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**Increasing the Resilience of Financial Intermediaries through Portfolio-Level Insurance against Natural Disasters**

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***Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.***

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## Forthcoming in *Natural Hazards*

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### Abstract

*Financial intermediaries [FIs] in developing and emerging economies are poorly equipped to manage natural disasters. These events create losses for FIs, eroding capital reserves and compromising their ability to lend. Portfolio-level insurance against disasters can improve FI management of these events. We model microfinance intermediaries [MFIs] exposed to severe El Niño in Peru that can now insure against this disaster risk. Our analyses suggest that insurance allows these lenders to manage this risk more efficiently and effectively. These risk management improvements can translate into better financial performance, expansion of banking service outreach, lower interest rates, and reduced volatility in access to credit. Based on these analyses, a large MFI in Peru with which we collaborated is now managing its disaster risk using El Niño insurance.*

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## **Disasters, development, and financial services**

Natural disasters create many problems in developing and emerging economies. Disasters limit income and investment opportunities; destroy the assets of households and firms; dismantle public infrastructure, isolating communities and disrupting markets; and increase health and disease problems.

The effects of disasters can be even more acute in regions with underdeveloped financial markets where communities rely on informal substitutes to financial services. Informal risk-sharing arrangements break down as entire communities need assistance. Commonly used illiquid ‘savings’ such as livestock or building materials must be sold at fire sale rates during a crisis (Dercon, 1998). While formal financial services would improve the risk management capacities of these communities, their vulnerability to disasters, ironically, constrains financial market development.

Financial intermediaries [FIs] such as banks are poorly equipped to manage the community and regional effects of disasters. Because disasters affect so many borrowers concurrently, FIs experience portfolio-level problems that can threaten their solvency. In many contexts, loan losses are the major threat as FIs write down and write off loans due to the inability of borrowers to repay; in others, the largest threat is liquidity risks due to withdrawals by depositors and reduced revenue from poorly performing loans. As a result, the risk of these disasters reduces borrower quality, increases interest rates, and impedes FI expansion.

FIs in developing and emerging economies tend to be more exposed to natural disaster than those in developed countries for several reasons. To name a few, these FIs tend to manage portfolios with greater geographic and economic sector concentrations (BCBS, 2010), fewer households and firms are insured, social safety nets are less developed, and households tend to be more interdependent (Townsend, 1994). These differences limit the effectiveness of developed country approaches for developing and emerging economies that are exposed to natural disasters. As one alternative, this paper presents portfolio-level

insurance against natural disasters as a mechanism that may be particularly pertinent to FIs in developing and emerging economies.

Given the potential value of portfolio-level insurance for FIs, we evaluate the specific example of microfinance intermediaries [MFIs] operating in Peru that are exposed to severe El Niño and can now purchase insurance against this disaster risk. This paper describes the work that we conducted with several MFIs and the detailed analyses we developed with three of them. The remainder of the paper is organized as follows. First, the conceptual underpinnings for why natural disasters hurt FI performance are developed. Second, a process of assessing FI risk using both historical data and the estimations of potential losses in the current portfolio is described. Limited data due to the infrequency of these events complicate the risk assessment; we use a modified Delphi method to estimate the risk by eliciting the views of local experts — agronomists, loan officers, and credit risk managers working in the MFIs. Third, we discuss a banking model that we developed as a decision tool for the risk managers in the MFIs that simulates disasters and evaluates the effects of insurance on MFI performance. Fourth, Monte Carlo simulation demonstrates the risk-return tradeoffs in taking on different levels of insurance. Out of respect for the confidentiality of those MFIs, we present findings for a ‘representative MFI’ which combines the results of each. These analyses are motivated by three objectives: 1) evaluate portfolio-level El Niño insurance in terms of banker and policymaker objectives, 2) demonstrate the effects of a severe systemic risk on an FI portfolio, and 3) describe the risk assessment process needed to conceptualize and manage this severe natural disaster risk in a banking context.

## **1.1 The effects of disasters on financial intermediaries**

Disasters affect many aspects of the operations of an FI, not only destroying its loans but constraining loan origination after the event. The income statement and balance sheet are important accounting tools that highlight FI vulnerability. Net income comprises three broad categories: revenues, costs, and changes in asset values. Each of these can be affected by a disaster. As borrowers have trouble repaying loans, revenues decrease. Funding costs increase due to deposit withdrawals, stiffer competition for funds

among affected FIs, and the increased risk of lending to these FIs. In the worst cases, FIs may be unable to access additional funds and face a liquidity crisis. FIs also incur higher administrative costs from loan restructuring, exercising rights on collateral, and so forth. Asset values decrease through provisioning as nonperforming loans increase. Each of these effects reduces net income, and net losses on the income statement translate into equity losses on the balance sheet.

FIs are highly sensitive to equity losses because they tend to be much more leveraged than other firms. One of the key mechanisms used to assess and manage banking risk is the capital ratio, which is a ratio of FI capital to its risk weighted assets (for example, loans). International banking standards recognize several forms of capital, but the highest quality and main element of capital is equity (see BCBS, 2006, for example, issued and fully paid ordinary shares of common stock). This capital acts as a buffer to protect liability holders, and international standards set a minimum capital ratio of 8 per cent (BCBS, 2006). An FI holding this minimum capital ratio should be able to withstand losses of up to 8 per cent of its risk weighted assets and remain solvent.

Disasters create portfolio-level losses that deplete FI capital and so reduce the capital ratio. When the capital ratio is below its targeted amount, the FI has two possible strategies: recapitalise or deleverage. Recapitalising is undesirable to current shareholders as new equity investments dilute current shares and enter the FI when equity values are lowest. Moreover, many FIs in developing and emerging economies may be unable to find investors willing to recapitalise them during a crisis. FIs that are not recapitalised need to deleverage to improve their capital ratios by reducing their risky asset holdings to align with their smaller capital bases. In developing and emerging economies, deleveraging generally entails originating fewer loans. Cutting back on lending post-disaster is problematic as this is the moment that the community needs funds the most. Furthermore, returns on lending may actually be higher after the disaster as the demand for credit increases as communities work to recover and rebuild. Thus, the process of deleveraging represents a substantial opportunity cost to an FI as it reduces its ability to generate revenues (Van den Heuvel, 2006).

## 1.2 Managing risks and the discrete goals of bankers and policymakers

The inability of FIs to manage natural disasters challenges the policy goals of many developing and emerging countries, which emphasize both increasing financial inclusion and limiting credit supply shocks. Regarding financial inclusion, improving access to financial services is an important policy goal as underdeveloped financial markets can slow economic growth and perpetuate poverty (King and Levine, 1993; Levine, 1997; Levine and Zervos, 1998; Ray, 1998; Armendáriz and Morduch, 2011). Another important goal is protecting the real economy from banking shocks, which can occur for example when loan losses reduce the supply of credit and constrain the activities of firms relying on credit for production. These dynamics encourage policymakers to balance a tradeoff between the objectives of 1) increasing overall access to credit and 2) limiting volatility in access to credit by discouraging excessive risk taking. In this spirit, international banking standards now characterize banking policy goals as promoting ‘sustainable economic growth’ (BCBS, 2011, p. 1).

In contrast to the goals of policymakers, bankers and their investors tend to emphasize financial performance. These goals include maximizing expected financial returns over time, but also managing solvency risks. While managing risk can be an important goal for bankers and their investors, several theories of market failures in financial intermediation (for example, Carletti, 2008) and ample empirical evidence (for example, BCBS, 1999) indicate that FIs tend to take on more risks than policymakers would prefer. In sum, mechanisms that enhance the ability of FIs to manage risks at a limited cost are important to policymakers and bankers alike; however, policymakers are motivated to evaluate these mechanisms in terms of their cost to financial inclusion whereas bankers are motivated in terms of their cost to expected financial returns.

The status quo for managing systemic risks is capital adequacy requirements [CAR]. These requirements give FIs capital reserves that are flexible as they can be used to manage losses from any source, but they have several limitations. First, FIs in developing and emerging economies tend to operate in incomplete financial markets with limited access to capital. In this context, CAR limit the amount of loans an FI can

extend. Higher CAR reduce risk, but *ceteris paribus*, reduce access to credit. Second, managing losses with capital reserves can lead to deleveraging after a crisis, limiting the credit supply as described above.

