



2014

EARTHQUAKE RISK IN INDONESIA: PARAMETRIC CONTINGENT CLAIMS FOR HUMANITARIAN RESPONSE AND FINANCIAL INSTITUTION RESILIENCY

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Recommended Citation

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EARTHQUAKE RISK IN INDONESIA: PARAMETRIC CONTINGENT CLAIMS FOR
HUMANITARIAN RESPONSE AND FINANCIAL INSTITUTION RESILIENCY

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Agriculture, Food and Environment
at the University of Kentucky

By

Jason Hartell

Lexington, Kentucky

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ABSTRACT OF DISSERTATION

EARTHQUAKE RISK IN INDONESIA: PARAMETRIC CONTINGENT CLAIMS FOR HUMANITARIAN RESPONSE AND FINANCIAL INSTITUTION RESILIENCY

This dissertation explores the use of an index based contingent claims mechanism against earthquake risk in Indonesia. It focuses on time critical financing needs of international humanitarian relief organizations, and on efforts to improve the resiliency of geographically constrained financial institutions whose clientele are exposed to disaster risk. The approach uses measures of ground motion intensity as the basis for the index. The humanitarian response mechanism provides a new way for private sector partners to participate and gain visibility in their support of principled humanitarian funding. Index based contingent claims for local banks are shown to enhance their ability to recover and continue lending to the community after an event. Financial risk management may also substitute for a portion of the lender's precautionary capital buffer, enabling greater financial inclusion. Wholesale lenders with local bank networks having earthquake exposure can enhance these effects by offering group policies.

KEYWORDS: Earthquake Disaster, Index Insurance, Financial Resiliency, Humanitarian Response, Economic Development

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April 21, 2014

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For Mutti and Baby Sister.

ACKNOWLEDGMENTS

I would like to thank my dissertation committee members Dr. Jerry Skees, Dr. Leigh Maynard, Dr. Michael Reed, Dr. David Freshwater, Dr. Paul Childs, and Dr. Edward Woolery. Their perseverance and comments have helped make this dissertation a reality and a better product. In particular, Jerry Skees has provided patient insistence, encouragement, a wealth of good ideas, fatherly guidance throughout my graduate school experience and beyond, and kindly included me in fascinating development projects across the globe.

I would also like to thank Dr. Michael Spranger for sharing his knowledge of earthquake risk and probabilistic hazard modeling, Dr. Michael Shaw for helping me climb the learning curve of the R statistical environment, and Mr. Richard Carpenter for his sage advice and deft navigation of the insurance regulatory environments in the field.

Finally, I would like to extend my gratitude to the Ford Foundation, in particular Mr. David Hulse and Mr. William Smith, for enabling excellent work and education experiences in Indonesia and Vietnam, and for giving me the opportunity to provide some meaningful contributions to economic development.

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Chapter 1. Introduction

This dissertation explores the use of contingent claims mechanisms, index based insurance specifically, in addressing natural disaster risk exposure and financing within the setting of Indonesian earthquake risk. The applications focus primarily on solutions to financial constraints that have implications for the effectiveness of humanitarian response, and resiliency of banking services for the benefit of the working poor following an earthquake event. The connection between the two applications extends beyond the specific type of index mechanism. Both are concerned with the well-being and recovery of mostly poor households following a natural disaster, and in seeking innovative solutions to complex financing problems. Both applications are also concerned with improving resiliency—the ability of individuals, institutions and the economy to quickly react, recover, and adapt to severe events—through the use of index insurance and capital market risk transfer to complement appropriate infrastructure and other investments in disaster risk reduction and preparedness.

While the use of the index mechanisms to enhance humanitarian action is limited to response and early recovery, the consideration of financial services for the working poor extends further to those constraints that impose burdens to achieving greater financial inclusion. A proximity based lender not having the ability to diversify its lending portfolio geographically against natural disaster risk will ration credit to the local economy, or will face constraints in obtaining funds to on-lend. An index insurance designed to protect the local lender's portfolio against earthquake induced default of its clients has the potential to loosen these constraints to greater local lending and contribute meaningfully to economic growth and poverty reduction.

While earthquake insurance is not new, it is much less common in developing economies and nearly inaccessible to the working poor and small businesses in its current form. Natural disaster risk of all types have become a public policy priority, in part spurred by recognition of the increased frequency and severity of hydrometeorological phenomena attributed to climate change effects. In developing economies, the magnitude of natural disaster losses is recognized as a growing threat, jeopardizing progress toward achieving and sustaining development goals. These real concerns have contributed to a continued interest in investigating unique index based approaches to risk transfer in developing economies as a means to protect livelihoods and advance economic development.

This dissertation has grown out of project work supported by the Ford Foundation in Indonesia. The field work, in support of a market development initiative of index based risk transfer for livelihoods protection, was an invaluable opportunity to hear first-hand from individuals and organizations about their concerns and experiences with severe earthquake events. It also provided a solid context for the many obstacles to successful financial innovation in support of livelihood protection, financial services resiliency, and economic de-

velopment. Addressing earthquake risk of financial institutions by agricultural economists may seem unusual. However, previous work, particularly in Peru regarding severe El Niño effects, have shown that these types of correlated risks can strongly influence the behavior and ability of financial institutions to serve the working poor in the agricultural sector and beyond (Collier, Katchova, and Skees 2011; Collier, Miranda, and Skees 2013; Collier and Skees 2012; Skees 2010; Skees, Varangis, et al. 2004) . Exposure to earthquake risk appears to have similar effects in limiting financial inclusion, slowing economic development and, in particular, restricting the ability of affected populations to access credit for coping and recovery after the event. It is hoped that this work will provide some insights and new approaches for enhancing the ability of financial institutions and individuals to address their risk exposure in a way that contributes to greater institutional and livelihood resiliency and ultimately to development and poverty reduction.

The dissertation's objectives are five-fold:

- To provide background for how seismological events are measured and the risk quantified through probabilistic hazard analysis. It will propose that ground motion mapping can serve as the basis for developing an index for risk financing purposes, and will review hazard mapping for Indonesia;
- To propose an index based financing instrument for the unique funding needs of international non-governmental organizations who respond with humanitarian aid following an earthquake disaster event;
- To provide evidence and rationale for focusing on financial institutions and their lending portfolios as an appropriate target for an earthquake insurance hedge, one that will ultimately serve to benefit the livelihoods of the working poor and small businesses.
- To present the results of a banking model that incorporates an insurance hedge against loan portfolio losses due to earthquake, having both immediate recovery benefits as well as longer term economic growth benefits;
- To propose an alternate means of supplying an earthquake insurance hedge more widely to local financial lenders, through their suppliers of wholesale credit, and to investigate the magnitude of cumulative direct benefits.

The remainder of this introduction will briefly establish the context of earthquake risk in Indonesia, sketches the advantages of index based approaches to risk transfer, and provides a perspective for targeting insurance interventions away from individual households and instead toward institutions that aggregate and hold risk due to the exposure and vulnerability of their clients.

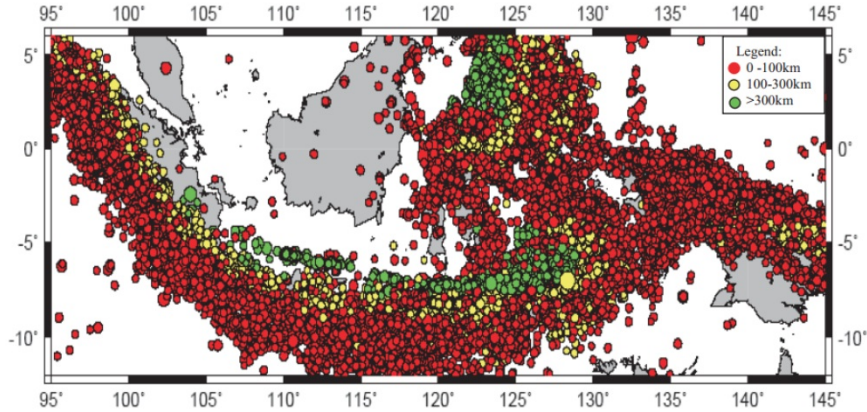


Figure 1.1: Indonesian Seismicity, $M_W > 4$, 1779–2010 (Putra et al. 2012).

1.1. Earthquake Disaster Impact

Indonesia’s seismic hazard is pervasive and country-wide. Multiple tectonic plates surrounding Indonesia cause it to be highly exposed to earthquake risk in both frequency and intensity. Overall, approximately 20 percent of the world’s damaging earthquakes occur in Indonesia. A simple mapping of historical earthquake occurrence shows the distribution of earthquakes by severity and depth, where shallower are generally more destructive (Figure 1.1). The impoverished and the working poor face the bulk of natural disaster risk and remain highly vulnerable, with an estimated 40 percent of Indonesia’s 230 million citizens living in areas at-risk for multiple hazards, such as earthquakes, tsunamis, volcanic eruptions, floods, landslides, droughts and forest fires (World Bank 2009; IBRD/World Bank 2001; Skoufias 2003).

Severe earthquakes destroy private property and public infrastructure, and can have a devastating humanitarian impact. In late 2009, the 7.6 and 6.8 magnitude earthquakes in Southern Sumatra alone resulted in 1,300 people killed and 1,214 persons severely injured. More than 250,000 households were affected by a total or partial loss of their homes and livelihoods. Following the events, the Indonesian government estimated the rehabilitation and reconstruction costs to be USD 745 million. A few examples of the scope of damage and consequential losses included:

- The collapse of 4 hospitals, 12 community health centers, 1,078 schools, 80% of government buildings, and the largest university in the region;
- Destruction of public water and electricity infrastructure, estimated at 170 billion IDR (US \$18.59 million);
- Over USD \$8 million in direct emergency humanitarian aid was provided by the United States Government alone;

- Up to 400 commercial and rural bank branches mobilized to restructure small loans of people and businesses who lost their homes, their livelihoods, or both.

These estimates do not account for the second round, long-term disruptions in business activities and peoples' livelihoods that most certainly were part of this event. Without efficient risk transfer and financing mechanisms, the costs associated with major earthquakes and other catastrophes are absorbed throughout the economy, often disproportionately by the poor. In the immediate aftermath, the poor pay through direct losses and disruptions to income until productive assets can be recovered and local markets function. When maintaining a basic level of existence requires liquidating productive assets or curtailed investments in human capital, the victims of natural disaster face the possibility of persistent poverty (Barnett, Barrett, and Skees 2008; M. Carter and Barrett 2006).

Lenders such as banks and microfinance institutions (MFIs) operating in vulnerable regions also suffer beyond the physical loss of assets and infrastructure. When households are impacted, severe disruptions flow up the financial community as households and small businesses become unable to service their debt, forcing restructuring and incurring losses. Weary of large-scale default, lenders may withdraw access to working capital, curtailing opportunities for productivity and mitigation investments *ex ante* and recovery *ex post*. These low risk, low return behavioral responses to natural disaster risk have a large adverse net effect on the entire economy, slowing growth and reducing resilience to future shocks.

Governments also incur expenses to coordinate and deliver emergency assistance and to rebuild damaged infrastructure. Catastrophic events can quickly overburden government and donor disaster budgets, and can divert resources from other long-term development priorities. Inadequate delivery systems for aid, and complex eligibility and accounting requirements often delay the speed at which public resources can be deployed to assist the economically vulnerable.

1.2. Index Insurance: An Alternative Risk Transfer Innovation

Index insurance is a different class of contingent contract having unique features that distinguish it from most other forms of insurance (Hull 2002). An index is a single numerical value calculated from observations of one or more physical events that indicates its position over a range of possible outcomes. Examples of common insurable indices include directly measured weather variables (e.g., cumulative rainfall, temperature), indices derived from weather variables (e.g., heating and cooling degree days), magnitude-based indices (e.g., maximum flood level or wind speed, counts of days with or without rainfall, measures of ground shaking), indices related to weather and climate (e.g., measures of drought intensity, measures of sea surface temperature, remotely sensed measures of vegetative health or precipitation) (Dinku et al. 2008); and even celestial weather in the form of disruptive geomagnetic radiation from solar flare activity (Hyman 2002). An index may also be de-

signed for combinations of perils, such as for snowfall and extreme temperature (Dischel 1999; Ruck 1999).

Index insurance payouts are based on the realized value of the underlying index that is proportionate with the direct losses and additional costs of the insured, rather than on a direct estimate of ex post losses. This feature negates the need to conduct individual loss assessment and removes most opportunity for the insured to influence their likelihood of receiving a payment. As a result, index insurance has potentially lower operating costs than traditional, loss-based insurance. Because insurance payments depend only on the value of the index, the amount of payment can be quickly determined and distributed to the insured.

Index insurance is most effective for insuring catastrophic risks as the index is more likely to be representative of individual losses when the triggering event has a widespread homogenous impact—when the losses are highly correlated. This minimizes the potential mismatch between the realized value of an index and the loss experiences of individual policyholders, known as basis risk (Martin, Barnett, and Coble 2001; Richards, Manfredo, and Sanders 2002). The lack of high correlation between payments and losses is one of the limitations of index insurance, particularly for individual policyholders. One of the advantages of index insurance is that its standardized structure makes it more feasible to pool risk geographically and transfer the financial exposure, via reinsurance or other means, into larger competitive capital markets (Dischel 2002).

The flexible structure of index insurance allows it to be deployed for the needs of a wide range of stakeholders including the provision of contingent financing for disaster relief, protecting financial institutions and other risk aggregators from business interruptions when a disaster occurs, and as a microinsurance product that protects individual households against the financial consequences of catastrophic risks. Of these, the many microinsurance applications have presented the greatest challenges, with few having developed beyond the pilot stage (Hazell et al. 2010). Index insurance pilots have required significant investment from donors and governments to provide for development costs since private domestic insurers usually possess neither the human capital nor a willingness to heavily invest in an uncertain innovation. Many index insurance schemes have also relied on premium subsidies to influence demand, which raises doubts about the long-term efficiency and sustainability of these products (M. Burke, de Janvry, and Quintero 2010).

1.3. Segmenting Risk and Sequencing Risk Management Instruments

A risk management scheme, whether at the individual, enterprise, or governmental level, will involve selecting a mix of risk mitigation, retention and transfer approaches appropriate over different segments of the distribution of potential losses. Figure 1.2 illustrates the risk spread in a way that emphasizes the segmenting of risk as probability and severity change. The figure is of a generalized density function typical of many natural disaster loss distributions

where the horizontal axis is the range of possible outcomes of increasing severity while the vertical axis is the probability (expected frequency) of each potential outcome. The distribution already subsumes risk mitigation that alters the exposure to loss. Mitigation effort displays declining marginal effectiveness (or increasing marginal cost) so that at some point it becomes more effective to switch to loss financing.

The distribution in Figure 1.2 is segmented into four layers. The first layer represents relatively small loss events that can occur frequently. The second layer represents moderate loss events that occur less frequently than the loss events in the first layer. The third layer represents high impact loss events that occur infrequently. Finally, the fourth layer represents the least frequent and most highly destructive loss events.

An efficient risk management strategy may involve different financial approaches and instruments for different segments of the risk profile. The ideal blend will depend, in part, on the relative costs of loss financing (Andersen et al. 2010). Minor and more frequent losses are retained and absorbed using reserving or other source of liquid funds which is typically the most cost effective means of managing more frequent but less severe losses. Less frequent but slightly more severe losses will also be retained but financed through credit. The holding of reserves will exhibit lower opportunity cost than credit up to the point where the expected value of forgone investment returns over some time horizon exceeds the expected cost of using credit. For events of greater severity, reserves may be easily exhausted and credit may be difficult to obtain if revenue streams are jeopardized. In these situations other strategies are needed.

Insurance markets enable the transfer of risks with a potential magnitude of loss that is beyond what can be handled with reserving and credit. However, insurance can be expensive because it necessarily entails costs for marketing, actuarial services, underwriting, loss adjusting, administration, legal services, and other functions. Insurers also load heavily for the ambiguity associated with infrequent but potentially catastrophic events. Loading factors apply even when insurance is used to make payments on small but more frequent losses (Andersen et al. 2010). For these reasons, insurance is typically not a cost effective mechanism for managing more frequent but less severe losses.

The choice of instruments across the distribution of risk can be highly subjective, information intensive, and depend upon many factors that can change rapidly over time including the opportunity costs of capital (e.g., due to the arrival of an investment opportunity) and the comparative price of different risk management tools (Andersen et al. 2010; Culp 2004). For instance, reinsurance pricing can rise substantially following significant industry losses and the default probability of debt providers can change rapidly. Risk management furthermore is lumpy in that there are fixed costs that are prohibitive when involving small transactions, which complicates a marginal analysis assuming divisibility. The choice therefore is not static but one which must be updated periodically.

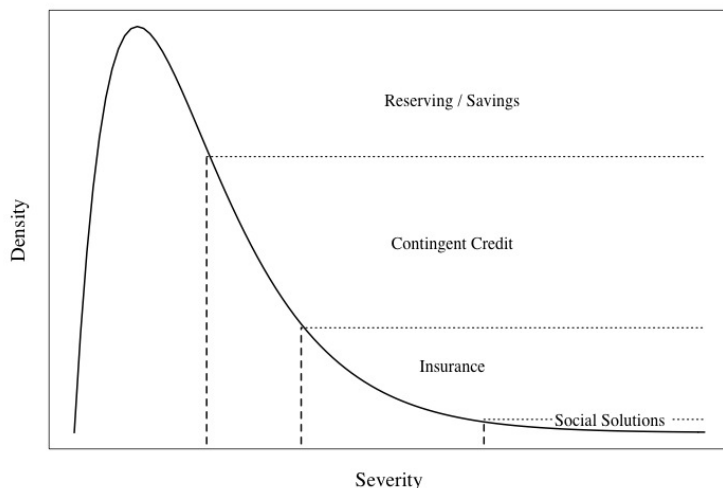


Figure 1.2: Risk Segmenting and Sequencing of Risk Management Instruments.

Market based risk transfer may not always take place for a number of reasons. Very infrequent but potentially catastrophic losses are particularly problematic. Low frequency but severe risks represent a case where myopia and cognitive failure lead decision makers to assume that the probability of loss is near zero and thus ignore their risk exposure (Hogarth and Kunreuther 1989). In this segment, great uncertainty surrounding the probability and scale of catastrophic losses leads insurers to add a significant risk load. Consequently, the market for risk transfer in this layer tends to be quite small or non-existent because parties find it difficult to negotiate a mutually agreeable price (Kunreuther, Hogarth, and Meszaros 1993; Skees, Hartell, and Hao 2006). This extreme loss segment usually requires social solutions and responses with safety net programs and *ex post* disaster and recovery assistance.

In the following chapters, consideration of risk segmenting and loss frequency will influence which type of instrument is used to address a particular need. It will be seen that the relatively more frequent payments in the example of emergency humanitarian response services will suggest a contingent credit approach, while the risk transfer for financial institutions can be supported using insurance solutions.

1.4. Risk Transfer for Aggregators Serving the Working Poor

Risk aggregators are businesses and financial service providers who provide critical services to the working poor in times of crises and whose operations are also impacted through the vulnerability of their client base. Financial institutions are leading risk aggregator candidates in Indonesia who could benefit themselves and their clients by strengthening

their resiliency to earthquake impact through the appropriate use of an index-based risk transfer mechanism.

Income distribution is highly skewed in Indonesia—9 percent of total national income is earned by the poorest 20 percent of the population, and approximately 50 percent of the population lives on 2 USD a day or less. International donor agencies and NGOs have been active in fostering and supporting microfinance development as a means to improve the livelihoods of the working poor and to address this income imbalance. Government regulated rural banking entities and cooperative organizations are also active in this market. It is these types of risk aggregators, and their clients, on which the index based risk transfer is focused (Skees and Barnett 2006).

Concentrating on risk aggregators as the first beneficiaries of index insurance is a practical step in the sequence of creating a sustainable insurance market. Risk aggregators often possess a level of sophistication and financial literacy that allows them to more easily assess the value of a new financial product than do individual households. The products also face fewer data constraints and costs associated with capacity building, administration, and product delivery than do individual household products. Household insurance provision in many developing economies is hindered by low insurance experience or bad experiences which increase the educational demands on a supplier. Some mechanisms and methods for facilitating insurance sales may also not provide for the level of consumer protection or avenues of redress found in more advanced economies, very often because ensuring these legal protections also increase the educational demands at the household level.

Market development can be a tenuous process whereby quickly building a minimum market volume is important for participation and price efficiency in thin international risk transfer markets. Policies sold to risk aggregators tend to be larger in value relative to the fixed costs and helps ensure the long-run financial viability of the product introduction. The viability of a new insurance offering is one ingredient in attracting commercial insurers and reinsurers whose presence is needed to develop and grow a sustainable long-run market. Beginning with a commercially sustainable risk aggregator product is one means to build capacity and establish functional institutional foundations that create an enabling environment for the development of individual household products at a later time.

Chapter 2. Overview of Seismic Hazard

2.1. Introduction

The applications of earthquake index risk transfer for financial portfolio protection benefit from some basic understanding of how seismologists measure the magnitude and ground shaking generated by an earthquake event, and how seismic hazard is modeled to generate probabilistic curves that quantify and communicate earthquake hazard. The specification of a specific index is not discussed in this section, but it is envisioned that an index for financial institutional resiliency will utilize ground motion measurements discussed herein, an approach appropriate for geographically constrained lenders in Indonesia. This section includes a brief discussion of the following topics using specific reference to Indonesia when appropriate:

- Measuring earthquakes and ground motion intensity
- Shake map technology to communicate geographic ground motion intensity
- Quantifying earthquake hazard with exceedance probability curves
- Probabilistic earthquake hazard modeling and mapping
- Uncertainty in hazard modeling

This material is drawn in part from BMKG (2010); Baer (2006); Baker (2008); Field (2007); Freeman, Irfanoglu, and Paret (2004); Irysam (2010); MAIPARK (2010); McGuire (1993); Putra et al. (2012); Spranger (2013); USGS (2010); Wald, Quitoriano, et al. (1999); Wald, Worden, et al. (2006); Wang (2006); Wang et al. (2003).

2.2. Characterizing Earthquakes and Ground Motion

The Moment Magnitude Scale (MMS or M_W) is the modern equivalent of the Richter Scale (ML, or local magnitude) measurement of the size, or the energy released, of an earthquake rupture at its epicenter. While there are at least eight different magnitude measures, M_W is usually preferred as it is consistent in measurement across most earthquake sizes, those above magnitude 3.5, and can be calculated from data gathered from most types of ground-motion instruments. Regardless of the method used, however, each is designed to yield a single number that is consistent with other methods over their appropriate range. M_W is a function of the stiffness or rigidity of the earth's material at the site of rupture, the area of the rupture, and the average displacement (slip) of the rupture. Magnitude is estimated using ground motion data recorded from seismometer and accelerograph networks. Seismometers are able to detect very slight motion while accelerographs record strong

ground-motion that causes seismographs to go off scale. These networks of sensors are also used to locate the earthquake’s epicenter and estimate its depth. While M_W is dimensionless, it is measured on the logarithmic scale, which implies an exponential increase in energy released as the magnitude of an earthquake becomes larger.

The damage caused by an earthquake, however, is related to the intensity of ground motion, the acceleration, at any particular location. Ground shaking intensity is a function of the energy released at the epicenter of the earthquake (the magnitude), the distance of a particular site from the epicenter because shaking intensity decays with distance, and localized effects such as amplification that is related to the soil topology. Intensity of shaking experienced by an unanchored mass (such as a person) at a seismic recording station is commonly reported as peak ground acceleration (PGA) and peak ground velocity (PGV). Peak velocity is the largest measured speed that the ground moves in response to an earthquake in units of (cm s^{-1}). Peak acceleration is the largest measured change in ground motion (velocity) and reported in terms of acceleration force of gravity, where $1g$ is 981 cm s^{-2} . Both measures are usually reported in terms of horizontal amplitudes with PGA relating better to outcomes experienced due to small to moderate earthquakes while PGV relates better to stronger earthquakes.

An example of the relationship between earthquake magnitude, distance and PGA, ignoring localized effects, is depicted in Figure 2.1. To provide reference for the figure, a PGA value of $0.005g$ ’s is hardly detectable by humans, values in the vicinity of $0.05g$ ’s are experienced as unpleasant shaking while values above $0.5g$ ’s imply the destruction of most building types. This relationship is given by an attenuation or ground-motion function that describes how the seismic waves (which are experienced as shaking) generated by an earthquake decrease in amplitude as they move away from the source. Attenuation relationships are estimated from historical earthquake and ground motion records.

Different levels of ground-motion shaking intensity are related to the human experience and resulting damage of an event using the Modified Mercalli Intensity scale, abbreviated either as MM or MMI, which ideally includes an assessment of damage to buildings and infrastructure. While observed and qualitative, having a systematic means to categorize earthquake ground motion severity is important for effective communication of earthquake risk and potential damage to a wide range of stakeholders not having the technical expertise to readily interpret other measures of ground motion.

Modified Mercalli intensities ranges from Roman numeral I (not felt) to XII (total destruction), though values above numeral X are difficult to distinguish apart and are rarely observed. In the absence of direct shaking experience and verification of damage, MMI is derived from PGV and PGA data gathered from seismometers and accelerographs using previously estimated relationships. Instrumentally derived, estimated Modified Mercalli intensities are known as “Instrumental Intensity” (I_{MM}) or sometimes as Shake Map Intensities (SMI). Instrumental Intensity, as a proxy for MMI, is one of the most widely reported

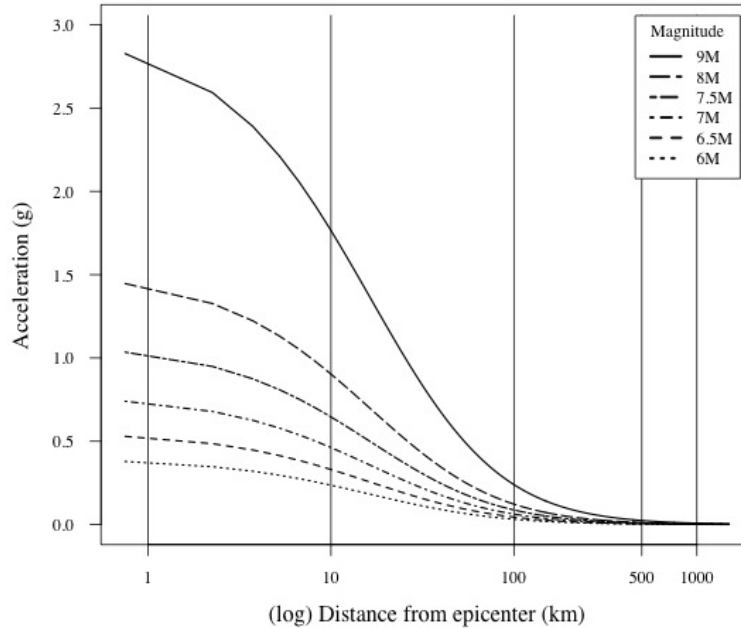


Figure 2.1: Earthquake Acceleration vs Distance.

intensity measurements of ground shaking in a particular area. Because of this, I_{MM} will be used as one element in constructing an earthquake index.

Figure 2.2 provides descriptions for each category of I_{MM} with correspondence to M_W , the shaking intensity experience as if one were at the earthquake epicenter. Figure 2.3 demonstrates the correspondence between I_{MM} and ground motion acceleration and distance for different magnitude events from Figure 2.1.

Aside from PGV, PGA and I_{MM} , earthquake impact can be characterized by a number of other measures of ground motion or shaking intensity, depending on the capabilities of seismic recording equipment, that provide additional information useful for structural engineering and damage prediction during an event. Spectral acceleration (SA, though sometimes “response spectra” or “spectral response”) provides information about the frequency content of ground motion and possible amplification effects for anchored structures over specific reference periods. Acceleration time history (sometimes “acceleration time series”) is the sequence of values in earthquake ground-motion over the duration of shaking, measured at a set of fixed times. Other ground motion intensity measures include cumulative absolute velocities, kinetic energy, the Japan Meteorological Agency (JMA) intensities, and the Earthquake Engineering Intensity Scale (EEIS).

| Modified Mercalli Scale | | Magnitude Scale |
|-------------------------|---|-----------------|
| I | Detected only by sensitive instruments | 1.5 |
| II | Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing | 2 |
| III | Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibrations like passing truck | 2.5 |
| IV | Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably | 3 |
| V | Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects | 3.5 |
| VI | Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small | 4 |
| VII | Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos | 4.5 |
| VIII | Panel walls thrown out of frames; walls, monuments, chimneys fall; sand and mud ejected; drivers of autos disturbed | 5 |
| IX | Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken | 5.5 |
| X | Most masonry and frame structures destroyed; ground cracked, rails bent, landslides | 6 |
| XI | Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent | 6.5 |
| XII | Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air | 7 |
| | | 7.5 |
| | | 8 |

Figure 2.2: I_{MM} Scale Descriptions.

2.3. Mapping Earthquake Impact

Information about magnitude and epicenter location are the usual variables reported following an earthquake event, but do not convey much information about the location of actual or potential damage. Rapid access to spatial information of earthquake ground shaking intensity can aid in emergency response efforts and even be used in some instances for loss assessment or estimation purposes when combined with information about the built infrastructure and other environmental variables. Similarly, an index based strategy for earthquake risk transfer can be improved beyond the “quake in a box” approach when the spatial distribution of ground shaking intensity is more specific than magnitude and location.

The expansion and networking of seismic recording stations combined with near real time data acquisition has led to the development and standardization of so-called “shake maps” which depict the distribution of earthquake ground-shaking intensity over geographic space. Preliminary shake maps are automatically generated within minutes for any significant earthquake world-wide by the United States Geological Survey and made available electronically. Shake map revision does occur based on later arriving information, with maps considered to be stable within three to five days.

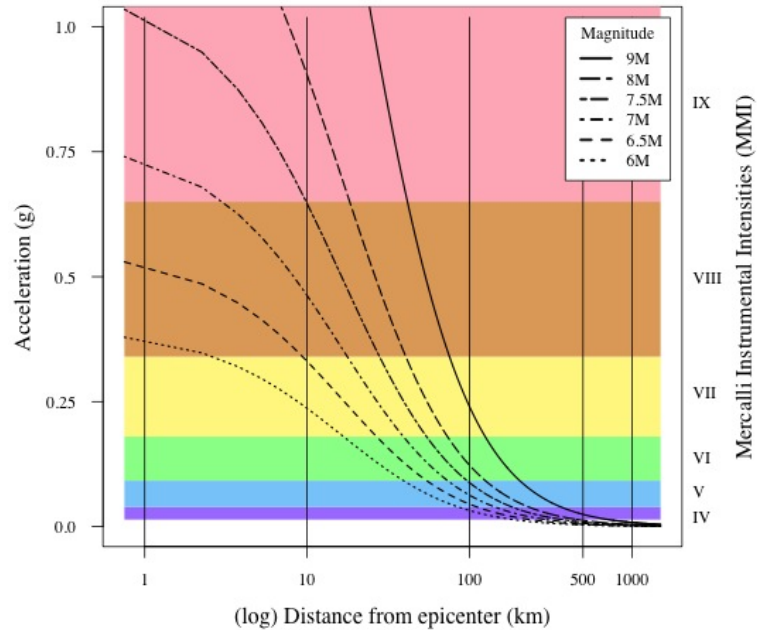


Figure 2.3: I_{MM} Scale and Acceleration Relationship.

