurance's index-based insurance has required substantial investment in advertising education to stimulate demand. Questions remain as to whether PSNP's decision to expand the safety net depends on the existence of risk financing, and

whether rural households adjust their investment of capital and labor on the basis of expected PSNP expansions to cover drought, and again whether rural households are well informed about the risk management strategies of the PSNP.

If the ultimate point of the predictability of transfers is not rural households' investment decisions, then the purpose of credibility is less about the long term sustainability of HABP, and more about the financial position of PSNP and the Government of Ethiopia. The World Bank and the donors are extensively involved in the design of PSNP. They have control over the program's objectives. They have a strong say in the manner in which funds may be allocated and ultimately disbursed. They are parties to the agreement that describes the parallel channels of project selection and reporting (in MOARD) and project financing (in MOF). The funds for PSNP come from the donor community and not the Government of Ethiopia. So, the path to household graduation and program sustainability represents a design feature for the donors as much as it does the solvency of the Government. Even the Government of Ethiopia's debt position is something over which the World Bank and other donors have a degree of control, as demonstrated by Ethiopia's debt forgiveness under HIPC.

The majority of index-based risk transfer products in emerging markets, as I discuss in the literature review, are underwritten by governments and extended to smallholders and enterprises. The primary advantage of these products is that they permit greater transparency and lower transaction costs than competing risk management strategies. In the OECD, weather derivatives are one of a set of tools for large firms that hold weather-correlated risk portfolios to manage those risks. Here the firms can drive down costs and eliminate counterparty risk if they can live with the additional basis risk weather derivatives introduce. In this case the humanitarian organization whether a works project from the government or a WFP relief operation takes a product underwritten by the donors. Unless the government has access to international capital markets, the negotiation for marginal funds is a political transaction, rather than a market transaction. The cost of funds might not be a simple per-

centage of the funds required, but rather the investment of time and effort into negotiations over the appropriate level of spending. When the money is given, it may be given freely or at a highly discounted rate; but until the decision is made, the price might as well be infinite. And as I have argued at length, the price of an incremental tranche of funding might be negative, in that the government needs to expend effort to keep donor funds out of the program.

Another serious theoretic question is why the donors appear bent on stamping out basis risk. The classic use of a weather derivative is to accept some basis risk in exchange for cheaper, good-enough coverage of a portfolio of risks. While this introduces a few future states of the world where the basis risk could leave the customer unequivocally worse off than without the coverage, on the whole, there is a greater likelihood that the customer will realize a net benefit from the policy. There is even a specific instrument to manage this risk, called gap insurance, which can address the basis risk while preserving the generic, and therefore potentially more liquid, nature of the underlying security. For the majority of cases, either the option expires worthless and the customer is in the black, or the option triggers and provides a supplemental payment; or occasionally the customer may win the payout without suffering losses. In the few cases that the customer is in the red and the option does not trigger, a supplemental insurance policy can provide special payouts overseen by traditional insurance adjusters. This policy, of course, requires an additional premium, which dilutes the benefits of risk management.

It is less clear why the donors should be willing to subsidize the decentralization of beneficiary calculations in the rural areas. The primary benefits of this could include higher fidelity calculations of income shocks, greater ownership, and capacity building in the rural areas. It would be hard to compare the intangible benefits of ownership and risk education with comparable programs. And the purported increased fidelity of the beneficiary forecasts seems neither (1) to align with international and professional estimates, nor (2) to serve the interest of holding down either the costs of the donor or the partner governments.

The timeliness of donor disbursements, as opposed to the certainty thereof, arose as a separate issue in interviews and internal WFP reports. WFP emphasized the value of timely logistical efforts. Missing an optimal season to transport heavy goods can drive up costs. From an empirical perspective, it is easier to measure the difference in delivery costs at different times of year than to compare the value of services provided to beneficiaries. A school feeding program might provide more effective targeting of benefits than any comparable program. Without an empirical strategy to document the difference between the school feeding program and a comparable effort to target children, it is difficult to establish the value a missed opportunity to run a school feeding program. Nearly every coping behavior that rural households have at their disposal affects the value of services provided to the beneficiaries: adjusting the basket of foods consumed, altering portions, skipping meals, pulling children out of school, adjusting herd sizes, avoiding medical expenses, etc. Households that avoid destructive coping are unequivocally better off as a result. Identifying equivalent interventions that provide the basis for cost comparisons, however, is much more difficult. If herds are shrunk during droughts when livestock is cheap and grain and water are expensive, it is not clear what baseline price economists should use to calculate the value of livestock lost to the household. Monitoring reports can only estimate the likely level of caloric restriction and food substitution that would have occurred without a timely intervention. Without more careful evaluations, such as randomized controlled trials, it is not clear that the value of timeliness can be established in economic terms. Performance can be tracked year-on-year in the same program; but estimates of cost-efficacy will remain elusive.

6.6 Future Research

The discrepancy between GOE and donor estimates of beneficiaries, ostensibly using the same statistical model, demands explanation. Several motivations for this problem have

been outlined in the analysis chapter. Essentially, they fall into three categories: biases and incentives of the global humanitarian community, biases and incentives facing the national government in Addis Ababa, and incentives facing the rural boards that provide local estimates to the national government.

Barriers to contingent logistical contracting should be identified. In industries such as telecommunications and electrical power, companies routinely contract for conditional access to backup facilities and incremental capacity. When existing resources are overtaxed or knocked off line, companies can switch capacity over to either shared or dedicated alternate facilities. These facilities may be virtual servers in the cloud, or they may be heavy equipment, such as transformers and power lines, or they may be entire office buildings, ready for the arrival of a workforce on a specified period of advance warning, from moments to days or weeks. Access to backup resources may be exclusive or shared, depending on the company's risk profile and willingness to pay. Contractors with whom I spoke found the notion of contingent access to human resources, trucks, and other facilities naive. One of the principal barriers is that contractors face strict time limits on their work; and project expenses can only begin once the project is activated. Contractors believed that the bidding structure of contracts prevents the maintenance of suitable pools of professionals and equipment for rapid emergency response. It would be valuable to discover whether any changes to contract structures and bidding processes could alleviate the restrictions on how contractors prepare for these risks.

The monetization of American food aid was also a key issue for contractors. Contractors delivering food aid inserted products into the economy by selling the products in bulk. The contractors reaped the proceeds of the sales, which could then be used to finance operations for the same programs. The expected value of future sales was a regular part of the budgeting by contractors for food security operations. Due largely to concerns about the inefficiency of this system, contractors raised objections in 2005 and subsequently USAID agreed to phase out monetization of aid, at least in Ethiopia. This has several advantages,

such as local sourcing of food for safety nets, choice over foods for safety nets, and potentially lower cost for contractor services.

Finally, it is plausible that international organizations experience capital scarcity differently than do partner governments. Whereas private firms experience costs of financial distress, such as margin calls, rising costs of debt and equity, and loan covenants, it is not clear what the costs of financial difficulty might be for a multilateral humanitarian effort, and similarly for the Government of Ethiopia. Neither Ethiopia's nor WFP's access to funds for marginal programs are determined by creditworthiness or profitability; so further effort to describe the consequences of financial distress for these organizations could provide further insight for a theory of global humanitarian finance. Capital scarcity may simply constrain the ability of international organizations to deliver on their mandates, rather than imposing costs of financial distress, as it would for a private firm.