Portfolio-level insurance is an alternative mechanism that may be particularly suitable for events that cause large portfolio losses such as natural disasters. Insurance against a disaster acts as a form of asset diversification that can limit the effects of the disaster on the FI. Such insurance pays when many of the other assets (loans) of the FI are performing poorly. The insurance payout protects the capital base of the FI, and should put it in a stronger position to lend after the disaster — an important objective for policymakers. By protecting the ability of the FI to lend after the disaster, insurance has the potential to contribute to the financial performance of the FI — an important objective for bankers. Additionally, for vulnerable regions where disaster risk limits the supply of credit, insurance against these disasters can provide effective means for transferring this risk and increasing the supply of credit more generally.

## **Background: Banking and severe El Niño in Peru**

Severe El Niño creates significant flooding in northern Peru. El Niño is associated with a warming of the Pacific surface temperature off the coast of Peru (Lagos et al., 2008). Warm air from the west meets cool air coming down the Andes in the east, resulting in extreme rainfall in the northern, coastal regions (McPhaden, 2002). During the severe events of 1983 and 1998, rainfall was roughly 40 times normal levels for the months January to May. The water volume in the Piura River, a major river in the region, was also about 40 times normal levels during these events (Skees and Murphy, 2009). As a result of the extreme weather, lives are lost, bridges are wiped out, roads are destroyed, crops are inundated, assets are lost, communities are isolated, food prices rise, and pest and disease problems increase.

Severe El Niño creates problems for MFIs and limits access to credit. The 1998 El Niño created loan repayment problems that lasted years (Trivelli, 2006). Ten per cent of all agricultural loans in northern Peru defaulted due to the 1998 El Niño (Trivelli, 2011). Furthermore, the increased risk of default associated with El Niño increases interest rates by approximately 3 percentage points in northern Peru



(Skees and Barnett, 2006). If access to credit were increased through lowering interest rates and reducing credit rationing, Boucher et al. (2008) estimate that total output for Piura, an important region in the north, would increase by 26 per cent.

Because of these severe events, the MFIs have invested significantly in El Niño risk management. After the 1998 event, some of them drastically reduced access to credit in the sectors they perceived as most vulnerable to El Niño, especially agriculture. They also expanded to less vulnerable regions such as southern Peru and the jungle. For the MFIs discussed in this paper, between 30 and 50 per cent of their loan portfolios are currently in vulnerable northern regions of Peru. The MFIs employ specialists such as agronomists and engineers to consider the physical consequences of El Niño conditions during loan underwriting. They also take strategies to mitigate losses such as refusing to extend loans in flood prone regions and offering very few long-term loans. While these strategies reduce their risk, severe El Niño affects so much of Peru and affects the north so acutely that these MFI managers continue to report that their institutions are vulnerable to these events.

El Niño insurance is a form of index insurance. Index insurance bases payouts on an objective measure of the severity of the disaster and is being used widely in places where traditional forms of insurance are insufficient to meet the needs of the target market. El Niño insurance bases payouts on the warming of the Pacific surface temperature, which is the standard measure of the severity of El Niño among climatologists. These temperatures are highly predictive of catastrophic flooding in northern Peru (Khalil et al., 2007). Because higher Pacific temperatures are predictive of flooding, the insurance was designed to pay *before* the most catastrophic flooding occurs. Thus, the extreme El Niño insurance in Peru may be the first regulated forecast insurance in the world. The contract being evaluated is based on November and December Pacific temperatures and pays in January. Reports of the previous severe events indicate that flooding began no earlier than January and increased to dramatic levels in the following months. In this context, the benefits of an index insurance structure include 1) early insurance payouts that can be used to help the FI dynamically manage the disaster; 2) coverage against business interruptions and

increased costs that would not typically be covered under a traditional insurance structure; and 3) lower costs for the insurance as the adverse selection and moral hazard problems of traditional insurance are substantially reduced with index insurance, assuming proper underwriting standards such as appropriate sales closing dates are followed.

## **El Niño risk assessment**

Conducting a proper risk assessment in this context is an important yet daunting exercise. Two effects of severe El Niño on the MFIs were deemed particularly important to estimate: 1) the level of nonperforming loans, that is loans that are close to default or must be restructure to prevent default, which is an indication of the effect of the event on MFI revenues; and 2) the per cent of the loan portfolio that is written off due to loan defaults, to which the capital base is particularly sensitive. Assessments indicated that for these MFIs, vulnerability to liquidity risks was low due to access to a strong and responsive central bank, active secondary lending market, and emergency liquidity facility and so are not discussed in this paper.

Historical data analysis and physical loss models can inform these estimates. Yet, only two severe El Niño events have occurred in living memory and the most recent in 1998. The economy, financial sector, public infrastructure, production methods, and even landscape have changed significantly since 1998 so estimating the effects of the next severe El Niño requires local expertise to integrate historical records with current conditions.

## **Factors complicating risk measures in historical data**

Understanding the effects of disasters on key risk metrics such as the capital ratio is further complicated by market development, flexibility in reporting loan losses, and institutional and political decisions. The Peruvian banking regulator provides income and balance sheet records for all of the registered FIs since 1994. Three MFIs have been and continue to be the largest providers of microfinance in northern Peru and are used here for illustration. These MFIs were established in the early 1980s by local municipalities

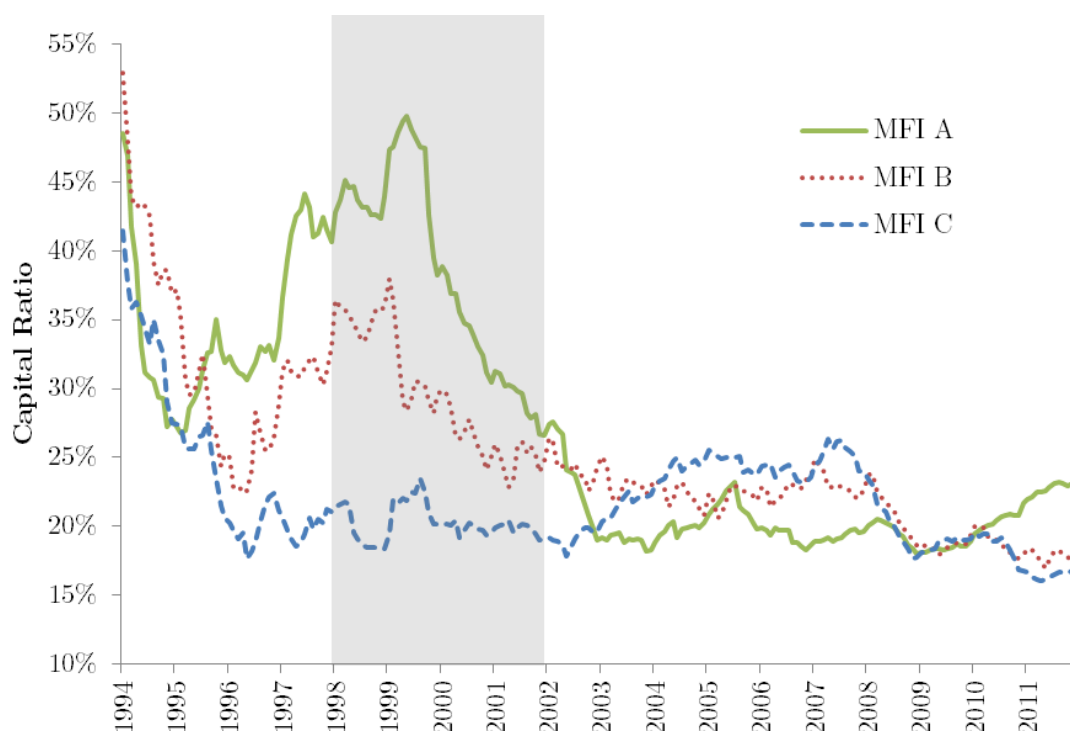
to increase access to financial services. Out of respect for their privacy, we call them *MFI A*, *MFI B*, and *MFI C*.

