Rural and Financial Development for Inclusive Growth

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI‘I AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN

ECONOMICS

May, 2015

By

Emiko Naomasa

Dissertation Committee:

James Roumasset, Chairperson
Lee Endress
Inessa Love
Nori Tarui
James Richardson
## Table of Contents

List of Tables ......................................................................................................................... iv  
List of Figures ......................................................................................................................... v  
Chapter 1 Introduction .............................................................................................................. 1  
Chapter 2 Social Ties and the Consequences of MFIs for Informal Credit Markets .............. 6  
   2.1 Introduction .................................................................................................................... 7  
   2.2 The Nature of The Rural Credit Market ......................................................................... 9  
   2.3 Model without MFI ........................................................................................................ 14  
   2.4 Model with MFI ............................................................................................................. 25  
   2.5 Conclusions and the Direction of Future Research ..................................................... 36  
   Appendix 2A .................................................................................................................... 40  
   Appendix 2B ..................................................................................................................... 41  
Chapter 3 Competition and Microfinance: Interaction effects between MFIs and Banks ...... 43  
   3.1 Introduction .................................................................................................................... 43  
   3.2 Theoretical Discussion ................................................................................................. 47  
   3.3 Methodology .................................................................................................................. 50  
   3.4 Results ........................................................................................................................... 53  
   3.4 Conclusion and Future Work ....................................................................................... 57  
   Appendix 3A .................................................................................................................... 70  
   Appendix 3B ..................................................................................................................... 75  
   Estimation of the Lerner Index .......................................................................................... 75  
Chapter 4: Optimizing the timing of fertilizer applications ..................................................... 77  
   4.1 Introduction .................................................................................................................... 78  
   4.2 Discussion of Farmers Practice (FP) and NM’s recommendations using field data ...... 82  
   4.3 Theoretical Discussions ............................................................................................... 85  
   4.4 Conclusion and Discussion for Future Research ......................................................... 105  
Chapter 5 Conclusions ............................................................................................................ 110  
References ............................................................................................................................... 113
Abstract

Chapter 2 focuses on the impact of Microfinance Institutions (MFIs) on informal credit markets. I construct a theoretical framework for an entrance of an MFI into a monopolistically competitive moneylenders’ market. Then it numerically compares the interest rates, coverages, and differences in social welfare for a market with and without an MFI. I also examine the impact of subsidies on an MFI. I found that moneylenders charge monopolistic interest rates for their borrowers within a close distance and increasingly competitive rates in the overlapping areas. Some low type borrowers, who are far away from the moneylenders, are excluded from access to credit. The MFI serves previously excluded people. The subsidy to the MFI enhances competition between the moneylenders and the MFI, which reduces the market interest rate and increases surplus of borrowers.

Chapter 3 estimates how many default risks in the microfinance sector can be explained to have resulted from within-sector competition and the sector’s competition with the formal banking sector. Since MFIs’ enforcement method is vulnerable to increased competition, I empirically examine competition–stability linkage with country-level data. Results show that the microfinance sector’s within-sector competition and competition with the formal banking sector negatively influence MFI portfolio risks, but it varies by countries’ income levels. In lower- and upper-middle-income countries, bank competition increases MFI portfolio risks, while there is no effect on MFI portfolio risks in low-income countries. MFI competition increases MFIs’ default risk across all income groups.

Chapter 4 combines agronomic and economic considerations regarding the optimal timing of nitrogenous fertilizer. I set up a farmer’s profit maximization, and numerically determined the optimal splits, timings, and amounts of fertilizer applications while considering the extra labor costs for additional rounds of fertilizer. The results show that the increase of yield from the additional split is larger than the additional cost of labor, except for the very small amount of N input. The result also shows that splitting nitrogen equally is suboptimal. Applying more nitrogen at the time of panicle initiation than at the active tillering stage increases yield over an equal split of the same amount of nitrogen.
List of Tables