Bibliography

- Alesina, Alberto and David Dollar. "Who gives foreign aid to whom and why?" *Journal of Economic Growth* 5.1 (Mar. 2000), pp. 33–63. DOI: 10.1023/A:1009874203400. URL: <http://dx.doi.org/10.1023/A:1009874203400>.
- Arrow, Kenneth Joseph. *Aspects of the Theory of Risk-Bearing*. Helsinki: Unknown, 1965.
- Arthur, W. Brian. "Inductive reasoning and bounded rationality." *The American Economic Review* 84.2 (May 1994), pp. 406–411. ISSN: 00028282. URL: <http://www.jstor.org.ezproxy.library.tufts.edu/stable/2117868>.
- Barnett, B. J., C. B. Barrett, and J. R. Skees. "Poverty traps and index-based risk transfer products." *World Development* (2008).
- Barnett, Michael N. and Martha Finnemore. *Rules for the World : International Organizations in Global Politics*. Ithaca, N.Y.: Cornell University Press, 2004. ISBN: 0801440904 9780801440908 0801488230 9780801488238.
- Barrett, Christopher B. et al. "Market information and food insecurity response analysis." *Food Security* 1.2 (2009), pp. 151–168. ISSN: 1876-4517. DOI: 10.1007/s12571-009-0021-3. URL: <http://www.springerlink.com/content/20t80w3656428335/>.
- Barrett, Christopher B. et al. "Poverty traps and climate risk: limitations and opportunities of index-based risk financing." *Policy Roundtable on Climate Risk, Poverty Traps and Index-Based Financing, hosted by the International Research Institute for Climate and Society, Columbia University* (Sept. 2007).
- Barrett, Scott. *Why Cooperate?: The Incentive to Supply Global Public Goods*. Oxford: Oxford University Press, 2007. ISBN: 9780199211890.
- Becker, Brandon and Jennifer Yoon. "Derivative Financial Losses." *Journal of Corporation Law* 21 (1995), p. 215. URL: <http://heinonline.org/HOL/Page?handle=hein.journals/jcorl21&id=225&div=&collection=journals>.
- Borchgrevink, Axel. "Limits to Donor Influence: Ethiopia, Aid and Conditionality." *Forum for Development Studies* 35.2 (2008).
- Brown, Molly E. *Famine Early Warning Systems and Remote Sensing Data*. Springer, 2008. ISBN: 9783540753674. URL: <http://dx.doi.org/10.1007/978-3-540-75369-8>.
- Bryla, Erin and Joanna Syroka. "Unlocking Development Potential in Malawi." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.

- Bureau for Democracy Conflict and Humanitarian Assistance. *Ethiopia–Complex Emergency*. Situation Report 2. United States Agency for International Development, May 2008.
- *Ethiopia–Complex Emergency*. Situation Report 6. United States Agency for International Development, Apr. 2009.
- *Ethiopia–Complex Emergency*. Situation Report 8. United States Agency for International Development, June 2009.
- *Ethiopia–Complex Emergency*. Situation Report 7. United States Agency for International Development, May 2009.
- *Ethiopia–Complex Emergency*. Situation Report 5. United States Agency for International Development, Mar. 2009.
- *Ethiopia–Complex Emergency*. Situation Report 9. United States Agency for International Development, July 2009.
- Buzby, Jean and Hodan Farah Wells. *Food Availability (Per Capita) Data System: Food Availability Documentation*. Economic Research Service. United States Department of Agriculture. Mar. 2010. URL: <http://www.ers.usda.gov/Data/FoodConsumption/FoodAvailDoc.htm>.
- Calmanti, Sandro. *Calibration of a Log Model for Drought Related Livelihood Assistance in Ethiopia*. Mar. 2010.
- Calomiris, Charles. “The IMF’s imprudent role as lender of last resort.” *Cato Journal* 17.3 (1998), p. 275. ISSN: 02733072. URL: <http://proquest.umi.com/pqdweb?did=30273544&Fmt=7&clientId=28972&RQT=309&VName=PQD>.
- Charmaz, K. “Grounded theory.” *Strategies of qualitative inquiry*. Ed. by J. F Gubrium and James A Holstein. 2003, p. 249.
- Chaudhuri, S., J. Jalan, and A. Suryahadi. “Assessing Household Vulnerability to Poverty from Cross-sectional Data: A Methodology and Estimates from Indonesia.” *Unpublished Manuscript* (2001).
- Christiaensen, L. and K. Subbarao. “Towards an Understanding of Household Vulnerability in Rural Kenya.” *Journal of African Economies* 14.4 (2005), pp. 520–558.
- Christiaensen, L. J. and R. N. Boisvert. *On Measuring Household Food Vulnerability: Case Evidence from Northern Mali*. Dept. of Agricultural, Resource, and Managerial Economics; College of Agriculture and Life Sciences. 2000.
- Clay, Jason W and Bonnie K Holcomb. *Politics and the Ethiopian Famine, 1984-1985*. Rev. ed. Cambridge, MA (11 Divinity Ave., Cambridge 02138): Cultural Survival, 1986. ISBN: 0939521342.
- CME Group. *Weather Products Homepage*. Website. URL: <http://www.cmegroup.com/trading/weather/index.html>.
- Coates, J. et al. “Commonalities in the Experience of Household Food Insecurity across Cultures: What Are Measures Missing?” *Journal of Nutrition* 136.5 (2006), 1438S.
- Conning, Jonathan, Michael Kevane, and Stefan Dercon. “Why Is There Not More Financial Intermediation in Developing Countries?” *Insurance Against Poverty*. Oxford: Oxford University Press, 2005, pp. 330–357.
- Culp, Christopher L. *Structured Finance and Insurance: The ART of Managing Capital and Risk*. Hoboken, N.J: Wiley, 2006. ISBN: 0471706310.

- Dana, Julie, Christopher L Gilbert, and Euna Shim. "Hedging Grain Price Risk in the SADC: Case Studies of Malawi and Zambia." *Food Policy* 31.4 (Aug. 2006), pp. 357–71. ISSN: 0306-9192.
- Dercon, S. *Insurance Against Poverty*. Oxford; New York: Oxford University Press, 2005.
- Devarajan, Shantayanan, Andrew Sunil Rajkumar, and Vinaya Swaroop. "What Does Aid to Africa Finance?" *World Bank Policy Research Working Paper* WPS 2092 (Jan. 1999). URL: <http://go.worldbank.org/B4BWUDZ7J0>.
- Development Assistance Committee. *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2003.
- *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2005.
- *Harmonising donor practices for effective aid delivery*. DAC Guidelines and Reference Series. Paris, 2006.
- *Paris declaration on aid effectiveness and Accra agenda for action*. Organization for Economic Cooperation and Development. Mar. 2005.
- DevTech Systems, Inc. and United States Agency For International Development. *U.S. Overseas Loans and Grants*. Dataset. June 2009. URL: <http://gbk.eads.usaidallnet.gov/>.
- Doherty, Neil A. and Andreas Richter. "Moral Hazard, Basis Risk, and Gap Insurance." *The Journal of Risk and Insurance* 69.1 (Mar. 2002), pp. 9–24. ISSN: 00224367. URL: <http://www.jstor.org/stable/1558637>.
- Downing, T. E. *Assessing socioeconomic vulnerability to famine: Frameworks, concepts, and applications*. Alan Shawn Feinstein World Hunger Program, Brown University, 1991. ISBN: 0944960081.
- Elmendorf, D. W and Gregory N. Mankiw. "Government debt." *Handbook of macroeconomics* 1 (1999), pp. 1615–1669.
- Epstein, David and Sharyn O'Halloran. *Delegating Powers: A Transaction Cost Politics Approach to Policy Making Under Separate Powers*. Political economy of institutions and decisions. Cambridge, U.K: Cambridge University Press, 1999. ISBN: 0521660203.
- "Sovereignty and Delegation in International Organizations." *Law and Contemporary Problems* 71 (2008), p. 77. URL: <http://heinonline.org/HOL/Page?handle=hein.journals/lcp71&id=85&div=&collection=journals>.
- European Commission. *Food facility: EU rapid response to soaring food prices in developing countries*. Website. 2010. URL: http://ec.europa.eu/europeaid/how/finance/food-facility_en.htm.
- Famine Early Warning Systems Network. *Livelihoods and FEWSNET*. Website. 2009. URL: <http://www.fews.net/ml/en/info/Pages/livefn.aspx?l=en>.
- Faruqee, R., J. R. Coleman, and T. Scott. "Managing Price Risk in the Pakistan Wheat Market." *The World Bank Economic Review* 11.2 (1997), pp. 263–292.
- Fischer, Stanley. "On the Need for an International Lender of Last Resort." *The Journal of Economic Perspectives* 13.4 (1999), pp. 85–104. ISSN: 08953309. DOI: 10.2307/2647014. URL: <http://www.jstor.org/stable/2647014>.
- Froot, K. *The Financing of Catastrophe Risk*. University Of Chicago Press, 1999.
- Froot, Kenneth A. "The market for catastrophe risk: a clinical examination." *Journal of Financial Economics* 60.2-3 (May 2001), pp. 529–571. ISSN: 0304-405X. DOI: 10.