The capital ratios at which FIs operate are a function of financial market development. FIs in nascent financial markets often operate with higher capital ratios because of 1) difficulty finding suitable borrowers in a new market, 2) unrefined underwriting standards that may lead to larger losses than expected, and 3) limited competition, leading to strong financial returns under low levels of leverage. These conditions limit the size of an FI and prevent it from fully utilizing its risk capital. Under-utilized risk capital increases flexibility for recovery from a disaster because an FI can incur loan losses that impair the capital ratio without falling below the regulated CAR. If an FI is not in danger of falling below its CAR, it may even increase lending, further reducing its capital ratio, to grow in order to recover. Expanding the loan portfolio after a disaster can improve financial returns because demand for credit is high and opportunities for investment are many. Expanding the portfolio also dilutes the proportion of nonperforming loans in the portfolio. In contrast, in more fully developed markets, FIs tend to operate closer to the minimum CAR and so expanding the loan portfolio in order to grow out of a disaster is not typically possible. Instead, they must resort to recapitalization or deleveraging, as described above.

Figure 1 shows a close approximation for the capital ratio (equity/loans) for the MFIs from 1994 to 2011. Over this time, local financial markets evolved from nascent to competitive conditions. For example, the average return on assets for these three MFIs was 4.9 per cent in 1994 and 2.5 per cent in 2011. As the market matured, the capital ratios of these MFIs declined, generally converging toward the regulated 14 per cent CAR. The shaded area in Figure 1 identifies a four year period marking the occurrence of severe El Niño in 1998 and the subsequent recovery<sup>3</sup>. Capital ratios are most volatile in this period as the MFIs manage loans losses and attempt to recover, yet because these MFIs were operating with such high capital ratios leading into the 1998 event, the decline in the marked decline and recovery of the capital ratio is not seen in this figure.

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<sup>3</sup> Collier et al. estimate that recovery from the 1998 El Niño took four to five years.

**Figure 1: Capital ratio for three MFIs operating in northern Peru.**

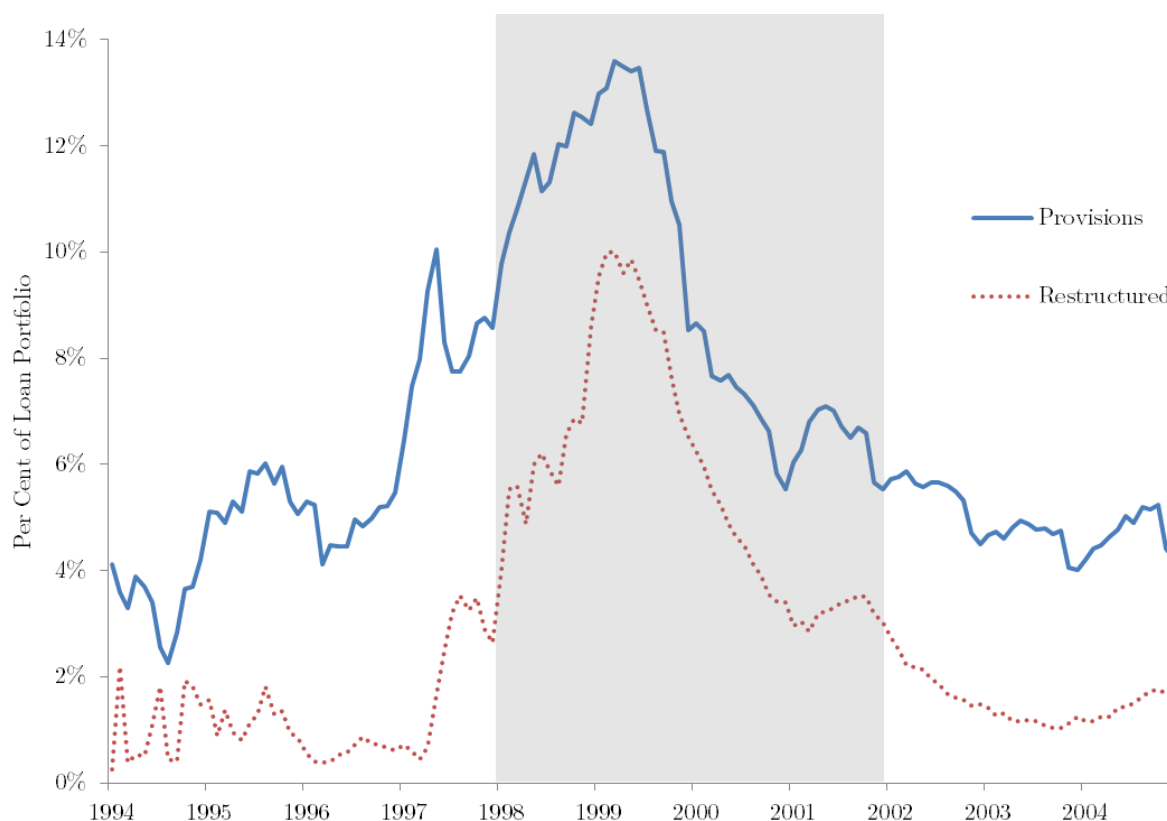
The consequences of disasters on the MFIs are more fully understood by examining the effects on loan quality. Provisioning and loan restructuring standards provide additional flexibility for managing disaster losses. In many jurisdictions including Peru, FIs are required to rate loan risk among several discrete categories and to ‘write down’ the value of a loan based on the identified risk category. These specific provisions for troubled loans are intended to be assigned ex ante, before the FI incurs losses, with the goal that these steps will motivate FIs to manage losses proactively. Peru, like other jurisdictions, allows FIs to mark a loan with a lower risk rating and so hold fewer specific provisions if a risky, poorly performing loan is restructured (SBS, 2008). FIs can even offer borrowers a ‘grace period,’ an allotted amount of time in which borrowers do not need to service their loan. Eventually FIs must realize their losses, but strategic reporting can make a crisis look less acute by delaying the realization of those losses on the balance sheet.

Figure 2 serves to illustrate this dynamic using data from MFI A. The solid line identifies loan provisions and is presented as a per cent of the total face value of the loan portfolio. The dotted line represents the proportion of the loan portfolio that has been restructured. Provisioning levels in Figure 2 illustrate that

loan portfolio quality was worsening in the months before El Niño and that the disaster exacerbated these quality problems. Restructuring levels indicate that the MFI began more actively managing nonperforming loans during and after the severe El Niño. Collier et al. (2011) find evidence that MFIs in the region started to restructure before catastrophic flooding began in early 1998. Whereas Collier et al. find that one MFI restructured approximately 4 per cent of its total loan portfolio due to El Niño, these data suggest that MFI A restructured up to about 8 per cent of its portfolio due to this event.

In October 1999, MFI A originated a large volume of new loans, increasing the size of the portfolio by 12 per cent — the average monthly growth rate for the loan portfolio is 3.4 per cent for the series. The purpose of those loans is unclear in the data. There were certainly many communities needing credit after the 1998 El Niño, and perhaps these new loans were made to meet that need. Making these loans reduced the capital ratio of MFI A, as can be seen in Figure 1; however, one benefit to the MFI of these loans is that they improved measurements of portfolio quality by increasing the amount of well-performing loans in the loan portfolio, the effects of which can be seen in Figure 2 where provisioning and restructuring levels substantially decline in the final months of 1999.

It is to this complex and sometimes opaque reporting system that political intervention can add additional complexity during a crisis. Policymakers face pressure to help maintain a stable banking system and sometimes change reporting standards during a crisis, which for example happened during the Japanese banking crisis in the 1990s (Hoshi and Kashyap, 2000; Kanaya and Woo, 2000). In Peru after a 2007 earthquake, the banking supervisor announced that loans potentially affected by the earthquake would be treated with lower levels of specific provisioning than under the general law (SBS, 2007). Additionally, in a more dramatic form of intervention in late 2001, the Peruvian State purchased outstanding and poorly performing agricultural loans from the 1998 El Niño at a deep discount from the MFIs (El Peruano, 2001).