Table 2.1 The Nature of Rural Credit Market Segmentation .............................................. 10
Table 2.2 The Total Effect of the Distance to the Monopoly Interest Rate ......................... 20
Table 2.3 Interest Rates for High Type ............................................................................. 23
Table 2.4 Interest Rate for Low Type ................................................................................ 24
Table 2.5 Market Equilibrium Interest Rate with Varied Levels of Subsidy ....................... 32
Table 2.6 Social Welfare before and after MFI’s Entrance .............................................. 36
Table 3.1 The Effect of Competition on MFI’s Default Risks, Cross-country data, OLS Regression ........................................................................................................... 59
Table 3.2 The Effect of Competition on MFI’s Default Risks, Panel data, Country Fixed Effect Regression ......................................................................................................... 60
Table 3.3 The Effect of Competition on MFI’s Portfolio Risks by Income Groups, Cross-country data, OLS Regression ................................................................................. 61
Table 3.4 The Effect of Competition on MFI’s Portfolio Risks by Income Groups, Panel data, Country Fixed Effect Regression ................................................................................. 62
Table 3.5 Coverage by formal banks and MFIs across income groups ............................. 64
Table 3.6 Interaction w/ Bank Branch per 1000 adults, Panel data, Country Fixed Effect Regression ................................................................................................................. 65
Table 3.7 Interaction w/ Bank Accounts per 1000 adults, Panel data, Country Fixed Effect Regression ................................................................................................................. 67
Table 3.8 The Interaction Effect of Competition and Financial Development, Panel data, Country Fixed Effect Regression ..................................................................................... 68
Table 3.9 Marginal Effect of Lerner Index by Income Group ............................................. 69
Table 4.1 Timing and Amount of N application by the number of fertilizer applications ................................................................................................................................. 83
Table 4.2 Period of yield component formation at certain growth stages ..................... 89
Table 4.3 Net Profit with different levels of fixed labor cost of fertilizer application ................................................................................................................................. 105
List of Figures

Figure 2.1 Social Distance between ML1 and ML2 ....................................... 15
Figure 2.2 MLs’ Interest Rate for High Type.................................................. 23
Figure 2.3 ML’s Interest Rate for Low Type..................................................... 24
Figure 2.4 Market Equilibrium Interest Rates after Entrance of an MFI without
Subsidy........................................................................................................ 31
Figure 3.1 Flow Chart: The Effect of Competition from the Banks on MFIs’
Repayment Rates .......................................................................................... 50
Figure 4.1 Various N Fertilizer Applications Based on Farmers’ Field Practices.... 83
Figure 4.2 Larger N loss within FP.................................................................. 84
Figure 4.3 N loss from Bad Timing .................................................................. 84
Figure 4.4 Crop cycle for transplanted rice after 100 days of maturity .............. 87
Figure 4.5 Rice plant........................................................................................ 88
Figure 4.6 Diagram of Nitrogen Dynamics ...................................................... 90
Figure 4.7 Growth of a rice plant’s biomass over time for 100 days of maturity.... 91
Figure 4.8 Maximum rate of N uptake by days after transplanting .................... 92
Figure 4.9 Rice production function by part..................................................... 97
Figure 4.10 Yield and Net Profit with various timing of N application.............. 100
Figure 4.11 Nitrogen Loss over various timing of application.......................... 101
Figure 4.12 Yield from model calibration and yield from field observation ....... 102
Figure 4.13 Yield and Net Profit allowing for field conditions ......................... 103
Figure 4.14 Net Profit with Credit Borrowing.................................................. 104
Chapter 1  Introduction

The overall goals of this dissertation are to advance our understanding of "poor economics" (Banerjee and Duflo, 2011) and governmental policies conducive to poverty alleviation and inclusive growth. The recently established, new development goals for the post-2015 period that motivated this study are the “reduction of extreme poverty to no more than 3% globally by 2030” and the “promotion of shared prosperity by fostering the income growth of the bottom 40% of the population in each country” (World Bank 2013a).

Millennium Development Goal (MDG) 1 -- to reduce poverty and hunger by half before 2015 -- has nearly been achieved. The goal of halving poverty was achieved in 2010. Meanwhile, the prevalence of hunger is 12.5% of the global population (FAO 2012), which though still above the MDG target of 11.6% represents a fair decline from 23.2% in 1990. Nevertheless, figures indicate that 1.2 billion people were still living below the extreme poverty line in 2010 (World Bank 2013a) and 870 million people were suffering from chronic hunger during in the period of 2010 – 2012 (FAO 2012). Reducing the poverty and hunger that still persist at this stage will be a more difficult problem that will require more targeted policies. Since the world’s population is projected to reach 9.1 billion by 2050 — 34% higher than the population in 2009 (FAO 2009) — food consumption is expected to increase by 70% (FAO 2009). In effect, people still living in poverty will become even more at risk of hunger and malnutrition. The new goals for the post-2015 period emphasize relative inequality along with the importance of the traditional, absolute numbers of poverty. Thus, government policies need to promote inclusive growth.