- 1016/S0304-405X(01)00052-6. URL: <http://www.sciencedirect.com/science/article/B6VBX-433W7FJ-B/2/6bae8b68e1731b994400191b9366df12>.
- Froot, Kenneth A. and Paul G. J. O'Connell. "On the Pricing of Intermediated Risks: Theory and Application to Catastrophe Reinsurance." *Journal of Banking and Finance* (2007).
- George, Alexander L and Andrew Bennett. *Case Studies and Theory Development in the Social Sciences*. BCSIA studies in international security. Cambridge, Mass: MIT Press, 2005. ISBN: 0262072572.
- Gilligan, Daniel O. et al. *An Impact of Ethiopia's Productive Safety Nets Program*. Washington, D.C, June 2009.
- Glaser, B. G and A. L Strauss. *The discovery of grounded theory*. Aldine Chicago, 1968.
- Glauber, Joseph and Keith Collins. "Crop Insurance, Disaster Assistance, and the Role of the Federal Government in Providing Catastrophic Risk Protection." *Agricultural Finance Review* (2002), p. 81.
- Glauber, Joseph W. "Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 86.5 (2004), pp. 1179-1195. DOI: 10.1111/j.0002-9092.2004.00663.x. URL: <http://dx.doi.org/10.1111/j.0002-9092.2004.00663.x>.
- Google Maps. *Djibouti to Addis Abeba, Ethiopia*. <http://maps.google.com/>. 2010. URL: <http://maps.google.com/>.
- Government of Ethiopia. *Ethiopia: Building on Progress A Plan for Accelerated and Sustained Development to End Poverty (PASDEP)*. Sept. 2006. URL: http://www.etundp.org/index.php?option=com_docman&task=doc_download&gid=8.
- Hanrahan, C. E. *International Food Aid Provisions of the 2008 Farm Bill*. Report for Congress RS22900. Congressional Research Service, 2008.
- *Local and Regional Procurement for US International Emergency Food Aid*. Report for Congress R40759. Congressional Research Service, 2009.
- Hartell, Jason and Jerry Skees. "Vietnam: Flood Insurance in the Mekong Delta." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.
- Hawkins, D. et al. "Delegation under anarchy: States, international organizations, and principal-agent theory." *Delegation and agency in international organizations*. 2006, pp. 3-38.
- Hazell, Peter et al. *The Potential for Scale and Sustainability in Weather Index Insurance for Agriculture and Rural Livelihoods*. International Fund for Agricultural Development and World Food Program, Mar. 2010. URL: <http://www.ifad.org/ruralfinance/pub/weather.pdf>.
- Hellmuth, M. E. et al. "Index insurance and climate risk: Prospects for development and disaster management." *International Research Institute for Climate and Society, Columbia University, New York* (2009). URL: http://mahider.ilri.org/bitstream/10568/932/1/Hellmut_IndexClimateSocietyNo2.pdf.
- Hess, U. and J. Syroka. "Weather-Based Insurance in Southern Africa: The Case of Malawi." *Agriculture and Rural Development (ARD) Discussion Paper* 13 (2005).

- Hess, U., W. Wiseman, and T. Robertson. "Ethiopia: integrated risk financing to protect livelihoods and foster development." *WFP Discussion Paper* (2006).
- Hess, U. et al. "Managing Agricultural Production Risk: Innovations in Developing Countries." *The World Bank, Agriculture and Rural Development Department, Report* (2005).
- Hess, Ulrich. *Innovative Financial Services for Rural India: Monsoon-Indexed Lending and Insurance for Smallholders*. 2003. URL: <http://www.itf-commodityrisk.org/documents/indiafinsvc.pdf>.
- Hess, Ulrich, Erin Bryla, and John Nash. *Rural Finance Innovations: Topics and Case Studies*. Tech. rep. Washington, DC: World Bank, 2005. URL: <http://www.worldbank.org/rural>.
- Hoefsloot, Peter. "LEAP version 1.2 for Ethiopia User Manual." May 2008. URL: <http://www.hoefsloot.com/downloads/LEAP.pdf>.
- IDL Group Risk Financing Mechanism. *Final Guidelines for the PSNP Risk Financing Mechanism in Ethiopia*. World Bank. Apr. 2009.
- International Development Association and International Monetary Fund. *Highly Indebted Poor Country (HIPC) Initiative and Multilateral Debt Relief Initiative (MDRI) Status of Implementation*. World Bank, Sept. 2009. URL: <http://go.worldbank.org/85B908KVE0>.
- IPC Partners. *Integrated food security and humanitarian phase classification*. Technical Manual 1.1. July 2008. URL: <ftp://ftp.fao.org/docrep/fao/010/i0275e/i0275e00.pdf>.
- IRIN. *Taking the Disaster out of Drought*. Addis Ababa, Ethiopia, Nov. 2010. URL: <http://www.irinnews.org/Report.aspx?ReportID=91176>.
- Jalan, Jyotsna and Martin Ravallion. "Household Income Dynamics in Rural China." *Insurance Against Poverty*. Ed. by Stefan Dercon. Oxford: Oxford University Press, 2005, pp. 107–123.
- Jayne, Thomas S. et al. "Targeting of food aid in rural Ethiopia: chronic need or inertia?" *Journal of Development Economics*. *Journal of Development Economics* 68.2 (2002), pp. 247–288. URL: <http://ideas.repec.org/a/eee/deveco/v68y2002i2p247-288.html>.
- Jeanne, Olivier and Jeromin Zettelmeyer. "International bailouts, moral hazard and conditionality." *Economic Policy* 16.33 (2001), pp. 407–432. DOI: 10.1111/1468-0327.t01-1-00080. URL: <http://dx.doi.org/10.1111/1468-0327.t01-1-00080>.
- Jeliffe, D.C. and E.F.P. Jeliffe. "The effects of starvation on the function of family and society." *Famine. A symposium dealing with nutrition and food operations in time of disaster*. Ed. by G. Blix, Y. Hofvander, and B. Valquist. Swedish Nutrition Foundation, Symposium IX. Upsalla: Alquist and Wiksells, 1971.
- Jepma, C. J. *The tying of aid*. Development Centre of the Organisation for Economic Cooperation and Development, 1991.
- Johnson, Simon and James Kwak. *13 Bankers: The Wall Street Takeover and the Next Financial Meltdown*. Random House, Inc., Mar. 2010. ISBN: 9780307379054.