Using the attenuation relationships demonstrated in Figure 2.3, a purely modeled shake map can be generated for any earthquake of known location and magnitude. Patterns of shaking intensities, however, do not uniformly radiate from the epicenter, and are influenced significantly, even over short distances, by complex geological formations and characteristics of the faulting. In practice, patterns of shaking intensity are derived from the network of seismometers and accelerometers, with spatial interpolation methods used for the space between seismic recording stations. Ground motion attenuation is modified based on soil type catalogs when available. Ground motion intensity estimation is derived continuously over a fine grid before identifying isoseismic contours. Hence, all shake maps are considered modeled outside the proximity of seismic stations. A potential source of basis risk, a difference between experienced shaking intensity and the modeled result, can arise when seismic stations are sparsely populated.

Shake maps are generated first for the native measurements of the seismic instrumentation, PGA and PGV. Both are then used to derive an instrumental intensities map, such as shown in Figure 2.4 for the magnitude 7.6 earthquake in Southern Sumatra near Padang. I_{MM} scaled maps are frequently depicted using continuous color gradation across space. However, I_{MM} contours are identified and provided in other mapping products, such as the geographic information system (GIS) file shown in Figure 2.5. Note that the contours are identified on intervals of two-tenths within each traditional I_{MM} intensity category.

Shake maps can be easily combined with other applicable GIS information such as population density (for example, Figure 2.6) or the location of critical infrastructure to help

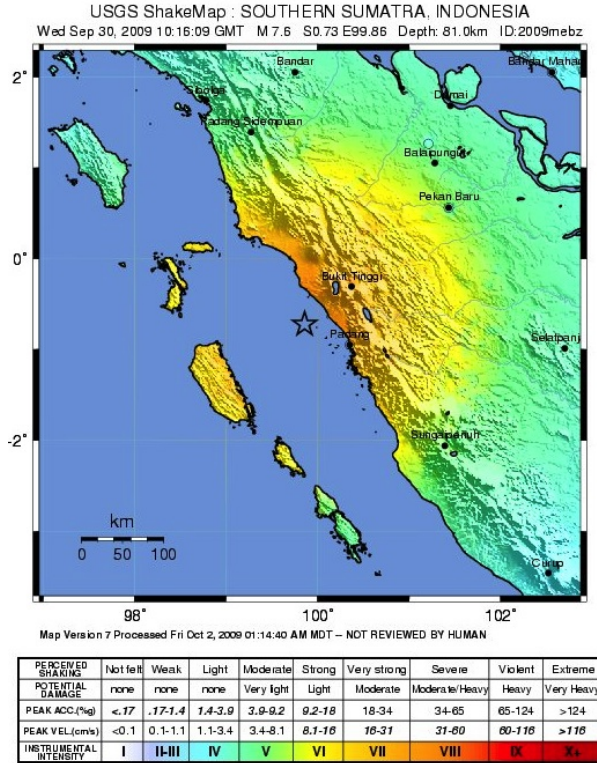


Figure 2.4: Instrumental Intensity, Southern Sumatra (9/30/2009).

focus earthquake emergency response to those areas having the most potential problems. For financial risk transfer purposes, shake map technology can be used to generate an index against which payments can be made. And because ground shaking intensity can be rapidly identified, the use of an index approach for many broad classes of loss and cost is particularly attractive.

2.3.1. Indonesian Seismic Monitoring Capabilities

The Indonesian seismic network, operated and maintained by the Agency for Meteorology, Climatology, and Geophysics (BMKG), has undergone significant expansion of its land-based seismic monitoring capabilities. The infrastructure includes 160 seismometers (52 maintained by foreign agencies) and 500 accelerometers that will be networked through ten regional centers to the national operational center where the seismic data is processed in near real time. It is at the national center where regional earthquake time, magnitude, depth, and location are determined, usually within three minutes of the event. Assessment of the need for tsunami warnings when the earthquake occurs off-shore is completed within 5 minutes. Figure 2.7 shows the individual sensor locations of the seismic monitoring network (seismometers), with sensor spacing being in the range of 100 km.

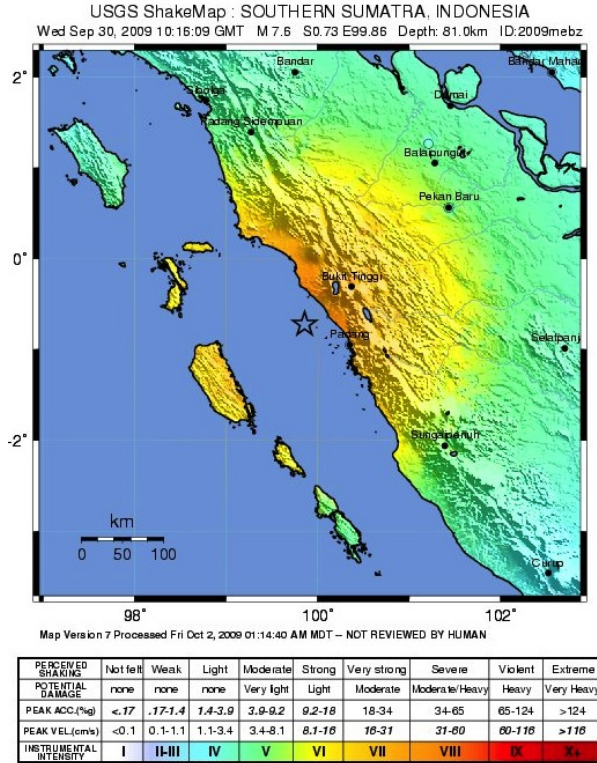


Figure 2.5: Instrumental Intensity Isoseismic Contours, Southern Sumatra (9/30/2009).

BMKG, in cooperation with foreign assistance, has upgraded its ability to automatically generate shake maps for regional earthquake. Part of this is a by-product of tsunami monitoring efforts but also helps to serve the needs of Indonesia’s national earthquake emergency disaster response efforts. BMKG’s shake maps may be technically similar to those of the USGS, but when used as the basis for a legal contract in a risk transfer scenario, it is unlikely that international reinsurers or other risk bearers would exhibit the same level of agency confidence as it would have with the USGS, whose institutional performance and stability is well regarded. For the time being, USGS shake map reporting and associated infrastructure remains the international standard.

2.4. Probabilistic Seismic Hazard Analysis

Seismic hazard analysis is focused on modeling and quantifying the probabilities of ground shaking intensity (seismic hazard) caused by earthquakes for a defined time period. The summary output of seismic hazard risk analysis is an earthquake hazard curve that shows the annual frequency that different levels of ground motion intensity will be exceeded at a particular location of interest.

Seismic hazard analysis can be either probabilistic or deterministic, though in principle the two can be used to help check the results of the other. Deterministic hazard anal-

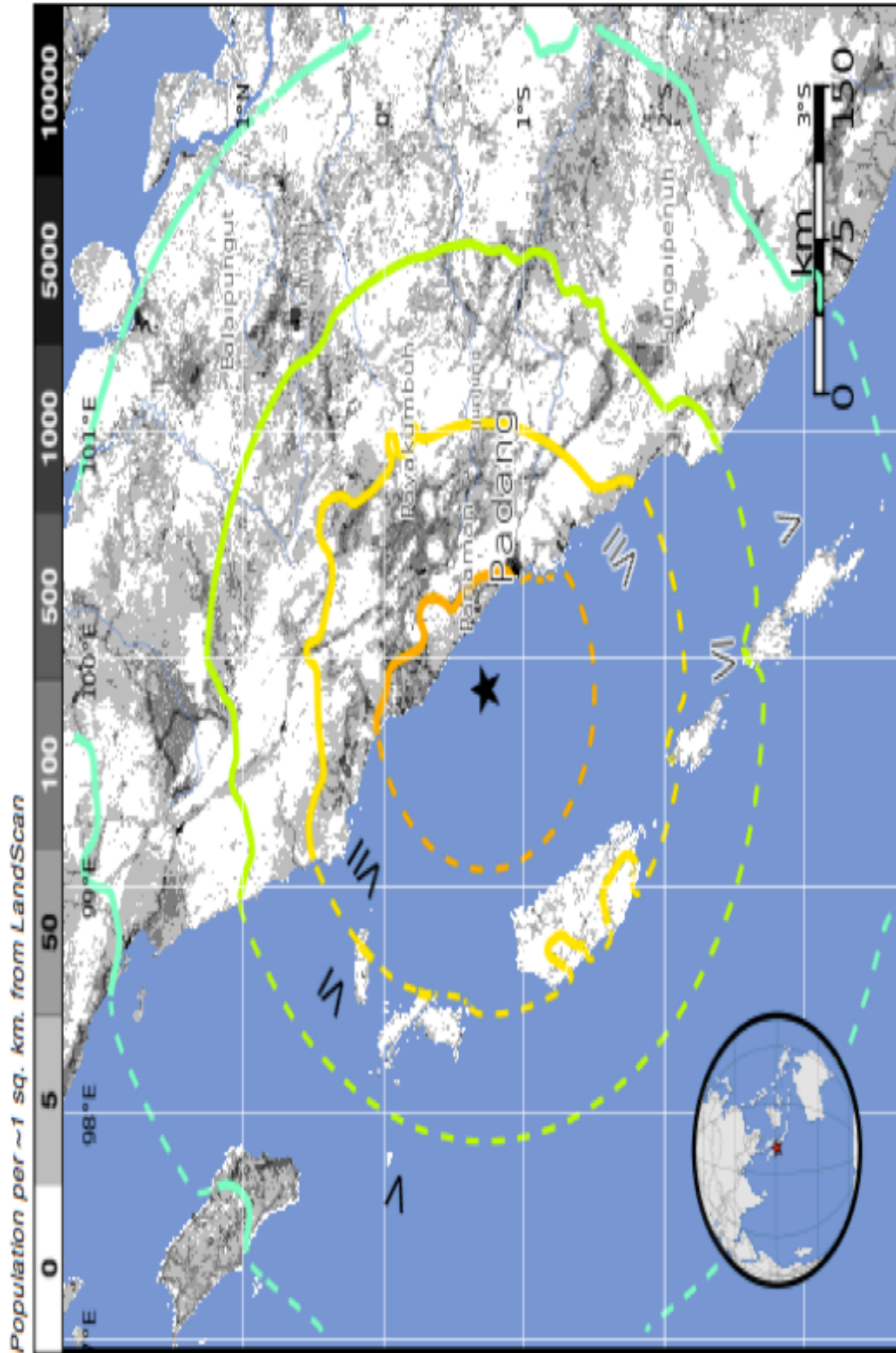


Figure 2.6: Instrumental Intensity with Population Density, Southern Sumatra (9/30/2009).

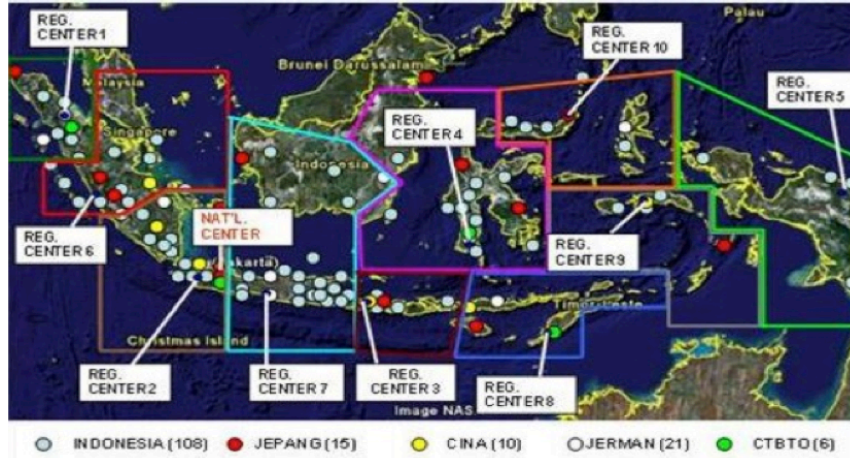


Figure 2.7: Indonesian Seismometer and Accelerometer Network (BMKG 2010).

ysis is location specific and assumes a single scenario, such as the effects of the largest possible earthquake on the building site of a critical structure, and is used as part of the design criteria. In deterministic analysis, the distance to potential earthquake sources and magnitudes are fixed parameters which excludes incorporating uncertainty. Deductive probabilistic seismic hazard analysis (PSHA), which treats the sources, locations, distances, time of occurrence, and magnitudes as random variables, is the standard method for estimating probabilities of future ground motion (Baker 2008). By considering all possible levels and combinations, PSHA is able to explicitly incorporate uncertainty in rates, location and magnitude in a way that enables construction of standard confidence intervals around the hazard curve output.

Probabilistic models are the basis for constructing regional hazard maps depicting the likelihood and magnitude of earthquake occurrence. Probabilistic models paired with models of structural response can be used for developing earthquake resistant building recommendations and codes and for characterizing earthquake risk. Probabilistic earthquake models are also used by the insurance and reinsurance industry to price earthquake risk transfer.

For traditional earthquake insurance, the risk analysis is combined with damage simulation using characteristics of the built inventory to form an aggregate loss distribution in order to derive premium rates. For an application to index insurance, the modeled probabilities are combined with a proposed insurance payout structure to generate a loss distribution and the technical risk premium. It is because of this need for an assessment of potential damage, and the uncertainty surrounding the loss estimates, that traditional insurance is expected to be more heavily loaded than index insurance. Otherwise, both forms of insurance are subject to the same sources of uncertainty that emerge during a seismic hazard risk analysis.

A fundamental and prerequisite input into an application of PSHA is a processed (cleaned and standardized) earthquake catalog that contains the locations, times of occurrence, and size of historical earthquakes. The procedure for computing hazard curves then follows four standard steps:

- Identify the size and distance distribution of all seismic sources (e.g., active faults or areal sources) to a location of interest, described geometrically in three dimensions.
- Characterize the seismic hazard source model or models to determine the frequency distribution of earthquake occurrence, usually described as a Poisson process, and the distribution of magnitudes for each previously specified seismic source.
- Specify the attenuation model, such as that exemplified in Figure 2.1, specific to or adapted to local geological conditions, and find the distribution of possible ground motion values at the location of interest.
- Calculate the probabilities and plot the hazard curve through a triple integration over all possible sizes and locations, ground motions, and occurrence frequencies of earthquakes impacting a specific location.

Seismic hazard analysis recognizes two main sources of uncertainty, epistemic and aleatory, and treats each differently in the probabilistic analysis. Epistemic uncertainty results from incomplete knowledge most obviously reflected in modeling and statistical relationships. Epistemic uncertainty can be reduced with additional data and advances in modeling and incorporated into the analysis through the generation of a family of hazard curves. Aleatory uncertainty results from the intrinsic variability or randomness of natural processes and cannot be reduced. Aleatory uncertainty is incorporated in the analysis via the probability distributions and standard error of the key variables, which are averaged when computing the exceedance rates. This uncertainty is expressed through the probabilistic nature of the hazard curve itself as well as by the construction of confidence intervals. Again, the sources of uncertainty lie in the inherent variability of earthquake hazard:

- Location (source-site distance)
- Size (magnitude)
- Effects (attenuation relationships)
- Timing (temporal uncertainty)

2.4.1. Hazard Curves

Figure 2.8 demonstrates an example of a standard hazard curve with PGA on the horizontal-axis, the mean annual frequency of exceedance on the vertical-axis, and the return period in

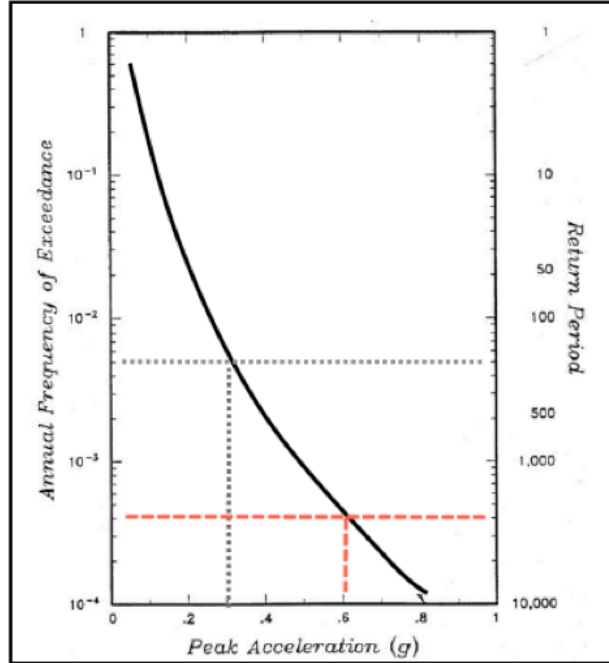


Figure 2.8: Example Mean PGA Hazard Curve.

years on the secondary vertical-axis (the secondary axis is not always included). Given that the hazard curve is the purpose of the PSHA exercise, it is worth reviewing its interpretation and use.

Working from the curve, one is able to identify the annual frequency of exceedance (also λ , annual rate of exceedance, annual number of events) for a maximum ground-motion event. The return period (TR, recurrence interval) is the average time between large earthquakes at a particular site and is the reciprocal of the annual frequency of exceedance ($1/\lambda$). Then, the *probability* of exceeding a ground motion parameter value in a given period of time (t) is given by $P_E = 1 - e^{(-\lambda t)}$. Referring to the grey dotted lines in Figure 2.8, one finds the probability of exceeding a PGA of 0.3 in 50 years by referencing the corresponding value of annual frequency and solving $P_E = 1 - e^{(-.005)(50)} = 22.1$ percent. That is, there is a 22.1 percent chance of exceeding a PGA value of 0.3 in 50 years. Conversely, if one wants to find the value of PGA corresponding to a 2 percent probability of exceedance in 50 years then solve for $\lambda = -\log(1 - P) \cdot t^{-1} = -\log(.98) \cdot 50^{-1} = 0.0004$ and from the curve find the PGA of 0.6 having a return period of 7,000 years. If the time interval is held constant, the familiar plot of probability of exceedance against PGA can be produced for each value of the hazard curve. Using $t = 50$ years, Figure 2.9 confirms that for a PGA value of 0.3 there is approximately a 22 percent probability of exceedance.

Hazard curves developed from PSHA are also used to produce maps of seismic hazard. In a probabilistic hazard map, areas of equal seismic hazard are identified (“rating territories” for insurance purposes) with the ground motion parameter indicated for each area, given

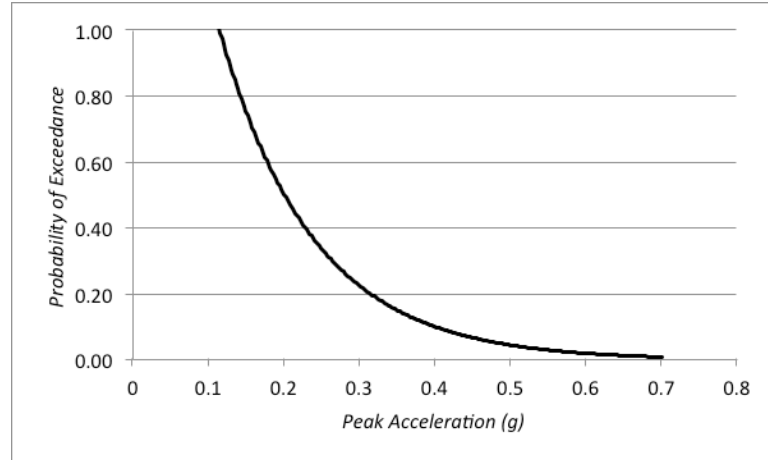


Figure 2.9: Example Seismic Probability Plot for 50-Year Interval.

x-percent probability of exceedance in t years. That is, each uniform area represents a single point on a hazard curve, or a range on the curve. Seismic hazard risk maps can be produced for many different configurations of probability exceedance and time period. Of the following common formats, the first is typical for insurance and general building design purposes while the latter are usual for more advanced engineering purposes:

- 10 percent probability of exceedance in 50 years
 - 500 year earthquake (return interval)
- 5 percent probability of exceedance in 50 years
 - 1000 year earthquake
- 2 percent probability of exceedance in 50 years
 - 2500 year earthquake

2.4.2. Indonesian Seismic Hazard Maps and Models

Since the Aceh earthquake and tsunami of 2004, considerable new investment has been placed in both upgrading the seismic hazard-monitoring network as well as in mapping seismic hazard for building code recommendations and for disaster preparedness. Prior to that, the most recent officially released national earthquake hazard map dated from 2002, and underpinned the Indonesian Seismic Building Code, SNI-03-1726-2002.

The 2002 hazard map has recently been updated by the Team for Revision of Seismic Hazard Maps of Indonesia as part of a collaborative effort between numerous Government of Indonesia agencies (Ministry of Public Works and Ministry of Research and Technology) and external donors, notably the Australia-Indonesia Facility for Disaster Reduction (AIFDR).

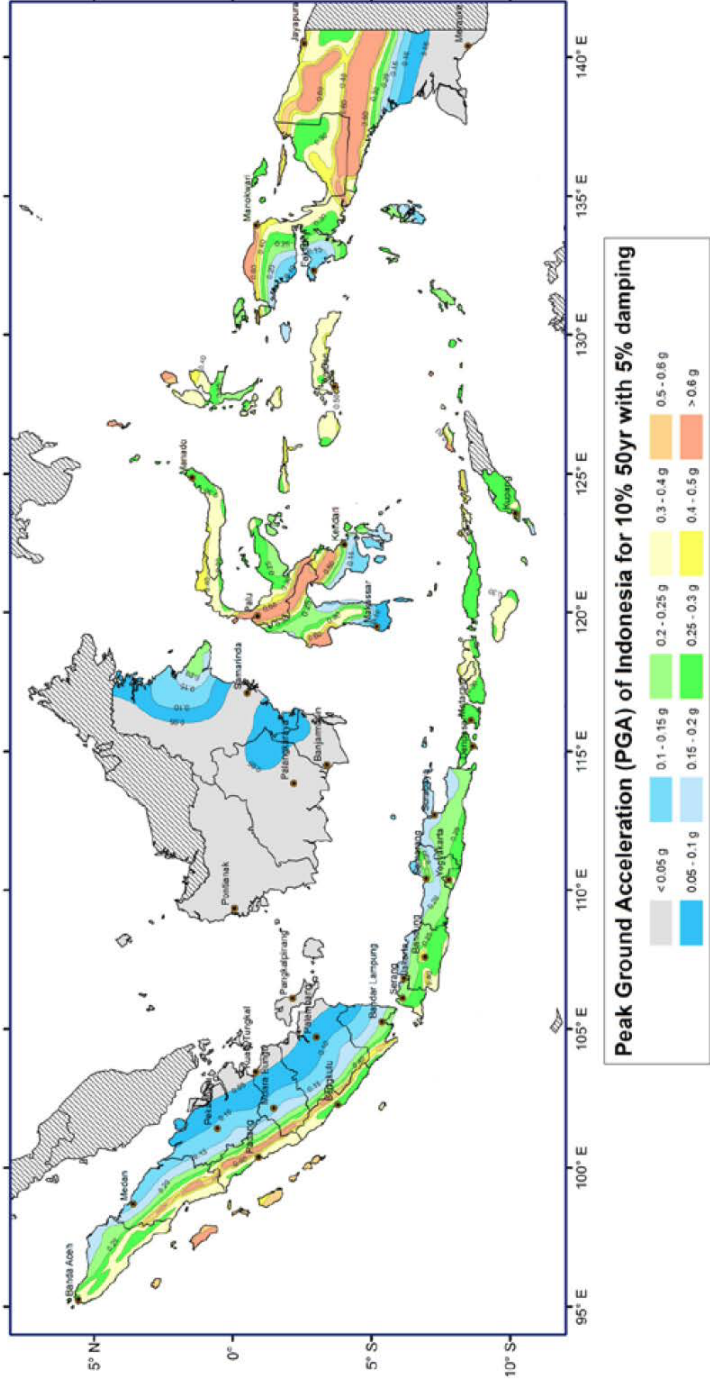
The overall effort not only updated the hazard map with the main purposes of contributing to building code revision and enabling better informed disaster preparedness decisions, but to strengthen national capacity in seismic hazard analysis. The PSHA generated three PGA contour maps at 10 and 2 percent probability of exceedance in 50 years and the 10 percent probability of exceedance in 100 years. The analysis also produced a series of spectral acceleration maps. The first of the PGA maps is reproduced here as Figure 2.10. Noteworthy about this PSHA effort is that it began by constructing what is probably the most complete earthquake catalog to date while at the same time acknowledging that fault structures in some regions have not yet been well studied. The mapping effort has a high degree of spatial specificity, reflecting the detailed knowledge of faulting in the better-studied areas. As much of the software used to develop the hazard maps is contributed from the USGS, the methods used in the analysis are well documented. However, this recent modeling effort has not been integrated with damage and loss models for detailed risk analysis nor necessarily made available to private industry.

While the national hazard map update project was primarily government driven, others in Indonesia are also modeling earthquake hazard for catastrophic insurance applications. PT Asuransi MAIPARK Indonesia is the successor organization and public liability company of Pool Reasuransi Gempa Bumi Indonesia (PRGBI), or Indonesian Earthquake Reinsurance Pool, that was formed as a result of government regulation requiring all general insurance and reinsurance companies to participate in sharing of catastrophic risks, including earthquake risk. MAIPARK serves as the reinsurer and earthquake risk clearing-house on behalf of its members and invests in its own capacity for research, modeling and quantifying seismic hazard risk for the purposes of developing the official earthquake insurance tariffs.

Figure 2.11 provides a map of insurance rating territories produced by MAIPARK. These territories, or premium zones, are the result of a PSHA combined with loss estimation models to develop rates for different types of insured structures. The graphic also includes an identification of the earthquake sources used in the analysis, a hazard map for PGA (though the probability of exceedance and time period is not identified), and a map of I_{MM} estimated from the PGA values.

Note that the risk (premium) zones are fewer than the possible categories of PGA values of the hazard map. This is not necessarily a shortcoming for insurance purposes as long as the intervals of PGA appropriately reflect meaningful differences in relative risk. Fewer risk zones have the advantage of lending greater simplicity to earthquake insurance sales and administrative activities.

Hazard maps and the underlying models used to produce them continue to undergo revision as knowledge of seismic processes improve, with advances in fault mapping and monitoring, and with new modeling techniques. While earthquake science has improved, there remain considerable sources of uncertainty in modeled results as well as differences in



Developed by Indonesia Seismic Hazard Map Revision Team 2010.
 Supported by: Ministry of Public Works, Ministry of Research and Technology, Australia-Indonesia Facility for Disaster Reduction (AIFDR), and software from USGS.
 July 2010

Figure 2.10: National Seismic Hazard Map for Indonesia (Irysam 2010).

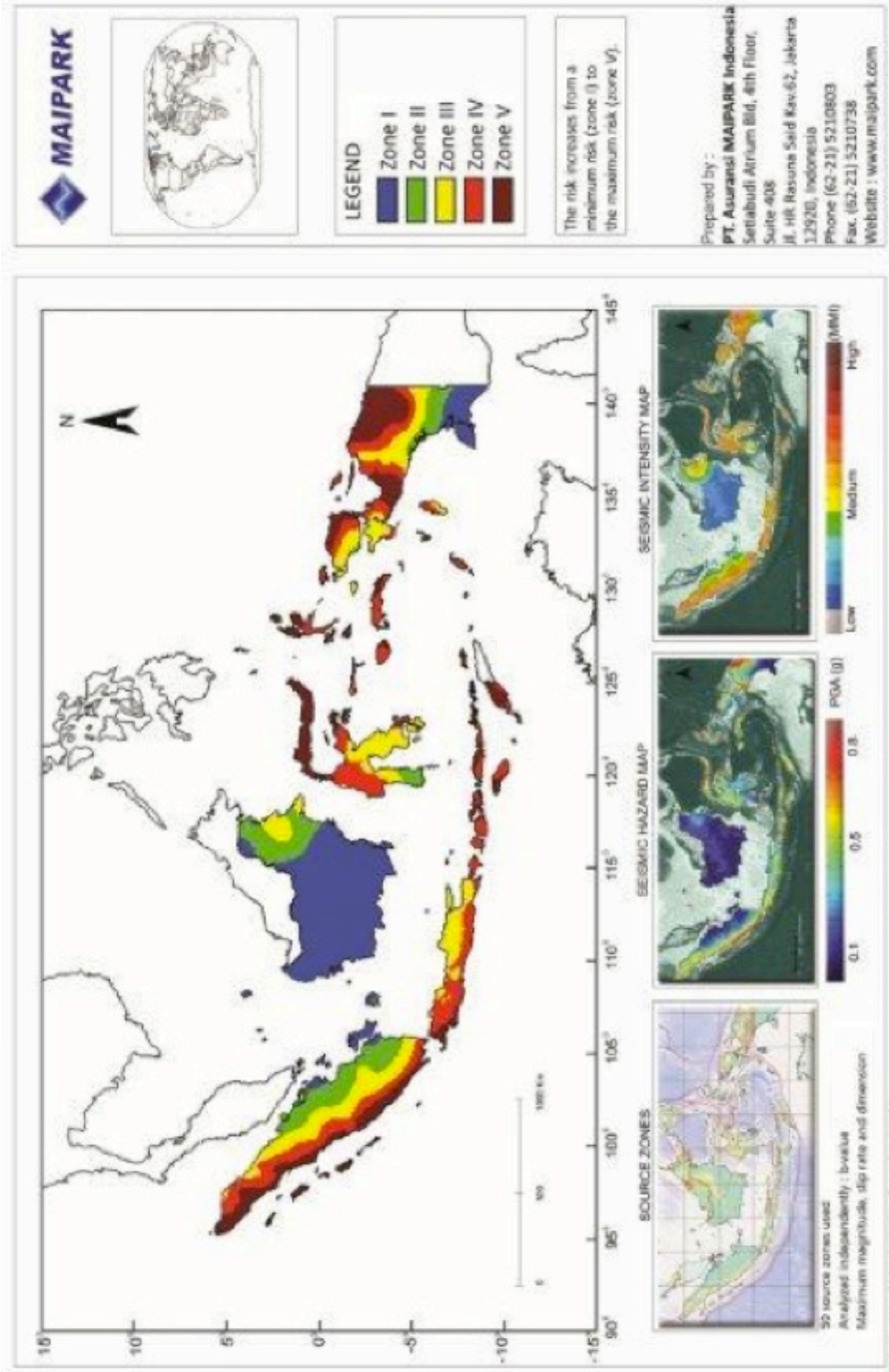


Figure 2.11: Indonesian Earthquake Insurance Tariffs, (MAIPARK 2010).