**Figure 2: Provisioning and Restructured Loans for Financial Intermediary A**

In sum, the underlying fundamentals of how a disaster affects retained earnings and is transmitted to the capital ratio of the FI can be obscured by market conditions, strategic loss reporting, and political interventions. While conditions created an opportunity for these MFIs to grow out of a crisis, the financial market has matured and the MFIs are now more leveraged, precluding the use of this strategy during the next disaster. These MFIs have grown substantially — the loan portfolio of one has grown roughly 50 times its 1997 value. Moreover, microfinance market expansion is often associated with financial deepening, reaching less resilient clients as the market grows. This deepening may significantly increase El Niño vulnerability for these MFIs. In sum, historical records should be interpreted with caution, and we have taken the position that loss scenarios should be built on ‘primitive’ variables such as the expected effects of a disaster on loan performance over the life of the loan. These primitives can then be used in banking models where alternative risk management strategies can be tested.

### 3.2 Using an adapted Delphi Method to estimate El Niño risk

Because of the challenges of limited data and confounding policy decisions, we used an adapted Delphi Method to assess MFI exposure to severe El Niño. We worked closely with three MFIs operating in northern Peru, two of which are profiled in the historical data above. The Delphi Method relies on the knowledge and opinions of experts to forecast outcomes. Experts are interviewed in an iterative process that allows them to express their views and respond to the feedback of other experts (Linstone and Turroff, 1975; Landeta, 2006). This process is intended to help experts converge toward a predicted outcome and to identify the level of uncertainty associated with that prediction.

While the Delphi Method outlines a very specific protocol for the interview and data collection process, we adopted a modified approach more suitable to the risk assessment. Because the portfolio composition of each MFI differed, this application differed from other uses of the Delphi Method. Typically, a variety of experts are working to forecast a single outcome; however, in this application, the experts at each MFI were forecasting distinct but related problems — the exposure of their MFI to severe El Niño. Using the collective expertise across MFIs required careful consideration to respect the confidentiality of each firm. Consistent with the Delphi Method, we provided experts with general estimates developed by their peers at other MFIs while protecting the anonymity of those firms.

Over the course of several meetings, we used historical data and the views of other experts to help the risk managers at each MFI develop informed estimates of the exposure of their firm. The references for severe El Niño were the events that occurred in 1983 and in 1998. We organized interviews with MFI field officers and credit risk managers in the vulnerable regions. This process provided estimates from their physical loss assessments and institutional memory as each of the MFIs employed risk managers that had worked in the MFI during the 1998 event. Their risk estimates indicate several highly vulnerable economic sectors, namely, agriculture, fishing, and transport sectors. Each of these sectors is exposed to a different aspect of the event. Agriculture is affected by severe rain and significantly higher ambient air temperature. Fishing is affected by elevated ocean temperatures. Moreover, loans to small fishers were

thought to be highly vulnerable because many of these loans are not collateralized and the MFIs anticipated that troubled borrowers would default on these loans. Transportation is affected due to the potential breakdown of roads and bridges. Table 1 outlines results from a representative risk assessment. In sum, the estimate suggests that 10 per cent of the portfolio of a representative MFI will require restructuring and 4 per cent of the portfolio value will be written off during a severe El Niño.

**Table 1: Severe El Niño Risk Assessment Results**

Sector	Nonperforming loans	Write-offs
Agricultural	75	50
Fishing	75	70
Transport	30	15
Other	10	3
Total MFI portfolio	10	4

Source: Authors from detailed interviews. Table notes: The sector estimates are presented as a per cent of the loan portfolio in the vulnerable regions, which are the northern coastal regions. The final line 'Total MFI portfolio' summarizes these effects as percentages of the whole portfolio of the MFI as these MFIs have diversified nationally to reduce their exposure to severe El Niño.

Because of the many sources of uncertainty, we developed at least three loss scenarios with each MFI, an optimistic, moderate, and pessimistic scenario. Modelling several scenarios allowed for sensitivity analyses, assessing the performance of risk management strategies under differing conditions. The moderate scenario describes the expected value of losses, the risk managers' estimates of the most probable outcome. From this moderate scenario, we asked risk managers to consider, given a severe El Niño similar to that in 1998, the conditions that would lead to much less or much greater losses than expected. We asked the managers, whenever possible, to identify specific events that might substantially alter MFI losses. For example, the rainfall pattern and timing of the 1983 El Niño differed from that of the 1998 event, and differences in the geographic presentation of these events could result in notably different loss profiles. Additionally, the State created a precedent in Peru where after the 1998 event, it bought nonperforming agricultural loans at roughly 50 per cent of the original loan value (El Peruano, 2001). One MFI wanted to compare risk scenarios where the State purchased poorly performing loans with one where they did not. From these conditions, we developed at least one optimistic and pessimistic scenario for



each MFI, which are intended to capture the risk managers' best and worst expectations of losses, respectively. Table 2 summarizes the three scenarios in terms of the total portfolio for a representative MFI. It also provides the range of values across the three MFIs, the high and low for values for each scenario.

**Table 2: Three Loss Scenarios for Severe El Niño**

Scenario	Nonperforming loans	Range for NPL	Write-offs	Range for Write-offs
Optimistic	7	4-9.5	2	1.5-2.5
Moderate	10	6.5-11	4	3-4
Pessimistic	13	8.5-14.5	6	5-6

Source: Authors from detailed interviews, all numbers are percentages of the loan portfolio value.

## Description of the banking model

The banking model used in these analyses comprises an income statement and balance sheet that simulate the dynamics of banking activities over time. It is based in a spreadsheet and was designed to be accessible to credit risk managers. The model is recursive. Each month, the amount that the modelled MFI earns depends on the assets and liabilities on the balance sheet (for example, the level of loans on the balance sheet determines the gross interest income). Monthly net income is then allocated on the balance sheet as retained earnings that increase the capital base. The modelled MFI retains all earnings, no dividends are paid to shareholders, and the possibility of external capital infusions is not included<sup>4</sup>. The modelled MFI uses a target capital ratio and originates loans based on this target. Generally, each month, the MFI is profitable and increases its loan portfolio and so has the potential to earn more income in the following month.

<sup>4</sup> Inclusions of these payments would embed additional assumption in the model and potentially obscure the results. Dividend payments during a crisis further undermine the capital base of a troubled FI making it more vulnerable. FI managers anticipating that shareholders will demand a payment during the next severe disaster have an increased incentive to manage their financial risk with insurance. Capital infusions can save an ailing FI; however, relying on recapitalization is problematic for several reasons, as described above. In this context, portfolio-level insurance may represent an attractive alternative for FI managers as it reduces uncertainty associated with attracting capital and for equity holders as it reduces the probability that the FI will require a capital infusion during a crisis.

We use data from one of the MFIs to illustrate the process of calibrating the model and testing its performance. First, the model is calibrated based on the average performance of variables on the income statement, accounting for any trends in the data. For example, monthly interest income from that period indicates its expected value is approximately 2.35 per cent of the value of the loan portfolio. On the balance sheet, cash and loans comprise assets; interbank debt and deposits comprise liabilities. Liabilities are modelled as the residual of assets minus equity. Deposit and provisioning levels are set in the model based on historical averages, but both include an error term to capture volatility seen in the data. The CAR for MFIs in Peru is 14 per cent, and we specify a target capital ratio of 15 per cent based on our interviews with the MFI managers. To test the model, we compare the empirical indicators of financial performance for August 2010 to August 2011 with those generated by the model, which is shown in Table 3.

**Table 3: Comparison of Monthly Actual and Modelled Financial Performance**

Indicator	Empirical	Modelled
Gross financial margin	1.63	1.62
Net financial margin	1.40	1.40
Net operational margin	0.39	0.35
Return on loan portfolio	0.19	0.17
Return on equity	1.17	1.16

Source: Authors. Table notes: All indicators in the figure are as a per cent of productive assets, except for return on equity, which is net income divided by equity.