- Kamanou, Gisele and Jonathan Morduch. "Measuring Vulnerability to Poverty." *Insurance Against Poverty*. Ed. by Stefan Dercon. Oxford: Oxford University Press, 2005, pp. 155–175.
- Kaul, Inge and Katell Le Goulven. "Financing Global Public Goods: A New Frontier of Public Finance." *Providing Global Public Goods*. Ed. by Inge Kaul et al. New York: Oxford University Press, Inc., 2003, pp. 329–370.
- Kolb, Robert W and James A Overdahl. *Financial Derivatives: Pricing and Risk Management*. Hoboken, N.J: John Wiley & Sons, 2010. ISBN: 9780470499108.
- Kramer, Andrea S. "Critical Distinctions between Weather Derivatives and Insurance." *Structured Finance and Insurance: The ART of Managing Capital and Risk*. New Jersey: John Wiley & Sons, 2006.
- Kunreuther, Howard C. and Joanne Linnerooth-Bayer. "The Financial Management of Catastrophic Flood Risks in Emerging-Economy Countries." *Risk Analysis* 23.3 (2003), pp. 627–639. DOI: 10.1111/1539-6924.00342. URL: <http://dx.doi.org/10.1111/1539-6924.00342>.
- Lautze, S. et al. "Risk and Vulnerability in Ethiopia: Learning from the Past, Responding to the Present." *Preparing for the Future. Report for the US Agency for International Development, Feinstein Famine Center, Tufts University, Medford* (2003).
- Livelihoods Integration Unit and Disaster Risk Management and Food Security Service. *Seasonal Assessment Manual*. United States Agency for International Development and Government of Ethiopia. Sept. 2009.
- Mallaby, Sebastian. *More Money Than God: Hedge Funds and the Making of a New Elite*. 2nd Printing. Penguin Press, June 2010. ISBN: 1594202559.
- Mankiw, N. Gregory. *Principles of Economics*. Cengage Learning, Sept. 2008. ISBN: 9780324589979.
- Maxwell, Simon. "Evolution of Thinking about Food Security." *Food Security in Sub-Saharan Africa*. Ed. by Stephen Devereux and Simon Maxwell. Institute of Development Studies, 2001.
- Mearsheimer, John J and Stephen M Walt. *The Israel Lobby and U.S. Foreign Policy*. 1st ed. New York: Farrar, Straus and Giroux, 2007. ISBN: 9780374177720.
- Melito, Thomas. *International Food Assistance: Local and Regional Procurement Can Enhance the Efficiency of US Food Aid, But Challenges May Constrain Its Implementation*. GAO-09-570. Government Accountability Office, 2009. ISBN: 1437917941. URL: <http://www.gao.gov/products/GAO-09-570>.
- Merton, R. C. "An analytic derivation of the cost of deposit insurance and loan guarantees An application of modern option pricing theory." *Journal of Banking & Finance* 1.1 (1977), pp. 3–11.
- "An Analytic Derivation of the Efficient Portfolio Frontier." *Journal of Financial and Quantitative Analysis* 7.04 (1972), pp. 1851–1872.
- "On the pricing of contingent claims and the Modigliani-Miller theorem* 1." *Journal of Financial Economics* 5.2 (1977), pp. 241–249.
- Miller, Merton H. "The social costs of some recent derivatives disasters." *Pacific-Basin Finance Journal* 4.2-3 (July 1996), pp. 113–127. ISSN: 0927-538X. DOI: 10.1016/0927-538X(96)00007-8. URL: <http://www.sciencedirect.com>.

- ezproxy.library.tufts.edu/science/article/B6VFF-3VW90G6-8/2/b6b149ef7f1de7eab710a86e2d77d106.
- Millman, S. and R. W. Kates. "Toward understanding hunger." *Hunger in History: Food Shortage, Poverty, and Deprivation* (1990), pp. 3–24.
- Milner, Helen. "Why Multilateralism? Foreign Aid and Domestic Principal-Agent Problems." *Delegation and Agency in International Relations*. Ed. by Darren G. Hawkins et al. New York, NY: Cambridge University Press, 2006.
- Moyo, Dambisa. *Dead Aid: Why Aid Is Not Working and How There Is a Better Way for Africa*. Farrar, Straus and Giroux, Mar. 2010. ISBN: 0374532125.
- Munck, G. L. "Tools for qualitative research." *Rethinking social inquiry: Diverse tools, shared standards* (2004), pp. 105–21.
- Neftci, S. N. and Y. Lu. "Financial Instruments to Hedge Commodity Price Risk for Developing Countries." *IMF Working Papers* 8006.200 (2008), pp. 1–20.
- Neumann, John Von and Oskar Morgenstern. *Theory of games and economic behavior*. Princeton Univ. Press, 1947.
- Office of Foreign Disaster Assistance. *USAID Disaster Assistance: Annual Reports Index*. Website. 2010. URL: http://www.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/publications/annual_reports/index.html.
- Oxfam America. *HARITA project report: Nov 2007 - Dec 2009*. Rural Resilience Series. Aug. 2010. URL: <http://www.oxfamamerica.org/publications/harita-project-report-nov07-dec09>.
- Ozcan, Banu. "Market Convergence, Catastrophe Risk and Sovereign Borrowing: An Empirical Analysis for Emerging Market Countries." PhD thesis. Fletcher School of Law and Diplomacy, 2005.
- Paarlberg, Robert L. *Food Trade and Foreign Policy: India, the Soviet Union, and the United States*. Ithaca: Cornell University Press, 1985. ISBN: 0801493455.
- Pankhurst, Richard. *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*. Addis Ababa: Relief and Rehabilitation Commission, 1990.
- Panko, Ron. "Doing Something About the Weather." *Best's Review* (Apr. 2006).
- Pollack, M. A. "Learning from the Americanists (Again): Theory and Method in the Study of Delegation." *West European Politics* 25.1 (2002), pp. 200–219.
- PricewaterhouseCoopers. *Weather Risk Management Association Survey Results*. June 2006. URL: <http://www.wrma.org/wrma/library/PwCResultsJune22006.ppt>.
- Refugees International. *Haitian Disaster Spotlights Funding Gaps for Humanitarian Crises*. <http://www.reliefweb.int/rw/rwb.nsf/db900sid/MYAI-82C47P?OpenDocument>. Feb. 2010. URL: <http://www.reliefweb.int/rw/rwb.nsf/db900sid/MYAI-82C47P?OpenDocument>.
- ReliefWeb. *Ethiopia: Multi-Sectoral contingency plan, january to june 2010 – joint government and humanitarian partners' national contingency plan*. Dec. 2009. URL: <http://www.reliefweb.int/rw/rwb.nsf/db900sid/AMMF-7YRS3C?OpenDocument&rc=1&cc=eth>.