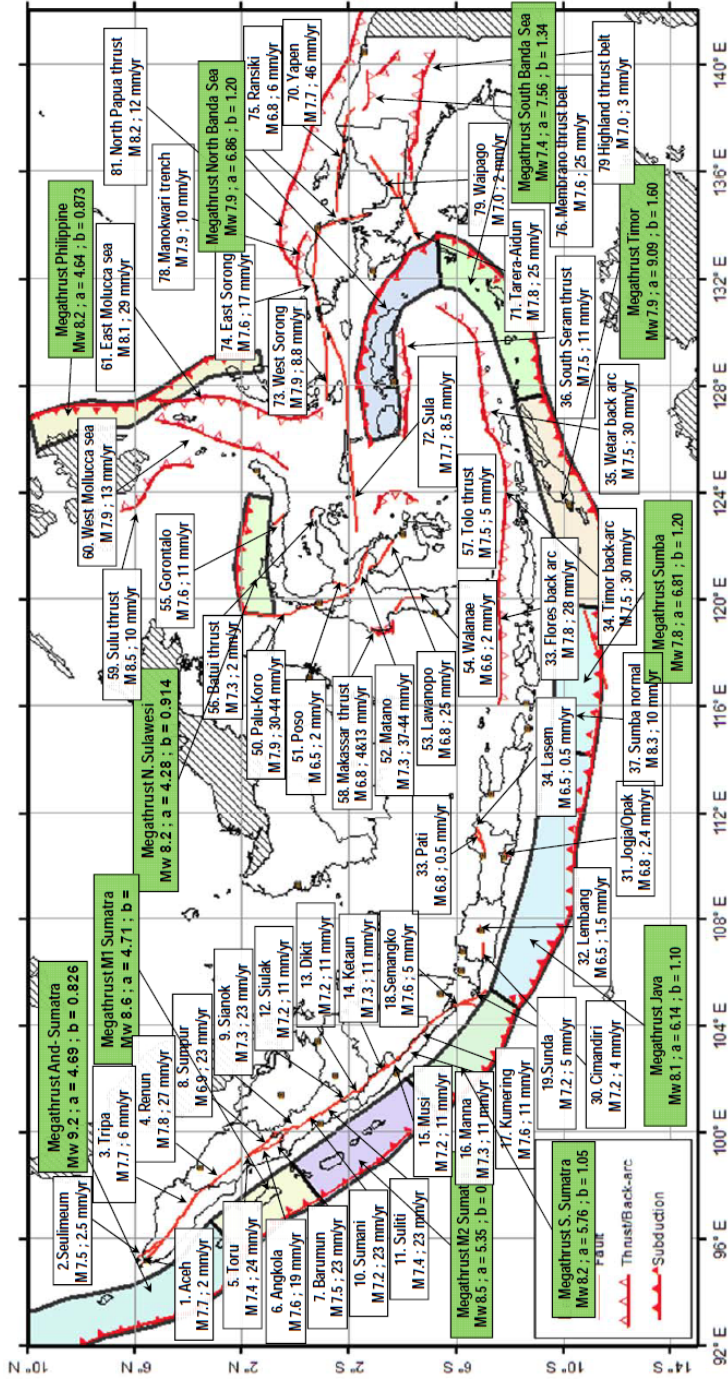


Figure 2.12: Indonesia Fault Mapping and Assumptions (Fauzi 2011).

results among “competing” models. For example, one source of uncertainty stems from the standard method of considering the largest possible magnitude even that could be generated from a particular fault zone. Figure 2.12 graphically shows many of the underlying source parameters for subduction earthquake modeling for Indonesia. In general, the maximum magnitude modeled is based on the maximum observed in the historical catalog. In a number of instances, this assumption has led to dramatically unexpected outcomes such as in the case of the December 2004 earthquake off Northern Sumatra, Indonesia. Similarly, the March 2011 Tohoku earthquake near the east coast of Honshu, Japan fell outside model predictions. Not only have these large earthquakes increased the uncertainty around current best estimates, many earthquake models have not incorporated the knowledge learned from these and other more recent significant events. For example, some so-called “vendor models” (AIR EQ, EQECAT EQ, RMS EQ) were all built prior to 2004 and do not include these recent events nor most recent advances in modeling science. Most earthquake models for Indonesia do not consider issues such as induced seismicity or time dependency of seismicity nor explicitly model other related hazards such as tsunami, landslide or liquefaction.

Proprietary models held by major reinsurance companies likely have similar sources of uncertainty and obsolescence though they have strong incentives to incorporate new knowledge as they “own” the risk they accept. Nevertheless, even the most current models will produce varying results that reflect underlying uncertainty and assumptions imposed by analysts. Output from a PSHA for risk mapping or risk transfer pricing should be considered a best estimate. Whenever possible, hazard estimates or premium quotes should be consulted from multiple sources.

Chapter 3. Finance Gaps in Humanitarian Response to Natural Disaster

3.1. Introduction

It is a stylized fact that natural disaster events disproportionately impact developing countries and the poor (IBRD/World Bank 2001). Severe regional climate anomalies driven in part by climate change (e.g., drought, extreme rainfall events, floods) are expected to increase in frequency and intensity in many of these already vulnerable regions. Furthermore, the continued concentration of population and economic activity in regions of geophysical hazard will increase the need for humanitarian disaster response and financial support of those organizations and agencies that respond.

This case report identifies the rationale for, and develops, an index based contingent claims mechanism to assist non-governmental humanitarian response efforts to earthquake disaster. The proposed index based approach provides rapid funding for natural disaster relief efforts and can help overcome a variety of mismatches and information needs in the financing of these activities. It also represents a highly visible social application of financial risk management, one that also supports principled humanitarian action. While the focus here is of earthquake disaster, similar contingent *ex ante* financing mechanisms can be used for response to other types of natural disaster events.

3.2. The Humanitarian Space and Disaster Finance

Non-governmental humanitarian relief for affected populations is delivered by a number of organizations including United Nations agencies, the International Federation of Red Cross and Red Crescent Societies, and both local and international non-governmental organizations (INGOs). The latter are of particular interest since they are often viewed as being particularly efficient in quick, on-the-ground, mobilization of relief services (McCoskey 2009). Some of INGOs' ability to respond is related to already having personnel in place, serving a dual role as emergency and development professionals, and their greater freedom in not working through often bureaucratic government channels. While the number of Western-based INGOs is quite large, as many as 4,000, those with a humanitarian emergency relief mandate as part of their programming is estimated to number several hundred, a group (Table 3.1) which is dominated by a few large, well-known, and well-funded organizations (Stoddard 2003).

Many of the oldest INGOs have their origins in humanitarian relief. Most, however, have expanded their missions to include other activities including development programming, disaster preparedness and mitigation, disaster rehabilitation, investments in microfinance, and health initiatives. Still, emergency humanitarian response represents a significant share of INGO expenditures, as evidenced from recent INGO annual reports. For instance, emer-

Table 3.1: Dominant International Non-Governmental Organizations with a Humanitarian Relief Mandate.

| | |
|--------------------------|--------------|
| CARE | Mercy Corps |
| Catholic Relief Services | Oxfam |
| Save the Children | World Vision |
| Médecins sans Frontières | |

agency relief comprised 17 percent of CARE USA’s program activities in 2010 and 32 percent of Save the Children USA’s program activities the same year. In 2010, life and security expenditures accounted for 39 percent of Oxfam Confederation program expenditures, while relief and rehabilitation expenditures accounted for 22 percent of World Vision International’s program expenditures. Nearly 60 percent of international programming of the American Red Cross in 2011 was allocated to relief. Expenditures for emergency relief specifically for natural disaster are quite varied and comprise a fraction, about one-fifth, of overall aid for conflict and other humanitarian purposes (figure 3.1). Aid for disaster in conflict zones, however, may be difficult to disentangle from that for natural disaster, particularly given that natural disaster impact is often exacerbated in combination with conflict.

While the proportion of government and international development organization contribution to humanitarian aid has increased over the last ten years, private donations from

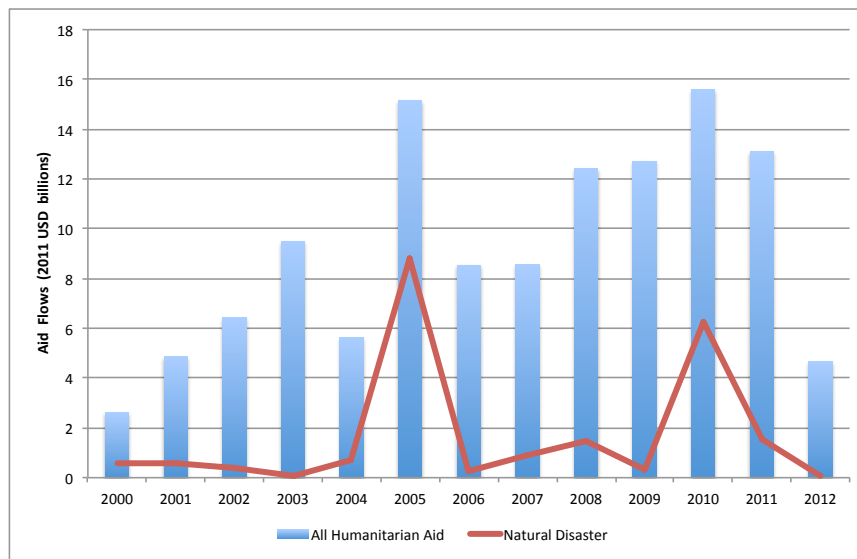


Figure 3.1: Natural Disaster Aid Flows as a Component of Total Humanitarian Aid, 2000-3/2012. Data source: Financial Tracking Service (FTS) of the UN Office for the Coordination of Humanitarian Affairs. All humanitarian aid includes reported humanitarian contributions recorded in FTS, including those for INGOs, the Red Cross/Red Crescent Movement, bilateral aid, in-kind contributions, and private donations.

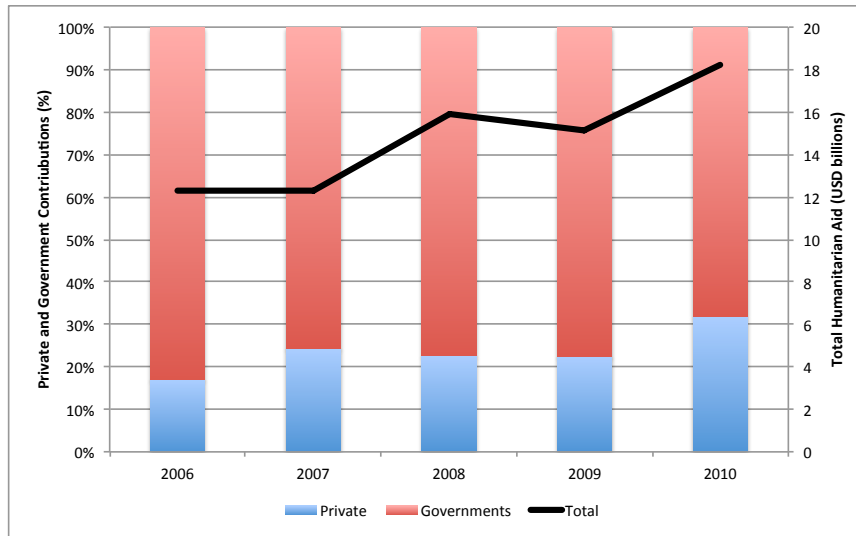


Figure 3.2: Decomposition of Humanitarian Aid, 2006-2010. Source: Adapted from Stoianova 2012, 2010 values estimated.

individuals, corporations and foundations have also grown and remain significant (figure 3.2) (Kolpinak 2013; McCoskey 2009; Stoianova 2012). INGOs are the primary recipients of private funding and have, on average from 2006–2010, received nearly 86 percent of their humanitarian income from this source.

The availability and prevalence of private funding to INGOs leads to an opportunity to mobilize this funding source in a different way, one that supports humanitarian relief efforts *ex ante* via the structure of a contingent claim mechanism. The idea of reaching the private sector through a contingent claims for humanitarian work, and especially those in the social responsibility movement, was first discussed in the context of “charity bonds” by Goes and Skees (2003). Their idea was that social investors would be willing to accept a lower return on an index based disaster bond while also helping to diversify an investment portfolio. Like other contingent bonds, the investor risks losing the interest and principle depending on occurrence and size of the disaster event. The approach in the context of Indonesian earthquake risk and INGO financing focuses instead on corporate social responsibility and other private giving for natural disaster response.

3.3. Disaster Relief Funding Appeals and Mismatches

International non-governmental organizations are well known for their ability to rapidly assess and respond to humanitarian crises precipitated by severe natural disasters. To enhance their effectiveness, some INGOs as well as UN agencies have developed joint response protocols and decision-making tools to avoid costly duplication of effort. However, humanitarian response financing, which is critical to mounting an effective campaign, remains vulnera-

ble to resource constraints distinct to each organization and is less commonly coordinated between independent INGOs.

Private and government funds are mobilized through appeals following a major natural disaster event, or sometimes upon advance warning. However, even when a known humanitarian crisis is unfolding, funds of significant amounts may not materialize until crisis images are released to international audiences. Some disaster events, though locally severe, fail to ever gain enough public attention to motivate sufficient giving. While media coverage is frequently thought to be important in prompting individual humanitarian giving, government and donor funding is strongly influenced by political and security interests (Drury, Olson, and Van Belle 2005; Macdonald and Valenza 2012). The politicization of humanitarian aid may in part explain the relatively low levels of humanitarian aid flowing to some regions. The presence of strong INGOs and other humanitarian stakeholders operating in the political sphere may countervail the former factors (Olsen, Carstensen, and Høyen 2003).

Disaster response managers must take a strategic view in overseeing their organization's multiple funding streams to best meet the demands of their humanitarian mission. The source, type and timing of the flow of funds can dramatically impact how an INGO is able to respond to the needs of affected populations. Funding can also hinder an organization's ability to implement humanitarian action based on the principles of humanity, impartiality, independence and neutrality (Macdonald and Valenza 2012).

Some government aid can be conditional, tied to a specific project, beneficiary or materials supplier, and fail to reflect the on-the-ground needs of the relief effort. Some donors prohibit or restrict funds being used to replenish an INGOs own limited emergency reserves frequently exhausted during the immediate response effort. In-kind material contributions both from individuals and some, mainly local, corporate donors may similarly not reflect the needs of relief operations or present expensive logistical and transport barriers (Telford 2007).

INGOs prefer unconditional liquid funds that they can use to immediately act following a disaster and which gives them the freedom to allocate resources to where it determines is the most pressing humanitarian need (Van Wassenhove, Tomasini, and Stapleton 2008). Modern emergency response relies less on prearranged stockpiling of materials and instead internationally sources the specific items needed for each situation. Cash funds facilitate this this type of emergency supply chain management.

3.3.1. Financing Gaps

The situations described above represent a type of gap or mismatch between the needs of relief operations and the aid available. Interviews held with numerous INGOs during and Emergency Capacity Building (ECB) project meeting in Jakarta in November 2011, and later individually, identified two general types of funding constraints. While formed in the

context of Indonesian earthquake response, the financing gaps are said by those interviewed to be similar for other natural disaster response efforts.

- **Timing / Liquidity Gap.** Some organizations maintain relatively small emergency response funds that are used for the cost of initial emergency assessment activities. Once the assessment is completed, emergency response activities are specified and donor appeals are submitted. While the INGO may be able to access some relief aid relatively soon from institutional donors (i.e., DIFD’s Rapid Response Facility that involves a pre-approval process) or through letters of commitment, a financing gap often emerges between the time the assessment is made and when significant funds arrive—there is a lack of cash to respond quickly. Hence, the gap in financing can also be characterized as a temporary liquidity constraint that impedes immediate action. This gap, after assessment and before significant funds arrive, can vary between between two to four or even more weeks. For earthquake events, these weeks coincides with the period of the highest vulnerability and where prompt response is critically important for saving lives, preventing the spread of disease, and reducing suffering.
- **Scale Gap.** A few organizations maintain relatively large regionally-based emergency response funds for financing humanitarian relief past the initial assessment phase. Usually these funds are sufficient to support activity until additional donor support arrives. However, the funds are generally geared to larger scale natural disasters defined in terms of the affected population. For some country offices, a scale gap may emerge during the need to respond to a severe event that impacts a smaller population. When the scale of the event does not garner sufficient public or institutional attention, the fund may not be accessible or it may be difficult to replenish if it were accessed. Consequently, INGO country offices sometimes use resources from technical assistance programming to fund the humanitarian response.

The structure of an index-based earthquake contingent financing for liquidity and scale gaps will be different, and must be customized to the context of each INGO. The common element is that the contingent-financing product provides high value resources embodied by speed and non-conditionality. However these benefits may come at high cost, particularly if triggering events are frequent. This type of index based contingent financing should should be targeted to those gaps where the funds will result in the greatest humanitarian benefit.

While not an appropriate solution to the funding needs of an entire emergency response, earthquake contingent financing is an additional stream of resources in the INGO’s portfolio mix that strengthens its overall financial position. Because payments are triggered automatically, the mechanism will help reduce uncertainty of funds availability and timing for earthquake disaster response, a critical element in an effective, and principled, response to humanitarian crises (Kolpinak 2013; Macdonald and Valenza 2012).

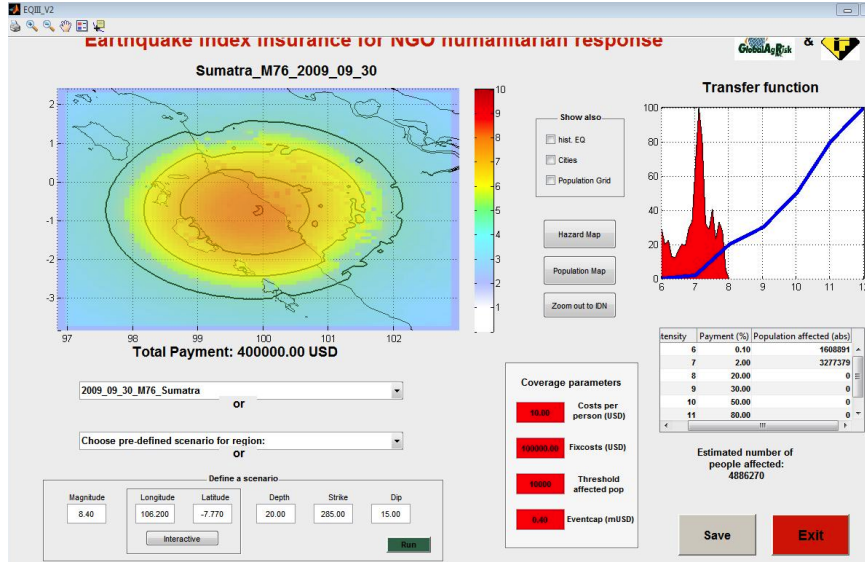


Figure 3.3: INGO Needs Assessment Tool.

3.4. Earthquake Index and Needs Assessment Tool

The earthquake index uses ground motion intensity (the hazard) linked to population exposure (the vulnerability of concern) as the basis for triggering contingent payments. The mechanism will provide INGOs with rapid, unconditional gap financing when it is most needed—the immediate aftermath of an event.

A specially designed earthquake assessment tool (figure 3.3) helps INGO Indonesia country staff identify the parameters of a contingent product that could help finance the timing or scale gap in humanitarian emergency response. That is, the tool is used to interactively develop the payment function for a contingent financing mechanism that matches the INGO’s historical experience.

The assessment tool, as well as the contingent contract, uses United States Geological Survey (USGS) generated shake maps to provide a geographical representation, a footprint, of the ground motion intensity induced by an earthquake. The shake map depicts Instrumental Intensity (I_{MM}) levels, a proxy for the Modified Mercalli Intensity scale, and is overlaid on a population count grid. The *exposed* population are those who experience an earthquake defined as $I_{MM} \geq VI$. Weights are assigned to I_{MM} scale values of VI and greater to gauge the *affected* population in need of emergency humanitarian services.

Gridded population count data are obtained from the Center for International Earth Science Information Network (CIESIN). This freely available data product provides estimates of future world population based on vector census data from approximately year 2000. The grid cell resolution is 2.5 arc-minutes, about 5 km measured at the equator, where proportional allocation is used to assign population values to individual cells. Pop-

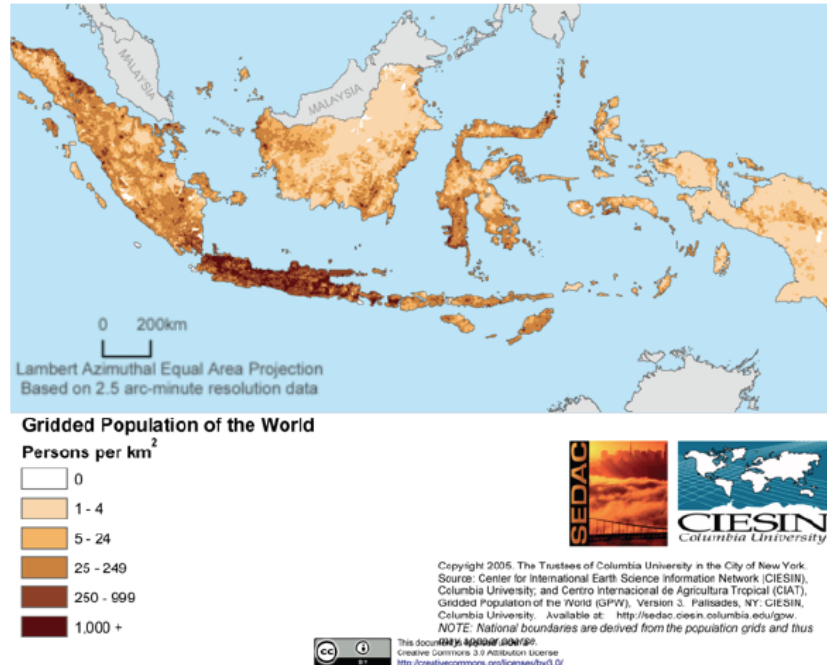


Figure 3.4: 2000 Population Density of Indonesia.

ulation count estimates for Indonesia used in the assessment tool are of year 2010. Figure 3.4 provides a year 2000 population density grid map of Indonesian assembled by CIESIN. The Indonesian statistical office (BPS) completed a new census for 2010 but, as of writing, a similar gridded data product is not yet available.

The initial intensity level weights are given below (table 3.2) and define a step function of affected population given an observed intensity level. Values of X and greater are extremely rare in the historical earthquake record but are included for completeness. Indonesian earthquakes over the past ten years have not exceeded an intensity level VIII. The intensity weights can be altered in the assessment tool. The initial values provided here are informed but not statistically estimated or sourced. For instance, typically, an earthquake of intensity VI is felt by everyone and can result in minor building damage. A very small proportion of the population is likely to be impacted to the extent that significant emergency relief is necessary. The weight applied to intensity VII is drawn from the proportion of buildings likely to be significantly affected. Subsequent weights are chosen to mirror the higher ground motion intensity of greater magnitude earthquakes.

Finally, the cost per person of immediate relief provisions can be applied to the estimated affected population to provide a total payment per earthquake event. The cost of initial response “family packs” in Indonesia was generally quoted by INGOs as being approximately 50 USD with a family unit consisting of five persons, or 10 USD per individual.

The unrestricted payment function is then:

Table 3.2: Population Count Weights Applied to Ground Motion Intensity.

| I_{MM} | Weight | Description |
|----------|--------|---------------------------|
| I–V | 0 | Not felt to rather strong |
| VI | 0.001 | Strong |
| VII | 0.2 | Very strong |
| VIII | 0.2 | Destructive |
| IX | 0.3 | Violent |
| X | 0.5 | Intense |
| XI | 0.7 | Extreme |
| XII | 0.9 | Catastrophic |

Total payment = $PR \cdot \sum_i (P_i \cdot Wt_i)$, where

i is the index of population grids,

P is population of grid i ,

Wt is the assigned weight of the observed I_{MM} of population grid i ,

PR is the cost of relief provisions per person, or the payment rate, and

$\sum_i (P_i \cdot Wt_i)$ is the sum of the affected population.

During an iterative process with a number of INGOs in Indonesia using the needs assessment tool, the payment rate and intensity level weights could be modified, but in practice these were held constant while three limiting conditions were adjusted to generate a total gap financing value that seemed appropriate when applied to a number of historical Indonesian earthquakes. These restrictions include:

- Minimum payment per event, which was described as a fixed cost,
- Maximum payment per event, and
- Minimum affected population threshold.

The minimum affected population parameter is based on the sum of the affected population experiencing earthquake ground motion of $I_{MM} \geq VII$.

3.5. Private Sector Engagement to Support Contingent Financing

Contingent claims financing requires upfront costs either in terms of premium (i.e., insurance) or establishment fees (i.e., contingent credit). While the payout from the contingent claim is unconditional, the funds needed to finance the upfront costs may also be of the same

type, and could be viewed as competing with other pressing needs. Similarly, credits to be repaid also requires cash. The concept for supporting the financing mechanism is to access contributions from a growing segment of supporters who place value on an INGO proactively and smartly managing its future funding options while at the same time improving its ability to respond to crisis.

INGO funding streams and partners in humanitarian assistance have evolved to include the growing participation of the private sector (Baur and H.P. 2012; Jamali and T. 2009; Kent and J. Burke 2011; Van Wassenhove, Tomasini, and Stapleton 2008). The index-based approach, with transparent rules for triggering payments, opens a natural avenue for new private sector engagement with INGOs through their support of the contingent financing. Many corporations provide resources for natural disaster response beyond their established corporate social responsibility (CSR) commitments. However, they may prefer a more structured approach that also follows familiar industry best risk management practices. Ideally, private entities could be persuaded by a thoughtfully constructed financing model to support a contingent claims mechanism on an ongoing basis as part of their official CSR activities. Such a “disaster response CSR” may also be preferred due to the benefits of predictable timing and smoothing of contributions relative to ad hoc emergency assistance. Further, the CSR contributor could earn positive publicity throughout the year by demonstrating their commitment to *ex ante* financing of natural disaster emergency response whether or not a disaster event actually occurs.

Humanitarian organizations sometimes earmark funds as an assurance that the charity is going to the need for which the appeal was made. This practice dissuades some donors who are familiar with the absorption capacity issues humanitarian organizations are known to experience following a major catastrophe (Telford 2007; Toyasaki and Wakolbinger 2011). Impact and social investors concerned by the resulting inefficiency, however, may be quite willing to finance gaps in humanitarian funding by supporting the *ex ante* financing of a contingent claims that makes payments in proportion to the response needs. The appeal to the sophisticated donor is further bolstered by the transparent mechanisms of the insurance for funds dispersal in combination with coordinated emergency response plans.

For INGOs, private sector contributions to *ex ante* financing are superior to *ex post* contributions, since they directly address the described response gaps and provide the INGO with a level of certainty in the timing and amount of funds available to respond to a natural disaster crisis. This facilitates an INGOs ability to pre-plan for the use of funds which is also important and consistent with ensuring accountability to the corporate donor. While accountability is in place, the contingent claims also serves to strengthen the institutional independence and effectiveness of the INGO through better leveraging of an existing willingness to meaningfully address gaps in humanitarian response funding (Baur and H.P. 2012). The disaster response CSR approach is even more compelling when it substitutes

for *ad hoc*, in-kind disaster contributions that are not readily transformable to the needs of the crises response.

In summary, private corporations are eager to respond to the needs of the community in the aftermath of a disaster as a demonstration of corporate social responsibility. Index-based contingent claims mechanism offer the private sector a new, yet familiar, venue for active community engagement even before a disaster occurs through support for pre-financing. These solutions can complement and improve existing disaster emergency funding mechanisms and partnerships through:

- Providing greater certainty in the timing and amount of funds available for earthquake disaster response
- Supporting robust INGO disaster response pre-planning for use of the new funds
- Enabling private corporations to engage as active partners before a disaster event
- Providing for predictable timing and smoothing of contributions
- Demonstrating a commitment to innovation that is consistent with best risk management practices

3.6. Mercy Corps: Response Characterization and Financing

Mercy Corps has operated a country office in Indonesia since 1999, initially focusing on urban poverty, health and nutrition, growth in economic opportunity, and access to finance. Mercy Corps' first disaster response took place in December 2004 following the 9.1 magnitude Northern Sumatra earthquake and resulting tsunami. Its country programs now include disaster risk reduction and climate change adaptation activities.

Mercy Corps maintains a 30-person Indonesia Response Team (IRT) whose members are based throughout the country. Team members are typically cross-trained and normally work on some facet of ongoing development programs. Once alerted and deployed, at least one team member should arrive at a disaster site within 24 hours to provide immediate, albeit limited, relief and to begin a needs assessment. The response skill set of the IRT includes hygiene, water, sanitation and occasionally transportation and shelter. Mercy Corps has moved away from emergency resources stock-piling and now relies more heavily on local and regional purchasing to obtain needed equipment and supplies beyond the basic humanitarian relief packages.

The majority of Mercy Corps' regular interventions take place in Sumatra, Java and Maluku, and it frequently leads immediate response in these areas. As with other INGOs working in Indonesia, an invitation from the government is required to participate in an emergency response outside of Mercy Corps' regular working area.

Mercy Corps falls in the category of INGOs experiencing a timing gap or liquidity constraint in emergency response funding. Outside of support for the immediate disaster

needs assessment, very limited funds are on hand to initiate and sustain action before outside donor funds are required. Some institutional donors are able to respond within a few weeks of a request, usually via standing contingent credit for large-scale events and letters of commitment.

The context of one earthquake disaster event to another alters the financial resources needed for an effective response. In general, remoteness significantly increases the fixed cost of a response. The length of the timing gap in funds arrival is shorter for very large events where there is strong international media attention. The timing gap is longer for smaller but severe events that fail to gain traction in the media.

3.6.1. Index Parameters

The needs assessment tool was used interactively with Mercy Corps country staff to design a contingent financing product that would meet their liquidity needs in the immediate aftermath of an earthquake disaster. During the review of a number of historical earthquake events, Mercy Corps chose a minimum payment level of 100,000 USD with exhaustion at 400,000 USD. The minimum affected population needed to trigger any payment is set at 10,000 people, and possibly at 25,000 people for areas outside Mercy Corps' normal engagement areas. Note that the minimum payment level and minimum affected population (10,000) are redundant constraints. The initial weighting scheme to determine the affected population was unchanged.

Mercy Corps indicated that a potential contingent claims mechanism should include its financing needs across the entire Indonesian archipelago, although perhaps with differing minimum triggers as mentioned above. A product should also allow for the possibility of multiple events occurring during a contract period.

Table 3.3 describes the exposed and affected population for a number of different earthquake events exceeding magnitude six and the resulting payments given the assigned parameters of the prototype contingent claims contract derived from using the needs assessment tool. The lower minimum affected population threshold was used throughout the examples, although the higher minimum threshold would not change the outcomes.

When applied to the last nine years of significant Indonesian earthquake events, this specific schedule would have made payments almost 1-in-2 years and mostly at the maximum amount. This frequency and level of payment suggest that a contingent claim mechanism in the form of insurance will involve a high premium and that alternative financing be explored or the payment schedule altered to reduce the payout rate.

3.6.2. Affected Population Weighting Sensitivity

When the exposed and affected population levels are disaggregated, it is apparent that affected populations from intensity levels VII and greater largely drive the results. Changing the weighting of intensity level VI to zero alters only the payment for Sumatra (2007-09-12)

by a reduction of 20,000 USD, whereas the binding maximum still applies for the other triggered events. At higher intensity levels, the results can be sensitive to small changes in the weighting scheme, which can be manipulated to impose greater variation in payment outcomes to influence the potential cost of the contingent claim. The presumption, however, of the iterative exercise with the INGOs is that the modeled payments are what would have been needed to maintain useful gap financing across the different events.

Several different weighting scheme were explored to limit the number of times the maximum payout is reached while still making payments for those events Mercy Corps indicated were necessary. Overall, the variation between the weighting schemes is small when comparing the coefficient of variation and may have limited value in modulating the pricing of some financing mechanisms relative to delivering the amount of resources desired.