Poverty profiles show that 78% of poor people reside in rural areas and that 63% of the poor depend on agriculture for their livelihoods (World Bank 2008, World Bank 2013a). Since poverty remains overwhelmingly in rural areas, development policies, which target the rural economy, can effectively reduce poverty and hunger and uplift the bottom 40%. At the same time, increase in agricultural productivity is necessary to feed the world’s population, especially since food consumption is expected to rise by 70% by 2050. This dissertation focuses on rural development policies, especially two promising strategies for increases in agricultural productivity and improvements in financial access.
Higher agricultural productivity increases farm income and generates employment opportunities both in the farm and non-farm sectors of the village. In addition, increasing the production of staple foods increases their affordability thereby benefiting the poor, who spend large shares of their expenses on food. Chapter 2 relates to agricultural productivity through the channel of rural finance. More inclusive financial institutions promote agricultural productivity by lowering the shadow prices of agricultural inputs. Chapter 4 relates to agricultural productivity through the channel of better extension services, including the provision of information and skills related to available technologies and management practices.

Improved access to financial resources can provide the poor, both in rural areas as well as the urban poor, with better ways to cope with poverty, reduce the stress of negative shocks, and enable larger purchases (Morduch 2013). Half of the world’s adult population lacks an account at a formal financial institution, while among the bottom 40% of the population in developing countries, only 23% regularly use a bank account. People in rural areas have been much less likely to use bank accounts (World Bank 2013b). With these circumstances, Microfinance institutions (MFIs) have been filling in the gaps by extending financial services to both the poor and young as well as to the small enterprises. Chapter 2 and chapter 3 discuss microfinance policy.

Chapter 2 assesses the impact of the entrance of MFIs into the rural credit market. Poor people and people in remote rural areas conventionally rely on informal finance, which is believed to offer interest rates above marginal costs. Government policy towards MFIs needs to be informed by an understanding of how MFIs would change rural credit markets. Therefore, this chapter examines the impact of MFIs, including their influence on traditional moneylenders. Given the literature’s lack of any impact assessment from this perspective, the framework outlined in Chapter 2 is the first conceptual impact analysis of MFIs in a rural financial market. The result of this chapter will contribute to the evaluation of MFI subsidies.

I model the informal credit market as a system of monopolistic competition by moneylenders and compare the market equilibrium before and after the entrance of MFIs. I also numerically show the coverage of borrowers, the interest rates, and their effects on social welfare. The numerical examples demonstrate that with the entrance of the MFIs, high-social-distance borrowers that previously faced high interest rates from moneylenders switch to the lower interest rates of the MFIs. The MFIs serve previously
excluded people as well, and social welfare increases, assuming costless MFI entrance. I also discuss the impact of subsidies on an MFI by comparing the welfare changes of the entire rural credit market from the entrant of a non-subsidized MFI and the entrant of a subsidized MFI. It shows that the subsidy to the MFI increases its number of low-type clients, while the majority of high-type borrowers remain with their original moneylenders. Moreover, the subsidy to the MFI enhances competition between the moneylenders and the MFI, which dramatically reduces the market interest rate and increases surplus of high-type borrowers.

Chapter 3 is motivated by the observation that as MFIs have experienced steady profits with high repayment rates, pro-profit MFIs have increasingly entered the microfinance market. As a consequence, the microfinance sector has rapidly expanded and become highly saturated in recent decades. At the same time, since commercial banks have started to extend their services to previously excluded people. Therefore, coverage by MFIs is more likely to overlap coverage by the formal banking sector. Furthermore, corresponding to rising competition in the microfinance sector, MFI portfolio risks have also risen, which reveals that their enforcement method that involves using soft information has made MFIs vulnerable to extensive entrants and highly competitive environments.

Chapter 3 therefore empirically analyzes the effect of this increased competition on the stability of the microfinance sector, using country-level data from 2000–2010. Since increasing trend regarding number of entrants into MFIs will continue, identifying this situation’s effect on MFI stability is critical to discussions of policy concerning reducing the cost of microfinance crisis. The results shed light on whether microfinance complements or replaces the mainstream financial market, which clarify current understandings of the role of microfinance amid the bigger picture of financial development, as well as understandings of MFIs in both rural and urban settings.

These results support the hypothesis that MFIs in countries with higher competition among MFIs and between MFIs and banks are more likely to face greater risks of default. In upper-middle–income countries, competitiveness in the banking sector is more strongly associated with higher MFI portfolio risks in that country. This finding indicates that formal banks are more likely to compete directly with MFIs in upper-middle–income countries, meaning that MFIs and banks can be considered as substitutes. As financial sector develops, the advantages of MFIs’ lending mechanisms weaken, on the other hand,
the lending technology of formal banking will be more suitable. In sum, this chapter shows the importance of understanding the relationship between formal banks and the microfinance sector and of assessing the influence of any policy upon other sectors when financial inclusion is the goal.