## Modeling El Niño

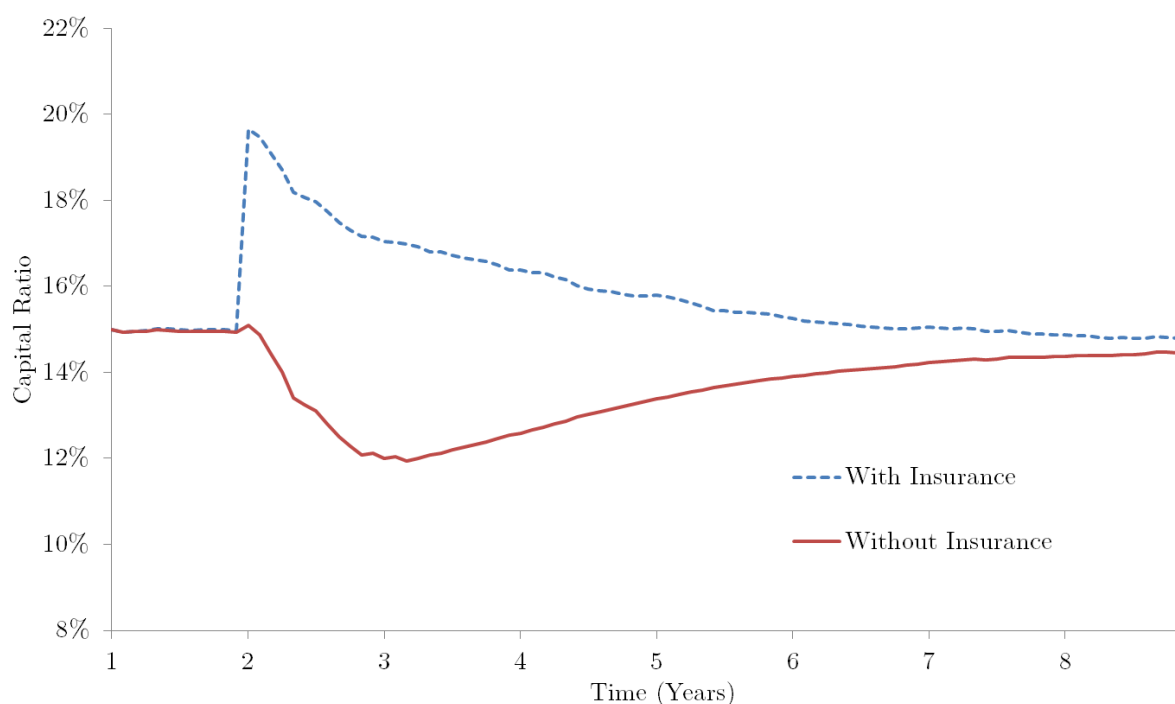
Based on the last 30 years of data, severe El Niño occurs with about a 1 in 15 probability. While climate scientists recognize the very remote possibility of severe El Niño conditions for two (or more) years in a row, stakeholders in Peru report strong beliefs that severe El Niño will not occur for several years after a year with an extreme event. To model stakeholder beliefs, severe El Niño occurs with a 1 in 15 probability, cannot occur for two years after an event has occurred, and cannot occur more than twice in the 10 year evaluation period in the model.

We model the effects of El Niño on the MFIs through its influence on income statement and balance sheet variables. For example, the increase in nonperforming loans created by severe El Niño reduces monthly interest income. We also model the time anticipated for each variable to converge back to pre-disaster performance levels. The risk managers in the MFIs estimated that monthly interest income would converge to pre-disaster levels after 36 months.

We also attempted to model very basic management decisions as reported by the risk managers. For example, the managers reported that they plan to stop lending as severe El Niño conditions emerged, especially to vulnerable sectors like agriculture. At the start of the event, it will be difficult to estimate the extent of losses and which communities will be affected most. Thus, the modelled MFI stops originating new loans just before severe El Niño begins and begins making new loans when net income becomes positive.

## 4.2 Benefits of insurance during El Niño

Figure 3 was generated by simulating an El Niño in the second year of the model that results in the moderate loss scenario. The solid line illustrates the effect on the capital ratio. As described above, losses in net income, especially loan losses, reduce the capital ratio. The dotted line illustrates the ability of the insurance to protect MFI capital. The sum insured in this scenario is equal to 6 per cent of the value of the loan portfolio. The insurance pays just before a severe El Niño. The insurance payout would enter the balance sheet as new equity through retained earnings. Therefore, it increases the capital ratio. The capital ratio for the insured MFI falls after El Niño. This occurs because 1) the insurance for the MFI portfolio does not directly address the default problems of its borrowers so the value of the loan portfolio still declines; and 2) the insured MFI expands lending after El Niño. While the MFIs report that they have mechanisms to manage liquidity risks due to severe El Niño, the timely insurance payout also improves the cash position of the MFI and so can address unforeseen liquidity needs that might arise.

**Figure 3: Effects of El Niño on the capital ratio with and without Insurance**

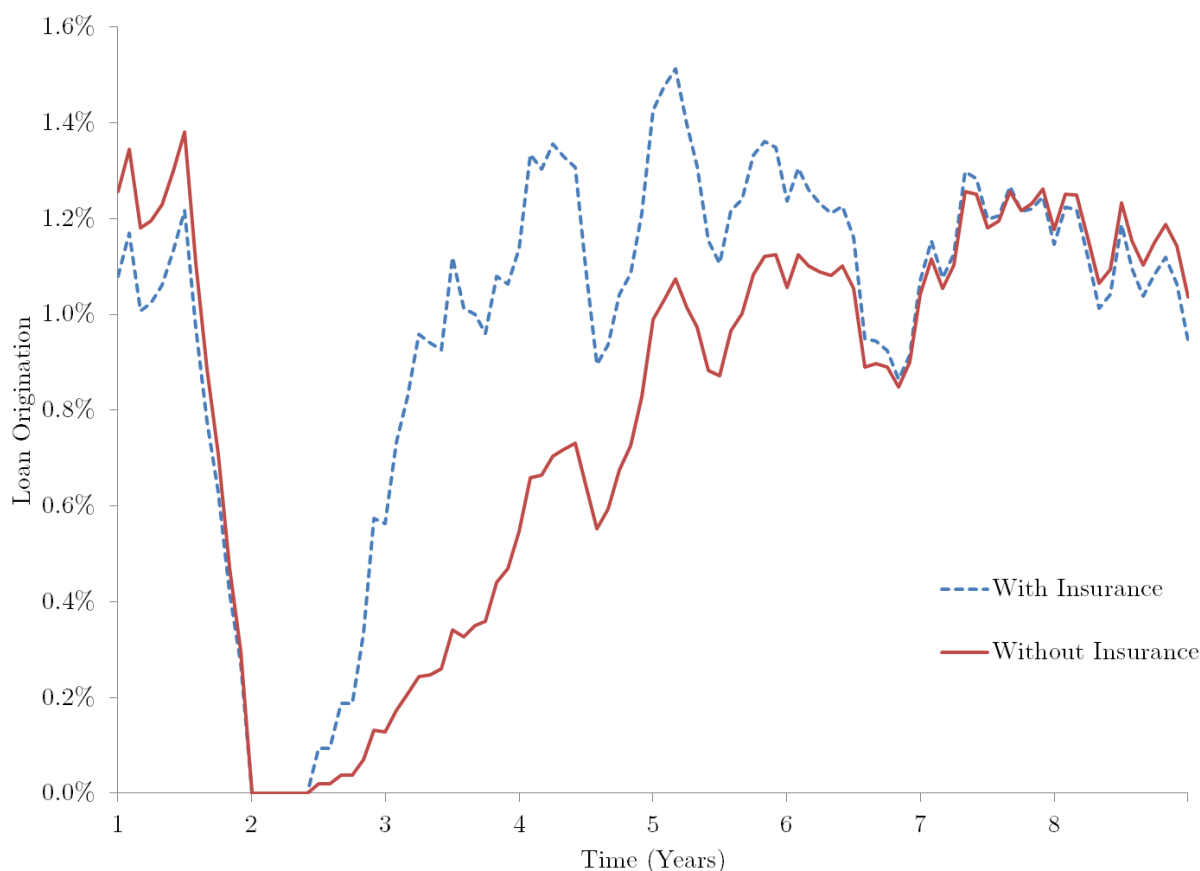
Source: Authors. Figure notes: The dotted line corresponds with insuring a value equal to 6 per cent of the value of the loan portfolio. The capital ratio is measured as equity divided by the value of the loan portfolio net of provisions.