- Robb , Jan Job de Vries and Paul A. U. Ali. *Securitisation of derivatives and alternative asset classes: yearbook 2005*. Kluwer Law International, June 2005. ISBN: 9789041123756.
- Rogoff, Kenneth. "International Institutions for Reducing Global Financial Instability." *Journal of Economic Perspectives* 13.4 (1999). Fall 1999, pp. 21–42. ISSN: 0895-3309.
- Ruttan, V. W. *United States Development Assistance Policy: The Domestic Politics of Foreign Economic Aid*. Johns Hopkins University Press Baltimore, 1996.
- Scamilla, Jesus et al. "Disaster Relief in Mexico." *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*. Climate and Society 2. International Research Institute for Climate and Society, 2009.
- Sen, A. K. *Poverty and famines*. Oxford University Press New York, 1981.
- Sen, Amartya. *Development as Freedom*. 1st. ed. New York: Knopf, 1999. ISBN: 0375406190.
- Senay, G. B and J. Verdin. "Characterization of yield reduction in Ethiopia using a GIS-based crop water balance model." *Can. J. Remote Sensing* 29.6 (2003), 687692.
- Skees, Jerry, P. B. R. Hazell, and Mario Miranda. *New approaches to crop yield insurance in developing countries*. 1999. URL: <http://ideas.repec.org/p/fpr/eptddp/55.html>.
- Skees, Jerry et al. *Can Financial Markets be Tapped to Help Poor People Cope with Weather Risks?* Tech. rep. Washington, DC: World Bank, 2005, pp. 1–32.
- Skees, Jerry R. "Opportunities for Improved Efficiency in Risk Sharing Using Capital Markets." *American Journal of Agricultural Economics* 81.5 (Dec. 1999), pp. 1228–1233. ISSN: 00029092. DOI: 10.2307/1244112. URL: <http://www.jstor.org/stable/1244112>.
- Stiglitz, J. E. "A re-examination of the Modigliani-Miller theorem." *The American Economic Review* 59.5 (1969), pp. 784–793.
- Stiglitz, J. E. "Incentives and risk sharing in sharecropping." *The Review of Economic Studies* (1974), pp. 219–255.
- Storm. "News Analysis: Weather Derivatives Volume Plummet." *Storm* 43 (June 2009). URL: <http://www.wrma.org/pdf/weatherderivativesvolumeplummet.pdf>.
- Swift, J. "Why are rural people vulnerable to famine?" *IDS bulletin* 20.2 (1989), 815. ISSN: 1759-5436.
- Syngenta Foundation. *Fact Sheet: Kilimo Salama*. URL: http://www.syngentafoundation.org/__temp/Kilimo_Salama_Fact_sheet_FINAL.pdf.
- Treynor, Jack L. "The Principles of Corporate Pension Finance." *The Journal of Finance* 32.2 (May 1977), pp. 627–638. ISSN: 00221082. URL: <http://www.jstor.org.ezproxy.library.tufts.edu/stable/2326796>.
- Triana, Pablo. *Lecturing birds on flying: can mathematical theories destroy the financial markets?* John Wiley and Sons, June 2009. ISBN: 9780470406755.
- Turvey, Calum G. "The Pricing of Degree-Day Weather Options." *Agricultural Finance Review* 65.1 (2005), pp. 59–85.
- Udry, C.R. and J.H. Conning. "Rural financial markets in developing countries." *Handbook of Agricultural Economics*. Ed. by Robert Evenson and Prabhu Pingali. Vol. 3.

- Handbooks in Economics. Elsevier, 2007. URL: http://www.econ.yale.edu/~cru2/pdf/Rural_Finance.pdf.
- United Nations. “Hyogo Framework for Action 2005-2010: Building the Resilience of Nations and Communities to Disasters.” Kobe, Kyogo, Japan: United Nations International Strategy for Disaster Reduction, Jan. 2005. URL: <http://www.unisdr.org/en/hfa/hfa.htm>.
- *ReliefWeb: Appeals and Funding*. Website. 2011. URL: <http://ocha.unog.ch/fts/pageloader.aspx>.
- United Nations Development Program. *United Nations Development Assistance Framework in Ethiopia 2007-2011*. 2007. URL: http://www.et.undp.org/index.php?option=com_docman&task=doc_download&gid=10.
- United States Agency for International Development. *U.S. International Food Assistance Report 2008*. 2008. URL: http://www.usaid.gov/our_work/humanitarian_assistance/ffp/fy08_usifar.pdf.
- *USAID, CARE Launch PSNP PLUS to Improve Micro-Finance and Market Linkages*. Website. Mar. 2009. URL: <http://ethiopia.usembassy.gov/pr1209.html>.
- Verdin, James and Robert Klaver. “Grid-cell-based crop water accounting for the famine early warning system.” *Hydrological Processes* 16.8 (2002), pp. 1617–1630. DOI: 10.1002/hyp.1025. URL: <http://dx.doi.org/10.1002/hyp.1025>.
- Waal, Alex de. “Famine Mortality: A Case Study of Darfur, Sudan 1984-5.” *Population Studies* 43.1 (Mar. 1989), pp. 5–24. ISSN: 00324728. URL: <http://www.jstor.org/stable/2174235>.
- Wallerstein, Mitchel B. *Food for War-Food for Peace: United States Food Aid in Aglobal Context*. Cambridge, Mass: MIT Press, 1980. ISBN: 0262231069.
- Weather Risk Management Association. *History of the Weather Market*. Website. 2007. URL: http://www.wrma.org/risk_history.html.
- Webb, P. et al. “Measuring Household Food Insecurity: Why It’s So Important and Yet So Difficult to Do.” *Journal of Nutrition* 136.5 (2006), 1404S. URL: <http://jn.nutrition.org/cgi/content/abstract/136/5/1404S>.
- Webb, Patrick and Joachim Von Braun. *Famine and Food Security in Ethiopia: Lessons for Africa*. Chichester: John Wiley, 1994. ISBN: 0471948217.
- Webb, Patrick et al. “Measuring Household Food Insecurity: Why It’s So Important and Yet So Difficult to Do.” *J. Nutr.* 136.5 (May 2006), 1404S–1408. URL: <http://jn.nutrition.org.ezproxy.library.tufts.edu/cgi/content/abstract/136/5/1404S>.
- Whaley, Robert E. *Derivatives: Markets, Valuation, and Risk Management*. Hoboken, N.J: Wiley, 2006. ISBN: 0471786322.
- World Bank. *Africa — productive safety net project (PSNP)*. Website. 2011. URL: <http://go.worldbank.org/E4PE1DEGS0>.
- *Global Food Crisis Response Program Project Status*. Dec. 2009. URL: <http://www.worldbank.org/foodcrisis/pdf/GFRPPProjectStatus.pdf>.
- *News & broadcast—World Bank launches \$1.2 billion fast-track facility for food crisis*. Web page. URL: <http://go.worldbank.org/2VMOHRKEY0>.
- *Project appraisal document*. Report 48633-ET. World Bank, Sept. 2009.

- *World Development Indicators Online*. Dataset. 2010. URL: <http://databank.worldbank.org/>.
- World Food Program. *Budget Increases to Protracted Relief and Recovery Operation Ethiopia 10665.0*. Protracted Relief and Recovery Operation WFP/EB.2/2007/9-C/5. WFP/EB.2/2007/9-C/5, Sept. 2007.
- *Business Process Review: Working Capital Financing*. Executive Board Documents WFP/EB.1/2005/5-C. Jan. 2005.
- *Country Programme–Ethiopia 1430.0 (2007–2011)*. Country Programmes WFP/EB.2/2006/8/8. Aug. 2006. URL: http://one.wfp.org/operations/current_operations/project_docs/104300.pdf.
- *Ethiopia - FAO/WFP Crop and Food Security Assessment Mission: Phase 1*. Crop and Food Security Assessment Mission WFP179344. Jan. 2008. URL: <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp179344.pdf>.
- *Ethiopia Country Office Food Security Update*. Feb. 2009. URL: <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp198785.pdf>.
- *Final Report on the Ethiopia Drought Insurance Pilot Project*. Executive Board Documents WFP/EB.1/2007. 2007. URL: <http://one.wfp.org/eb/docs/2007/wfp113643~1.pdf>.
- *Operational priorities*. Website. 2008. URL: <http://www.wfp.org/operations/priorities>.
- *Overview of Operations in 2009*. 2008. URL: http://www.wfp.org/appeals/Projected_needs.
- *Pilot Development Project–Ethiopia Drought Insurance 10486.0*. WFP/EB.2/2005/8-A, 2005.
- *Protracted relief and recovery operation Ethiopia 10665.0*. Protracted Relief and Recovery Operations WFP/EB.A/2009/9–C. May 2009.
- *Report on the use of the immediate response account (1 january–31 december 2009)*. Executive Board Documents WFP/EB.A/2010/11-D. Rome: World Food Program, Apr. 2010. URL: <http://documents.wfp.org/stellent/groups/public/documents/eb/wfp219203.pdf>.
- *Resourcing Update*. Feb. 2010.
- *WFP Advance Funding Mechanisms: Review and Recommendations*. 2008.
- *WFP Enterprise Risk Management Strategy*. Sept. 2005.
- *WFP’s Operational Requirements, Shortfalls, and Priorities for 2008*. Oct. 2008.
- *World’s first humanitarian insurance policy issued | WFP | United Nations World Food Programme - the UN food aid agency*. Website. 2006. URL: <http://www.wfp.org/node/598>.