The results in Chapter 3 show lessons from middle income countries that developing countries should heed, accounting for the impact of competition on the MFI’s portfolio risks as the financial market develops. Chapter 2 shows that in a financial market dominated by informal lenders, the subsidy to the MFI is justified as a way to enhance competition and break the monopoly rate by moneylenders. However, as the financial market develops and competition becomes fierce, the MFI’s portfolio quality deteriorates, and for that reason policies should change their focus, trying to minimize borrowers’ default by improving credit reporting regimes.

Chapter 4 focuses on the optimal timing of nitrogenous fertilizer. Recent recommendations for fertilizers aim to match nutrient supplies with the varying nutrient demands of plants across time. Agronomists have proposed split nitrogen application: once at active tillering and again at panicle initiation. However, most field farmers apply a large amount of nitrogen at once or twice during early production stages. This conventional practice increases nitrogen loss and reduces nitrogen uptake, which produces smaller yields along with higher fertilizer costs. One explanatory hypothesis is that the additional labor costs for split applications renders a single application more profitable. The chapter combines agronomic and economic considerations regarding the optimal timing of nitrogenous fertilizer to investigate whether a missing economic concept explains the gap between field farmers’ practices and the recommendation. Results show that the fixed labor cost of fertilizer application does not explain why farmers do not typically split nitrogen application into two stages. The increased yield from the additional split is larger than the additional cost of labor.

This chapter also examines the role of credit. Most farmers rely on credit to purchase fertilizer. Applying fertilizer at panicle initiation—approximately 40 days after transplanting—would save about a month’s payment of interest. This means that a higher cost of credit should cause farmers to apply more nitrogen at panicle initiation rather than earlier in the season.

The findings of this chapter can contribute to the improvement of current fertilizer recommendations. Moreover, this chapter shows the importance of combining agronomic
knowledge of nitrogen dynamics with economic analysis to calculate optimal fertilization timing.

Chapter 5 summarizes the major findings of the three chapters and discusses implications for future research.
Chapter 2 Social Ties and the Consequences of MFIs for Informal Credit Markets

Abstract

Many countries integrate microfinance into their poverty reduction policies. The pro-poor Microfinance Institutions (MFIs), which try to serve poorer households and women, are mostly subsidy-dependent MFIs. This paper aims to assess the social benefits of MFIs. The results will contribute to discussions on subsidies directed toward MFIs for the goal of poverty reduction.

This paper focuses on the impact of MFIs on informal credit markets. First, I construct a theoretical framework for an entrance of a pro-profit MFI into a monopolistically competitive moneylenders’ market. Then it numerically compares the interest rates, coverages, and differences in social welfare for a market with and without an MFI. Second, I examine the impact of subsidies on an MFI by comparing the welfare changes of the entire rural credit market from the entrant of a non-subsidized MFI and the entrant of a subsidized MFI.

The model assumes that moneylenders can distinguish the types of borrowers, but they need to spend an enforcement cost to collect a repayment from their borrowers. The social ties between moneylenders and borrowers are assumed to be inversely related to physical and or social distance, which affects the moneylenders’ cost of collecting a loan. This in turn modifies the probability of the borrowers’ strategic default. In contrast, an MFI cannot observe borrower type. Yet, it can collect repayment without any costs.

From the result of the numerical analysis, in a market without an MFI, moneylenders charge monopolistic interest rates for their borrowers within a close distance and increasingly competitive rates in the overlapping areas. Some low type borrowers, who are far away from the moneylenders, are excluded from access to credit.
With the entrance of an MFI, borrowers that previously faced high monopolistic interest rates of the moneylenders switch to the lower interest rates of the MFI. The MFI also serves previously excluded people due to the assumption of no cost of collecting an MFI’s loan. Social welfare increases due to an entrance of an MFI.

The subsidy to the MFI increases its number of low-type clients. In addition, the subsidy to the MFI enhances competition between the moneylenders and the MFI, which dramatically reduces the market interest rate and increases surplus of borrowers.

2.1 Introduction

As I discussed in Chapter 1, improving credit access in developing countries is one of the key policies for poverty reduction. Among the bottom 40% of the population in developing countries, only 23% regularly use a bank account. For some individuals, lack of access to credit causes them to sacrifice their potential as well as their ability to generate higher incomes (World Bank 2013). If they can gain access to credit, and if their risk-taking behavior did not change after receiving it, then these people may be able to contribute to an increase in the production of the economy (Myer and Nagarajan 2000). Also, access to credit for the vulnerable poor would facilitate consumption smoothing, and protect the poor from serious damage to their lives (Armendariz de Aghion and Morduch 2005). Therefore, since the old days, substantial amounts of subsidy have been going in the direction of financial policy. Nowadays, a market based, financial policy called microfinance attracts large subsidies from various governments and international organizations (The World Development Report 2008).