3.6.3. Financing Instrument and Pricing

A number of different instruments can be used to finance the timing gap in resources, including index insurance, contingent credit, and contingent catastrophic bonds. The choice of instrument depends on the profile of the financing need and the relative cost and features of each instrument. Catastrophic bonds are typically used to secure risk financing of very large sums for a single event and involve significant setup costs and so are not considered here given the size of the gap financing. Micro bonds involving smaller sums are a newer innovation that may be applicable, particularly if tailored to the philanthropic community in a way that encourages early giving. However, it is generally the case that bonds of all types should be reserved for quite infrequent events. Index insurance and contingent credit approaches are considered in turn

Earthquake Index Insurance

Insurance and re-insurance companies underwrite index insurance and other insurance-like contracts. While index insurance is designed to lower the cost of monitoring against moral hazard and adverse selection, the use of insurance for natural disaster risk can also imply substantial loading for ambiguity in tail risk when loss distributions are not well defined. Insurance is generally not well suited for frequent events which drives up premium cost, including the cost of ambiguity loading, which can be as much as three-times the estimated risk premium. While ultimately priced by the risk holders in the market, an estimate can be made from the application of a probabilistic hazard model to the desired payment schedule to derive an indicative technical premium (pure risk premium).

The MAIPARK probabilistic earthquake hazard model was used to generate an indicative technical premium based on the payment schedule organized with Mercy Corps. The probabilistic hazard model was iterated for 20,000 years to generate ground motion intensity footprints for earthquakes magnitude six and higher, as would be depicted in a shake map, and the payment schedule applied to the footprint and population density information

Table 3.3: Affected Population and Payments of a Prototype Contingent Claims Contract for Historical Earthquakes.

| Location | M _w | Date | Exposed Population per I _{MM} | | | | Total Exposed | Total Affected | Total Payment |
|------------|----------------|------------|--|-----------|---------|-----------|---------------|----------------|---------------|
| | | | VI | VII | VIII | | | | |
| Papua | 7.1 | 2004-11-26 | 42,586 | 19,932 | | 62,518 | 411 | 0 | |
| Banda Aceh | 9.1 | 2004-12-26 | 939,290 | 2,019,990 | 5,082 | 2,964,362 | 42,355 | 400,000 | |
| Sumatra | 8.6 | 2005-03-28 | 3,768,025 | 881,163 | 138,956 | 4,788,144 | 49,182 | 400,000 | |
| Yogyakarta | 6.3 | 2006-05-26 | 1,590,280 | 1,882,162 | 23,760 | 3,496,202 | 43,986 | 400,000 | |
| Sumatra | 8.4 | 2007-09-12 | 1,952,192 | 670,481 | 4,189 | 2,626,862 | 16,200 | 161,966 | |
| Minahasa | 7.4 | 2008-11-16 | 388,152 | 17,584 | | 405,736 | 740 | 0 | |
| Papua | 7.7 | 2009-01-03 | 22,137 | 14,345 | | 36,482 | 309 | 0 | |
| Sumatra | 7.6 | 2009-09-30 | 1,608,891 | 3,277,379 | | 4,886,270 | 67,156 | 400,000 | |
| Mentawai | 7.7 | 2010-10-25 | 18,481 | 5,406 | | 23,887 | 127 | 0 | |

described above. The technical premium of this “300 excess 100” contract structure is then the mean of the resulting distribution of payments. For the original population weighting scheme the annual technical rate was calculated to be 1.79, or 179,000 USD which gives a rate on line of 45 percent. With minimum loading the realized premium could easily be as high as 80 percent—rendering an insurance solution inefficient and unattractive to private sector supporters.

Earthquake Contingent Credit

Given the entry and limiting parameters identified by Mercy Corps, the characterization of gap financing as a temporary liquidity constraint may better be addressed using a pre-arranged credit agreement, or an earthquake contingent credit instrument. The index and triggering mechanism would be identical to the insurance approach, but the funds are drawn from a financial entity as a pre-structured loan up to a maximum commitment amount. This approach could be particularly efficient in certain circumstances. For instance, some INGOs including Mercy Corps have said that when an event is sufficiently large, most donors are receptive to and understand the need to replenish reserve funds expended for immediate response. Donors should be willing to extend the same consideration to the repayment of a contingent credit line that enables a more timely and more robust response in the initial stages of a humanitarian crisis. Moreover, donor and private sector supporters, many of whom are regular users of commercial contingent credit, should respond positively to the consideration of options that reduce the cost of gap financing relative to insurance.

The cost structure of a contingent credit instrument differs from an insurance-like contract where the policyholder pays a single premium up front. Contingent credit involves some combination of various initial and ongoing fees plus interest on the amount of the commitment that is drawn (Loukoianova, Neftci, and Sharma 2013). These fees may include placement fees if a broker is used to facilitate transactions, an upfront commitment fee when the credit is established, an annual fee on the total commitment amount, and a usage fee against the unused portion of the credit. Interest is generally based on a risk premium, or spread, over a reference rate such as the Prime lending rate or LIBOR, although the spread can also depend on the level of the usage fee. Identifying a current “typical” fee and premium spread for commercial contingent credit is difficult, particularly since banks do not readily disclose this information and because the types of fees vary from one institution to another.

Contingent credit is often structured as a multi-year agreement, which helps to reduce transaction costs relative to insurance that almost exclusively operates on an annual renewal cycle. A contingent credit agreement can also accommodate multiple event drawdowns, by having a commitment larger than the maximum payment from a single event, by relying on rapid repayment to re-establish the commitment level, or a combination. The drawdown

repayment conditions are specified in the credit agreement and can be tailored to the characteristics and context of the borrower.

Such a contingent credit agreement can offer Mercy Corps' private sector partners meaningful and visible means of contributing to early disaster response needs. Financing, for instance, the upfront costs or other fees provides immediate recognition of a commitment to humanitarian assistance. A strong credit rating usually backs contingent credit for commercial entities in addition to some form of collateral provision. Most INGOs very likely cannot offer collateral and may otherwise be reluctant to expose themselves to this type of debt obligation. Private sector supporters could address this issue through the provision of letters of credit, effectively guaranteeing loan repayment. Ultimately, the recipient INGO will need to provide assurance to the lender and private partners that a portion of donor funds can be directed to repayment of the contingent credit or that private sector supporters will ensure repayment as part of their philanthropy.

3.7. Discussion

An assessment of early humanitarian response to earthquake disaster for a number of INGOs operating in Indonesia indicates a need for gap, or liquidity, financing to complement subsequent donor funds. An index based contingent claims mechanism tied to ground motion intensity and population density helps address the early constraining mismatch of timing and type of relief and recovery funds. Specifically:

- Unconditional and rapidly available liquid funds empowers an INGO to immediately act following a disaster and gives it the freedom to allocate resources to where it determines is the most pressing humanitarian need.
- Financing a portion of its natural disaster risk through contingent claims mechanisms diversifies an INGO's funding portfolio and allows for greater financial efficiency and financial security.
- Financing can partially offset, and be blended with, high opportunity cost contingent reserve funds for disaster response.
- Ex ante financing supports targeted response planning, including the coordination of partnerships with local NGOs and governments, and enables more effective and efficient humanitarian practice.

Ultimately, the use of financial risk transfer in this manner should free resources for disaster risk reduction and other investments in monitoring and preparedness for vulnerability reduction.

Scenario results of a proposed earthquake contingent claims mechanism for Mercy Corps suggest payout frequencies of 1-in-2 years and near to the maximum level established as

sufficient for larger events. Altering the weighting parameters induce relatively small variations in payment levels but in doing so may not reflect the actual liquidity need. The frequency and level of payments suggest that an insurance-like solution may not be viable, and that a contingent line of credit may be more appropriate and affordable. This approach is particularly suitable when institutional donors and/or private sector supporters recognize the value of liquidity in aiding early response and are willing to facilitate credit-line repayment.

The needs assessment tool and the resulting payment schedule could be refined through greater disaggregation within intensity levels. For example, it is apparent from examining alternate weighting schemes that the bulk of the payment occurs between I_{MM} VI and VII. USGS shake maps can be obtained with iso-intensity increments of 0.2 to provide greater refinement within the weighting scheme. While this could provide greater variation in the payments, it is unlikely that there is much prior knowledge on which to base a more refined weighting scheme. In fact, Mercy Corps has moved in the direction of considering “Gap-Plus” as a way to position the contingent claims to its private sector supporters to enable higher payment levels.

The gap financing assessment, however, should be considered an expression of a real desire to improve the timeliness, and effectiveness, of humanitarian response. The proposed contingent financing model attempts to meet this need, while making a compelling argument for the *ex ante* financial support by an INGO’s private sector partners. This approach represents a new way of thinking about the use and value of applying financial instruments in the humanitarian context and its intersection with the private sector. The INGO who decides to be a first mover in initiating contingent gap financing will position itself to provide leadership in humanitarian practice.

Chapter 4. Natural Disaster Recovery, Financial Services, and Indonesia’s Microfinance Sector

4.1. Introduction

This chapter is organized in two parts. The first provides a brief review of the empirical literature’s examination of the impacts of natural disasters on economic activity, moving from broad macro impacts to households’ efforts to smooth consumption and recover from a systemic event. Credit and insurance market imperfections are frequently described constraints to timely and effective recovery from natural disasters, whereas exposure to correlated natural disaster risk can distort the availability of these financial services to households. The use of index insurance is one means to help ease these constraints. The direct impact of natural disaster on the performance of banking entities to contribute to recovery and economic growth is examined, particularly for those who are geographically constrained, as well as how basic banking regulation can result in credit contraction. The use of risk transfer to mitigate negative growth effects of natural disaster events is reviewed in light of previous research that fails to account for insured losses.

The second part of this chapter helps establish the environment of lending activity in Indonesia in the context of earthquake risk, beginning with an overview of Indonesia’s large and diverse microfinance landscape. This is followed by two different appraisal efforts of microfinance institutions that have experienced severe earthquake disruptions to their operations and clients. Finally, these appraisals and insights from the literature are brought together to establish a motivation to explore using an index insurance mechanism to protect a lending entities’ portfolio from earthquake risk.

4.2. Economic Impact of Natural Disaster

Natural disasters, apart from a scientific understanding of their physical manifestation, are a relevant object of economic inquiry and should be viewed as an economic event. The direct losses and indirect costs of a natural disaster are largely related to public policy, institutional development and private economic incentives that contribute to different levels of destruction, different abilities to respond, different paths and duration to recover, and varying adaptive responses to new information of disaster probability and intensity (Cavallo and Noy 2010). The observation of increasing frequency and severity of natural disasters and questions of an appropriate policy response is generating interest in a better understanding of disaster impact on economic performance, distributional outcomes, and economic resiliency of severe events. The public policy response and efforts to enhance disaster risk reduction will become more pointed with increasing calls for compensation for perceived “climate injustice” (Myers and Kulish 2013). A better understanding of the

immediate and long run impact of natural disasters on economic growth, and identifying those variables and channels through which impacts evolve, will help planners evaluate and identify an appropriate mix of *ex ante* mitigation investments and other risk management instruments (Kellenberg and Mobarak 2011).

4.2.1. Macro Economic Impacts

What is the current understanding of natural disaster impact on economic processes and welfare outcomes? The first observation from several recent surveys of the empirical literature is that this area of research is still emerging, and that there are frequently conflicting results between studies (Cavallo and Noy 2010; Clay and Benson 2005; Kellenberg and Mobarak 2011; Loayza et al. 2012; Wenzel and Wolf 2013). It is important to clarify that natural disaster events are almost always welfare reducing in that they involve a reduction in society's level of wealth, with the unreasonable exception that only obsolete assets are destroyed. Many of the following studies are concerned with the effects of natural disaster on an economy's current output (changes in gross domestic output) and the growth path of current output as the economy responds to the destruction of wealth.

At the most general level, moderately destructive natural disasters are found to be somewhat conducive to growth while severely destructive events are not (Loayza et al. 2012; Wenzel and Wolf 2013). However, most studies attempt to disentangle short run and long run growth effects as well as the heterogeneous impact of different disaster types, conditioned on severity of the particular event. This differentiation is important since disasters impact economic sectors differently over different time horizons. In the short run for example, Skidmore and Toya (2002) find that productive output increases as the economy works to replace lost capital stocks. However, the severity of damage is a negative determinant to short run growth (Loayza et al. 2012; Noy 2009), most likely because the damage to supply chains impedes short term recovery and overwhelms other potential growth effects. Such is the case with earthquakes which are found to result in positive industrial growth but only at moderate levels of severity. Flooding appears to contribute to greater output in the agricultural sector, very likely due to moisture and nutrient availability in subsequent growing cycles, while droughts of any magnitude do not. Average hurricane strikes, however, are found to reduce growth, at least among countries of Central American and the Caribbean (Strobl 2012).

In the long run, meteorological disasters are associated with higher growth while volcanoes and earthquakes are negatively associated with growth (Cavallo and Noy 2010). Skidmore and Toya (2002) concurs but also finds no correlation between disaster and long term capital accumulation. Wenzel and Wolf (2013) add that if growth effects are due to recovery and reconstruction activity only, it can only be viewed as a neutral welfare effect at best. Furthermore, disasters occurring during a full capacity growth period results in

unequivocal loss since resources are diverted to reconstruction rather than investment of new capital.

Vulnerability to severe losses have also been found to be related to a variety of socio-economic characteristics that play a role in mitigation, the stage of economic development that speaks to the efficacy of institutions to respond to crises and capacity to absorb costs, and the inherent probabilistic risk being confronted. Recovery and potential growth effects are dependent on the availability of emergency and reconstruction funding, where capacity can depend on the functioning and penetration of credit and insurance markets, discussed further in section 4.2.3 (Kellenberg and Mobarak 2011; Loayza et al. 2012).

Natural disaster impacts on human capital, in addition to physical capital growth, are also of interest, particularly since this may have long term effects on economic performance via deficiencies in nutrition and education. With increasing population growth in disaster prone areas, the number of people affected by natural disasters has increased over time. However, the sheer number of people affected during an event does not appear to have an impact at least on short run growth (Noy 2009), whereas Skidmore and Toya (2002) find that meteorological events correlate with higher rates of human capital accumulation. Wenzel and Wolf (2013) reports that there is a strong negative relationship between human capital development and the frequency that people are exposed to natural catastrophes, which is of great concern given the concurrent observation that the frequency of natural disasters has been increasing. In all cases however, the outcome of natural disaster on human capital development are thought to depend importantly on the functioning of local credit markets that enable household to smooth consumption and potentially avoid the need for child labor contributions to household income.

4.2.2. Natural Disasters and Distributional Concerns

A frequent introductory observation of natural disaster occurrence and impact is that the poor and developing countries are more vulnerable and incur greater costs relative to the size of the economy than do the wealthy and developed countries (Clay and Benson 2005; Kellenberg and Mobarak 2011; Loayza et al. 2012; Wenzel and Wolf 2013). While a number of studies have included indicators of development as part of their investigations, more is needed for a fuller understanding of the channels and magnitudes through which natural disasters influence income distribution and poverty (Noy 2009).

Common observations include that smaller and poorer states are more vulnerable to natural disaster impacts (Cavallo and Noy 2010; Loayza et al. 2012), that they experience more disaster related deaths (Toya and Skidmore 2007), that larger disaster events have a proportionally greater impact on poor countries than rich countries (Noy 2009), including larger losses relative to their GDP (Wenzel and Wolf 2013). The possibility of economic growth following a natural disaster is therefore more sensitive than found in developed countries. This is particularly the case when the size of the agricultural sector is a large

share of an economy's output, one measure of economic development. Further, the working poor in the agricultural sector benefit less from growth when it does occur since the elasticity of poverty reduction to growth is less than observed for other sectors (Loayza et al. 2012; Noy 2009).

Viewing natural disaster impacts as the result of economic choices suggests a relationship between economic development and the degree of distributional inequality as important determinants of effects. For example, while poorer countries are unable or unwilling to spend additional resources on disaster mitigation perhaps also due to institutional and market limitations, high inequality at any level of average development also correlates with less resources being devoted to mitigation due to collective action problems (Cavallo and Noy 2010).

The apparent relationship between natural disaster vulnerability and the stage of economic development is not necessarily linear, however. Attempts to provide a systematic explanation of the various observations of the differential impact of natural disasters has been through the "inverted U hypothesis", characterized by the Kuznet's curve. Here, the relationship between income does not necessarily reduce vulnerability to loss or mortality, and is strongly conditioned by disaster type (Clay and Benson 2005; Kellenberg and Mobarak 2011). The mechanism behind the relationship may be related to the changing composition of direct losses and indirect costs experienced as a country develops and because mitigation activities may be more highly discounted relative to consumption at lower levels of income, although this is also dependent on the marginal benefits of mitigation effort for different disaster types. For example, the Kuznet relationship appears more pronounced for floods, landslides, and windstorms than for temperature extremes and earthquakes (Kellenberg and Mobarak 2011).

4.2.3. Credit Markets for Disaster Risk Management

Nearly every research effort contains the caveat that disaster vulnerability, recovery and prospects for growth at both the micro and macro levels are importantly determined by the depth and breadth of the financial sector, specifically credit and insurance markets. Not only are formal financial markets viewed as being critical for ongoing development and poverty alleviation, they serve as an important risk management function (Becchetti and Castriota 2011; Khandker 2007; Skoufias 2003). In particular, markets provide a means through which to efficiently allocate risk and help minimize economic losses when available for the timely finance of recovery and reconstruction efforts (Garmaise and Moskowitz 2009; Loayza et al. 2012; Yaron 1997). When these markets exist the human toll and economic effects of natural disaster are less pronounced by providing an insurance like function that helps to smooth consumption over time. For example, Khandker (2007) found that robust and well capitalized microcredit facilitated borrowing as a key coping strategy of poor and vulnerable households following severe flooding in Bangladesh. Access to credit enabled households to

maintain both consumption and asset holding. Similarly, Becchetti and Castriota (2011) found that tsunami stricken households in Sri Lanka who were able to access credit worked fewer hours and had higher real income following recovery.

These outcomes contrast strongly with circumstances where financial access and formal risk management are limited, as is more common than not in developing countries (Loayza et al. 2012). In addition to generally higher vulnerability to natural disaster risk, self insurance strategies are costly in terms of current income and opportunity cost while localized informal group risk sharing and consumption smoothing strategies employed by the working poor designed for idiosyncratic risks are overwhelmed in the face of highly correlated natural disaster events where group income moves strongly together (Anderson 1976; Becchetti and Castriota 2011; Skoufias 2003). Losses in the immediate aftermath of disaster are compounded by the temporary failure of local markets and employment opportunities, which further exacerbates livelihood disruptions. When consumption smoothing efforts force the sale of productive assets, poor households face a real threat of persistent poverty, trapped in a state of low productivity that inhibits future growth (Barnett, Barrett, and Skees 2008; M.R Carter et al. 2007; Dercon 2005; Wenzel and Wolf 2013). Poverty can be further transmitted into the future via curtailed childhood education and poor nutritional status when there are few sources of financing for disaster coping and recovery (Becchetti and Castriota 2011).

4.2.4. Credit Market Failure with Correlated Risk

While formal banking services can help improve the risk management capacities and disaster resiliency of the working poor, correlated risks also pose special problems for the availability and performance of these services. That is, disaster risk exposure of a lending institution's borrowers can greatly constrain financial market development and overall access to finance (Collier and Skees 2012; Garmaise and Moskowitz 2009; Skees and Barnett 1999; Skees, Varangis, et al. 2004).

Lenders, particularly those not well diversified across space or economic sectors, are ill equipped to manage the community and regional effects of disasters and face a number of problems that disrupt credit markets through the lending channel. First, because disasters can affect the repayment ability of so many borrowers simultaneously, lenders face the possibility of a sharp increase in loan default, portfolio quality decline, and subsequent threats to solvency (Collier and Skees 2012; Skees and Barnett 2006). Second, lenders may experience a liquidity squeeze during and in the aftermath of a natural disaster due to falling revenue from missed loan payments, and through reduced savings or withdrawal of savings by clients for disaster coping. Consequently, lenders may be unable to capitalize on a surge in credit demand for emergency needs and recovery, and may even be forced to reduce their level of overall lending (Becchetti and Castriota 2011; Berg and Schrader 2011; Mian and Khwaja 2006). Third, regulatory requirements may further constrain lending

activity when asset deterioration and falling income erodes the lender's capital base such that it can no longer support the previous loan volume. Minimum capital to asset ratios are one such regulatory requirement, which are sometimes voluntarily targeted at higher levels by management in volatile environments. Attrition of the capital base, which is sensitive to income losses due to a high degree of leverage (Van den Heuvel 2006), will bring the ratio into non-compliance and compel the lender to originate fewer or no loans (Collier and Skees 2012, 2013; Khandker 2007).

Natural disasters damage lenders and induce rationing in an number of different forms to preserve survival and profitability. In isolated credit markets, the combination of effects described above are internalized and force up interest rates (Ray 1998) or can be expressed as an increase in the minimum loan size in order to lower per unit administrative costs (Jonston and Morduch 2008). In some situations of slow onset disaster or where there are reliable indicators of an impending natural disaster, lenders may simply curtail additional lending until the crisis has past in order to avoid predictable default problems. This reaction was found among some agricultural lenders in areas of Northern Peru at risk to El Niño induced rainfall and catastrophic flooding (Collier and Skees 2012; Skees, Hartell, and Murphy 2007). In instances when lenders did extend credit it was done so at very high interest rates. Note that this strategy implies the lender have sufficient scope to continue its lending activities elsewhere during the temporary withdrawal.

Rationing can also be expressed through preferential lending in ways that minimize information costs and default risk. For example, Berg and Schrader (2011) shows that relationship lending is an important rationing device when credit demand exceeds bank capacity following volcanic disasters in Ecuador. While overall lending declines, clients with known histories of good repayment are just as likely to be approved for a loan before and after the disaster disruption. New and unknown clients experience a lower probability of being approved for a loan after the disruption. In related work, Berg and Schrader (2010) also find that the same known clients were offered preferential interest rates following the disaster while new clients were charged higher rates. While the higher rates also resulted in higher default among new clients, the preferential treatment of known clients help maintain a monopolistic lending dynamic that would allow the lender to recover lower returns in the future.

Similar bank lending channel impacts are documented by Mian and Khwaja (2006), who shows that developing market lenders facing liquidity shocks frequently transfer these instabilities to their client firms when there are credit market imperfections affecting both lenders and clients. The effect of lender damage is a rationing of the amount of credit offered, with both new and existing clients having a lower probability of obtaining a loan even if the client's creditworthiness is unchanged. Clients are forced to absorb the fluctuations if they are unable to access alternate sources of funding. In the example given from Pakistan,

relationships and social capital are important in the ability of firms to obtain loans from existing or new lenders.

The impact of natural disaster on banking services can also be found in countries with well developed financial markets and institutions. A study of damaged banks from the Kobe, Japan, earthquake of 1995 shows that the decline in their lending capacity was transferred to even unaffected borrowing firms. Hosono et al. (2012) find that the effects of damage to a bank's headquarters materializes immediately, transmitted through the decreased capacity to process loan applications. Effects of damage to a bank's network emerged after a year and reflect the decline in financial health and risk-taking due to direct damage and effects of possible loan non-performance. Firms borrowing from a damaged small and geographically concentrated bank face greater borrowing constraints than firms borrowing from compromised large banks. The effects of bank network damaged lasted about twelve months while all other effects faded within three years.

Lender capitalization interacts with regulatory requirements in ways that can reduce the supply of loans even when there is no immediate shock to lender income. These effects work not through the bank lending channels related to liquidity shocks described above but through the effect of shocks to bank equity capital. Van den Heuvel (2006) models lending decisions in the presence of regulated minimum capital adequacy, the ratio of risk adjusted assets to capital (CAR), in an environment where the regulator places a moratorium on new loan origination and dividend payments when a bank becomes undercapitalized through, for example, default loan write-offs that reduce the capital base. Hence, the cost of falling below a minimum CAR is forgone lending opportunities that will compel a lender to maintain a capital buffer in order to lower the risk of future capitalization problems that would jeopardize its lending decisions. This result holds only when the lender is constrained in frictionlessly obtaining debt equity. The primary implication of interest is that lenders will reduce loan origination following a shock to its capital base even when the regulatory constraint is not binding, and that this effect can be persistent. Interestingly, while minimum capital requirements are meant to help prevent insolvency, it can also counter-intuitively constrain lending growth and credit access.

Functional lenders and ample credit are found to be important for coping and recovery of households and for reducing the impact on the real economy of natural disaster shocks (Khandker 2007; Noy 2009). Hence, recapitalization may be a useful strategy to restore the role of the lender by compensating for the financial damage induced by natural disasters. Becchetti and Castriota (2011) evaluate the effects of a liquidity infusion provided to a damaged microfinance lender following natural disaster induced portfolio losses of nearly 24 percent. They found that the intervention did enable the lender to avoid credit rationing, in particular by being able to provide lending to damaged borrowers who might otherwise represent a poor risk, but for whom the lending was important for coping and restarting their small businesses. The perceived value of recapitalization has been reflected in a growing

number of donor supported liquidity funds (Becchetti and Castriota 2011). Disbursements from these funds are usually in the form of a loan and available only to those lenders who have pre-qualified and who are deemed recoverable. One such fund, relevant to Indonesia, is the Indonesia Liquidity Fund After Disasters (ILFAD) established by Mercy Corps. The fund is explicitly designed to ensure that microfinance lenders meet their obligations to savings account holders and to facilitate emergency lending and includes technical assistance for developing loan products for disaster coping and recovery.

4.2.5. Credit Markets and Economic Growth, Supplemented with Insurance

Aggregate natural disaster shocks can have negative consequences for economic growth and can compromise the role of the lender in a disaster's aftermath and thereby create conditions where banking services fail to fully develop in risk prone areas. This response can be particularly acute when there is an under provision of insurance in the market for households and businesses. The lack of credit and insurance markets then exacerbates the negative impacts of natural disasters. (Collier and Skees 2012; Garmaise and Moskowitz 2009; Kellenberg and Mobarak 2011; Loayza et al. 2012; Skees, Hartell, and Murphy 2007).

In order to help resolve some of the conflicting findings of natural disaster impact on economic performance, Peter, Dahlen, and Saxena (2012) examines the growth effects of disaster events but conditions on the presence of risk transfer. The intuition behind the investigation is that by ignoring the role of risk transfer the positive and negative effects may be confounded and result in insignificant or inconsistent estimates. The study finds that the negative effect of a disaster event on macroeconomic growth is propelled by the magnitude of the uninsured part of disaster losses and that the most severe natural disasters are unequivocally harmful to economic growth with permanent economic costs.

Completely uninsured natural disasters always result in negative economic growth, regardless of the type of calamity. When losses are well insured, the estimated effects of storms and flood events can be slightly positive but significant only for flooding. In contrast, even well insured geological disasters will not generate a positive growth effect. Among distributional consequences, lack of risk transfer results in negative growth for both low and high income countries but low income countries appear to suffer negative growth in the year following the event even with insurance. Small countries appear to benefit more than large countries from insurance but they also suffer greater effects when uninsured. In aggregate, the compensating effect of insurance against negative growth effects of natural disasters appears stronger for low and middle income countries. The conclusion from these observations is that risk transfer can support growth at least to the extent that it helps an economy avoid the negative long term cumulative effects of natural disasters.

For positive long run growth effects to occur following a disaster, the insured losses would need to be significant enough to enable a short run overshooting of the long run average growth rate. Preliminary work of Peter, Dahlen, and Saxena (2012) indicates that

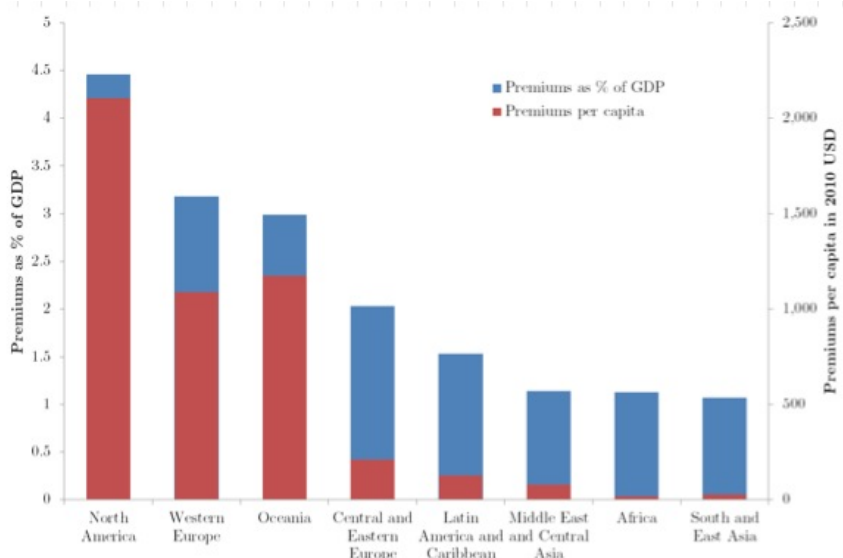


Figure 4.1: Global Insurance Penetration, 2010. GlobalAgRisk, Inc, using data from Swiss Re Sigma.

the break-even point, where the cumulative gains balance losses, is in the vicinity of 60 percent of insured losses. While developed and high income countries have higher insurance penetration than lower income countries (Figure 4.1), even there where markets and institutional frameworks to support risk sharing exist, a large portion of correlated risk remains retained (self insured or uninsured) by individuals and businesses, including primary insurance companies (Niehaus 2002). As an example, insured losses in the United States from hurricane Katrina (2005) were just 30 percent (Cavallo and Noy 2010). One condition for insurance demand is that it be less costly than the cost of diversification for minimizing the impact of risk (Mayers and Smith 1983). However, insuring against correlated risk can involve significant loading for ambiguity surrounding the probability estimates and significant precautionary loading because correlated risk is difficult to diversify cross-sectionally, unlike insurance for idiosyncratic risk (Niehaus 2002; Rejda 2001; Wenzel and Wolf 2013). Insurance for correlated risk may also suffer credibility problems related to default risk of insurers who may not hold sufficient capital to make good on potential claims. In view of high loading and default risk, inefficiencies arise in the sharing of correlated risk and an under investment in risk sharing, even if household and business diversification against natural disaster risk is less than complete. These inefficiencies in the supply of correlated risk sharing can have distortionary effects even in well developed financial market settings. For example, Garmaise and Moskowitz (2009) shows that a reduction in the supply of earthquake risk transfer reduced credit provision in risk prone real-estate markets, using the Northridge earthquake event in California as a case study.

More generally, the lack of correlated risk transfer coupled with the problems of credit market development and financial access in risk prone areas and in the aftermath of a natural disaster, imply significant costs and forgone investment opportunities that slow economic growth and poverty alleviation efforts. Hence, innovation and development of natural disaster risk transfer markets can have substantial value by reducing uninsured losses and via channels that improve the ability of credit markets to broaden financial access and respond during times of a natural disaster crisis (Collier, Miranda, and Skees 2013; Garmaise and Moskowitz 2009; Peter, Dahlen, and Saxena 2012; Skees and Barnett 2006).