Appendix A

Weather Derivative Valuation

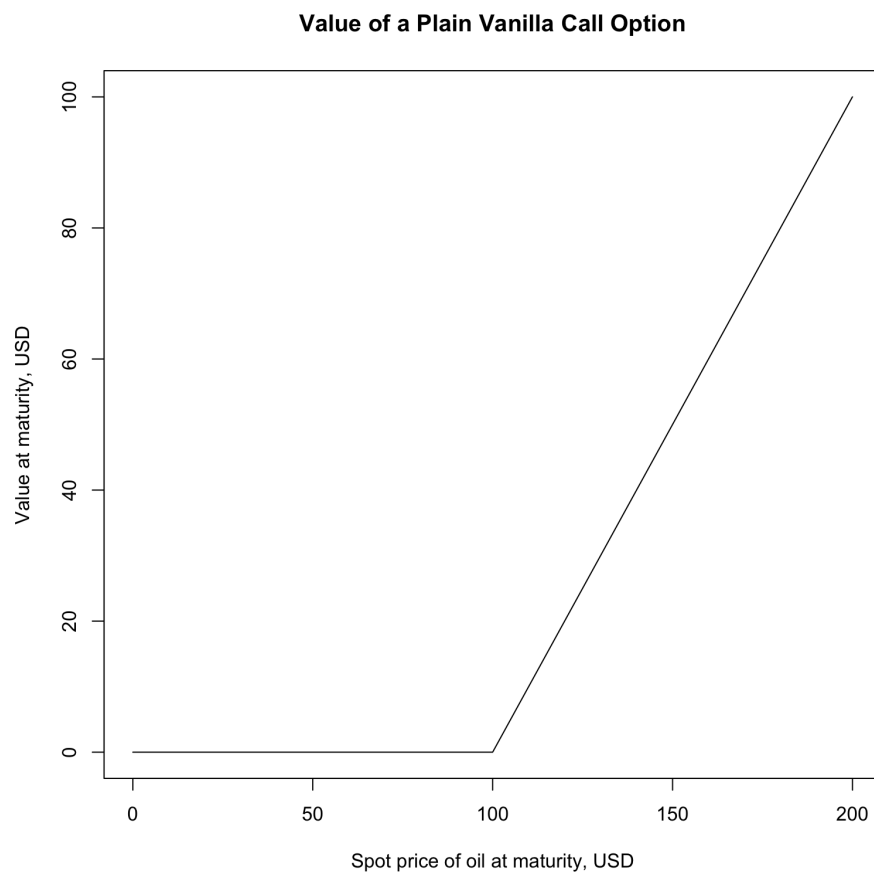


Figure A.1: Value of a plain vanilla oil call option at maturity

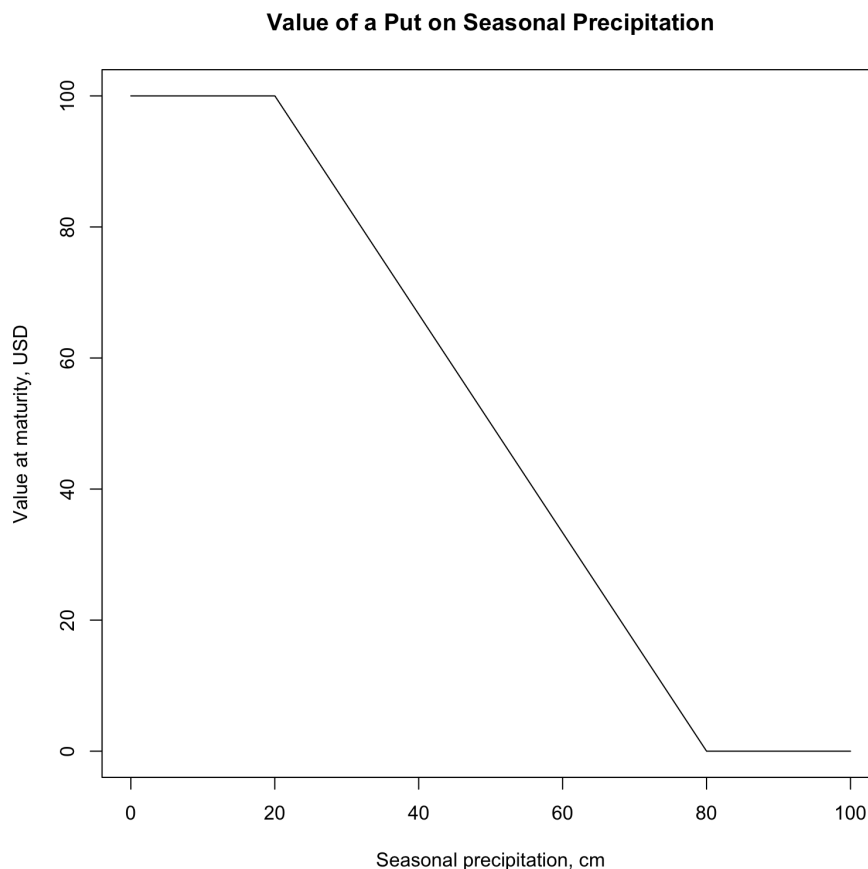


Figure A.2: Value of a seasonal precipitation put at maturity

A weather derivative contract is similar to a commodity derivative contract, except the underlying index is observed in the weather. Weather derivatives are a hedging strategy for businesses whose cash flows are significantly affected by the weather. Both temperature and precipitation contracts are widely traded in the United States.

For a commodity derivative, the value of the contract at maturity depends on the price of a commodity. The plain vanilla flavors of options are calls, puts, futures, and swaps; although many more complex products have been created in recent years. With a call option, the contract holder has the right to buy a commodity at the strike price of the derivative. If the spot price of the commodity at maturity is greater than the strike price, the call option has a value equal to the difference in price times the quantity of the commodity.

Here is an example of the value of a \$100-strike price call option on a barrel of oil.

A synthetic derivative provides the cash flows equivalent to a derivative contract without transacting the underlying asset. Synthetic derivatives enable businesses to take long and short positions in commodities, foreign exchange, bonds, interest rate spreads, and equities with much lower transaction costs. Synthetic derivatives provide the return equivalent to a position in an asset without the cost of receiving, for example, a large quantity of crude oil, gold, or foreign exchange.

A temperature derivative pays out a value based on the temperature at maturity. A heating-degree-day (HDD) contract has a strike temperature instead of a strike price in the winter. When the temperature falls below the strike temperature, the contract pays out based on the number of days for which the daily temperature is below the strike temperature.

A rainfall derivative, in its simplest form, would be a drought contract. If the total rainfall in a specified period of time failed to reach some minimum threshold, the contract could pay out a lump sum. The payout could also vary with the level of rainfall. Here is a hypothetical payout for a drought contract in the month of July, with a maximum payment of \$100, a drought floor of 20cm of rainfall, and a ceiling of 80cm of rainfall.

Weather derivatives can be written over-the-counter (OTC), i.e., by a single firm for a single customer, or traded on exchanges. OTC contracts are commonly called weather insurance, and weather derivatives commonly refer to exchange-traded weather derivatives.