In the 1960s to the early 1980s, direct cheap credit was a major financial policy in most developing countries especially. Many governments in developing countries established agricultural development banks, and they disbursed cheap credit to the small, poor farmers. However, this former financial policy resulted in failure with a high rate of bankruptcy and mis-targeting. Due to political intentions, some governments wrote off the debts. They also put pressure on banks for loan disbursements. This political environment distorted the banks’ monitoring and screening mechanisms, and it weakened the creditors' willingness to repay. As a result, the banks suffered from a high default rate. Also, loans were rationed for the privileged class instead of the originally targeted, small farmers (Adams, Graham, Pischke 1984).
This old-school justification of government intervention was based on the view that “exploitative moneylenders” charge usurious interest rates in the monopoly market, and they squeeze all of the benefit from the poor borrowers (Bhaduri, 1973). In contrast to the “exploitative moneylenders”, the Ohio State School proposed that the high interest rate of the moneylenders reflected high transaction costs in the informal credit market and that the market was more competitive. Thus, they recommended policies for reducing the large transaction costs with solutions such as land titling, establishing property rights, creating financial infrastructure such as credit bureaus, and facilitating the use of disposable assets (e.g. livestock or TVs) as collateral (Adams and Fitchett 1992).

Hoff and Stiglitz (1997) argue that “cheap credit policies” may create an increase in the interest rate and smaller coverage for the borrowers. Credit goes to the moneylenders, and then they lend to the borrowers. Cheap credit reduces the opportunity cost of money-lending, and it induces the new entrants of moneylenders. Enforcement costs go up with the number of moneylenders. Thus, cheap credit can actually increase interest rates. More detailed discussion is in section 2.2.1.

Microfinance is often thought to have originated in the late 1970s in Bangladesh as an experimental project to study how to deliver credit to the rural poor. By utilizing incentive mechanisms such as group lending, dynamic incentives, and weekly payment schedules, microfinance Institutions (MFIs) have succeeded in the reduction of transaction costs and achieved high repayment rates without securing collateral (Cull et al 2009).

Moreover, learning from the failures of previous interventions, policy targets have shifted from “cheap credit” to “access to credit,” and MFIs’ interest rates have been set up to cover most of their lending costs. Therefore, MFIs have not distorted their creditors' demand curves (Armendariz de Aghion and Morduch 2005, Morduch 2000). Their successes have demonstrated how microfinance can serve the poor without huge subsidies1, which has been appealing to many governments and donor agencies. As a result, microfinance has dramatically spread over the last few decades.

Even now, after the spread of the MFIs, the primary source for credit to the poor is still informal moneylenders, landlords, traders, friends, and relatives (Banerjee, Duflo 2010).

1 In fact, most MFIs rely on subsidies, but they are small compared to amounts of money spent on previous policies (Morduch 1999).
Informal financial markets are usually viewed as monopolistically competitive – somewhere in between exploitative moneylenders and price takers. Aleem (1990) shows in the data from Pakistan that there is free entry, but the interest rate is above the marginal cost due to a high fixed cost. Because of elevated initial fixed costs, informal financial markets are segmented by each informal lender. MFIs have successfully reduced their transaction costs due to their lending mechanisms. And the arrival of MFIs would create competition and changes the picture of the informal credit markets.

The objective of this paper is to construct an analytical framework for assessing the impact of MFIs on the informal credit market. So far as I know, very few papers have been written on the impact of MFIs on the credit market. I assume that MFIs will compete with informal, monopolistically competitive money lenders. I therefore provide a model of the informal credit market without MFIs, and I examine what happens to the market equilibrium when MFIs are introduced. I am particularly concerned with the effects of the interest rates, coverage, and welfare effects. This paper proposes a new framework to assess the impact of MFIs. The results of this paper will contribute to discussions on subsidies for MFIs inasmuch as most of them still rely on donations.

Section 2.2 reviews the pertinent literature for my objective and identifies gaps. In Section 2.3, I build a model of the informal credit market without an MFI, and I show the segmentation of borrowers among the informal moneylenders. In Section 2.4, I add a for-profit MFI into the model from Section 2.3, and I examine changes in the interest rates and the coverage of borrowers. In addition, I conduct a numerical exercise to see the welfare impact of the MFI. I also examine the impact of subsidies on an MFI by comparing the welfare changes from the entrant of a non-subsidized MFI and the entrant of a subsidized MFI. In Section 5, I summarize the findings and propose directions for future research.