In the model, the insured MFI is in a strong position entering a severe El Niño due to the insurance payout, and Figure 4 compares modelled loan origination for the MFI with and without insurance. After the severe El Niño, the insured MFI originates much higher levels of loans. In reality, the insured MFI will have a choice of how aggressively it would like to leverage this new capital into loans. It must balance the impending losses associated with borrower default, which will reduce MFI capital, with the new lending opportunities associated with households and firms needing to rebuild. We anticipate that the MFIs will rely on some blend of maintaining extra capital reserves as they ascertain the repayment capacity of their current borrowers while taking advantage of strong opportunities in the market. An unmodelled benefit of the insurance to financial performance is that after a severe event, the stronger MFIs have the potential to capture market share from weaker MFIs.

While the capital ratio and loan portfolio growth eventually recover for the uninsured MFI, the accumulated contributions of insuring to financial performance and portfolio growth are noteworthy in

this simulation. The insured MFI is able to generate 18 per cent more equity and expand its loan portfolio by 16 per cent more than the uninsured MFI by the end of the 10 year simulation period in this example.

**Figure 4: Loan Origination**



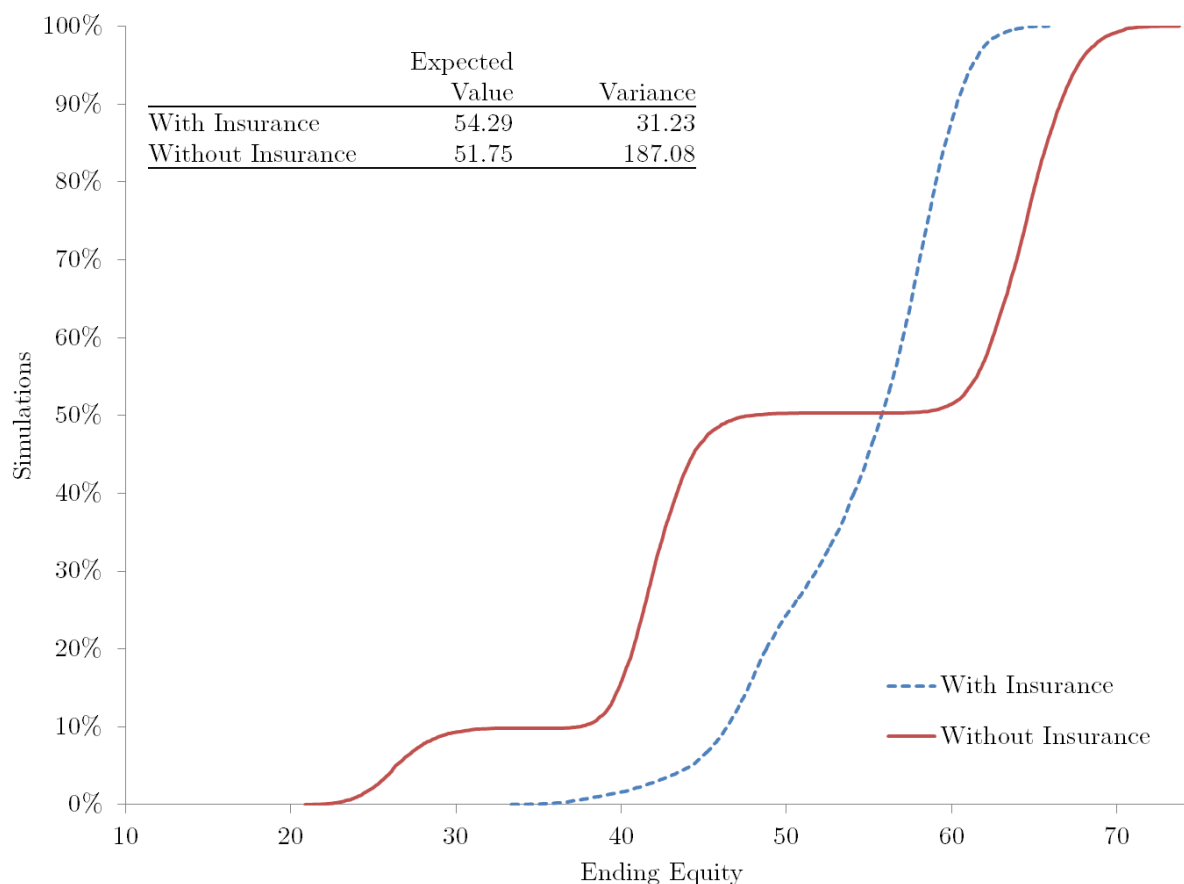
Source: Authors. Figure notes: The figure uses a six month moving average of loan origination. Loan origination is measured as a per cent growth in the face value of the loan portfolio.

### 4.3 Comparisons across Outcomes with a 10-Year Time Horizon

The above provides an example of the effects of a severe El Niño occurring in the second year of the model. The next analysis simulates a range of possible outcomes to determine the implicit tradeoffs of buying the insurance. Because the El Niño can affect the MFIs for several years, we use a long time horizon (10 years in this case) as a longer duration provides a clearer picture of the implications of different risk management strategies for the modelled MFI.

We use Monte Carlo simulation for this analysis. The random variable in this model is the occurrence of severe El Niño. The outcome of interest in this simulation is MFI equity at the end of the 10 year time horizon. Because the model includes no dividends or capital infusions, the equity position after 10 years represents the initial equity of the MFI plus its net income stream over the 10 year horizon. We evaluate risk management policies based on the expected ending equity and the variance in ending equity across Monte Carlo simulations. This analysis demonstrates risk-return tradeoffs generated by the simulation.