The use of the term insurance in the description of OTC weather derivatives is something of a misnomer. Insurance contracts, even parametric and catastrophic reinsurance contracts, typically use a direct loss to the buyer as an underlying index. House insurance, life insurance, shipping insurance, automotive insurance, and most other types of insurance refer to a lump sum payment due whenever the buyer suffers a loss to a specified set of assets.

Weather insurance is not agriculture yield-based insurance. The purpose of weather

insurance in agriculture is to avoid the transaction costs associated with yield measurement and information asymmetry. Weather derivatives may be useful for hedging the insurer's portfolio in agriculture.

Appendix B

List of Interviews

Name	Organization	Location	Date
Ulrich Hess	World Food Program	Rome	05/13/08
Bronwyn Cousins	World Food Program	Rome	05/14/08
Deborah Hines	World Food Program	Rome	05/15/08
Will Wiseman	World Bank	Washington	08/19/09
Sandro Calmanti	World Food Program	Rome	08/31/09
Niels Balzer	World Food Program	Rome	09/12/09
Tim Robertson	Department for International Development (UK)	Rome	12/07/09
Adrian Cullis	Save the Children US	Addis Ababa	01/25/10
Andrew Catley	Feinstein International Center	Addis Ababa	01/25/10
Mukhtar Reshid	World Food Program	Addis Ababa	01/26/10
Elliot Vhurumuku	World Food Program	Addis Ababa	01/26/10
Eyob Meherette	Nyala Insurance	Addis Ababa	01/27/10
Abby Maxman	Care	Addis Ababa	01/28/10
Suzanne Poland	USAID	Addis Ababa	01/31/10
Jim Nuttall	USAID Office of Foreign Disaster Assistance (USA)	Addis Ababa	01/31/10
Berhanu Wolde Michael	MOARD: Household Asset Building Program	Addis Ababa	02/01/10
Gijs van't Klooster	Food and Agriculture Organization	Addis Ababa	02/03/10
Kassahun Bedada	MOARD: Early Warning and Response Directorate	Addis Ababa	02/04/10
Florence Rolle	Food and Agriculture Organization	Addis Ababa	05/02/10

Appendix C

Water Requirement Satisfaction Index

The Water Requirement Satisfaction Index (WRSI) is a measure developed by FAO and subsequently adopted by Famine Early Warning System (FEWS, subsequently FEWS-NET).¹ It divides the growing season into ten-day periods called dekads. A coefficient for each 10-day period gives the crop's potential evapotranspiration (PET), or water use, relative to the seasonal reference value. Yield forecasts are based on the fraction of dekadal PET that soil received from rain.

For example: given a vector of dekadal coefficients, we can calculate the vector of dekadal PET water requirements for the crop.

$$\vec{d} : \{d_1, d_2, \dots, d_k\} \quad (C.1)$$

$$\vec{E}_c = \vec{d} \cdot E_c \quad (C.2)$$

where

E_c : potential crop evapotranspiration

d_i : coefficient for dekad i

Then, dekadal precipitation data and other soil and crop characteristics give an estimate of actual evapotranspiration (AET). Dekadal AET has the plant available water as a lower bound and the dekadal PET as an upper bound.

$$W_c = \frac{\sum \varepsilon_c}{\sum E_c * 100} \quad (C.3)$$

where

W_c : crop WRSI

ε_c : actual crop evapotranspiration

E_c : potential crop evapotranspiration

The model takes into account the soil water content, drainage, the root depth of the crop, precipitation, soil evaporation, and crop transpiration of water. It does not model crop damage due to erosion. Crop water requirements are typically higher late in the season and low early in the season. Intraseasonal variation in crop water requirements is reflected in the coefficients used to determine the dekadal water requirements.

Appendix D

Livelihoods Early Assessment and Protection Index

WFP's weather insurance program in Ethiopia used a considerably more complicated algorithm to determine premium and payout than a simple put option on total seasonal rainfall. The Livelihoods Early Assessment and Protection (LEAP) index is discussed in a user manual at the software developer's website.² The purpose of the complex algorithm is to reflect the true impact of a given pattern of rainfall on livelihoods in specific districts of Ethiopia.

Many features of rainfall patterns can affect yields, including the frequency, the season, the maximum intervals between rainfalls, and the daily and weekly rainfall totals. These variables all affect farmers' (and herders') decisions. They affect the availability of water in the soil for plants and at feeding sites for livestock. They affect the specific development of different crops, and differently so for traditional and improved varieties. Since the objective of the LEAP index is to reflect the impact on livelihoods, the timing of rainfall over each 10-day period in the year is explicitly modeled.

The LEAP software analyzes rainfall data, soils, crop water requirements, historical beneficiary counts, and predicted planting and herding behavior. Rainfall and soil data permit the modeling of water balance in the soil under various patterns of precipitation.

Water balance models, along with crop water requirements, permit forecasts of specific yield reduction. Yield reduction forecasts, together with data about farmers' crop baskets and livelihoods, lead to estimates of rainfall's impact on livelihoods in specific woredas, or $WRSI_w$. This livelihood impact is further specified in terms of the number of beneficiaries of WFP assistance.

$$W_R = \frac{\sum P_w \cdot W_w}{\sum P_w} \quad (D.1)$$

where

- P_w : Population of the *woreda*
- W_w : WRSI of the *woreda*
- W_R : WRSI of the region

The second iteration of the LEAP model went beyond a linear calculation of beneficiaries from yield shocks to a logarithmic model. The regional WRSI, (D.1) is a population-weighted sum of *woreda*-level WRSI. Recall from the preceding appendix that WRSI is a seasonal index based on dekadal precipitation patterns.

$$\partial N = -K \frac{\partial(W_R - F)}{W_R - F} \quad (D.2)$$

where

- N: number of beneficiaries
- W_R : regional WRSI
- K: empirical constant
- F: WRSI floor for zero yield

The logarithmic model, (D.2) also incorporates a WRSI threshold beneath which crop output is catastrophically low, meaning that coping capacities are exhausted and the contribution of rain-fed agriculture to household income is negligible. The number of beneficiaries varies with rainfall according to a differential equation:

The solution to the differential equation takes the form:

$$N = K \log \frac{100 - F}{W_R - F} + N_0 \quad (\text{D.3})$$

And the number 100 simply reflects that the WRSI is expressed as a percentage, rather than a decimal.

Appendix E

Funding Sufficiency Game

E.1 A Formalization of Aid Coordination

Consider the following funding game. In this game, there are three actors, A, B, and C, which allocate aid budgets over three programs, X, Y, and Z. Each actor has a budget, which can be spent on any of the aid programs; or it can remain unspent. Aid programs are funded or not funded as a result of the independent decisions of all three actors. Player's payoffs are a result of the outcome of funding status of programs X, Y, and Z, and not the allocation of funds. In this model, all three actors receive political returns on the portfolio of aid programs funded, rather than their own decisions on aid allocation.

Actors know their own utility functions, but not the utility functions of the other players. Actors know the sizes of their own budgets and others' budgets.

For simplicity, I will use three programs of identical budget size, and equal marginal utilities of programs for each actor.