2.2 The Nature of The Rural Credit Market

High transaction costs, caused by imperfect information, faulty contract enforcement, and uncertainty, characterize financial markets in the developing countries. Poor physical facilities, a lack of financial infrastructure, and an absence of markets drives up the cost of screening creditworthy borrowers. Weak legal systems, such as inadequate property rights and ineffectual creditor rights, inhibit private monitoring and enforcement. In the rural area, the dominance of agricultural production for the source of household income
generates high uncertainty. Commercial banks, which utilize collateral and legal systems to secure repayment, have less incentive to operate in this market because of high transaction costs and a small amount of credit transactions. Subsequently, many governments have tried to intervene in this market for a long time.

Many different types of business lenders operate -- from state owned banks, branches of commercial banks, to professional moneylenders, trader-lenders, input-suppliers, and MFIs. Typically, these lenders are classified into three general categories: formal, informal, and semi-formal (Von Pischke et al 1983). Table 2.1 summarizes the characteristics of formal and informal financial institutions.

<table>
<thead>
<tr>
<th>Type of Lenders</th>
<th>Formal Financial Institutions</th>
<th>Informal Financial Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>State owned banks/ Commercial Banks/ some MFIs</td>
<td>Trader lender/ Input-supplier/ Professional Moneylenders/ Pawnshop</td>
</tr>
<tr>
<td>Loan Type</td>
<td>Larger size / Lower interest rate / Longer periods</td>
<td>Smaller size / Higher interest rate / Shorter periods</td>
</tr>
<tr>
<td>Enforcement, Screening Mechanism</td>
<td>Collateral requirement / Legal enforcement</td>
<td>Private enforcement / Collateral substitutes with any kinds of assets or social relationships</td>
</tr>
<tr>
<td>Type of Borrowers</td>
<td>Wealthy class/ Larger farmers, landlords and traders</td>
<td>Small farmers who lack property rights</td>
</tr>
</tbody>
</table>


Table 2.1 shows that formal lenders specialize in lending to people with collateral, and informal lenders specialize in lending to people without collateral. Formal lenders have an advantage based upon low opportunity costs for funding. Meanwhile, high screening, monitoring, and enforcement costs are disadvantages for them. Thereby, they rely on collateral in order to screen and to enforce. As a result, they specialize their lending to wealthier people who hold enough collateral. Informal lenders are the insiders in the borrower’s community, and they have an informational advantage. Yet the opportunity cost for their funding is high. Consequently, informal lenders specialize in monitoring and enforcing skills based on their informational advantage, and they loan without

---

2Semi-formal institutions are in between these two types, and most NGO-led MFIs, cooperatives, and self-help groups, such as ROSCA, are categorized in this type.

Also, borrowers with collateral choose formal lenders, and borrowers without collateral either prefer or are forced to rely on informal lenders. Kochar (1992) empirically shows with data from India that informal loans, in particular loans from very close lenders, may be cheaper than formal loans due to their low information and enforcement costs. Thus, some borrowers prefer informal credit. Chung (1995) and Mushinski (1999) discuss how small farmers face high application costs in the formal sector, because they generally lack transportation and have a low literacy rate. In contrast, the application procedures are easier in the informal sector for small farmers. As a result, the larger farms with collateral apply for loans from formal financing. Despite the high interest rates, many small farmers, who are without collateral, choose informal loans. In this way, based on a transaction cost advantage, the financial market is segmented naturally (Conning and Udry 2005).

This kind of natural segmentation occurs even in the informal financial market as well. Each of the informal lenders has different informational advantages on their borrowers. For example, trader lenders, input-suppliers, and landlord lenders use their inter-linked contracts for credit and output, input, or land. Moneylenders provide a loan based on their personal ties that they build through long term relationships with their clients (Bose 1998b, Udry 1990, Aleem 1990). Therefore, the informal financial market is segmented based on borrower-lender ties at an equilibrium (Floro and Ray 1997).

2.2.1 Research Lacuna

Many authors model a rural credit market to examine the impact of cheap credit policy. In particular, there are two representative papers for a detailed model about the informal credit market, Hoff and Stiglitz (1997) and Bose (1998). They model the vertical relationship of formal and informal lenders, where the cheap credit from formal lenders goes to the informal ones, and the borrowers receive loans only from the informal lenders.

---

3 The definition of the terms “segmentation” and “fragmentation” in the context of the rural credit market varies (Conning and Udry 2005). In this paper, “segmentation” is associated with the sorting of different types of lenders into distinct groups of borrowers based on a transaction cost advantage. "Fragmentation” relates to highly diverse, shadow prices for credit due to enforcement and information problems as well as transportation issues.
Hoff and Stiglitz (1997) model the informal credit market with homogeneous moneylenders who have access to the formal institutions, and homogeneous borrowers who have no access to the formal credit. They show the negative impact of cheap credit on borrowers who are excluded from the formal credit market.