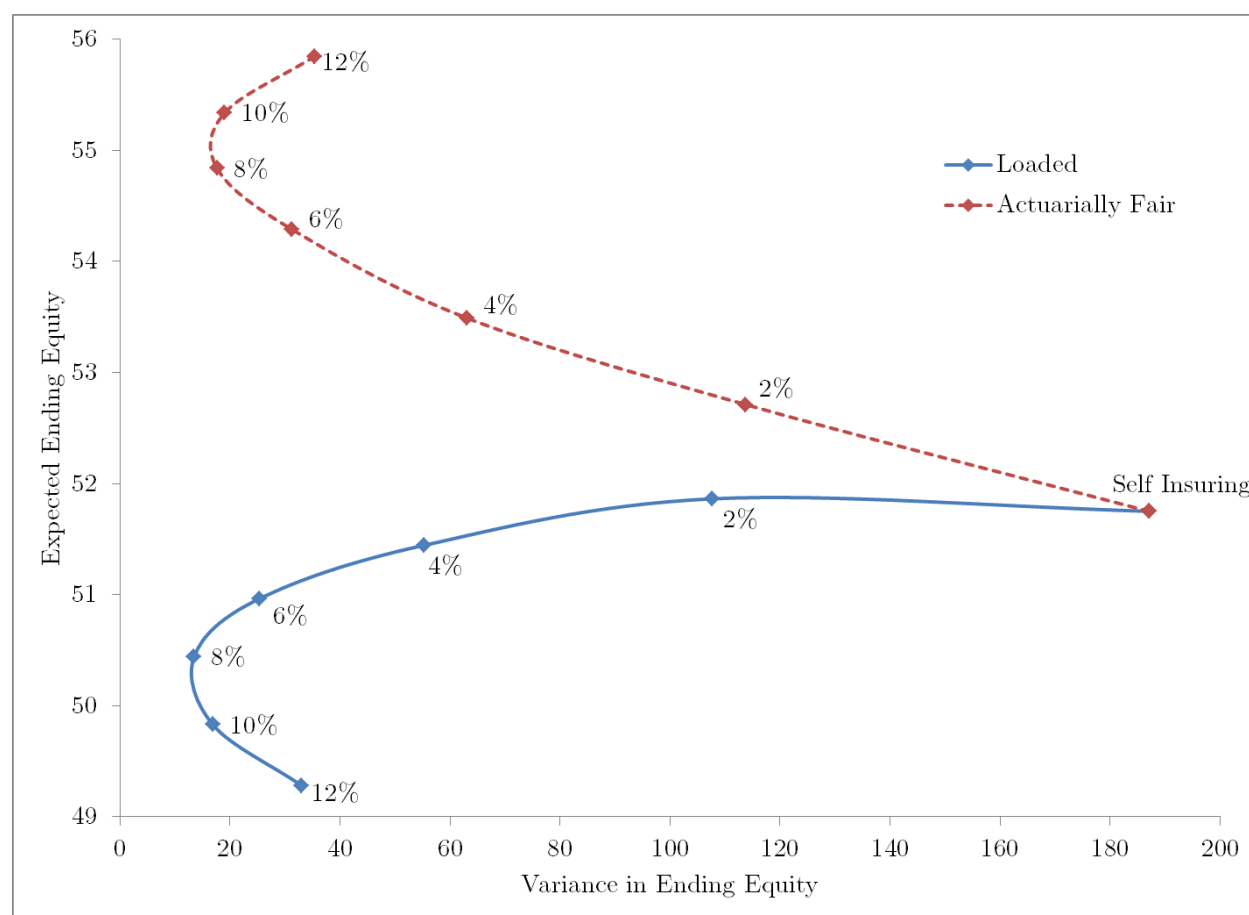
Continuing with our example of a sum insured of 6 per cent, Figure 5 presents the results of this analysis for the moderate risk assessment scenario. The price of the insurance used in this analysis is the actuarially fair rate (4.03 per cent of the sum insured each year), and this insurance contract would have made a payout of 76 per cent of the sum insured in 1998 and 45 per cent in 1983. Insurance payouts in the model are randomized between these two values (that is, when a severe El Niño occurs with an event frequency of 1 in 15 years, there is an equal likelihood in the model that the event will pay at the 1983 or the 1998 rate). We conduct 10,000 simulations for each risk management strategy (choosing a sum insured of 6% of the portfolio versus not insuring). The graph is organized so that simulations with the lowest ending equity are on the left and those with highest ending equity are on the right. Given the probability of the event, in roughly 50 per cent of the simulations El Niño did not occur. In the scenarios in which no El Niño occurs, the uninsured MFI has a higher ending equity position than the insured MFI. In any simulation where El Niño occurs, the ending equity position of the insured MFI is higher. This result is due to the concepts described above, that the insurance protects the capital of the MFI and allows it to continue originating loans — smoothing the net earnings of the MFI.

**Figure 5: Example Monte Carlo Simulation with Actuarially Fair Insurance**

Source: Authors. Figure notes: Monte Carlo simulation conducted with 10,000 draws. The insurance is priced at the actuarially fair rate in this simulation. The variable of interest is the ending equity value of the modelled MFI after a 10 year period. The dotted line corresponds with insuring an amount equal to 6 per cent of the value of the loan portfolio.

Comparing across all 10,000 scenarios, the average equity position after 10 years for the insured MFI is higher than for the insured MFI by about 5 per cent. The effect on risk is much larger. The variance in ending equity — that is the volatility in the capital base — is reduced by 83 per cent.

Next, we compare outcomes across different levels of sum insured. Each point in Figure 6 represents a Monte Carlo simulation similar to one of the lines displayed in Figure 5. The dotted line in Figure 6 represents the results for the insurance were it to be priced actuarially fairly. For each of these analyses, both the expected value and volatility of ending equity improve for relatively small sums insured compared to no insurance, what we have called ‘self insuring.’

**Figure 6: Comparisons Across Sums Insured: Ending Equity after 10 years**

Source: Authors

Figure 6 is a form of mean-variance analyses in portfolio theory. The actuarially fair result suggest that given the loss expectations of the representative MFI, choosing a sum insured that is less than 8 per cent of the loan portfolio would be inefficient as the MFI could earn higher returns for taking on the same level of risk. The range of insuring 8 to 12 per cent (and higher) of the loan portfolio is called the ‘efficient frontier.’ Portfolio theory indicates that the point chosen on the efficient frontier by FI managers depends on their risk preferences.

Also shown in Figure 6 is the ‘loaded rate’ for the insurance. Market-based insurance always includes loading due to administrative costs, the cost of capital for the insurer, etc. For example, if we use a market price of 6.8 per cent of sum insured, this should be relatively close to the market price that will be charged in Peru. As shown in the solid line in Figure 6, this loaded rate offsets the benefits of the insurance to the



expected ending equity of the MFI; however, the risk-reducing benefits of the insurance remain. For the solid line, the range in expected ending equity across sums insured is relatively small. Self insuring and insuring at 2 per cent result in equivalent expected ending equity (51.8 versus 51.9, respectively). Insuring at 8 per cent, the risk-minimizing level, reduces expected ending equity by 2.5 per cent. This model does not take into account a variety of possible return-enhancing behavioral changes that insuring against a catastrophe may motivate (e.g., lending to vulnerable borrowers in underserved regions) so given the advertised price, many opportunities may emerge to further increase the returns of an insuring MFI.

Experience suggests that, for large value contracts such as what would be purchased by an MFI, the advertised price may be effectively an opening offer in a negotiation for the transaction price. Thus, the two curves in Figure 6 represent an upper and lower bound for the risk-return tradeoff of the insurance for the MFI, depending on the final negotiated price.

Finally, the sold line is also influenced by the probability of severe El Niño. Because catastrophic events occur infrequently, estimating their probability is difficult. This model uses an estimate that severe El Niño occurs with a 1 in 15 probability each year. Given the advertised price of the insurance, if severe events occurred less (more) frequently, the expected return associated with insuring would decrease (increase). For this analysis, we have followed the convention of many reinsurers in using the last 30 years of data to estimate the risk; however, some climate scientists and statisticians believe the annual probability of severe El Niño may be lower than 1 in 15.

A striking result of these analyses is that the El Niño risk for the representative portfolio can be managed with a relatively small amount of insurance. For example, suppose that managers of the representative MFI wanted the lowest level of risk and chose a sum insured of roughly 8 per cent of the loan portfolio