E.2 Definitions

Players: There are three players (E.1), each endowed with a budget (E.2).

$$\exists\{A, B, C\} \quad (\text{E.1})$$

$$\exists\{b_A, b_B, b_C\} \quad (\text{E.2})$$

Each player chooses to spend his budget on programs, in order to increase utility (E.9) and subject to possible exhaustion of funds (E.6). We can also suppose marginal utility of unspent funds θ (E.7) and disutility of certain programs τ , e.g., Y as in (E.8). For simplicity, I will assume equal marginal utilities of X , Y , and Z for each player and for each program.

$$X = \sum_i X_i, \quad 0 \leq X \leq 1 \quad (\text{E.3})$$

$$Y = \sum_i Y_i, \quad 0 \leq Y \leq 1 \quad (\text{E.4})$$

$$Z = \sum_i Z_i, \quad 0 \leq Z \leq 1 \quad (\text{E.5})$$

$$c_i \equiv b_i - X_i - Y_i - Z_i \quad 0 \leq c_i \leq 1 \quad (\text{E.6})$$

$$\theta \equiv \frac{\partial P_i}{\partial c_i} \quad 0 \leq \theta \leq 1 \quad (\text{E.7})$$

$$\tau \equiv \frac{\partial P_i}{\partial Y} \quad 0 \leq \tau \leq 1 \quad (\text{E.8})$$

$$P_i \equiv u_i(X, Y, Z, \theta, \tau) \quad (\text{E.9})$$

The payoffs for each player are shown here in E.2.

P_i	X	Y	Z	c
A	1	1	0	θ
B	1	$-\tau$	1	θ
C	1	1	1	θ

Table E.1: Payoff matrix for the funding sufficiency game

E.3 Assumptions

A number of flexible assumptions will give us insight into how decision processes can affect the optimal strategy for each player.

First, consider *nonperishable budgets*. With perishable budgets, there is no marginal utility to unspent funds in this funding game. Unspent funds are worthless to the participant. Under nonperishable budgets (E.10), each actor can retain unspent funds for other purposes, which might include other aid programs (besides X, Y, and Z) or non-aid uses.

$$\theta > 0 \tag{E.10}$$

Second, *decision order* plays an important role in optimal strategy. Simultaneous decisions yield different payoff sets from ordered decisions; and therefore, states can also deduce preferences over decision orders.

Third, budgets can each be lumpy or smooth. With *lumpy budgets* (E.11), each actor can only allocate budgets in the same units as programs require; no partial funding of programs is possible. With smooth budgets, actors can allocate fractional budgets to programs.

$$X_i, Y_i, Z_i \in \mathbb{N} \tag{E.11}$$

Fourth, we can permit an *antagonistic player* into the game: one of the players may have a marginal disutility over one of the three programs (E.12). That player's objective would be to prevent that disliked program from achieving funding, as opposed to a program that simply provided no marginal utility.

$$\tau > 0 \tag{E.12}$$

Fifth, *budget sufficiency* can have an overweening effect on the behavior of actors (E.13). Together, all the actors may have excess, sufficient or insufficient funds for all three programs; and the same may be true for any of the individual donors. With excess, perishable funds available for each actor in the game, the results are trivial: all programs are funded all the time. In the other cases, however, more interesting results are possible.

$$\sum b_i \begin{cases} > X + Y + Z & \text{excess} \\ = X + Y + Z & \text{sufficient} \\ < X + Y + Z & \text{insufficient} \end{cases} \tag{E.13}$$

There are some important consequences to the differences among A, B, and C's preferences as outlined above. Player A is the only player that supports all three projects. Players B and C support some of the initiatives but not all. Only player B, the antagonist, has marginal disutility for one of the programs.

There are also important differences among programs X, Y and Z. Program X enjoys universal support. Programs Y and Z enjoy partial support. Only program Y is controversial, in that it has an antagonist.

The game generalizes well to more than three players and more than three programs. Further aid programs that do not enjoy the support of more than one player are indistinguishable from pure utility of unspent funds; so that formal possibility is not built into the game.

E.4 Results

Result 1

Given perishable, lumpy, equal and sufficient budgets b_i , various decision orders determine possibilities of underfunded programs. The behavior of actors B and C is poorly defined in this game. Because there is neither marginal utility to spending nor to retaining B's marginal funds if Y is the only program left, B's behavior is poorly defined here. With nonperishable budgets, a more realistic assumption, the behavior is clearer.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	0
Ordered, C not last	Uncertain

Result 2

Given nonperishable, lumpy, equal, and sufficient budgets b_i , various decision orders determine possibilities of underfunded programs.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	0
Ordered, C not last	Greater than 0

Result 3

Given perishable, smooth, equal, and sufficient budgets b_i , without an antagonist, various decision orders determine possibilities of underfunded programs.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	0
Ordered, C not last	Greater than 0

Result 4

Given nonperishable, smooth, equal and sufficient budgets b_i , without an antagonist, various decision orders determine possibilities of underfunded programs.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	0
Ordered, C not last	Greater than 0

Result 5

Given perishable, smooth, equal, and sufficient budgets b_i , with an antagonist, various decision orders determine possibilities of underfunded programs.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	Greater than 0 if $\tau > \frac{1}{3}$
Ordered, C not last	Greater than 0

Result 6

Given nonperishable, smooth, equal and sufficient budgets b_i , with an antagonist, various decision orders determine possibilities of underfunded programs.

Funding order	Probability of a program's underfunding
Simultaneous	Greater than 0
Ordered, C last	Greater than 0 if $\tau > \frac{1}{3}$
Ordered, C not last	Greater than 0

Result 7

Players A, B, and C have preferences over funding order. The player with the last position in the decision order has a greater ability to ensure favorable outcomes, when funding decisions are observable by all but utility functions are known only to individual actors.

Players A and B have an even greater incentive to obtain the last place in the decision tree when the group of donors have excess budget capacity.

Result 8

The incentive to choose last can be diluted when two conditions are met: first, the group's capacity has excess budget capacity, and C's preferences are known to include all three programs. Specifically, the excess capacity should be great enough to permit the full funding of all projects without the participation of one of the players. At that point, that player whose budget is superfluous should opt for the earliest point in the decision tree, and refuse to fund any programs.

As a corollary, C's strategy should aim to limit both (1) the perception that it will cover other donors' funding shortfalls, and (2) the position of announcing funding decisions last. If possible, C must find ways to signal the limits to its funding sources before A and B make final decisions about funding sources. With uncertainty over A and B's utility functions, however, making an early decision entails risks for C: namely, that skimping on budgets for certain programs could leave them underfunded.

Result 9

Simultaneous decisions about funding without clear communication about donors' capacity and intentions can lead to clearly inefficient outcomes, particularly when budgets are lumpy and scarce.

E.5 Significance

The purpose of the foregoing is to demonstrate the importance of decision order on program funding outcomes. Relatively simple assumptions about players' knowledge, capacity, and decision orders lead to different possibilities that budgets for aid will be optimally allocated.

Result 8 is an example of coordination. Expectations about other players' behavior are driven by knowledge about their utility functions. Coordinated expectations about a donor of last resort can cause minor players to hoard their budgets. Once players can safely

assume all program funding is beyond doubt, the objective of the game becomes to retain budgets for other purposes.

In the model of this game, idiosyncratic aid programs are one of the purposes for which donors might hoard budgets. Rather than spend on shared priorities, donors might prefer to let someone else fund those programs, and retain their own funds for programs that have only their own support.

Much of the literature on aid decision making is concerned with the behavior of donors with diverse mandates and preferences. Hawkins et al. focus on the central role of institutional structures in coordinating decisions among multiple and collective principals. Barrett's categories of international public goods give a central role to the production function: either the maximum (first-best effort), or the summation (aggregate effort), or the minimum of states' efforts (such as commons problems).

Concerning this dissertation, this model specifies a mechanism and conditions which can lead to outcomes of interest. Hypotheses 1(a) and 1(b) describe free riding behaviors that this model treats equivalently: namely, that states in a multiple principal setting may choose to free ride either because they prefer to hoard budgets, or because they disagree with the collective portfolio of aid programs. This model also explains motivations for a large donor, such as the United States, to prefer a negotiated, *ex ante* funding process to the appeals process. Funding appeals go out to all potential donors simultaneously, and permit each donor to take up individual appeals at a convenient time, whether to game the funding negotiations or to accommodate the parliamentary calendar.