In order to show the effect of cheap credit on the moneylenders’ interest rates, Hoff and Stiglitz focus on the entry of new moneylenders, and the impact of a number of moneylenders on the enforcement costs. The optimal number of moneylenders in the market is derived from equalizing the benefit of moneylending and the opportunity cost for lending. Here, cheap credit reduces the opportunity cost of money-lending and induces the new entrants into moneylending. Moreover, enforcement costs go up with the number of moneylenders through the following two channels.

The first channel is through economies of scale caused by the fixed enforcement cost. The new entrants of moneylenders derive a smaller number of borrowers for each lender. The smaller number of borrowers for each lender weakens economy of scale. The second channel is through the externality-like effect of enforcement cost. The externality-effect is that, as the number of moneylenders increases, as a result of the cheap credit policy, the borrowers have less incentive to repay, because it is easier to access other lenders. This results in a higher collecting cost for the moneylenders.

Under this setting, Hoff and Stiglitz show how the equilibrium informal interest rates can rise if increases in the enforcement costs dominate decreases in the opportunity costs of cheap credit. As such, Hoff and Stiglitz did not support a trickle-down effect on cheap credit for small farmers. However, their model is based on the strong assumption that cheap credit causes an excess of entrants by moneylenders. They omit the strategic interaction between new entrants and existing moneylenders. The existing moneylenders can reduce the interest rates to prevent new entrance.

Bose (1998) modeled heterogeneous borrowers and two asymmetrically informed moneylenders. And he focused on the screening of the type of borrowers instead of the enforcement effect discussed in the Hoff and Stiglitz (1997). The key mechanism of his model is the “composition” effect of a pool of two types of borrower. There are two types of informal lenders that already exist in the market -- the informed moneylender who is an insider in the community and the uninformed lender who is an outside of the community. The insider moneylender lends to the good type of borrower first. Then, the
outsider, who cannot see the type, randomly lends to borrowers in the residual pool of people after the insider has already screened for the good type. The decrease of the formal interest rate reduces the opportunity cost of funds, which allows the insider to lend to more of the good borrowers, and this worsens the composition of the residual pool for the outsider. Thus, if this negative composition effect dominates the reduction of opportunity costs, the outsider moneylender increases the interest rate and reduces the number of borrowers served. However, the total aggregated impact from cheap credit is ambiguous.

The two models above incorporate key features of the informal credit market: enforcement and screening of borrowers. However, these model settings are not suitable for adding MFIs and discussing their impact on the informal credit market. Firstly, unlike formal lenders of cheap credit, MFIs lend directly to borrowers. Therefore, I need to add MFIs as lenders in the model. Secondly, to examine the impact of the entrance of MFIs, I need to discuss the types of borrowers that have incentive to go with the MFIs. I would also like to reflect on which ones have reasons to stay with the moneylenders.

However, the two models remain silent on these matters, because the sorting rules between lenders and borrowers are not clear. Hoff and Stiglitz’s model assumes homogeneous borrowers. Bose differentiates good and bad types of borrowers, but there is no explicit rule for who goes to which of the groups. In his model, some of the good types receive satisfactory deals, but some of the good types are excluded from access to credit too. Thus, I need to introduce an additional measure of heterogeneity for borrowers in addition to their types.

In order to specify a sorting rule, I include the concept of a social tie between the borrowers and moneylenders. Social ties are built through long term personal relationships between borrowers and lenders, and the strength of the tie affects the moneylenders' enforcement costs. Thus, the enforcement costs vary among the villagers. It creates segmentations between informal lenders in the same community.

2.2.2 Research Question

The model of informal credit market which explores how transaction costs generate a natural segmentation will contribute to the understanding of the informal credit market. This paper adopts the concept of social ties as the key parameter of the transaction cost. The existing literature presents informal lenders that preferentially loan to people within
a close distance because of the cheaper transaction costs (Floro and Ray 1997). This spatial distribution of borrowers, based on the personal tie, creates one explanation as to why segmentations occur in the informal credit market. As a consequence, some borrowers, who are far away from lenders, are left out of the market. In addition, this spatial distribution of borrowers enables a strategic reaction between the lenders.

Once I derive a natural equilibrium in the informal credit market, I allow for the entrance of MFIs. There are few papers which discuss the impact of MFIs on the informal credit market. Most of the literature on microfinance analyzes the impact of MFIs from the following aspects: the mechanism designs of microfinance lending (Ahlin, Townsend 2007, Gine, Karlan, 2009, Banerjee et. al. 2010), project evaluations from each program, especially on the welfare analysis of the borrowers (Kandker2005, Pitt, Kandker 1998), and the macro economic impact along the lines of financial deepening (Ahlin and Jiang 2008).