4.3. Microfinance Sector in Indonesia

Indonesia has a long history of microfinance that originated a century ago, one of the oldest in Asia. This section provides a taxonomy to Indonesia's diverse microfinance landscape, including the formal regulated sector and the semi-formal and non-bank sector.

By far, the largest provider of microfinance services are regulated banking institutions, many of whom are publicly owned. They tend to serve the upper levels of the micro-enterprise market with a typical loan size of 300 USD and higher, generally used for working capital purposes. Semi-formal and non-bank institutions, ranging from cooperatives, local and community-based MFIs, and some NGO initiatives, aim at the lower market levels and are often involved in poverty schemes subsidized by the government. Unlike formal sector lending, the majority of the semi-formal and informal lending are for household consumption purposes (Jonston and Morduch 2008). While the formal financial sector dominates Indonesian microfinance and outperforms the semi-formal and non-bank sector, the two can be found operating side-by-side due to segregation along social and poverty status and resulting lending purposes (BWTP 2009).

Despite the diversity and number of regulated microfinance institutions operating in the country, the degree of financial inclusion is often found to be lower than in other countries in the region. For example, it is estimated that less than half of the adult population has access to formal financial sector services such as savings, and under 20 percent has ever borrowed from a regulated bank. While many individuals can access informal services, about 17 percent of all Indonesians cannot, whereas this financial exclusion represents nearly 40 percent of those considered poor (Jonston and Morduch 2008; Srinivas 2013). While not intended to understate the degree of financial exclusion, credit use may not always be a straightforward function of access or risk rationing, but one of financial education and debt aversion, as suggested by Jonston and Morduch (2008) in observing that a significant proportion of the unbanked poor are in fact credit worthy individuals that chose not to borrow.

Financial inclusion is made more difficult by the low level of financial intermediation performed by the overall Indonesian banking sector compared to its regional neighbors. By

one measure, loan-to-deposit ratios, BWTP (2009) find the sector to be under-performing, with values ranging between 51 percent for regional development banks and 79 percent for private commercial banks. While the government has made efforts to increase the private commercial sector participation in the microfinance sphere, even at these levels of intermediation there are some stability related concerns over the rising exposure to retail and small and medium enterprise credit risk, primarily due to information asymmetries in a new environment (Srinivas 2013). For example, while the small businesses of the working poor appear to be low risk, they also experience wide seasonal fluctuations, the opposite of what is observed among businesses of the less poor (Jonston and Morduch 2008). Less understood is the role of natural disaster risk exposure to financial sector deepening under served poor populations.

4.3.1. Formal Banking Institutions in Microfinance

Commercial institutions dominate the Indonesian microfinance sector, with both large commercial banks (bank umum) and smaller regulated financial institutions playing a significant role. By “formal” it is understood that the banking institutions are regulated under the 1992 Banking Act, subsequent legislation, and subject to regulatory oversight and reporting to the central bank, Bank Indonesia, and now to the recently organized Financial Services Supervisory Authority (OJK).

Table 4.1 gives an overview of the range of formal banking institutions engaged in microfinance provision in Indonesia, either directly or through linkages to primary providers. Two institutions comprise approximately 60 percent of Indonesia’s regulated microfinance market:

- Bank Rakyat Indonesia (BRI) specialized microfinance Units, and
- Bank Perkreditan Rakyat (People’s Credit Bank, or BPR),

Bank Rakyat Indonesia (BRI) is a state-owned bank run on commercial principles, the second largest commercial bank in Indonesia. Among the regulated banks, the Unit division of Bank BRI (formerly known as Unit Desa or village units) facilitates the most lending to lower-income people, and has a wide reach even into rural areas, a distinguishing feature from other commercial banks. BRI Units dominate the microfinance market, receiving roughly two-thirds of total savings (both formal and semi-formal) and issuing 40 percent of loans by value. In 2006, it numbered 3.44 million micro-borrowers in its “Kupedes” loan program, totaling IDR 27.3 trillion (USD 2.73 billion) in loans outstanding. The average BRI micro-loan size in 2007 was 7.93 million IDR (793 USD) and, while BRI Units primarily focus on lending for investment purposes, they also offer non-collateralized loans of up to 5 million IDR (500 USD) that are repayable over two years.

There are approximately 121 commercial banks operating in Indonesia, which engage in microfinance to varying degrees, depending on their view of microfinance as a profitable

enterprise or as a component of a social mission. Some, such as Bank BRI and Bank Danamon, are eager to commit resources. Others are compelled to enter the field at a minimum level due to government and/or central bank requirements, and commit a portion of assets either directly through their own branch offices or through linkage programs with regulated BPRs.

Bank Perkreditan Rakyat (BPR or the “Peoples’ Credit Banks”) operate throughout the country and are characterized by a small client base (500–4000) in a limited geographic area, providing credit, savings, and term deposits. They generally serve clients having insufficient collateral to access Bank BRI loans.

BPRs serve approximately 15–20 percent of the credit market and focuses on lending that supplies working capital. Current annual lending interest rates are 30.5 percent for working capital credit, 26.3 percent for investment credits, and 25.5 percent for consumption credit (Bank Indonesia statistics, August 2013).

Three common types of commercial bank lending to BPR customers, the linkage program mentioned above, include:

- *Executing*, which involves a direct credit from the commercial bank to the BPR.
- *Channeling*, which involves a credit that is fully financed by the commercial bank with the BPR serving as a delivery agent.
- *Sharing*, which involves joint financing between the commercial bank and BPR.

BPR performance has been variable, prompting regulators to close poorly performing banks and consolidating others (Jonston and Morduch 2008). As of August, 2013, Bank Indonesia statistics indicate an average return on assets of 33.5 percent, return on equity of 3.5 percent, and a non-performing loan ratio of 5.5 percent. BPR expansion is further contained through high capital requirements to open new branches and through prohibitions on operating outside of specific districts. Currently there are 1,641 BPRs supporting 4612 total offices.

4.3.2. Semi-Formal and Non-Bank Institutions in Microfinance

Non-bank institutions that provide microfinance services include a large, regulated pawning company owned by the state and a diverse amalgam of semi-formal institutions, including non-bank financial entities (e.g., BKDs, LKDPs), finance and insurance companies, co-operatives, credit unions, and NGOs. The thousands of institutions that comprise the semi-formal sector are termed non-bank to indicate that they are not regulated directly as banks thus falling under the purview of state and/or regional authorities other than Bank Indonesia. Table 4.2 gives an overview of the diverse semi-formal and non-bank entities engaged in Indonesia’s microfinance sub-sector. Historically, the semi-formal financial sector has focused less on financial intermediation than on social mobilization and government poverty reduction programs.

The dominant participant in the non-bank microfinance sector is Perum Pegadaian, which specializes in small loans, which were less than IDR 500,000 (USD 50) in 2001. In 2004, it served in excess of 15 million customers through its 812 branches.

Badan Kredit Desa (village credit organizations or BKDs) are small, village-owned organizations that have long history but are often lacking in management capacity that is reflected in poor performance. LKDPs (rural credit fund institutions) are supervised by provincial governments. In Java, Badan Kredit Kecamatan (BKK) are strong, while Lembaga Perkreditan Desa (LPDs) are dominant in Bali. LPDs are considered to have the best LDKP system in the country, staying profitable and generating funds by mobilizing savings and deposits.

Cooperatives, which were used in the past as distribution channels for cheap credit to preferred groups, remain subject to political forces and weak regulation. Two types of cooperatives provide microfinance services in Indonesia: credit and savings (Koperasi Simpan Pinjam or KSP) and the saving and credit units (Unit Simpan Pinjam or USP). Most are subsidized, although recent years have seen the rise of several grassroots organizations that show promise. Owing to the Suharto regime policies that discouraged independent social action, NGOs have historically been minimally engaged in the direct provision of microfinance. However, many government programs have used NGOs as facilitating agents for microfinance services. Some NGOs have recently ventured into commercial microfinance, establishing their own BPRs.

Informal credit and savings schemes have had a long presence in Indonesia, consisting of Rotating Savings and Credit Associations (RoSCAs) or Arisan and other forms of traditional finance. These informal social arrangements rely on social cohesion but are of limited importance to the working poor since the sums involved are usually fairly small.

Table 4.1: Formal Microfinance Providers in Indonesia.

| Type of Institution | Description |
|---------------------------------------|---|
| Apex Institutions | Second tier lending institutions that provide financial and technical assistance to BPRs; In development of more regions. |
| Regional Development Banks (BPDs) | Provincial, government-owned commercial banks that act as fund managers for provincial government programs, and facilitates the government's Kredit Usaha Rakyat (KUR) program to expand access to microfinance by coordinating financing from commercial banks and providing state-backed guarantees to microfinance lenders. There are 26 BPDs nationwide represented by the group association ASBANDA. |
| Bank Rakyat Indonesia (BRI) | "BRI Unit" program is a nationwide microfinance branch system targeted to poor households; Investment-oriented microfinance loans greater than USD 300; Small corporate lending portfolio; Holds 40% of market share of microfinance loan volume and 60–70% of savings market share; Primarily state owned. |
| Other Commercial Banks (Bank Umum) | Provides full line of financial services including foreign exchange; Has largest capital requirements; Provides direct credit to SMEs or channels funds through BPRs. |
| Licensed BPRs (People's Credit Banks) | Mix of public and privately owned; Credit, savings, and term deposits; Provide credit mainly for working capital; Predominantly loans greater than USD 300; Holds 15% of microcredit market share. |

Adapted from Bank Indonesia (2013); BWTP (2009); Jonston and Morduch (2008); ProFI (2009) and Sunarto (2007).

Table 4.2: Non-Bank Microfinance Providers in Indonesia.

| Type of Institution | Description | Governing Regulation and Regulatory Authority |
|--|---|---|
| Permodalan Nasional Madani | Government run wholesale lender that provides financing mostly for SME development; Supports linkage programs between commercial banks and non-bank microfinance providers; Finances non-bank microfinance providers via regional development banks (BPDs) with savings as a unique form of collateral; Mandate to support Sharia microfinance. Typified by small uncollateralized microfinance with compulsory savings; Numbers roughly 9000 public rural institutions; LPDs are social solidarity groups owned by community organizations; Strongest of the non-formal institutions reaching 80% of the population in 1999. | Ministry of Finance |
| Unlicensed BPRs | | |
| <ul style="list-style-type: none"> • BKD (village credit associations) • LKDP (rural fund and credit institutions, including Badan Kredit Kecamatan (BKs) and Lembaga Perkreditan Desa (LPDs)) | <ul style="list-style-type: none"> • BKD supervision by BRI on behalf of BI; • LDKP licensed and regulated by provincial governments, supervision and technical assistance by Regional Development Banks (BPDs); <p>Efforts underway to convert many to village-level business entities to formalize and regulate their operations as BPRs.</p> | |

Continued on next page

(Table 4.2 – continued from previous page)

| Type of Institution | Description | Governing Regulation and Regulatory Authority |
|---|--|---|
| Perum Pedgadaian (State-owned pawn brokers) | Provides easy access to small loans of less than USD 50. | Ministry of Finance |
| Cooperatives | Most provide subsidized credit tied to government programs; USP have very extensive reach with 36,000 units and nearly 5 million borrowers (2007). | Ministry of Cooperatives and Small and Medium Enterprises; Cooperatives Act; Government regulation of 1995, 1998. |
| <ul style="list-style-type: none"> • KSP (Savings and Loan Cooperatives) • USP (Lending Cooperatives) | | |
| BMT (Islamic self-help groups) International Non-Governmental Organizations (NGOs) | Provides savings and investment services according to principles of Sharia Law. Subsidized loans to target self-help groups; Socially oriented objectives; By law, NGOs can only engage in microfinance services as licensed BPRs. | 2008 Islamic Banking Act; Cooperatives Act. New regulation prohibits NGOs owning a majority share in any BPR or other financial provider. |
| Rotating Savings and Credit Associations (“Arisan”) | Small, informal group-based savings and credit schemes. | n/a |

Adapted from BWTP (2009) and ProFI (2009).

4.4. Microfinance Earthquake Impact and Response

This section reviews the experience and response of one segment of the banking sector important to the working poor in Indonesia following a severe earthquake event to ascertain whether the problems that banks are found to have following a correlated shock are equally evident in Indonesia, and if any special circumstances emerge.

The first part summarizes a performance review of one type of formal, and regulated, banking institution following the 2009 Padang earthquake. The study had the benefit of detailed balance sheet and income statement information and the cooperation of the banking regulator, in order to provide insight and recommendations for future policy or regulatory action.

In the second part, two sets field assessment were conducted with various geographically concentrated MFIs where recent severe earthquakes in Yogyakarta (2006) and Panang (2009) caused major disruptions to the livelihood activities of their clients. The assessments were conducted as part of a rapid needs appraisal and educational effort to help in the design of a potential earthquake risk transfer mechanism, or insurance product, and to aid potential clients in evaluating the value of additional liquidity/capital that could be made available by such a contingent contract. The interviews sought to understand the costs and consequences the earthquake events had on the performance of the MFI portfolios, how the institutions responded, and whether they were able to meet the needs of their clients. Bank management was specifically asked about the evolution of loan non-performance, the impact that may have had on their desired or regulated ratio of capital to risk weighted asset exposure (capital adequacy), and if liquidity constraints emerged. They were asked about other support systems they may have access to and if a capital infusion would have been valuable for them to cope during the aftermath. In every case (summarized in section 4.5), MFI leadership confirmed that their ability to meet the needs of their borrowers would be enhanced by such an infusion, and that they could envision other possible services during an earthquake crisis.

In both Padang and Yogyakarta, lending for home construction is less common than small business lending, with the practice more prevalent in Yogyakarta than the former. This difference is said to be generally true throughout Sumatra (Padang) and Java (Yogyakarta). The management of several MFIs explained that people generally prefer to save for home building rather than borrow, and will undertake construction in increments as resources become available. This is one reason why the recovery of home-based businesses sometimes takes as much as a year following a destructive event.

4.4.1. Earthquake Impact on Bank Performance in Padang

Evidence on how severe earthquakes affect the banking sector in Indonesia is provided in a study by Hiemann (2009) that was commissioned by GTZ ProFi shortly following the 2009

Padang earthquake. The study assesses the evolving financial impact on Bank Perkreditan Rakyat (People's Credit Bank or BPR), and provides recommendations to Bank Indonesia (BI) to strengthen the risk management capacity of the sector. To reiterate section 4.3, licensed BPRs are secondary banks that operate under the supervision of the central bank either as limited liability companies, regional government enterprises, or cooperatives. The network of these rural banks is extensive and have a strong presence in remote rural areas. Consequently, the BPRs reach middle and lower income population segments as well as small rural entrepreneurs.

The assessment revealed a significant impact on BPRs operating in the most affected regions, although consequences for individual BPRs varied depending on the losses of their clients and the financial standing of the institution prior to the event. Roughly 20 of the most affected BPRs were expected to face significant deterioration in their portfolio quality and reductions in income, which would take several years to recover. Among BPRs that had experienced portfolio problems prior to the quake, several were expected to fail without substantial recapitalization. Resulting liquidity and capital shortages were predicted to significantly limit the capacity of these institutions to respond to community needs during this critical time.

BPRs in the affected regions would simultaneously face lost interest income, due to an increase in the rate of non-performing loans (NPLs), and considerable costs for bad debt reserves (BDR), particularly where damages to homes reduces collateral value below the outstanding credit amount. Approximately 9000 borrowers suffered losses, with an average outstanding debt of IDR 10 million (US 1,090). Half of the hardest hit BPRs reported that over 70 percent of their clients were affected. Interest income, an important indicator of sustainability, immediately fell and was expected to remain low due to loan restructuring and defaults. Lost interest income for the most severely affected BPRs was estimated to be 15–35 percent of the income before the quake. In general, BPRs that were performing well before the earthquake were expected to have a stronger capacity to absorb income losses and a temporary increase in defaults. The sustainability of under performing BPRs (with NPL rates above 15 percent) was doubtful. In most cases, income would be able to cover cash expenses, but it would not be sufficient to cover allocations to rising BDRs. Final write-off for losses were not expected to exceed 10–15 percent of the credit volume.

Trends in bank loan non-performance following the earthquake documented by Hiemann (2009) were verified using a small sample of quarterly balance sheet data for 19 BPRs in the impacted area of Padang from 2007 through 2010. Figure 4.2 describes the evolution in the average percentage point change in loan non-performance, which focuses on the change rather than the level of delinquency. Despite the aggregation of high and low performers relative to earthquake intensity, loan non-performance among distressed clients clearly increases following the earthquake and continues to worsen over the next twelve months.

This trend is evident despite special reporting exemptions that allowed many BPRs to under report bad loan problems in order to avoid facing under capitalization penalties.

Though liquidity was not apparent in the immediate aftermath of the Padang earthquake, it was bound to become a problem in early 2010. It is customary that retail deposits actually increase in the aftermath of a disaster; however, these were expected to be withdrawn in the near term. Credit demand was initially also low, since many people had suffered losses in income. Despite the initial influx of deposits and a flat demand for credit, managers fully anticipated a surge in savings withdrawals in the coming months to finance home rebuilding and merchandise replenishing. According to assessments, roughly 20 most affected BPRs would require access to some 4 million USD in additional finance to withstand the resulting liquidity shortfalls. The timing of these withdrawals would coincide with a swell in loan applications for rebuilding and rebounding from the quake. Yet, facing significant liquidity squeeze due to deposit withdrawals and slower credit repayments, BPRs would not be in a position to accommodate the credit needs for reconstruction.

Some of the BPR offices also experienced structural damage from the earthquake. Although the majority of the offices are rented, it is not common for either the tenants or the owners to carry earthquake insurance. As a result, BPRs have two costly options of financing repairs themselves (if possible) or relocating. If relocating, rents, which are paid in advance, are written off as a loss. The net effect of these losses and additional costs is a decline in portfolio quality of the lending institution. Declining portfolio quality affects the ability of BPRs to access credit from second tier financial institutions, which in turn limits the ability of the BPR to recover their business by responding to increased demand for credit for reconstruction. The projected volume for financing house rehabilitation “could easily double the BPR balance sheet” (Hiemann 2009). Most BPRs have a capital adequacy

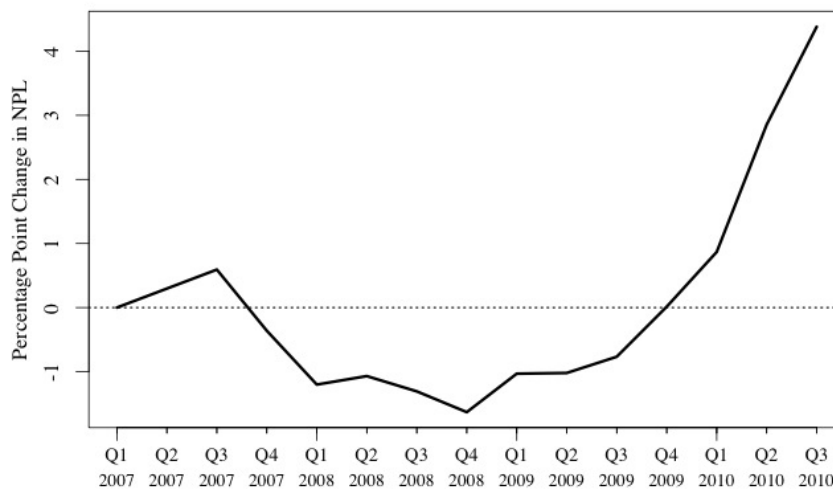


Figure 4.2: Trends in Padang BPR Loan Non-Performance, 2007–2010.

ratio (CAR) in the range of 15 percent to be able to carry this additional lending, but the margin for the house-repair market segment is low and BPRs need access to long-term funds at competitive rates. However, BPRs would have difficulties acquiring new inter-bank loans given their weakened business. In times of disaster, BPRs often look to Bank Nagari, their apex institution for financing. Bank Nagari provides some 6 million USD in loans through the “linkage” framework. However, only sound institutions can qualify for the funds, a rating some BPRs could no longer meet. Following an earthquake, shareholders have a limited capacity to mobilize sufficient equity to meet BI reserving requirements. In light of portfolio imbalances and inability to recapitalize, the rating of many BPRs was expected to drop from ‘sound’ to ‘sufficiently sound’ or even ‘less sound,’ further restricting their access to much needed financing.

A complicating factor in assessing bank performance is a Bank Indonesia regulation that allows BPRs to classify restructured loans issued before and after a disaster as sound for up to three years following a disaster. A second difficulty in assessing portfolio performance is the practice of allowing a loan to be delinquent for up to 3 months before it is considered to be nonperforming. Thus, higher loan nonperformance resulting from the September 2009 earthquake is not accounted for with impairment reserving until at least January of the following year. These practices shield the balance sheet from the financial impact of the earthquake, keeping the non-performing loan levels low for a time. However, this also falsely boosts profit and resulting tax liabilities of institutions that may in fact be facing capital constraints.

The report made several important recommendations to BI following the review. First, encourage BPRs to increase voluntary reserves beyond the minimum level. BPRs are already encouraged to reserve 20 percent of the paid-up capital—the study recommends going beyond that, recommending that BPRs increase capital buffers beyond the required levels by an extra 5–20 percent of the loan portfolio to accommodate interest income drops after disasters. Most BPRs go beyond the internationally accepted CAR of 8 percent, choosing 15 percent or higher. The report projects that only BPRs with CAR in the range of 20 percent would be able to withstand substantial earthquake losses. This represents a large opportunity cost, since according to Hiemann, investors could earn over 25 percent on their capital through lending for housing reconstruction.

4.4.2. Case Interviews: MFI Earthquake Experience in Yogyakarta

Earthquake summary: The May 26, 2006, 6.3 magnitude shallow earthquake near Yogyakarta (south-central Java) caused heavy damage to buildings with a loss of 300,000 houses, contributed to the deaths of approximately 5,750 people, displaced nearly 600,000 individuals, and caused an estimated 6.3 billion USD in losses (USGS).

Appraisal Case 1: Pt. BPR Margirizki Bahagia

Established in 1994 with Sharia (Islamic banking) principles, this Peoples' Credit Bank was founded by a group of Muslim Professors with 1 billion IDR in capital, which has since grown to 21 billion IDR. The bank has approximately 3,000 clients concentrated in two areas outside of Yogyakarta and another 30–40 percent of all clients located in three districts of the city, within a 25–30 km area. The bank's clients, evenly divided between men and women, engage in a variety of commodity trading, services, and some micro-enterprises. Working capital loans are offered up to a maximum of 5,500 USD and some idiosyncratic lending is offered up to a maximum of 1,200 USD for such items as school fees, health needs, and funeral expenses. Some home building loans are made but these have fallen since the expiration of a government subsidy. The bulk of lending, 80 percent, is mobilized from member savings. Prior to the 2006 earthquake, the BPR voluntarily aimed for a 10 percent capital adequacy ratio. During that that time, loan non-performance was under 2 percent.

This bank also has some client exposure in areas that were affected by the October 2010 volcanic eruption of Mt. Merapi. From the bank's perspective, these are very different natural disasters. With earthquake events, even if clients have lost their homes and businesses, they still have their land holdings. Victims of volcanic activity have effectively also lost their land, at least in the short term, due to ash cover and the danger of returning. For this there is no real good solution.

Following the earthquake, loan non-performance rose to 7 percent and took two years to recover. Bank Indonesia intervened allowing some non-performing loans to be reclassified such that the bank was able to report a 4 percent NPL. Without this adjustment, the bank would have had to start writing off loans sooner. Normally, the bank waits 12 months until making a write off, using reserves to match the amount of the loan. The special treatment delays this requirement for up to three years in times of disaster. Nevertheless, the bank restructured and wrote off many problem loans using its own assets. The current non-performance rate of 3.4 percent is the result of lingering serious problems with non-performance related to the Mt. Merapi disaster. Many clients withdrew their savings following the earthquake, up to 30 percent of the entire portfolio and nearly 40 percent among clients in the most affected areas. Loan demand also slowed, by 25 percent, and took six months to a year to recover. After the earthquake, the bank established a higher internal capital adequacy of 15 percent to provide additional buffer from future shocks.

Management indicated that they survived the impact by expanding business outside of the affected areas. While they have access to some external funds, through a cooperative which whom they have a prior relationship, it would only be used as an emergency backup since it involves very high interest. Given the observation of heavy savings withdrawals, the BPRs management speculated there could be high demand for emergency lending if it were possible for the bank to support such lending.

Appraisal Case 2: BMT Binn Ihsanul Fidri

A Sharia cooperative with 15,000 members, making small loans for trading and micro-enterprises which normally perform very well. The cooperative currently has 1.1 billion IDR. available for lending, with its funding sources being initial investors, member shareholders, second tier bank loans, a Ministry of Cooperative revolving fund, and other donors. The cooperative retains 20 percent of savings deposits for liquidity. Savings deposits earn 1 percent interest. Agriculture and agricultural activities account for 60 percent of the lending portfolio with the remaining 40 percent in craft activities. Loan non-performance stood at 4 percent prior to the earthquake, well below the 10 percent maximum level considered acceptable to the Ministry of Cooperatives.

The 2006 earthquake directly affected the cooperative, damaging three offices that were subsequently relocated. Management initially feared that staff would need to be temporarily laid off but the need did not materialize. The cooperative estimates that approximately 30 percent of its clients were affected in some way with loan non-performance rising to 7 percent. Savings behavior by clients was unremarkable during this time. It took one year for loan non-performance to recover. The cooperative sent staff to the disaster areas to meet with clients, adjust loans as needed, and in some cases made loans available to help people recover. Loan adjustment involved a three-month grace on repayment. Emergency lending included one month interest free loans after which the interest rate varied between 1.5 and 2 percent a month depending on the client's condition.

Appraisal Case 3: Kopdit Adil

This credit union (savings and loan cooperative) offering non-bank financial services has grown substantially and now has three service points and offers services over the entire district. The credit union has just over 6,000 members of which 2,000 are full members who maintain mandatory savings. Income is primarily from the savings and loan activity although the credit union also has some second party income. Before the earthquake, the management felt the performance was good overall despite a non-performing loan value of around 10 percent. Most of its members operate micro-businesses. The Ministry of Cooperatives regulates the credit union and requests a minimum capital adequacy of 20 percent but this requirement is not routinely enforced with the exception of new cooperative businesses. Non-mandatory savings are excluded from the capital adequacy calculation.

Many credit union members were in the most badly affected areas of the earthquake and forced to live in emergency shelters after the complete destruction of their homes and businesses. Loan non-performance jumped to 17 percent. The credit union consulted with affected members to assess their repayment ability. Most affected members were able to service only the interest on their loans during this time. Most people took at least a year to restart their business and recover. The savings rate increased after the earthquake and loan

demand fell, as there was less business activity to finance. Normally, for reconstruction, members save for over a year and then start withdrawing for rebuilding activities. In part this may be due to donor emergency assistance that provided for basic needs. In 2008 the government provided for some loan write off assistance. The credit union has experienced positive recovery trends in the past three years with loan non-performance falling to 7.8 percent after two years.

Management expressed a concern that in the future, should a similar event occur, that donor funds and shareholder contributions might not materialize. Liquidity and reserves fell to very low levels following the earthquake and they are concerned about the future liquidity problems should there be another event. Consequently, the credit union now voluntarily has approximately 1.7 billion IDR held in reserve, and a capital adequacy in excess of 20 percent, to be confident that they can survive another large earthquake.

4.4.3. Case Interviews: MFI Earthquake Experience in Padang

Earthquake summary: Situated in an area of high earthquake risk, the area around Padang City in West Sumatra experienced a magnitude 7.5 earthquake on September 30, 2009. In addition to severe ground shaking, landslides were triggered and a small local tsunami was generated. More than 2,600 buildings were damaged or destroyed and at least 1,100 people were killed (USGS).

Appraisal Case 1: Pt. BPR Padang Pariaman

This is a relatively large, urban, Peoples' Credit Bank with 11 branches offering savings and lending services. Most clients are traders/merchants and are located within a 20 km radius of the main office. Lending is for business purposes only with the most common loan size being 10-15 million IDR, although a few loans have been given for amounts of 100 million IDR. Repayment is over either 36 or 60 months. Two dominant shareholders provided equity capital although the bank borrows from other second-tier banks and on-lends customer deposits. Prior to the earthquake, the average NPL was 1–2 percent while the bank maintained a capital adequacy ratio of 11 percent.

The earthquake had widespread and strong effects with home-based businesses being the hardest hit. The bank closed its offices for three days following the earthquake to prevent a bank run. In fact, the bank experienced an overall increase in savings deposits as clients saved what revenue they had and temporarily halted new merchandise purchases. Some clients even sold assets which they deposited since they are aware of deposit guarantee provided by the government and were looking for this protection. Savings withdraws began immediately for those who suffered only moderate damage and were able to begin making repairs. Those who had a total loss kept their money in the bank longer. Two months after the earthquake, the built up savings started to be withdrawn but did not fall below previous levels.

Immediately after the earthquake, bank staff visited every customer having a loan, which took one month to complete. Seventy borrowers suffered a complete loss. For these customers the bank restructured their loans, prolonging repayment and reducing the interest rate. Two months later, Bank Indonesia issued a special order allowing restructuring without penalizing the bank's financial ratios. Non-performing loans increased to 4–5 percent where it has remained since the old repayment problems. Lending demand fell as many people were hesitant to restart their businesses. The Bank has not imposed any limit on lending but is more careful with underwriting; for instance, the value of a house used for collateral is now discounted.

The bank experienced a 20 percent reduction in revenue in the aftermath of the earthquake because of the reduced interest rates and lower new loan issues. Capital adequacy, now at 13 percent, never fell below the minimum requirement of 8 percent.

Appraisal Case 2: BMT Kube 048, Padang Pariaman

This Islamic banking cooperative of 800 members provides home industry and business start-up loans with its service area lying mainly along the coastal areas. Loan size for households is 2 million IDR on average with a maximum of 10 million depending on the type of business, business plan, and growth projections. The BMT, which is regulated by the Ministry of Cooperatives, has a legal status as a “Kube”, a joint enterprise group that works to incorporate social benefits with economic benefits. Under this cooperative's rules, a minimum 30 percent of funds obtained from savings are retained, although there is no specific requirement from the regulator. Cooperatives do not enjoy deposit guarantees backed by the government, as do the rural banks. Prior to the earthquake, non-performing loans amounted to 5 percent on average.

Many repayment problems were encountered following the earthquake, people no longer ran their business and previously lent funds were used for basic needs. Their clients are quite economically vulnerable and even a small disruption affects their repayment ability. The proportion of non-performing loans rose to 15 percent. The cooperative restructured loans, reduced the monthly interest rate by twenty basis points to 1.8 percent, and suspended loan repayment for three months. Many people withdrew savings and reduced the retained capital margin to 10 percent, although this recovered twelve months later. The cooperative decided to not suspend operations and, with the backing of the shareholders, committed to releasing all deposits that were demanded. The management noted that, since the earthquake, some banks operating in the coastal area now ration credit, limiting the amount that can be borrowed. They feel that earthquake insurance is particularly relevant in West Sumatra, especially since there are no bank deposit guarantees for cooperatives.