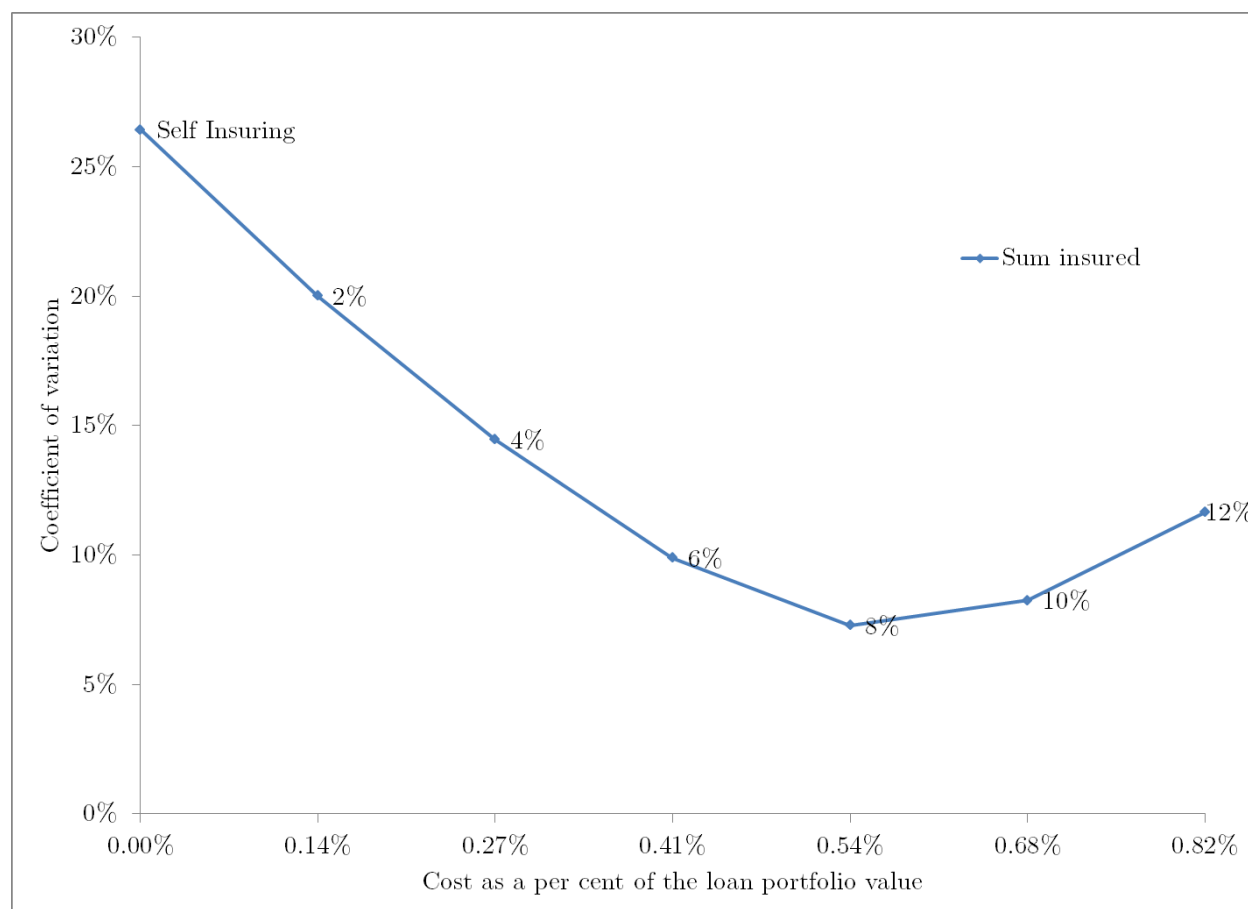
value. The cost represents 55 basis points on the loan portfolio to insure against the greatest climate risk faced by these MFIs<sup>5</sup>.

One of the MFIs with which we worked purchased El Niño insurance based on our collaboration during the most recent sales season, which ended in January 2012. Despite arguments about the seemingly low cost of managing this risk, our experience has been that purchasing portfolio-level insurance is a new and sometimes difficult proposition for many of the MFIs in Peru. Many operate on tight margins, and managers can be reluctant to pay 55 basis points for an untested innovation. Those stakeholders may benefit from recognizing that the marginal benefits are highest for low sums insured — in other words, moving from a strategy of self insuring to formally insuring a small portion of the risk provides the greatest risk reduction relative to the cost, as demonstrated in Figure 7.

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<sup>5</sup> With a premium rate of 6.84 per cent of the sum insured, insuring at 8 per cent of the portfolio results in 55 basis points on the portfolio,  $6.84\% \times 8\% = 0.55\%$ .

**Figure 7. Influence on the Coefficient of Variation from Purchasing Insurance at the Loaded Rate**



Source: Authors. Figure notes: The coefficient of variation (CV) is the standard deviation divided by the mean. In this case, the CV pertains to the ending equity position of the MFI across simulations.

## 5 Conclusion

Portfolio-level insurance against natural disasters has the potential to align banker and policymaker objectives for FIs exposed to natural disasters. These analyses suggest that insurance allows FIs to manage disaster risks more effectively than via capital reserves alone. Moreover, they demonstrate the potential efficiency gains of strategies that combine insurance and capital reserves. This improved efficiency can translate into better financial performance, expansion of banking services, lower interest rates, and reduced volatility in access to credit. Based on the risk analyses and demonstrated benefits of

portfolio-level insurance against disasters described in this paper, one of the modeled MFIs has begun purchasing El Niño insurance to manage its risk.

Policy goals of increasing financial inclusion are often motivated by improving access to credit for specific, marginalized groups that may be under-served (for example women, the rural poor, ethnic minorities, and so forth). Our analyses do not specify borrower type and so cannot directly inform these policy dimensions; however, marginalized groups tend to be particularly exposed to disasters as they often live and work in vulnerable areas (for example flood zones, squatter settlements, isolated rural communities, Schipper and Pelling, 2006; Collier et al., 2009). Yet, because insurance reduces the costs and challenges of offering financial services to those exposed to the disaster, it is highly vulnerable populations who have the potential to benefit most.

Because limiting FI risk taking tends to be a higher priority for policymakers than bankers, policymakers will need to provide incentives for FIs to insure at levels that are close to the social optimum. Collier et al. (under review) suggest that portfolio-level insurance is better suited than CAR to manage disaster risks given their nature, scale, and complexity. As a result, they suggest that insurance could be used as a legitimate substitute for a limited portion of capital reserves and suggest that policymakers put the onus on FIs to develop analyses demonstrating risk reduction to the regulating supervisor before they receive benefits. For example, the banking supervisor in Peru is increasing the use of stress testing for its MFIs, which is an excellent avenue for MFIs insuring their risk to demonstrate the value of insurance and for the supervisor to formally recognize the improved resilience of those MFIs. This approach would likely contribute to the objectives of policymakers, but would require some adjustments to international banking standards such as the Basel Accords. A great deal of research highlights the limitations of those accords for developing and emerging economies (for example Griffith-Jones, Segoviano, and Spratt, 2003; Stephanou and Mendoza, 2005; Tanveronachi, 2009), and the current transition to Basel III, which is even less relevant, may be a timely moment for tailoring solutions more appropriate for the needs of developing and emerging economies.

The metrics of financial performance, risk reduction, and financial inclusion are also important to ‘socially responsible’ investors who are increasingly investing in developing and emerging economies. These investors have the potential to reinforce risk management improvements among exposed FIs. Credit rating agencies play an important role in informing investors, and improved risk evaluations by rating agencies are needed in areas exposed to disasters. Too often, those agencies adopt the formats of developed country raters. As a telling anecdote from Peru, two risk analysts, one at a credit rating agency and the other at a socially responsible investor, reported independently that severe El Niño is a major threat to MFIs in northern Peru, but they also noted that disaster risk does not fit neatly into their rating protocols so this risk and its management are not considered in their risk analysis.

Our analyses have several limitations. First, while the model used in this paper demonstrates the fundamental effects of disasters on FIs, it was generated as a decision tool for banking risk managers and so it is therefore difficult to communicate all of its elements concisely. Our next planned research activities include producing mathematical models that demonstrate these mechanics more directly. Second, these analyses were conducted for an event, severe El Niño, which causes both income and physical losses in several economic sectors. We hope to replicate these findings with other disasters that cause income and physical losses such as earthquake and windstorms. We also hope to test other types of disasters such as drought where losses are likely to be concentrated more heavily in the agricultural sector. Because of the dependence of rural economies on agriculture, the consequences of drought may propagate through the rural economy, affecting loans in other economic sectors. Thus, an important extension of this research is to test the effects of other disaster risks on banking portfolio performance.

Finally, as an opportunity for further research, we suggest evaluation of how portfolio-level insurance might affect the use of other risk management strategies such as diversification. Since the last severe El Niño in 1998, the MFIs in northern Peru have invested a great deal in strengthening their risk management practices, as described above. It is only recently that El Niño insurance has been offered. Returning to the recent past where no insurance was available, MFI managers would have balanced the

perceived marginal costs of additional risk management investments with the perceived marginal costs of retaining risk (in other words, self insuring). As a result, we assume that the MFIs were operating at an optimal level of risk management based on their perceptions of the risk. It is in this context that insurance was introduced. The finding that portfolio-level insurance increases expected returns while also lowering volatility in returns is an indication of its efficiency. The results indicate that the marginal costs of insuring are lower than those of retaining risk given the risk management strategies used by the MFIs. The above suggests that the marginal cost of insuring is lower than strengthening risk management practices and so we predict that insured MFIs will re-optimize their risk management strategies by reducing strategies such as diversification, using insurance as a substitute.

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