Appraisal Case 3: BMT Kube Sejahtera

This banking cooperative has 1,500 members and 600 borrowers. It makes trader loans between 10–20 million IDR with repayment being one to two years. Like other cooperatives, there is no deposit guarantee from the government and they have no other insurance for losses. Loan non-performance before the earthquake was 3–5 percent. The cooperative does not require collateral on loans, and instead reserves 10 percent of the loaned amount, which is maintained in the individual's savings account. This cooperative keeps at least 20 percent of all savings deposits liquid and available at all times. Management pointed out that, as a cooperative, there is no legal requirement to maintain a minimum cash on-hand and no capital adequacy requirement.

Immediately following the earthquake people started having trouble repaying their loans and, because of the lack of deposit guarantee, many people withdrew their savings. Nearly 20 percent of all saving deposits, or 500 million IDR was withdrawn almost immediately while at the same time the cooperative's monthly net revenue fell 50 percent. While the cooperative's self-imposed cash minimum never dipped below 20 percent, it had to suspend lending to save cash. After two months post-earthquake the cooperative's net revenue position began to recover and by the third month depositors who withdrew their savings early had returned, assured by then that the cooperative would survive the crisis. Of the outstanding loans, 20 cases were restructured where the clients experienced complete destruction of their home or business. The restructuring process halts payments for two months and under mutual agreement of what can be afforded, modifies the length of time for repayment. Loan delinquency rose to 10 percent where it remains today, more than two years after the earthquake. This cooperative worries about moral hazard in that some clients use an earthquake as an excuse to postpone payment, and note that some BMT-kube's were forced to shut down and start over after the earthquake.

Appraisal Case 4: Pt. BPR EMP Nagari

This Peoples' Credit Bank recently reorganized from a non-formal MFI into a BPR and is mostly focused on agricultural and business lending. It has four cash offices in addition to the head office and 66 shareholders who are provided a 30 percent annual dividend yield on their equity capital. It is supervised by the Apex Bank Nagari on behalf of Bank Indonesia and therefore must maintain a minimum 8 percent capital adequacy ratio, although its ratio was 17 percent before the earthquake. Loan non-performance was 5 percent.

The bank suffered personal losses during the earthquake with the collapse of its head office. By the third day staff was able to recover cash deposits and client data from the ruins. Some clients, and whole families, were killed in the earthquake resulting in 1.5 billion IDR in loans being completely lost. Loan non-performance rose to 21 percent and remains high, as many businesses have not yet fully recovered. The bank did not want to write off loans,

and stepped up efforts to have direct contact with clients to encourage loan repayment. Annual interest rates were lowered 700 basis points to 17 percent. At the same time, the savings interest rate was lowered 400 basis points to 4 percent. The bank did experience some increase in savings immediately after the earthquake.

Additional capital was obtained from the bank's shareholders and from Bank Nagari, which provided a 40 percent infusion. Consequently its capital adequacy rose in the aftermath of the earthquake to 18 percent before settling to 15 percent currently. Bank Indonesia required special reporting on loan delinquency but did not take any action to adjust the bank's non-performance rate.

4.5. Synthesis

Empirical investigations of the cost of correlated natural disaster show that economies of all stages of development can incur negative macro economic growth effects, particularly as the degree of uninsured losses increase. The impact of natural disasters appear to fall most heavily on poor countries and poor households who are unable to make sufficient investments in risk mitigation and are who are often financially ill-equipped to manage in the aftermath. Without the means to adequately cope and rapidly recover, vulnerable households are at risk of chronic poverty and for that poverty to be transmitted into the future through deficiencies in human capital formation.

Similarly, credit market performance is significantly affected through the exposure of a lender's clients to natural disasters. Damage to lenders from a natural disaster results in the rationing of lending services precisely at the moment when credit access is most critical for household coping and business recovery. Furthermore, natural disaster risk exposure can impede broader financial development and access. These failures in the provision of financial services can only be a drag on development progress.

In reviewing the experience of micro finance lenders in Indonesia, their experience is largely consistent with that described in the literature. Institutional survival is clearly a priority of all these small, proximity-based financial institutions. Their inability to diversify spatially or across different lines of business puts them at high exposure to earthquake risk. Their aversion to institutional failure is clearly demonstrated in remarkably high self-imposed capital adequacy and liquidity rates. Loan non-performance rose in each of the case examples, sometimes dramatically, and remains higher years after the earthquake. These MFIs each employed different means to cope with the immediate financial strain of the disruption, ranging from temporary closure, suspension of lending, the calling in of additional capital from shareholders, and accessing funds from second tier lenders. Loan restructuring of at-risk clients imposed costs in all cases, and relationship-like banking behavior was observed through personal field visits by bank staff with distressed borrowers. Dramatic savings withdrawals were seen among institutions not having the benefit of deposit insurance, while savings increased among those having this client protection. In only one

instance did a financial institution attempt to respond to the needs of its clients with emergency lending services.

High liquidity and high capital adequacy as precautionary measures against future events clearly constrain the amount of funds available for lending. This behavior imposes an increasing opportunity cost that appears to be recognized by management of the interviewed micro finance lenders. Credit access for individuals and recapitalization of lenders appears to remove some of the constraints to disaster coping and recovery, and for broader financial access. This is also the logic behind the proposition of portfolio index insurance for lenders against earthquake risk. Financial management using *ex ante* insurance solutions can potentially reduce the cost of overall risk management, contribute to better access to finance of the working poor, and potentially add up to a measurable macroeconomic effect.

Chapter 5. Banking, Natural Disasters, and Risk Transfer

5.1. Introduction

This chapter adopts a parsimonious banking model to demonstrate the effects of using earthquake index insurance as part of a risk management strategy that is concerned with protecting bank capital to avoid insolvency while maximizing owner equity through investments in lending. A regulatory or management constraint is imposed on the amount of capital required to absorb an unexpected increase in credit default. The model is calibrated on a sample of Indonesian BPRs (People's Credit Banks) from a region having significant earthquake risk and recent experience with an earthquake shock. This effort extends to earthquake hazards the work by Collier and Skees (2012) who investigate the use of an El Niño Index Insurance Product (ENIIP) to help protect Peruvian microfinance institutions operating in Northern Peru against widespread credit default following El Niño induced catastrophic rainfall and flooding. The ENIIP, however, differs from a hypothetical earthquake index insurance in that the ENIIP index is based on sea-surface temperatures that serve as a reliable predictor for later severe weather and hence is able to make payments in advance of the event.

The first part of this chapter reviews the impact of natural disaster risk on banking behavior with specific reference to a bank's capital base. Banking standards with respect to capital holdings are reviewed first from an international perspective via the Basel Accords followed by a brief review of the Indonesian regulatory environment. A banking model is next specified for scenarios where natural disaster risk is retained, and where it is partially hedged with insurance, in order to trace the resulting evolution of important financial variables relating to lending activity and financial access. Once calibrated, results of the simulations are provided followed by discussion.

5.2. Banking and Natural Disaster Risk

The focus here on the banking sector, and of microfinance in particular, is its role of credit provision to the real economy, and for the working poor in particular. One way this intermediation is accomplished is through consolidation and maturity transformation of many small deposits of short term maturity into fewer larger loans with a longer maturity (retail funding), although there are lending institutions that do not take retail deposits. Funds for lending are also commonly obtained from wholesale funding sources such as second-tier banks or even donor organizations in the case of many microfinance lenders. Finally, owner equity in the form of common stock and reserves, comprised mostly of retained earnings from profitable operation, contribute to the pool of bank funds. Common stock and reserves represent the lender's core capital.

While banks perform a variety of functions and often have numerous investments and sources of revenue, consider a stylized situation where the sole business activity is retail deposit taking and lending to the working poor for business investment, working capital, and consumption smoothing. The bank earns revenue from the interest rate spread between its sources of funds (retail and wholesale funds) and the loans it makes to businesses and individuals. These activities also expose banks to various risks, with liquidity and credit risk being dominant concerns (Berger 2010; Collier and Skees 2012).

Liquidity risk refers to the inability of a bank, or any other firm, to meet its current obligations without incurring unacceptably large losses. For a bank, these obligations are its liabilities including demand deposits of bank customers, debt service of its funding, and operational expenses. A bank run is likely the most recognizable example of “funding liquidity risk” where a bank is faced with the sudden withdrawal of its sources of funds. This can occur with short term wholesale funding as well retail deposits. A bank run is the result of a collective confidence problem. A natural disaster can result in a similar effect, however, through the need of many depositors to access their funds for coping and recovery efforts. At the same time, banks are faced with a drop in revenue should the lending portfolio begin to experience repayment difficulties. Without a ready source of contingency funding, banks are forced to sell assets to meet the liabilities. Here, the bank can be faced with “market liquidity risk” where it is unable to quickly sell assets or is unable to do so without large value discounts. Either type of liquidity risk can default a bank and close operations. Both types of liquidity risk are prevalent in developing country settings where markets are thin for the sale of assets, particularly unsecured loans, and where the sources of funds are generally more scarce. This is the logic of emergency liquidity funds, such as the Indonesian Liquidity Fund After a Disaster (ILFAD), which provide a rapid injection of funds into otherwise healthy banks facing an unusual stress event. Liquidity risk is typically managed through an appropriate mix of funding sources to ensure stability and by maintaining a buffer of liquid assets.

Credit risk refers to the losses a bank incurs when its borrowers fail to repay their loans in part or in full on schedule. The usual default rate on lending is incorporated into normal business activity primarily through higher interest rates, particularly for riskier unsecured loans. Lenders can face insolvency, however, when there are unexpected spikes in loan default and the bank is inadequately capitalized. Capitalization here refers to the bank’s core or Tier 1 capital that is used first to directly offset asset losses while the bank is operational. Total bank capital includes Tier 2 capital used to satisfy obligations following a bank failure. The relationship between assets and capital is shown in the balance sheet accounting framework. In this adaption from Farag, Harland, and Nixon (2013), it is useful to view the bank’s assets (loans, cash and easily converted instruments) as the use of funds while capital and liabilities (retail and wholesale obligations) as the source of funds (Figure

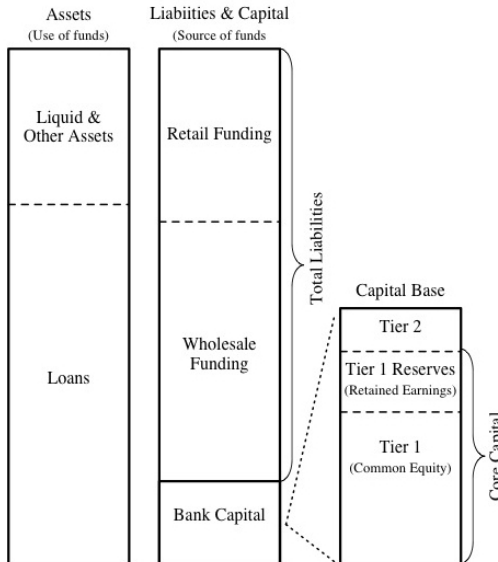


Figure 5.1: Bank Balance Sheet Representation.

5.1). Changes on either side of the balance sheet must be reflected by a corresponding change on the other.

The extent to which a lender is vulnerable to credit risk can be measured by the leverage ratio, the ratio of a lender's assets to its capital base. The smaller the ratio the less prepared is the bank to manage unexpected losses. A common variation of the leverage ratio is the risk-weighted capital adequacy ratio (CAR), which weights assets according to their quality, or likelihood of default. A mix of safer with riskier assets has the effect of increasing the CAR for the same level of capital under the risk-based approach to asset valuation.

Correlated natural disasters, such as earthquakes, are one such source of unexpected losses in assets that can rapidly deplete a lender's capital, particularly if it's lending portfolio is geographically concentrated and poorly diversified across different sectors of the economy. When a lender recognizes there is some likelihood of a loan not being fully repaid, it is considered impaired and provisions provided for the loss or deteriorated value of the asset (Krueger 2002). Impairment provisions are concurrently recorded as an expense on the income statement and on the balance sheet as a reduction in both assets and capital. When lenders are highly leveraged, these loan losses can quickly erode bank capital and constrain the lender's ability to support additional, or even the same level, of lending activity.

Lenders will seek to maintain a particular ratio of capital to assets based on regulation and ongoing internal assessment of institutional risk. Following losses, if a lender wishes to recover or increase its capital ratio it can chose to recapitalize and/or deleverage. Specifically (Roger and Vlček 2011):

- **Recapitalize**
 - Issue new equity.

- Increase retained earnings by reducing dividend payments, increase lending margins, or increase operational efficiency.

- **Deleverage**

- Reducing the size of the loan portfolio and originating fewer loans.
- Reduce risk-weighted assets by changing the composition of the portfolio in favor of less risky assets.

Banks may be reluctant to issue new equity shares since doing so dilutes the value to current shareholders. However, outside equity investments may not even be a viable alternative for many small lending institutions in developing countries, particularly while under duress (Meehan 2005). Additional capital may also be raised from existing equity owners, as was shown to occasionally occur in Indonesia following severe earthquake events, but this cannot be assumed to be reliable or prudent risk management generally.

Recapitalizing via retained earnings can also be difficult following a natural disaster that has precipitated in widespread repayment problems among clients. In addition to loan impairments charged as an expense, lenders will experience a decline in interest revenue as well as higher administrative costs associated with loan restructuring. Each of these reduce net income and hence the level of possible retained earnings. In Indonesia, many of the lenders surveyed had suspended dividend payments and some lowered the interest rate on retail deposits. If efforts to recapitalize are insufficient to recover the capital base, lenders may also choose to deleverage. Since in most developing economies, secondary markets for assets sales is likely to be thin for small business investment, working capital and consumption loans, the primary avenue to deleverage is through a reduction or temporary suspension of new loan origination (Collier, Miranda, and Skees 2013).

Unfortunately, deleveraging by distressed lenders comes at the precise moment when the affected community most needs robust or even expanding financial services to assist victims cope and recover, mechanisms shown earlier that help reduce the economic consequences of natural disasters (Zander 2009). These missed opportunities can represent a considerable opportunity cost for lenders.

Credit rationing may also involve spatial shifts in the portfolio, away from areas thought to be particularly vulnerable, including the working poor they contain, in order to reduce the probability of loss. For instance, some BPRs interviewed said they were more likely to lend in areas thought to be less vulnerable based on some knowledge of soil conditions, knowing that softer soils often results in more severe ground shaking from an earthquake. Those lenders who have limited ability to diversify their portfolio or avoid areas at higher risk to correlated disaster events are forced to maintain higher precautionary capital buffers.

However, maintaining high capital ratios also implies an opportunity cost, since less lending is supported by existing equity in order to cushion against infrequent but severe natural disaster. Here is where index insurance can potentially serve a valuable role, by

providing an equity injection specifically in response to a systemic event. The insurance conveys value by providing resources quickly during of crises but also enables the lender to maintain a lower leverage ratio, thus freeing equity to support additional lending and growth outside of crises periods. These outcomes will be demonstrated in the subsequent banking model.

Liquidity, credit, and other risks facing the lender should be systematically managed together since certain aspects are interrelated and complementary (Berger 2010; Roger and Vlček 2011). For example, increasing the share of safe and easily sold assets in a portfolio for liquidity risk will improve the risk-weighted capital ratio as well. The focus here, however, is solely on credit risk, the effects of correlated disaster events on bank capital and credit availability, and how index insurance can be used against this portfolio vulnerability. Bank capital preservation and growth is critical to lending expansion since a bank's sources of funds require capital to absorb potential losses (Meehan 2005). Many factors can influence how much capital must be held to support leveraged debt. For example, regulated financial institutions are prudentially required to meet minimum capital requirements to start or continue operating. A bank's own risk management decisions, requirements by wholesale sources of funds, and expert advice may result in fairly high targeted capital ratios.

5.3. Bank Capital Standards

Recommended standards for international banking regulation and supervision are largely contained in the Basel Accords, issued by the Basel Committee on Banking Supervision (BCBS). The BCBS is comprised of banking supervisory authorities of the major economies and seeks to facilitate cooperation and stability of the international banking system. While the recommendations of the BCBS are targeted primarily to large banks that operate internationally and intended to create a uniform regulatory environment, the standards have increasingly found adoption in domestic banking supervision, including Indonesia (Tonveronachi 2007).

The Accords (Basel I, II, and III) established recommendations for risk-based CARs—the minimum acceptable relative level of capital that a bank should hold to absorb losses of assets due to credit, market and operational risk. Capital is categorized according to its ability to absorb losses. Tier I capital, or core capital, is comprised primarily of owner equity (common stock) and reserves, mostly comprised of retained earnings. Tier 2 capital includes other reserves, general provisions, and debt that has limited claim against a bank's assets (subordinate or junior debt), but which are used to pay claims against the bank after it has gone insolvent, whereas Tier 1 capital off-sets losses while the bank is operational. Together these comprise the bank's capital base. The Accords also specify how assets the bank holds should be evaluated for computing the value of risk-weighted assets.

The following summarizes the Accords with respect to minimum capital requirements:

- **Basel I (1988)**

- CAR: Tier I capital of 4%, total capital of 8%.
- Menu of fixed risk weights of bank assets.

- **Basel II (2004)**

- CAR: Tier I capital of 4%, total capital of 8%
- A combination of fixed and variable risk weights determined using external credit ratings. Also allows sophisticated banks to use an internal ratings-based (IRB) approach to evaluate asset risk.

- **Basel III (2010)**

- CAR: Tier 1 capital of 6%, and total capital of 10.5%.
- Asset evaluation largely similar to Basel II.
- Additional capital buffers of up to 5% of risk weighted assets by 2015.
- Minimum leverage ratio (Tier 1 / total unweighted assets) of 3%.

Implementation of the Basel Accords is gradual and can vary widely among jurisdictions in terms of timing and additional requirements. The Accords, however, do not strictly supersede each other so banks in the same jurisdiction can operate under different Basel standards, the difference being related to bank size and importance in the economy. The Accords are minimum recommendations and many regulators impose higher capital requirements in a variety of circumstances.

Many banks routinely seek to maintain capital ratios higher than regulatory obligations. Additional capital may be held for future investment opportunities, for branch network expansion, to lower its overall risk rating, and in reaction to risk aversion among stock holders and boards of directors. The last incentive is important since banking institutions that fall below the minimum capital requirements can face punitive measures from the banking supervisor, including restrictions on the business it can conduct, replacement of bank management, and, in extreme cases when a bank's capital position does not improve, revocation of its banking license.

Recent trends in global aggregate bank capital ratios are examined by Cartas and Cervantes (2011) and shown in Figure 5.2. Regionally, most capital ratios have remained steady between 12–18 percent, with decline experienced among those where capital adequacy was already high. Following the global financial crises of 2008, capital ratios rose notably and have, generally, remained higher. For reference, among a number of Indonesia's largest banks, capital adequacy was reported to be 13.9 percent in 2012 and 14.6 percent in the first half of 2013 (Suryodiningrat 2013). What is noteworthy is that it was among the advanced economies where rising capital ratios came about through deleveraging, using a

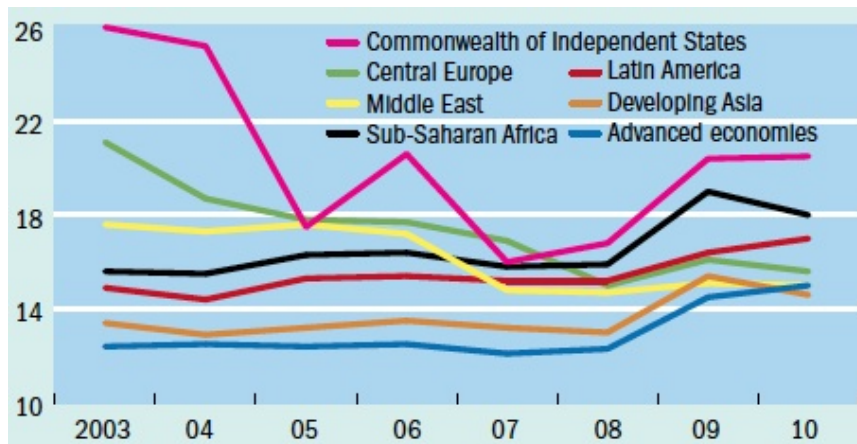


Figure 5.2: Regional Bank Capital Ratios, 2003–2010 (Cartas and Cervantes 2011).

combination of tighter credit access and a shift in portfolio composition toward less risky assets.

While it is anticipated that the largest banks will graduate to Basel III, many smaller local and regional banks will continue to operate under Basel I or II guidelines, partly due to the complexity of implementation (Tonveronachi 2007). However, in developing countries, some argue that the minimum CAR of MFIs and other proximity based lenders serving the working poor and small business should be higher, at least 12 percent, to account for a potentially higher variation in problem loans, higher operating expenses, potential for political instability, and where quick access to funds for recapitalization is less available (Berger 2010; Meehan 2005). An expert analysis of rural banks (BPRs) in the aftermath of the 2009 Padang earthquake further suggested CARs of 20 percent to be prudent for protection from similar events (Hiemann 2009). Abusharba et al. (2013) also recommend higher CARs for Islamic banking institutions in Indonesia due to the nature of profit sharing and because many bank assets are uncollateralized.

5.3.1. Indonesian Regulatory Authority and Standards

The formal Indonesian banking system falls under the purview of the 1992 Banking Act and 1998 amendments. The act regulates two kinds of banks: Bank Umum (commercial banks, both conventional and Islamic) and Bank Perkreditan Rakyat (BPRs). Commercial banks have access to the payment system and offer a full range of financial products, including general banking services and foreign exchange services. BPRs offer basic products which include loans, savings, and term deposits but not checking accounts.

The recently established Financial Services Supervisory Authority (“Otoritas Jasa Keuangan”, OJK) will integrate the regulation and supervision of banks, financial markets, insurance, pension funds and other financial services into a single institution. The OJK is

modeled on the United Kingdom's Financial Services Authority and will assume the functions previously held by Bank Indonesia (BI), the Ministry of Finance, the Capital Market and Financial Institutions Supervisory Agency, and Indonesia Deposit Insurance. The transition is scheduled for completion by the end of 2014. Banking supervision has already been transferred to the OJK, whereas BI, as the country's central bank, remains responsible for monetary policy and banking system development.

The Basel II recommendations have been fully adopted in Indonesia since December 2012 (Bank Indonesia 2013). However, commercial banks are subject to higher minimum capital requirements of between 8 and 14 percent based on an internal capital adequacy assessment process. For BPRs, the banking institution of interest, the minimum CAR is 8 percent of risk weighted assets. Bank Indonesia also stipulates the minimum absolute capital required to establish a new BPR or open a branch office, which is higher in the capital city and in certain regions than in others. BPRs can enter special supervision status ("DPK Rural Bank") if it encounters capital or liquidity problems that fall below minimum standards. Special supervision can be imposed if either the bank's capital adequacy falls below 4 percent or if its average cash ratio, the ratio of cash and cash equivalents to current liabilities, is less than 3 percent for six consecutive months. If DPK status has been determined, the supervisor may compel the bank and its shareholders to (Bank Indonesia 2013):

- Recapitalize;
- Write off impaired loans;
- Replace the bank's board of directors;
- Transfer bank management to a third parties;
- Freeze business activities as determined by the supervisor;
- Merge its operations with another bank;
- Sell a portion of the bank's assets and/or liabilities;
- Sell the bank in its entirety.

During special supervision status a bank may not distribute capital (dividends) or repay subordinate debt (Tier 2 capital), and is subject to asset growth limitations. A moratorium on funds collection and disbursement is further imposed on banks having a capital adequacy of 0 percent or less, or a six month average cash ratio of 1 percent or less. Special supervision can last as long as 6 months with one possibility for extension if supervisory conditions have been met. Non-compliance results in the bank's operating license being revoked.

Capital capital requirements and other regulation explicitly constrain BPRs to proximity banking. In this instance, the bank can only open a branch office in the same province at the head office and must have a CAR of no less than 10 percent for three consecutive months.

Bank Indonesia affords BPRs special consideration during times of natural disaster that have an impact on capital ratios and loan non-performance reporting (Bank Indonesia 2013). The directives were first executed immediately following the 2006 Yogyakarta earthquake of 2006 and soon after extended to the entire country. The special treatment allows BPRs to reschedule loans in affected areas that are impaired as a result of the impact of earthquake or other natural disaster for up to three years after the event. Under the provisions, restructured loans do not require impairment provisions which helps boost capital ratios higher than it might have been otherwise, as well as lowering the incidence of non-performing loans.

The eligibility conditions for loan restructuring is broadly defined and opens an avenue for excessive restructuring of loans impaired for reasons other than earthquake impact (Zander 2009). Opportunistic behavior on the part of at-risk borrowers was also mentioned as a concern among some of the rural bank managers interviewed in Padang and Yogyakarta, documented in the previous chapter. Hence, it is possible for both a bank's reported capital ratio and non-performing loan ratio to show no change or even improve following a natural disaster, potentially making it difficult to isolate the actual consequences of the event on a bank's lending portfolio.

5.3.2. Limitations of Capital Standards

The purpose of the Basel Accords minimum and supplemental capital adequacy standards are to improve the resiliency of individual banks to credit and operational risk, and consequently enhance the ability of the banking sector to weather systemic financial crisis—the so-called “microeconomic approach” to prudential regulation (Tonveronachi 2007). The Accords are also meant to provide a uniform regulatory environment for internationally active banks. The desirability of the recommendations are not universally shared, however, particularly with respect to their potential impact on banking systems and credit access in emerging and developing economies, many of whom have or are planning to adopt the standards. The following is not meant to be an exhaustive or even partial exploration of the literature in this area, but to note a number of themes and concerns of potential unintentional negative consequences, primarily of Basel I and II, that could stymie growth of financial inclusion or even increase the vulnerability of domestic banks in developing countries.

Several concerns stem from the methods used to determine weights in the risk weighted assessment of assets in the denominator of the capital ratio (Chiuri, Ferri, and Majnoni 2001; Cleassens, Underhill, and Zhang 2008; Diamond and Rajan 2000; Keefe 2005; Rojas-Suarez 2003; Tonveronachi 2007). In particular, Basel II methods increases the capital requirements on loans to borrowers with lower credit rating scores, a group that tends to be dominated by developing countries and their banks and firms. This creates a subtle bias against lending to these countries as international banks attempt to economize on bank

capital by lending more heavily in higher rated developing countries, which confers a 50 percent lower capital charge. Lower rated and unrated firms and banks even in developed countries face a similar bias. The higher relative capital cost may hence lower international flows of funds to these lesser developed countries and raise their borrowing costs. Similarly, even under the more risk sensitive IRB approach afforded under Basel II, the benefits of portfolio diversification across wealthy and poor economies, and across risky and less risky regions, are not fully appreciated since individual assets, and less so portfolio composition, is attached to the capital requirements. Once again, a bias away from lending to developing and emerging economies is introduced. Domestically, the Basel bias in combination with the costs associated with expansion can lead banks toward geographic portfolio concentration, leaving them more exposed to correlated natural disaster risk that spatial diversification would help limit (Collier and Skees 2013). Finally, the more risk sensitive IRB approach to asset weights could have the effect of increasing pro-cyclical international capital movements, compounding the funding difficulties of developing countries already faced with higher volatility.

Complexity and implementation costs of Basel II are also noted as frictions that put smaller banks, particularly those in developing countries, at a competitive disadvantage compared to foreign banks operating in the same market. Further, it is unlikely that the smaller banks will in the foreseeable future be able to take advantage of advanced IRB methods that potentially lower their capital requirements. To the extent that these smaller banks disproportionately serve the borrowing needs of small business and the working poor, the growth in financial access and lender profitability may be less than it could be otherwise.

A third area of concern is the weakness of financial market and regulatory institutions such that the “preconditions” on which the Basel Accords are framed are not met in many emerging and developing economies. Overemphasizing Basel recommendations on capital may very well be insufficient in conferring the desired banking sector stability in many developing countries and contribute to a myopic sense of security among regulators and less sophisticated banking institutions. Frictions increase, lending margins widen, and banking profitability falls when regulators attempt to further strengthen a system’s stability through even higher minimum standards, not only for capital but also for liquidity and other reserves (Chiuri, Ferri, and Majnoni 2001; Keefe 2005; Tonveronachi 2007). Moreover, among concerns for credit and operational risk, capitalization is best complemented with portfolio diversification and risk transfer, two risk management strategies largely excluded in the Basel recommendations for all but the most sophisticated banks using advanced IRB methods (Collier, Miranda, and Skees 2013). However, even the IRB methods exclude exceptional losses from capital requirements, such as those that might be encountered through a natural disaster, suggesting that even the Accords recognize that capitalization alone is an inefficient hedge against extreme events (Diamond and Rajan 2000). In many developing countries there is, however, little in the way of formal risk transfer solutions for systemic

risk, so that high capitalization, either through regulation or an internal precautionary stance, is one of the few tools available to small banks.

5.4. Model

The primary attribute of the model is the consideration of capital adequacy requirements in the presence of an insurance mechanism to help protect the bank from capital depletion. In the mix of risk management options available to banks, diversification is ignored insofar as proximity based BPRs are unable to significantly diversify spatially, a direct consequence of Indonesian banking regulation for rural banks. In Indonesia, proximity based lenders have witnessed how earthquake events and other natural disaster risk exposures can easily threaten the survival of the institution, and consequently hold capital in excess of the minimum recommendations, even if doing so offers only a partial hedge. An index based earthquake insurance that injects capital immediately following a severe event that precipitates borrower default should allow a lender to hold a lower precautionary capital buffer. Not only will the insurance enable the lender to sustain the immediate impact of the earthquake, the release of tied-up capital, and subsequent lower frictions, should result in expanded levels of financial inclusion over time. The following banking model is designed to demonstrate just how such a risk transfer solution might accomplish this goal.

The banking model closely follows the efforts of Collier, Miranda, and Skees (2013), similar to the work of Van den Heuvel (2006) and Roger and Vlček (2011). This model is one where the bank maximizes capital (equity) growth through lending activity, where the targeted capital ratio acts as a constraint to the realized level of lending. The focus on bank capital growth and capital adequacy is narrow, but it is this element that ultimately allows for expansion of lending and greater financial inclusion. The model simulates the impact of an earthquake event on the lender's financial performance, and then demonstrates how this outcome alters when a risk transfer instrument is available to mitigate the impact.

The model is multi-period but naive. Optimization occurs in each period using the inputs from the previous but is not forward looking. The model is also deterministic. The simulated earthquake event occurs with known probability and impact. While parsimonious, the model achieves the goal of tracking the evolution of key financial variables under several well defined scenarios: lender financial performance with and without a natural disaster, and with and without risk transfer.

5.4.1. Model Specification without Risk Transfer

A representative proximity lender maximizes its capital growth from retained earnings exclusively through profitable lending each period. It faces two states of the world, $s = (g, b)$, good and bad, where the bad state indicates a severe earthquake event. It holds an initial stock of equity and earns a net return, (r) , on lending (L) . Net return represents the margin

between the retail lending rate and wholesale cost of funds, less operational costs. The implication of fixed net returns is that the lender is unable to adjust profitability through the lending spread, nor through improvements in operational efficiency, two avenues normally available to aid in recapitalization. It also assumes that wholesale funding is unlimited and available at constant rates. Lender income in the good state is simply the product of the lending level and net returns. In a bad state, when an earthquake occurs, the lender loses a portion of its loan portfolio, (x) , suppressing income. The value of x is the level of impaired loans that are a consequence of the bad state, those losses which are in addition to the usual level of loan non-performance. Lender income, (Y^s) , in the two states can be written as:

$$Y^g = rL \quad (5.1)$$

$$Y^b = (r - x)L \quad (5.2)$$

Income less dividends, the lender's retained earnings, comprise the next period's stock of equity. The lender pays dividends at rate (v) to shareholders based on equity shares in good states of the world. Dividends are not paid during bad states in order to more quickly recapitalize following earthquake induced losses. Income and dividends define the evolution of capital, (K) for the subsequent $(t + 1)$ period, and can be written as follows for good and bad states:

$$K_{t+1} = \begin{cases} K + (1 - v)Y^g \\ K + Y^b \end{cases} \quad (5.3)$$

The lender's ability to absorb portfolio losses through loan impairment is dependent on its capital stock and monitored both by management, shareholders, and the banking regulator via the capital ratio. Here the assumption is that capital is exclusively core capital (equity and retained earnings), and that the lender's assets (loans to the working poor and small business) all carry a risk weight of 100 percent in line with the Basel II recommendations. In this scenario the capital ratio reduces to the leverage ratio. The capital ratio is measured as follows for good and bad states of the world:

$$c^g = \frac{K + (1 - v)Y^g}{L} \quad (5.4)$$

$$c^b = \frac{K + Y^b}{(1 - x)L} \quad (5.5)$$

The capital ratio includes the changes corresponding to the lender's financial position for good and bad states. In good periods, the ratio is the existing capital plus retained earnings over the loan portfolio. In bad states, the numerator of the ratio is the existing capital plus income which could include negative income, whereas dividends are not paid.

The denominator is the loan portfolio less the provisioning on exceptional losses, xL , that directly reduce the capital base.

As described previously, the lender is obliged by regulation to sustain a minimum capitalization and frequently holds additional capital as a precautionary buffer against unforeseen portfolio losses. The Basel II recommendation is that a capital adequacy ratio (γ) of 8 percent of risk weighted assets be maintained. The lender, its shareholders, and its board of directors will want to avoid falling below this level in order to avoid the intervention of the banking supervisor. The lender may in fact choose a higher target capital ratio, (c_γ), as a precautionary measure and/or to satisfy additional capital buffer requirements. At the margin, this constraint implies a cost of $1/\gamma$ of lost leverage.

For any precautionary capital to be held above the minimum requirement, the bank must also face constraints in issuing new equity, which would otherwise expand to meet any new profitable lending opportunity. Banks do not normally finance assets solely with equity capital as issuance is not cost free and because there are tax advantages to holding debt capital (Van den Heuvel 2006). Since new equity can be considered payments from new or existing shareholders to the bank, the prohibition against new equity issue can be imposed through the financial constraint that dividends must be non-negative in all states:

$$vY^s \geq 0 \tag{5.6}$$

To model the lender's aversion to falling below the capital target, a quadratic penalty condition is imposed on the realized capital ratio for good and bad states of the world (Van den Heuvel 2006):

$$H^s = \alpha \max(0, c_\gamma - c^s)^2 L \tag{5.7}$$

When the the capital ratio in either state falls below the desired target ratio, an increasingly harsh penalty, (H^s), is imposed on the objective function of the lender's maximization problem. It is scaled by the size of the loan portfolio to afford comparability across different sized lenders and different portfolio sizes. An alternate specification of the penalty condition could take the form $G^s(L) \equiv \alpha(c_\gamma - c^s)^2 L$, which discourages over capitalization to the same extent as under capitalization (Roger and Vlček 2011). In the current formulation, however, incentives are already aligned to keep the capital ratio as close to the target level as possible, given the penalty of falling below the target. The parameter α can be interpreted as a risk aversion scalar used to calibrate the model to the risk preferences of the institutions' management.

The previous equations are sufficient to define a lender's optimization problem that maximizes income each quarter, and equity growth by extension, by choosing the optimal level of loan origination, subject to its aversion to low capital ratios as conveyed through the penalty function. The optimization takes place over the good and bad states, where

the probability of a bad state, of an earthquake event, is given by θ . The optimization is written:

$$\max_{L \geq 0} (1 - \theta)(Y^g(1 - v) - H^g) + \theta(Y^b - H^b) \quad (5.8)$$

5.4.2. Model Specification with Risk Transfer

The possibility of purchasing a risk transfer hedge such as insurance is introduced. The insurance can be purchased in the amounts of Q , the sum insured, at a premium rate p . During good states, the lender's income is reduced by the amount of the insurance purchase. During bad states, income is also reduced by the amount of insurance purchase but receives an insurance payment of rate w on the sum insured. Equations (5.1) and (5.2) are rewritten as:

$$Y^g = rL - pQ \quad (5.9)$$

$$Y^b = (r - x)L + (w - p)Q \quad (5.10)$$

One incentive for the risk transfer is the possibility that shareholders could still receive dividend payments since the disruption to the bank and erosion of the capital base is mitigated through the insurance payment. Since income in the disaster period may still be negative, dividends are instead paid on the basis of the previous non-disaster period. Equation 5.3 for the evolution of capital and equations 5.4 and 5.5 for computation of the capital ratio are adjusted to reflect this treatment:

$$K_{t+1} = \begin{cases} K + (1 - v)Y^g \\ K + Y^b - vY_{t-1}^g \end{cases} \quad (5.11)$$

$$c^g = \frac{K + (1 - v)Y^g}{L} \quad (5.12)$$

$$c^b = \frac{K + Y^b - vY_{t-1}^g}{(1 - x)L} \quad (5.13)$$

The optimization problem now extends over choices of lending levels and the amount of the portfolio to insure:

$$\max_{L \geq 0, Q \geq 0} (1 - \theta)(Y^g(1 - v) - H^g) + \theta(Y^b - H^b) \quad (5.14)$$

5.4.3. Model Calibration

Model calibration is made from a selection of 24 BPRs operating in the vicinity of the September 2009 Padang earthquake, from the rapid risk assessment made in the same area, and secondary sources such as that of Hiemann (2009). Quarterly balance sheet and income statement data of these lenders were obtained from Bank Indonesia for the period 2007 through 2010.

Financial performance indicators were calculated from this data using the average values over this period. Table 5.1 describes the key parameter values, reported on an annual basis, although the model is calibrated for a quarterly time period.

Table 5.1: Calibrated Model Parameters, Annual Values.

| Parameter | Symbol | Value |
|------------------------------------|------------|-------|
| Return to lending | r | 5.9% |
| Assets held in loans | β | 70% |
| Dividend rate | v | 25% |
| Target capital ratio | c_γ | 20% |
| Disaster probability | θ | .02 |
| Expected payout rate | w | 60% |
| Expected increase in problem loans | x | 7% |
| Initial capital | k | 100 |

Return on lending is approximated by the lender’s return on assets (ROA), obtainable from financial records. Doing so may somewhat underestimate the true value of the return on lending since banks typically hold some amount of additional assets such as real property, cash, and securities whose average return is assumed to be lower, i.e., less risky. An approximation to the true return on lending can be made by dividing the ROA by the proportion of lender assets held in loans (ROA/β). This approach for estimating return on lending should be used only when the preponderance of the the institution’s assets are held in loans and when the return on other assets is known to be less than the return to lending.

Dividend policy among BPRs appears to be diverse and heavily dependent on current needs of the institution. It is not unusual for dividends to be as high as 30 percent of profits, and sometimes with additional disbursement to the BPR’s staff of up to 20 percent when the institution is performing well. Dividend calculations from the BPR sample data range from 23–33 percent. For the modeling scenarios, a 25 percent dividend rate is adopted.

The plot of capital ratios shown in Figure 5.3 confirms the observation from Hiemann (2009) that BPRs in Padang have typically attempted to maintain capital in excess of the regulatory minimum, usually in excess of 15 percent. These data demonstrate a small decline in the average capital ratio over the four year period but also a noticeable reduction in variance, suggesting that many BPRs are expanding lending and reducing their ratios from sometimes high levels. The effect of earthquake induced loan non-performance, including

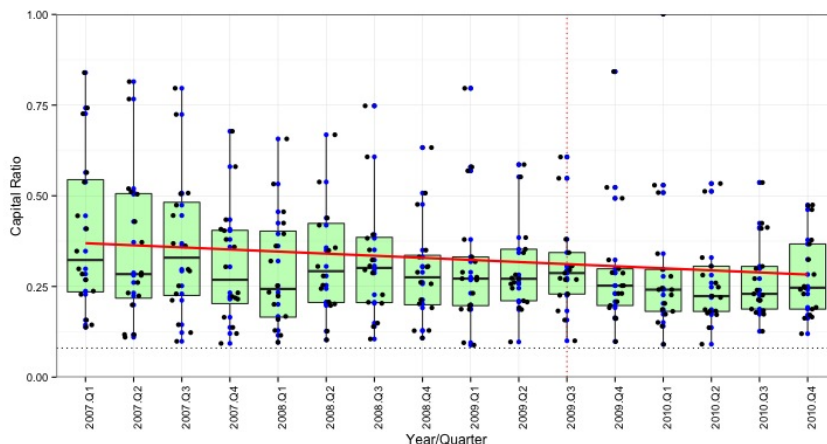


Figure 5.3: Sample BPR Capital Ratios, Padang, 2007–2010.

missed payments and restructuring or rescheduling, can take several months to be realized on capital ratios. Typically the portfolio at risk is reported on a 90 day basis (PAR90) and impairment provisions made at that time. Earthquake effects would first manifest in the first quarter of 2010. Capital ratios do exhibit a small average decline in the first and second quarter of 2010 before climbing again. However, special treatment of non-performing loans afforded by Bank Indonesia are very likely obscuring potentially stronger outcomes. For the model calibration, a capital ratio of 20 percent is chosen, treated here as the target ratio, c_γ , that management attempts to maintain.

Annual earthquake probability is fixed at 0.02, a 1-in-50 year event where the magnitude exceeds levels that typically cause little damage. Earthquake magnitudes are measured on a logarithmic scale implying exponentially increasing severity. So too should the payout rate to approximate expected lender disruptions. In these scenarios, an expected payout of 60 percent is assumed for a moderately severe earthquake. The increase in problem loans of course depends on the actual realization of ground motion experienced by the bank's clients and can vary widely between institutions experiencing the same earthquake event. Using feedback from the earlier rapid risk assessment, the increase in problem loans is set at 7 percent. The negative impact of the disaster event is assumed to be contained entirely in the period in which it occurs. In practice, the impact may occur over time as struggling borrowers eventually default or because lenders are able to push the consequences into the future via the regulatory exemption referenced above. The stylized model is meant to highlight the effects of the disaster and interaction with the insurance hedge as cleanly as possible through the assumption that lenders do not have redress to exemption and that borrowers default immediately.

The insurance premium rate, p , is calculated in the model as the expected frequency of the disaster, θ , with a reinsurance load multiple of two to give 4 percent. Finally, the

scalar α on the penalty condition increases the sensitivity of the lender to falling below the targeted ratio. This could be interpreted loosely as a risk sensitivity parameter, where higher values imply greater risk aversion. The parameter is not empirically estimated, but chosen to provide noticeable change in lender behavior which would be the intent of investor oversight and/or regulatory intervention.

5.4.4. Solution Technique

The solution technique identifies the level of loan origination that results in the greatest value of the objective function, recursively for each period. With the addition of insurance, it identifies the level of loan origination across all possible combinations of sum insured in determining the maximum value of the objective function. Once the maximum is identified, the value of beginning equity for the next period is calculated, after which the optimization is repeated for the subsequent period. Repeated over several time periods, the optimization traces the lender’s growth path of capital, lending volume, and income.

The binary max operation of the penalty condition (5.7) is not differentiable, but can be approximated by the continues function:

$$H^s \approx \alpha \left[\frac{1}{1 + \exp(-\vartheta(c_\gamma - c^s))} \right] (c_\gamma - c^s)^2 L, \quad (5.15)$$

where ϑ is arbitrarily large. The bracketed expression drives to zero for any realization of the capital ratio greater or equal to the target level, thus imposing no penalty. When the realized capital ratio exceeds the target, the expression quickly converges to unity, imposing the penalty at the level determined by the second half of the expression.

With this modification, the model can be solved analytically. A problem of constrained optimization would ordinarily suggest a Kuhn-Tucker Lagrangian approach, however, the constraints in the model, embodied in the penalty condition, are not Lagrangian constraints but rather limitations on the region in the domain of a surface over which to find the maximum. The Lagrangian technique does not apply because the constraints do not define a curve on the surface of which to derive the maximum.

Alternatively, the maximization problem can be approached numerically, in this case using a Newton method technique that relies on the gradient of first partial derivatives and the Hessian matrix of second partial derivatives to iteratively find the maximum of a surface. The model is implemented using the open source R language and environment for statistical computing (R Core Team 2013), calling the optimization routine “nlminb”, (Gay 1990). Additionally, a web-based graphical users interface has been developed using the R package Shiny, which enables the R environment to be used in interactive web applications (RStudio 2013). The application enables an individual to adjust calibration parameters and run simulations based on their specific interests or circumstances.

5.5. Recursive Simulation Scenario Results

The modeling effort encompasses four scenarios for a lender described by the calibration values in Table 5.1. Two scenarios include optimization where the lender retains the earthquake risk and where the lender hedges the exposure with insurance, and two scenarios with and without an earthquake disaster occurrence. Optimization is conducted by quarters for five years. In scenarios with an earthquake, the disaster occurs in the fifth quarter, leaving fifteen quarters to observe the effects of having the insurance hedge and the new growth trajectories of key financial indicators over time.

A concern among many lenders interviewed during the rapid risk appraisals is that the cost of the insurance hedge, particularly without a disaster event that produces a payment, must be passed on to borrowers in the form of higher interest rates which will depress credit demand. The idea that insurance premium cost must be passed to bank clients is investigated in the first set of scenarios shown in Figure 5.4, which compares an insurance hedge against a lender retaining the risk, but in the absence of any disaster event. Panels (a–c) demonstrate that the growth path of equity, net income, and lending volume of the insured case surpasses that of the uninsured lender with this representative calibration. Panel (d) provides an explanation for this outcome by comparing the resulting capital ratios held in each case, showing that disaster risk exposure has consequences for lender operations. The uninsured lender maintains additional precautionary capital in order to reduce the chance of falling below the target should a disaster event occur. The additional capital buffer comes with an opportunity cost of less lending and consequently less income and equity growth, slowing the pace of financial inclusion in the face of natural disaster risk managed by capital reserves alone. The insured lender is able to maintain a capital ratio closer to the target since the insurance payment reduces the potential negative shock of asset destruction, thereby reducing the volatility of the capital ratio and likelihood of incurring a large penalty for falling below the target.

In this scenario, the full cost of the insurance hedge to protect the lending portfolio is incorporated as a bank expense and not passed to borrowers. Critically, the amount of insurance to purchase is not the full portfolio, as is sometimes assumed, but a fraction that reflects the anticipated impact, probability of occurrence, and harshness of the penalty imposed for dropping below the target capital ratio (Table 5.2). Here, the amount of insurance to purchase is nearly the same as the anticipated increase in problem loans given an event, at a premium rate of four percent. However, in terms of the overall expense to the portfolio in this scenario, the hedge cost is about one-third a percent, or 33.5 basis points. From an insurers point of view, the expected loss ratio is critical for assessing the sustainability of an insurance product. The loss ratio is calculated as the expected losses ($.02 * 0.6 = 0.012$) over the rate-on-line ($.02 * 2 = .04$) which is total premium payments over the payment limit. The resulting expected loss ratio of 30 percent for this scenario is well within the range of sustainability.

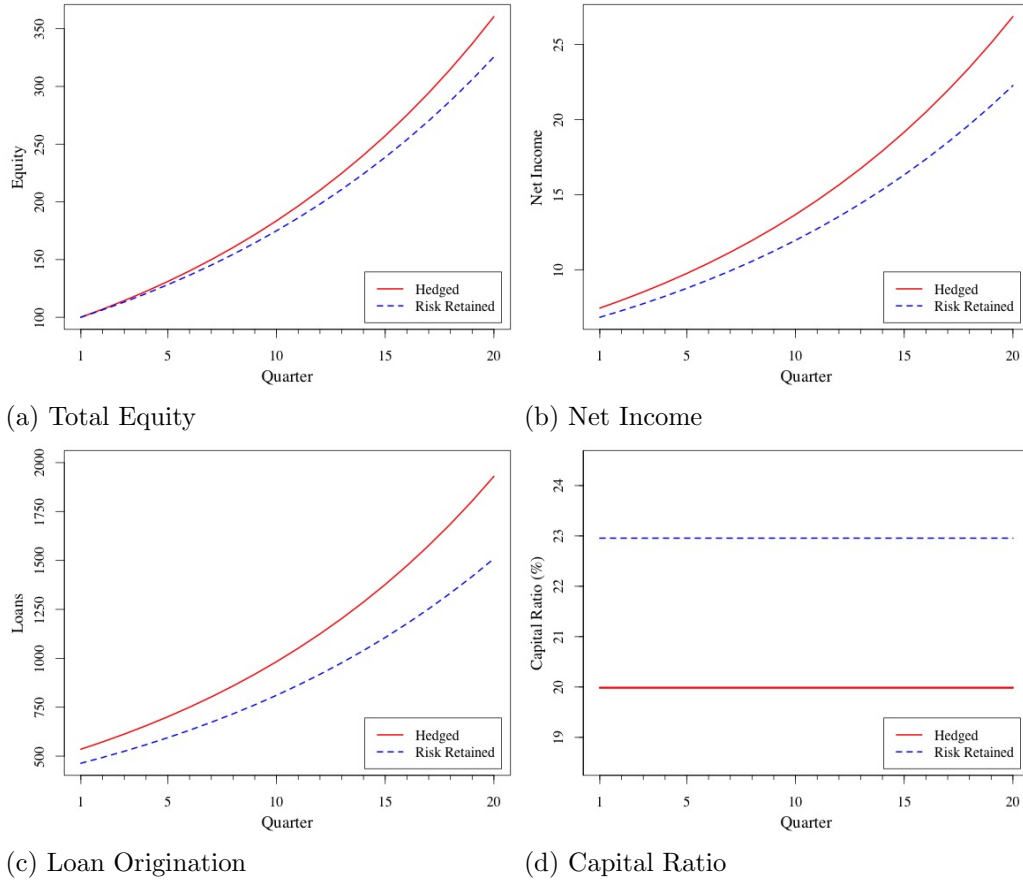


Figure 5.4: Scenario With No Disaster Event.

In many cases the lender should be able to reduce the level of precautionary capital held for earthquake disaster by incorporating an insurance hedge into its risk management activities. Even a modest reduction in precautionary capital can leverage enough additional lending to support the cost of the insurance and grow the equity base without increasing the lending margin to borrowers. This result is expected to be a compelling argument to lenders for the insurance hedge. This outcome for the calibrated case is of course an example and the results will vary with changes in the underlying parameters. For instance, the disaster probability, which directly determines the unit price of insurance, results in zero insurance being purchased for high frequency events, all else constant, due to the cost of the purchase exceeding its benefit. The lender simply holds a higher capital buffer. At very low disaster probabilities, the lender with insurance access will always make the purchase because the price is correspondingly lower. However, for the lender without access to insurance, the lower probability reduces the expected cost of a disaster event such that it no longer holds any precautionary capital above the target. While some of these parameter effects are explored in more detail below, these divergent outcomes demonstrate how even a relatively straightforward model can generate outcomes that may not be immediately apparent, and,

Table 5.2: Portfolio Hedge and Cost (Annual Values).

| | |
|--------------------------------------|-------|
| Notional hedged amount (%) | 8.40 |
| Premium rate (%) | 4.00 |
| Portfolio hedge cost in basis points | 33.50 |
| Expected loss ratio (%) | 30 |

because of this, a degree of caution taken in using the model to provide answers rather than guidance.

An earthquake disaster is imposed on the previous scenarios to again examine the resulting trajectory of important financial indicators of the lender and its level of intermediation (Figure 5.5). Impairment provisioning for disaster induced loan losses result in a reduction in both the lender’s assets and the capital base on the balance sheet. Because losses are absorbed one-for-one by capital, the lender’s capital ratio can quickly deteriorate below the desired target ratio or, in serious cases, below the regulatory minimum capital. Lower income and penalties reduce the ability for retained earnings to compensate for the capital losses. Panel (a) and (b) show how equity and income dramatically react for the lender who has retained the disaster risk. The lender responds by deleveraging, greatly reducing the value of its lending portfolio, shown in panel (c), until the target capital ratio is again restored, panel (d). While the lender eventually recovers, the scenario demonstrates how the availability of credit can be constrained following a disaster, precisely when it is most needed.

In contrast, the insured lender experiencing identical losses suffers much less disruption due to the payment which helps stabilize the capital base. Consequently, lender equity and income decline less, preserving the capital ratio and enabling the lender to recover and grow faster relative to its risk retained counterpart. Credit provision to the affected community is therefore much less rationed following an earthquake disaster event.

5.5.1. Sensitivity

While parsimonious, the model encompasses a considerable number of parameters that vary between lending institutions. It is worthwhile therefore to examine more closely a few that have implications for the some of the primary results obtained above. In addition, examining the optimization surface can provide insights to the behavior of the model as well as suggest some practical implications when considering the lender’s problem of an insurance hedge.

The optimization surface in Figure 5.6 shows the objective function values for combinations of lending and insurance and provides a visualization of the consequences of movements of the choice variables from the maximum. The circle point indicates the optimal lending volume when insurance is not available while the diamond point locates the maximum for combinations of lending and insurance. Connecting the two points locates the expansion path of insurance that allows for a reduction in the capital buffer and an expansion in lend-

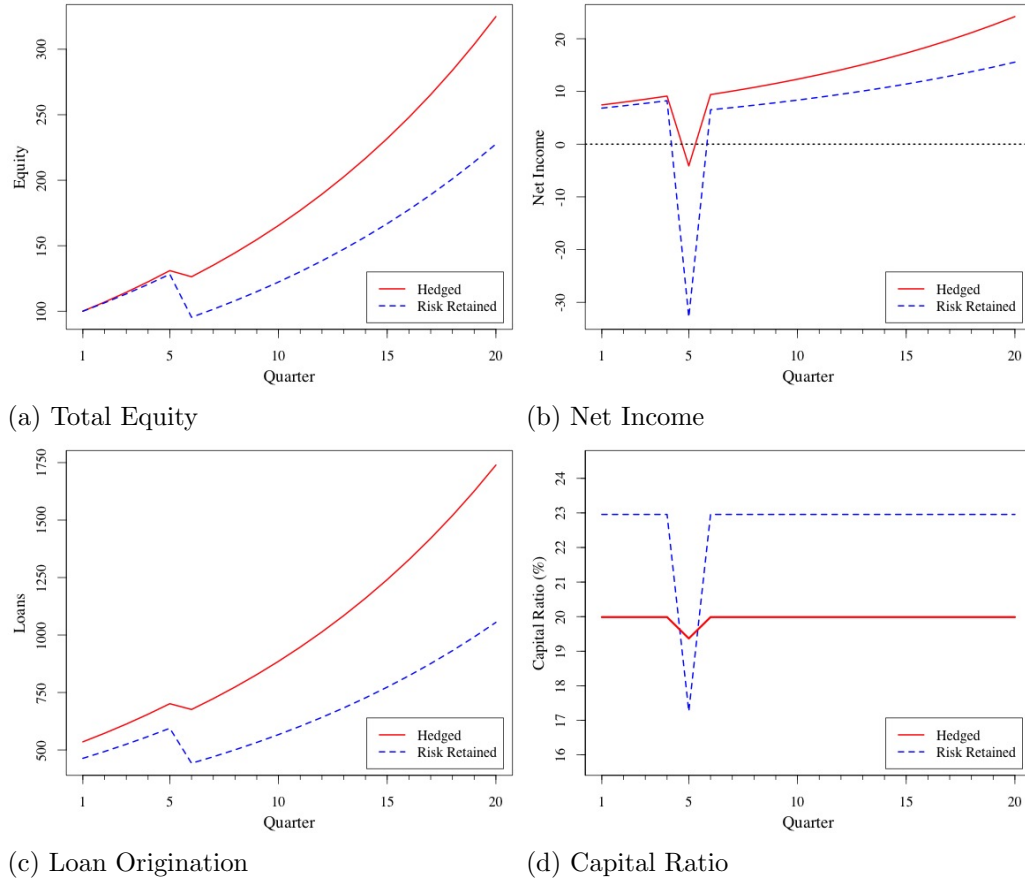


Figure 5.5: Scenario With Disaster Event.

ing. At a very practical level, this shows that the cost of not insuring at the optimal level is not of precipitous consequence, in terms of the objective value, for any level of lending. Very often potential users of insurance will focus on asking a model for an answer to “how much to insure”, without recognizing that the lender representation is indicative rather than exact. This figure shows clearly that the lender is better off purchasing an insurance hedge and expanding lending, but also that deviations from the modeled “optimal” level of sum insured is likely very tolerable in the more complex environment in which the lender operates. This idea can be seen from the gradual falling of the surface from the expansion path of the insurance purchase. On the other hand, in the direction of lending, the surface falls abruptly suggesting that over-lending has strongly negative consequences, in this case due to falling below the target capital ratio.

The model can also be used to demonstrate how the level of the targeted capital ratio influences the growth path of a lender over time, which has important implications for financial inclusion generally. Figure 5.7 shows how loan origination and lender equity changes with varying levels of the capital ratio target. At levels of capital holdings around the level recommended for BPRs in Padang, equity growth is low while loan origination is almost

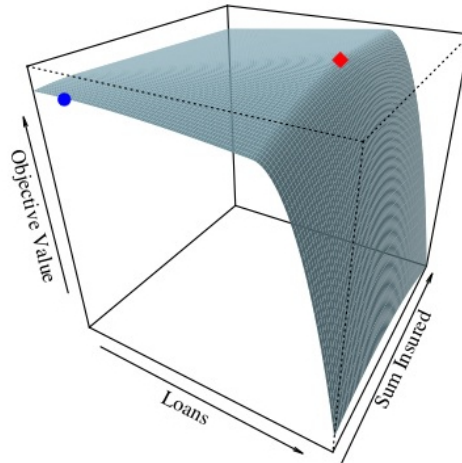


Figure 5.6: Optimization Surface with Lending and Insurance.

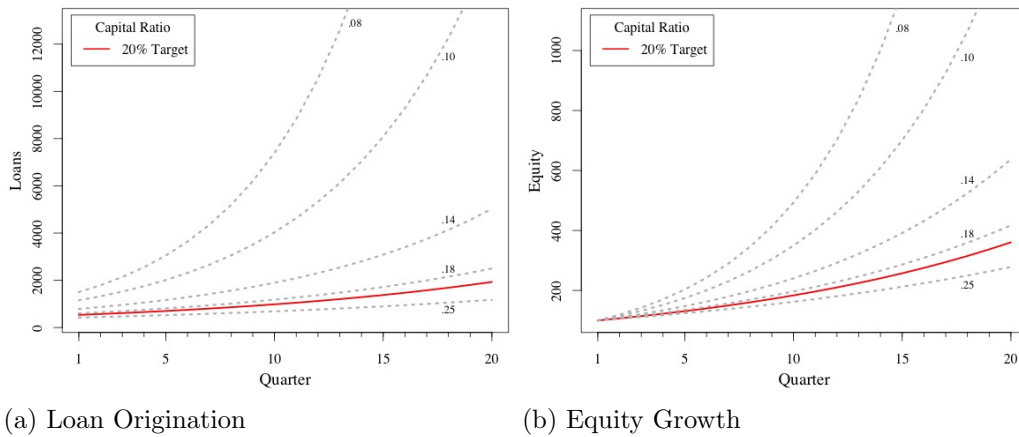


Figure 5.7: Evolution of Loan Origination and Equity, Varying the Capital Ratio.

flat. While an unlimited increase in lending and equity is not feasible as other constraints are in play, the illustrations make the point that the degree of financial inclusion available to a community could benefit significantly from a risk management strategy that focuses more broadly than on capital ratio management alone.

The sensitivity of the scenario results to the disaster probability, discussed above, can be visualized using the optimization surface for different probability values (Figure 5.8. Panel (a) provides for a frequent(one-in-ten) year event showing how any level of insurance reduces the objective value of the lender. For very rare events, depicted in panel (b) as a one-in-five hundred year event, insurance is always purchased. As for the calibrated case, deviations from the optimal insurance purchase when probabilities are low confers very little penalty against the objective value. These modeled results are consistent with the literature that insurance is more valuable for hedging against infrequent events,

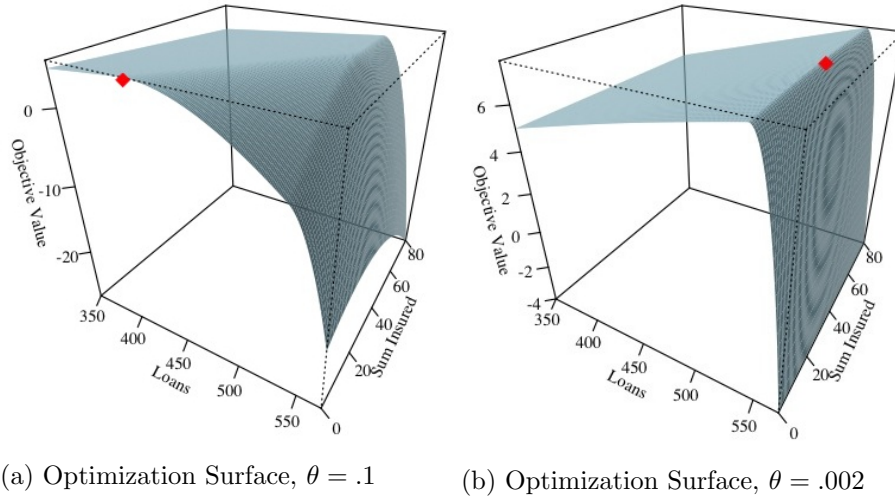


Figure 5.8: Optimization Surface, Varying Disaster Probability.

5.6. Summary

Regulated capital adequacy requirements, embodied in the Basel Accords and adopted widely, are one means for ensuring that lenders are sufficiently capitalized to absorb unanticipated shocks and remain solvent. In many developing economies, regulators often impose higher capital requirements while many lending institutions voluntarily maintain higher precautionary buffers. An emphasis on capital buffers alone to manage catastrophic risk however, imposes a friction with potentially high opportunity cost to the lender in foregone business and less financial inclusion for the communities served. Portfolio diversification and risk transfer are both portfolio risk management tools that can serve as partial substitutes for high capital buffers. Risk transfer solutions in particular may be more efficient than equivalent capital in mitigating the effects of correlated natural disaster risk and in preserving financial access during crises.

The banking model presented here attempts to provide a perspective on how parametric earthquake insurance can serve this role for proximity based lenders who are unable to diversify their portfolio's spatially and who rely heavily on capital ratio management as their risk strategy. The model is parsimonious, setting aside considerations of liquidity risk, variable lending margins, and taxation issues among others, in order to cleanly demonstrate the core principles related to the trade-offs between precautionary capital buffers, risk transfer, lender behavior and broader financial inclusion. The key insight offered by the model regarding the use of an insurance hedge against natural disaster risk include:

1. The presence of disaster risk can induce lenders to hold higher levels of precautionary capital to avoid penalties associated with falling below capital targets.

2. An insurance hedge enables the lender to hold precautionary capital closer to the target, allowing them to loan more heavily, earn higher profits, and generate higher equity growth.
3. The cost of the insurance hedge may be entirely born by the lender without passing the expense onto borrowers or jeopardizing the lenders competitiveness, even when no disaster event occurs.
4. Insurance payments enable the lender to offset income and equity losses of a disaster event, substantially increasing the pace of recovery and resumption of growth over lenders who retain the risk exposure.
5. The insurance hedge reduces the volatility of its capital ratio, thus reducing the disruption to credit provision following the disaster, and provides for the possibility of continued greater financial inclusion in the future.
6. Ever higher capital buffers flatten equity growth and loan origination, as do higher dividend payment rates.

While many Indonesian BPRs have the ability to make modest reductions in their capital ratios, the results given here do not suggest that all capital buffer above the minimum should be eliminated—BPRs and other proximity lenders face a variety of risks well served by additional buffer. This modeling exercise provides a reference point in demonstrating that a reduction may be made, given the lender representation calibrated on the set of BPRs in Padang.

Investigating how risk transfer can be used as part of an overall risk management strategy has both public and private benefits—excess capital buffers meant to protect the lending institution and its clients from insolvency may also have a dampening effect on overall financial access/inclusion and may be less effective than an insurance hedge for institutional recovery following an earthquake disaster.

Chapter 6. Wholesale Lending with Earthquake Portfolio Insurance

6.1. Introduction

Unmanaged natural disaster risk limits growth and imposes costs throughout the banking system. Proximity based lenders who cannot effectively manage their credit risk will ration lending to their borrowers. When local lenders experience asset losses due to an earthquake, the second-tier wholesale lender will also incur costs and losses from restructuring or adjudication of bad loans. Even when a local lender is able to meet its liabilities, the impact of the disaster may reduce its creditworthiness and reduce revenues from lost lending opportunities in the future. When a local lender is lost as a borrower, the second-tier bank incurs additional costs to identify and establish a relationship with a replacement. Similarly, when significant natural disaster risk exposure is recognized, second-tier wholesale banks may impose lower limits on the amount they lend if the risk were not present, dampening local growth in financial services. Equity investors may also be less willing to invest in local institutions with disaster risk exposure.

While proximity based lenders in Indonesia have been using capital management as a buffer against natural disaster induced portfolio losses, the second-tier bank can also use geographic diversification to help protect its overall portfolio from localized disruptions, although this does not imply that costs and losses are not incurred. A single strategy of diversification on the part of second-tier banks does not provide the coping and recovery benefits to local lenders and implies potentially significant lost opportunity cost due to the slower expansion of banking services.

The previous chapter showed how an individual lender who uses index insurance to hedge its portfolio exposure to disaster risk can enhance its ability to recover and increase its lending capacity by partially offsetting precautionary capital buffers. This chapter inquires as to whether the same insurance mechanism can be extended to second-tier wholesale lenders as a risk management compliment to diversification and ultimately improve access to lending, enhance local economic growth and increase income for the entire financial sector. In addition, would such a hedge, when added up in the manner suggested by Peter, Dahlen, and Saxena (2012) in examining the role of insurance in economic recovery, result in a meaningful economy-wide benefit?

The next section proposes a mechanism through which wholesale lenders can participate in the benefits of an index based earthquake portfolio insurance. This is not through the purchase of the insurance for themselves, but rather on behalf of their borrowers through the use of a master policy. To investigate the possible effect of such an arrangement, the banking model of the previous chapter is applied to a wholesale lender's portfolio of borrowers which presumes geographic diversification by imposing different levels of earthquake probability.

6.2. Master Policy to Widely Supply Earthquake Insurance

That insurance can help the proximity based lender grow more robustly even when it is not used to cope with a disaster event is a very powerful outcome. From the point of view of the second-tier bank, wholesale lending to local banks that carry insurance against earthquake risk, and adjust capital buffers accordingly, creates new revenue opportunities through additional lending. By enhancing the local banks resiliency to earthquake disaster, the insurance also makes them a less-risky client, conferring important tangible benefits to the wholesale funding provider.

While delivering useful earthquake insurance products to local lenders as a risk aggregator is less costly than sales efforts to individual households, the adoption of any new financial innovation can still take time to build volume and a sufficient pool established to be priced in aggregate rather than as a collection of single policies. Can portfolio protection be provisioned more widely, for groups of proximity based lenders exposed to earthquake risk, to help provide the capacity for meaningful market development and sustainability?

An insurance design that can achieve this is a “master policy”, or group scheme, which enables individuals belonging to a group to purchase protection through a single insurance policy. Common examples of master policies include employment based health insurance, property insurance for home owners associations, and liability insurance for professional associations. The objective of a master policy design is to protect the risks of the beneficiaries rather than that of the policyholder, to reduce the administrative burden of providing the coverage, and to provide a vehicle for pooling risk. While it is the named beneficiary that receives any payments, the premium on the individual coverage may be paid by the policy holder, the beneficiary, or shared in some agreed manner.

In the context of Indonesia, second-tier wholesale banks would be the policyholder where the beneficiaries of the policy is its network of client banks (the group). The policyholder must have a legitimate interest in providing cover for the defined group members, other than the provision of insurance. This condition is met since the primary interest of the policyholder is wholesale lending and other financial services to its group/network members. The premium could be born entirely by the second-tier institution or layered in such a way that it provides a basic level of coverage for rare events, to which additional coverage could be purchased by the local lender. In topping up coverage, the local lender benefits from the pricing advantage of the master policy since it helps create a more efficient risk pool. The local lender has the insurable interest. Therefore, if a strong earthquake triggers a payment, it is made directly to the local lender from the insurer, helping it to withstand the shock and continue lending when the community most needs access to financial services.

Second-tier wholesale lenders with client networks having earthquake exposure have incentives to take the lead as early adopters of the earthquake insurance hedge as it helps improve the resiliency and quality of its network members, and potentially increases the demand for wholesale services. A concern among the policyholders will be if the premium

costs will be less than the expected cost of a disaster conditional on having insurance, taking into account the probability of having a disaster and the expected value of revenue benefits from additional wholesale lending. Put differently, to what extent will the policy holder be compelled to pass on the cost of the insurance hedge.

In Indonesia, there are several potential aggregators of local financial institutions who could serve as the master policy holder for an earthquake insurance, many referenced in table 4.1 of formal microfinance providers. Several examples include regional development banks, such as Bank Nagari in Padang, which serves as Apex institutions for Bank Indonesia, providing wholesale funds to the 150 BPRs in West Sumatra and others in their jurisdiction. Bank Andara is a commercial bank originally founded by the INGO Mercy Corps with a social mission to focus predominantly on the small-business microfinance sector by providing wholesale funding as well as product development and technical services to its client lending institutions. Bank Andara currently has in excess of 400 proximity based lenders participating in its network. Indonesia's largest microfinance provider, and its second largest bank, is Bank Rakyat Indonesia (BRI). Its far flung network of over 4,000 branch offices serve the needs of micro, small, and medium enterprises. Each of these institutions were interviewed to ask about their awareness of earthquake exposure to their clients or branch networks. Unsurprisingly, Bank Nagari, having most recently experienced an earthquake event affecting its BPR clients was the most aware of the potential for earthquake disruption to financial services and that recovery took several years. Bank Andara expressed the view that the extent of earthquake risk to its network was unknown to it, while representatives of BRI indicated that it was sufficiently diversified to absorb losses. BRI annual reports indicate that risk management has taken a high priority in recent years, but established efforts to manage crises and disasters are mainly focused on managing reputational risk.

Each of these institutions are cautions in adopting a potentially expensive new financial technology. To provide insights for decision making, the objective here is to investigate to what extent a master policy for earthquake insurance for a local lender network confers benefits in terms of greater lending expansion and/or more robust recovery after a disaster event relative to the uninsured alternative.

6.3. Method

To examine the effects of a master policy provision of an index based earthquake hedge from the point of view of the policyholder, the banking model is applied to a group of geographically diverse local lenders, where the individual outcomes are aggregated to determine the group effect. The comparison is made between one where the local lenders are supplied the optimal level of insurance relative with the outcomes where no insurance is offered. In both cases, an earthquake event is imposed on a subset of the local lenders. The difference in the quantity of lending between the insured and uninsured cases constitute the aggregate benefits while the premium totals constitute the costs. These can be examined for break-

even points between the purchase of a master policy by an aggregator based on assumptions regarding the premium rate of the insurance as well as the spread on additional lending.

Spatial dissimilarity is captured by varying the probability of earthquake occurrence for the local lenders in the group. This is analogous to comparing the same level of ground motion exceedence from a multiple hazard curves, and thus a similar impact, between different locations.

The level of insurance that is chosen in the banking model is determined internally, and must be preserved even though in this exercise it is the policy holder that is paying the premium. Therefore, the cost of the insurance is returned to the local lender after the optimization routine takes place in order to not disadvantage the local insurance beneficiary relative to the uninsured. In other words, the level of insurance is determined in the banking model as though the local lender were paying the full cost.

6.3.1. Simulated Lender Profile

Wholesale lenders are often reluctant to release detailed financial information about their network members. And if not readily at hand, detailed information is also time consuming to compile. In order to complete this analysis, the financial parameters of local lenders are simulated to create a set of 500 distinct institutions to submit to the banking model. The basis for the parameters comes from a limited data set, obtained from Bank Indonesia, of BPRs operating in the region of Padang, for the period 2007 through 2010, from the rapid risk assessment made in the same area, and secondary sources (e.g., Hiemann 2009).

Here, the limited data are insufficient to confidently estimate parameters of a probability distribution from which to sample. Instead, the data are used to form estimates of the most likely value as well as minimum and maximum values of each parameter (as in Van den Heuvel 2006). These are used to generate a PERT distribution from which 500 random samples are drawn. The PERT distribution is based on the Beta distribution and uses the three point estimates to compute the Beta shape parameters. The PERT distribution is similar to the triangular distribution but without discontinuities at the minimum and maximum values, as well as placing less weight on those values. In this sense, the data are used as “expert opinion” as inputs to the PERT distribution.

The three point estimates for each parameter are provided in table 6.1. The disaster probabilities associated with each simulated lender are drawn from the uniform distribution to capture the idea of geographic dispersion of individual lenders. The realization of a disaster event for any individual lender over the five year period is a random draw from the set (0,1) where 1 represents the realization of an earthquake disaster event. The chance of an earthquake occurring during the five-year period represents a compound probability, so if the annual realization is 1%, then the total probability of an earthquake event during the period is $1 - (.99^5) = 4.9\%$.

Table 6.1: Simulated Distribution Parameters.

| Parameter | Distribution | Symbol | Min | Mod | Max |
|------------------------------------|--------------|------------|-----------------------|-----|-----|
| Return to lending | PERT | r | 1.5 | 4.1 | 9 |
| Assets held in loans | PERT | β | .60 | .70 | .80 |
| Dividend rate | PERT | v | .20 | .25 | .40 |
| Target capital ratio | PERT | c_γ | .08 | .15 | .25 |
| Expected increase in problem loans | PERT | x | .028 | .07 | .20 |
| Expected payout rate | PERT | w | | .60 | |
| Disaster probability | Uniform | θ | .005 | | .02 |
| Disaster Realization | 0/1 sample | | $Pr(1) = .049 = true$ | | |

6.4. Results

Results of submitting each simulated local lender to the banking model, with and without the provision of insurance under a master policy, are aggregated and presented in table 6.2. The values for each financial indicator represent the position of the local lenders at the end of the twenty quarter simulation period. The sum insured is the total amount of insurance purchased by the holder of the master policy at the end of the five year period for each of the lenders.

The provision of insurance has, in aggregate, improved the average outcome of the group for lending volume, income and equity, suggesting that the risk transfer does enhance the local lenders ability to provide additional financial services. A test of significant difference between the means of having insurance relative to not having access to insurance is performed using a paired Wilcoxon signed rank sum test. This test is appropriate since there are two observations for each lender (with and without insurance) and no assumption of normality is required. At the five percent significance level, all tests of the null hypothesis of equal means were rejected. The differences are economically significant as well. Lending volume is approximately 20% percent greater, supported by a 15 percent increase in equity, and which generates approximately 18 percent higher income, on average. The mean capital ratio for the insured group decreased slightly more than 2 percentage points from the uninsured case. Insurance has also contributed to a reduction in relative risk, as measured by the coefficient of variation, for each of the financial indicators.

In the master policy scenario, earthquake insurance was purchased for every member of the lender network. The amount of insurance purchased, the sum insured, is a choice variable in the optimization routine in conjunction with the lending volume. The level of insurance chosen to protect the portfolio will vary depending on the risk faced by the individual lender. The frequency distribution of the sum insured for each member of the group, as a ratio of lending to the amount of insurance purchased, is given in Figure 6.1, where the mean proportion of the portfolio hedged from the point of view of the master policy holder is approximately 10.7 percent, on average. The distribution is skewed to

Table 6.2: Summary: Local Network Lender Performance, Ending Values.

| Statistic | N | Mean | Med | St. Dev. | C.V. | Min | Max |
|-----------------------------|-----|-------|------|----------|------|-----|---------|
| Equity | 501 | 897 | | 1,396 | 1.56 | 85 | 14,702 |
| Equity (insured) | 501 | 1,066 | | 1,463 | 1.37 | 181 | 14,472 |
| Loans | 501 | 7,779 | | 17,283 | 2.22 | 472 | 198,349 |
| Loans (insured) | 501 | 9,672 | | 17,910 | 1.85 | 889 | 194,545 |
| Income | 501 | 154 | | 407 | 2.64 | 3 | 4,733 |
| Income (insured) | 501 | 189 | | 424 | 2.24 | 6 | 4,642 |
| Sum Insured | 501 | 1,061 | | 2,053 | | 39 | 20,214 |
| Earthquake Event (0,1) | | | | | 481 | 20 | |
| Capital Ratio (%) | 501 | 17.7 | 17.2 | | | | |
| Capital Ratio (insured) (%) | 501 | 15.4 | 15.5 | | | | |

the right since insurance is always purchased at all low frequency events, as the price is correspondingly lower, while for higher frequency events of the same effect, insurance will not be purchased.

While the provision of insurance under a master policy enhances the ability of local lenders to increase the supply of lending and builds their resiliency to earthquake impacts, does the increase in lending generate enough revenue to the master policy holder to support the premium? Here, it is assumed that the funds for the increased local lending are provided by the policy holder as an addition to its asset holdings.

Cost and benefit information is given in table 6.3. The insurance premium paid by the master policy holder in aggregate and on behalf of each local lender for each of twenty quarters is shown as the total and average cost. The difference in lending between the

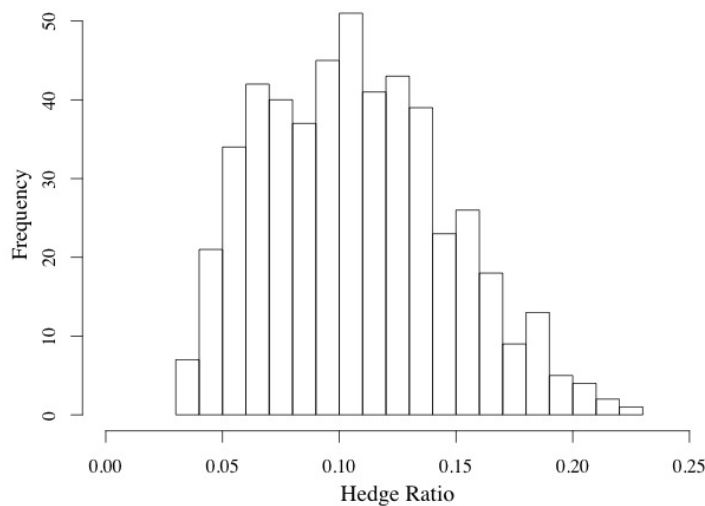


Figure 6.1: Insurance Hedge Ratios.

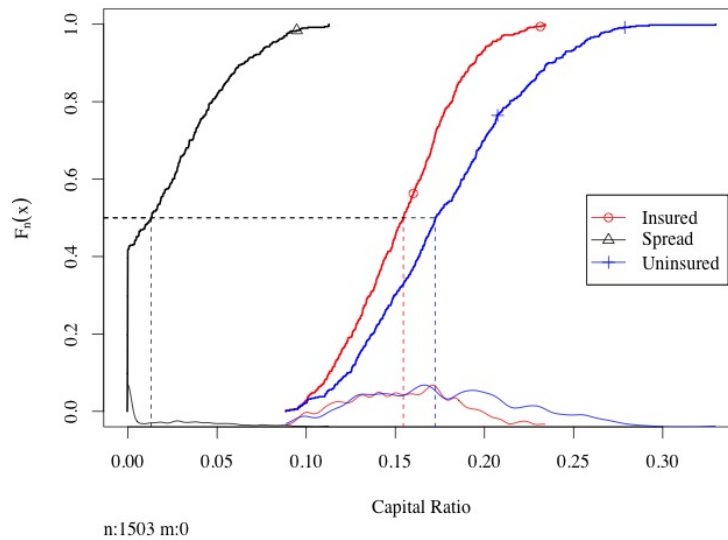


Figure 6.2: Cumulative Distribution of Capital Ratio.

insured relative to the uninsured group represents the total and average additional lending enabled by the leverage and recovery benefits offered by the insurance. Together, the provision of insurance enables a 2.47% increase in lending relative to the uninsured case. This value follows from the individual optimization for each lender in the model given the expected impact of an earthquake event. Additional insurance at the lender level would not leverage any additional lending. Rather, adding a member to the insured group would be expected to increase its lending by the amount of the lending leverage, on average.

The additional lending is made possible by the ability of the lender to slightly reduce its capital buffer in response to having the insurance, which reduces the likelihood of incurring a penalty for a following below the capital ratio target following an earthquake shock. Figure 6.2 gives the cumulative distribution of the capital ratio for the insured and insured cases, demonstrating the dominant leftward shift in capital ratio for the insured group. Pair-wise differences are taken to show the cumulative distribution of the spread in the capital ratio between the two cases. As expected, many of the lenders have identical capital ratio's between the two cases. This occurs when the probability of an earthquake is remote enough that the lender does not hold additional capital in anticipation of the shock. They do, however, continue to purchase insurance.

To further investigate potential aggregate benefits to the master policy holder, values for the net interest margin (NIM) were obtained from Bank Indonesia statistics. The NIM is the difference between interest income from assets to interest paid for the use of funds. The average values of NIM over the period 2007–2010 are given for commercial banks (such as Bank Andara), state-owned banks (such as Bank BRI), and regional development banks (such as Bank Nagari). The NIM is the rate of earnings on lending and is used to

Table 6.3: Cost-Benefit Comparison.

| | Total | Average (per lender) | Lending Leverage (%) | NIM (%) | Direct Multiplier |
|--------------------|---------|-------------------------|-------------------------|------------|----------------------|
| Cost of Insurance | 23,372 | 47 | | | |
| Additional Lending | 948,064 | 1,892 | 2.47 | | |
| Additional Revenue | | | | | |
| Commercial | 53,660 | 107 | | 5.66 | 2.30 |
| State-Owned | 56,979 | 116 | | 6.01 | 2.44 |
| Regional | 84,852 | 169 | | 8.95 | 3.63 |

determine the total and average revenue that could be earned from the additional lending. The ratios of the NIM to the lending leverage provides what can be considered a direct multiplier effect of the insurance purchase to wholesale lender revenue. This multiplier is shown for the commercial, state-owned, and regional development banks in Figure 6.3. For instance, the commercial bank that supports a master policy can expect that a dollar spent on insurance premium will generate 2.3 additional dollars of revenue, given the assumptions of the model. So long as the multiplier is greater than one, the wholesale lender should find it worthwhile to purchase a master policy for earthquake risk for its network of local lenders. This result is robust in the sense that the calculated multiplier could be reduced by half and still warrant the purchase of insurance by the wholesale lender.

Multiplier sensitivity is explored in table 6.4 using the commercial lender as the reference. In the banking model, the premium rate faced by the individual lender is the technical rate loaded by a multiple of two to accommodate uncertainty and ambiguity concerns in the probability estimates, plus other costs of insurance provision. The pooling across space of many individual policies should enable the master policy holder to obtain a somewhat lower group rate since the loss estimates of the aggregate should display less variability than would an individual policy holder. To explore the sensitivity of the multiplier to the premium, three levels of rate reductions are applied to the base loaded rate, as well as one level of increase to accommodate unusually high uncertainty in probability estimates and ambiguity in knowledge about the risk. A source of uncertainty can also lie in the estimates of the spread provided by the insurance in leveraging additional lending and consequently revenue for the wholesale lender. Three levels of reduction in the spread are provided against the baseline case for the commercial lender.

The case for insurance via a master policy appears to be robust to changes in the ability of insurance to provide leverage to additional lending. With the insurance cost fixed at the initial level, it takes nearly a 60 percent decline in the level of additional lending to reduce the direct multiplier below the level where it is no longer feasible to the policyholder. This is a strong outcome whereby already conservative reductions in the capital buffer can still produce a multiplier effect strong enough to justify the insurance purchase. Small reductions

Table 6.4: Multiplier Sensitivity, Commercial Lender.

| Additional Lending Spread (% reduction) | Variation in Loaded Premium (%) | | | | |
|--|---------------------------------|-------------|------|------|------|
| | 110 | 100 | 90 | 80 | 70 |
| 0 | 2.09 | 2.30 | 2.55 | 2.87 | 3.28 |
| 20 | 1.67 | 1.84 | 2.04 | 2.30 | 2.62 |
| 40 | 1.25 | 1.38 | 1.53 | 1.72 | 1.97 |
| 60 | 0.83 | 0.92 | 1.02 | 1.15 | 1.31 |

in the premium from group pooling and pricing have the effect of increasing the multiplier for any level of the additional lending spread. Further, even a premium rate that is 10 percent higher than the base still provides for the possibility of that additional lending be 40 percent less than anticipated in the model and still have a positive direct effect such that the marginal benefits to the policy holder of providing insurance to the group exceed the marginal cost.

6.5. Summary

This chapter has extended the results of the banking model with insurance of the previous chapter to investigate how the insurance might be provided more widely via second-tier wholesale lenders to networks of small proximity based financial institutions having earthquake exposure. Second-tier banks benefit from portfolio insurance that strengthens the resiliency of their network partners to earthquake risk.

When an earthquake event does occur and when a portion of a local lender’s portfolio is insured, it is in a better position to meet its liabilities to second-tier banks. Wholesale lenders don’t want their network partners to fail. Insolvency of a local lender imposes direct asset losses on the wholesale lender as well as search and other additional costs if it wishes to replace the failed local lender in its network. Portfolio insurance increases the ability the local lender to cope with the lending portfolio losses induced by an earthquake event, enables it to recover more quickly, and enables it to continue lending after the disaster when funds are critically needed by the community for reconstruction. In addition to the portfolio insurance addressing some of the direct costs associated with an earthquake event, it can also potentially enable the lender to lower the level of capital meant to buffer it from earthquake induced loan portfolio problems. Releasing capital allows the lender to expand credit availability within the community. Increasing demand for wholesale funds has corresponding benefits to the second-tier lender.

With these potential benefits, a second-tier lender has incentives to facilitate earthquake insurance for its network of local lenders. This can be accomplished through the use of a master, or group, policy. A feature of the master policy is that it enables the policy holder to directly extend the insurance to its group members who are the beneficiaries of the policy.

The banking model is used to aggregate the potential lending and revenue growth effects of extending earthquake insurance to a network of geographically dispersed lenders.

The results demonstrate significant differences in the mean level of lending, income, equity growth, and income for lender networks having insurance relative to not having insurance available. For a network of lenders, this first round effect from the provision of insurance can potentially leverage an additional 2.47 percent increase in lending. Further, provided that the policyholder is providing the additional wholesale funds to satisfy this higher level of lending, it can earn revenues in excess of the cost of insurance provision. For instance, a commercial lender can potentially realize an additional 2.30 dollars of revenue for each of the dollars used for insurance provision. The multipliers for state-owned and regional development banks are slightly larger than for commercial banks. These are first round effects. If the additional lending and investment stimulates economic growth, the level of financial services demanded in the economy should also increase.

These multipliers appear to be sufficiently robust to absorb additional costs not included in the model, such as the possibility of increasing costs of capital at the wholesale level. In addition, it is robust to substantial overestimation of the increase in additional lending. The master policy could still be viable to the policyholder with as much as a 40 percent decrease in anticipated additional lending volume. Pricing advantages associated with risk pooling increase the multiplier.

From a larger perspective, while the multiplier is relevant to the policyholder and source of wholesale funds, the wider supply of insurance protection against earthquake risk has public, economy-wide benefits. The effects of greater financial inclusion can have significant compounding effects, supporting additional investment, real economic growth, and contribute to overall poverty reduction in Indonesia.

Chapter 7. Summary and Extensions

Seismic hazard in Indonesia is pervasive, and yet there is little in the way of earthquake insurance or other risk transfer to help protect individuals from the disruptions and loss of livelihood that accompany a severe shock. Such losses, particularly when uninsured, have real and lasting effects not only for households, but also for the larger macro economy. For Indonesia's working poor, earthquake disasters have the potential to create the conditions for chronic poverty, through direct asset destruction and loss of livelihood, and through a reliance on coping mechanisms that break down in the presence of correlated disaster events. Recovery dynamics, however, are closely tied to the ability of households to obtain credit for reinvestment and consumption smoothing. Unfortunately, access to credit following an earthquake disaster can be increasingly rationed due to the level of nonperforming assets induced by the earthquake in the local lender's portfolio.

This dissertation has presented two applications of contingent risk financing developed around an index based approach to earthquake risk in Indonesia. One serves as a liquidity gap financing mechanism to enable more effective emergency response by an international NGO responding to the humanitarian crises that follows a severe earthquake event. Sufficient early funding in emergency response is critical for mitigating future health, sanitation and security issues if not addressed promptly during an emergency. The second application is meant to address a local lender's impairment of its capital base following increased loan nonperformance in the aftermath of an earthquake shock. Both mechanisms rely on the use of a ground motion index, that when combined with geographically coded vulnerability information, can serve as the basis for payment of a contingent contract that is reflective of the event's severity and likely financing needs. Because the magnitude of earthquake events can be quickly and reliably characterized, a triggered contingent claim has the ability to make payments promptly following the event, the hallmark of index based financing solutions.

The index based contingent claims for humanitarian response funding features a new way to engage the private sector in the humanitarian space. Commitments to a contingent credit or premium payment enable the private sector donor to make its commitments to corporate social responsibility visible to the public even in the absence of a disaster event. The index mechanism further strengthens efforts to ensure that humanitarian principles are observed in funding through the use of consistent criteria for the release of funds and, when combined with pre-planning, in funds allocation. The main objective of the mechanism, however, is to achieve rapid funds dispersal during the critical period between the completion of a emergency relief needs appraisal and the time when donor funds begin to flow into the disaster area. It is during this early period of emergency response when the marginal value of resources is likely the highest, and justifies the use of a relatively expensive contingent financing. The mechanism is not intended to fund an entire emergency response effort.

A similar mechanism could be used to help finance other aspects of humanitarian work, in particular those focused on disaster risk reduction and resiliency through building construction standards. Such “build back better” campaigns rely on saturating a disaster area with building experts and educators early in the recovery period, before households begin reconstruction, if new building and repair techniques are to be implemented. The index mechanism could provide the funds needed to quickly engage, transport, and house these building educators in the disaster area.

The primary feature of the banking model that describes a local lender’s financial performance following an earthquake event is its consideration of capital adequacy requirements in the presence of an insurance mechanism to help protect the bank from capital depletion. While the focus on the lender’s capital ratio is narrow, the observation that many of these financial institutions maintain a high level of capital buffer as a precaution against future events underscores their concern for institutional survival. Calibrated on a small sample of BPRs from Padang, the model demonstrates that an earthquake insurance can help the local lender recover more quickly than its uninsured counterpart due to the influx of funds that offset impairments against the capital base. The primary benefit is that the resilient lender is now in a much better position to continue lending following the event, helping the community to cope and more rapidly recover. In addition, the insurance protection may also enable the local lender to slightly reduce its capital buffer which allows for greater lending leverage even in the absence of an earthquake event. Overall, insured lenders are able to mobilize significantly more credit over time than when uninsured. This greater financial inclusion can have important growth effects in the local economy and beyond. Importantly, the results help emphasize that risk management can be a partial substitute for capital (Diamond and Rajan 2000), and that excessive capital buffers can contribute to lower financial inclusion in developing economies (Chiuri, Ferri, and Majnoni 2001). Finally, the model demonstrate that meaningful benefits are possible with quite modest levels of insurance relative to the portfolio. In the calibrated scenario, a sum insured of 8.4 percent was determined sufficient to protect the portfolio given the risk profile.

The banking model is parsimonious and rests on a number of assumptions. For instance, it assumes that the local lender has access to a ready pool of creditworthy households and faces zero search and screening costs and a constant cost of funds as lending expands. Incorporating increasing cost features would provide for less abstraction. However, it is not an unreasonable assumption that local banks face sizable excess demand at least in the short run. For example, the CEO of Bank Andara estimated that BPRs are capturing only about 50 percent of the potential market. Similarly, Meehan (2005) indicates a large unmet global demand for microfinance services, particularly in Asia. It would also be useful to parse out the proportion of the capital buffer held specifically for earthquake disaster protection, as well as imposing a preference function guiding the behavior of bank management, such as

a safety first utility preference to model management overriding concerns for institutional survival .

In the final chapter, the provision of earthquake insurance is imagined to be supplied entirely by a second-tier wholesale lender to its geographically diversified network of client banks via a master insurance policy. A master, or group, policy is purchased in whole or in part on behalf of the group members, who are the beneficiaries of the policy. From the perspective of the second-tier lender, and insured local lender that can more effectively manage its risk is more creditworthy and is potentially a source of additional lending revenue. To examine this idea, the characteristics of 500 local lenders is simulated and passed through the banking model to estimate the aggregate effects of group insurance on lending and other financial variables. The aggregated effects then allow the comparison of the cost of insurance provision to the wholesale lender relative to the revenue benefits of financing potentially higher levels of lending enabled by the insurance hedge.

The results reveal a significantly higher mean level of lending, income, equity growth, and income for a lender network having insurance than without. At the level of the network, each insurance premium dollar leverages 2.47 percent additional lending, at an average sum insured for the group of 10.7 percent. The additional lending above the uninsured case results from a more rapid resumption of local lending following an earthquake event and from a reduction in the mean level of the capital ratio by 2.3 percentage points, thus supporting a higher level of bank assets. A direct multiplier is calculated that relates the additional revenue to the policyholder for the insurance purchase. For a commercial wholesale lender, the multiplier is as high as 2.30 additional dollars of revenue for each dollar of group insurance premium. The multiplier effect is robust to substantial lower estimates of the anticipated additional lending. For instance, a 40 percent reduction of additional lending still leaves the wholesale provider as well off as not purchasing the group policy. The multiplier is strengthened in the presence of risk pooling with slightly lower premium than included in this scenario.

These results suggest there is value in supplementing diversification and capital buffers with other strategies that can more fully protect the financial interests of second-tier institutions and their network lenders. The accrued benefits, in terms of the revenue multiplier are private benefits within the banking sector. However, the compounding effects of increased lending and bank resiliency also contribute importantly to social goals of greater financial inclusion, economic growth, and poverty reduction.

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Vita

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Education

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Professional Positions

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Publications

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