This paper examines which borrowers are benefited from the entrance of the MFIs and by how much and how the entrance of MFIs affects informal lenders' offers. This is one piece of the picture for what is happening in the entire rural credit market. However, a discussion of MFIs from the aspect of informal credit markets may provide another justification for MFIs.

2.3 Model without MFI

This section presents a model of the informal credit market, where only moneylenders exist. I show a spatial segmentation based on social ties between lenders and borrowers. Moneylenders can tell the types of borrowers, but they have to pay an enforcement cost to collect payment. And the enforcement costs increase with social distance. In some cases, moneylenders cannot loan to the far away borrowers due to their high enforcement costs. In this way, a borrower, who is tightly connected with a certain moneylender, as is often the case with trader-lenders in many countries, tends to receive a monopoly interest rate. On the other hand, a borrower, who is away from a particular lender, receives a more competitive loan contract albeit one that includes higher transaction costs.

2.3.1 Model Framework
Moneylenders preferentially loan to people within a close distance. Often credit transactions are linked with other relationships, such as the landlord-tenant and trader-seller. Also, recent network theory literature supports that personal ties act as a substitute for collateral in an informal credit transaction (Karlan 2009). And several field studies support that borrowers often contract exclusively with one moneylender because it is very difficult to switch to new lenders (Aleem 1990, Floro and Ray 1997).

This model tries to show the zoning of borrowers between lenders based on the social distance between each client. I assume that moneylenders are exogenously and uniformly distributed in a village. And I cut out one of the line segments between two moneylenders as in Figure 2.1. The distance measures the level of the personal ties between the people. The level of the social tie between each lender and borrower is given, and borrowers are ordered based on their ties in the segment. Close distance means a close relationship. $d^j_i$ indicates borrower i’s distance to a moneylender j (MLj, j=1,2). Each borrower has an exclusive relationship with one lender. So, if a person is close to ML1, she is away from ML2. I assume the distance between ML1 and ML2 is 1. Then, $d^1_i + d^2_i = 1$ or $d^2_i = 1-d^1_i$.

**Figure 2.1 Social Distance between ML1 and ML2**

Given the location on the social distance map, each moneylender offers a loan contract to each borrower until a person gives the moneylender a negative profit. Then, there are three possible types for a market: a monopoly market, a competitive market, and a mixed market (i.e. a monopoly by ML1, a monopoly by ML2, and an overlapping area for both moneylenders). Since a borrower can only take a loan from one lender, the area with overlapping territories will function as a contestable market. If a moneylender charges a high, monopolistic interest rate, then another moneylender may offer a slightly lower interest rate than the existing one. Thus, the incumbent moneylender will respond by reducing the interest rate to a level at which the potential entrant cannot make a profit.

---

4 Unlike Hotelling’s spatial model, moneylenders do not move their location. A long term relationship establishes a social tie between each lender and borrower. So, building a new social tie with a new borrower requires prohibitive cost.
2.3.2 Model

2.3.2.1 Assumptions

Borrowers

I assume that all people in the informal credit market have been excluded from access to formal finance. Now all of the people have investment projects, and they are looking for a loan from informal lenders. As discussed in the model framework, borrowers are uniformly distributed on a line based on their social distance with respect to their level of personal connection with the lenders. $d_i^j$ indicates borrower i’s distance to moneylender, $j=1,2$. Besides their locations on the social distance map, their level of project management ability also differentiates the borrowers. Their capacity dictates to what extent they can avoid project failure. People with higher ability have greater likelihoods of success.

Assume there are two types of borrowers: high management types ($\theta = h$) and low management types ($\theta = l$). Let the probability of success for type $\theta$ be $p_\theta$, then $p_h > p_l$. If the project succeeds, the return for a borrower at $d_i$ is $R(X_i)$. The return function is the same for both types. And, if the project fails, the outcome is 0. When a project fails, borrowers do not repay their loans. I assume an equal distribution for each type of borrower. On each position of the social distance line, both types exist. N people of each type exist in the segment line, and there are 2N borrowers in total.

Given the interest rates proposed by the lenders, the borrower applies for a loan size which maximizes the expected profit from her investment in the project. Thus, the borrower i’s demand function is $X(r_i) = \arg\max_x \{ p_\theta \cdot (R(X_i) - r_i X_i) + (1 - p_\theta) \cdot 0 \}$, where $r_i = 1 + \{(the \ interest \ rate \ charged)\}^5$, $X_i = \{(the \ size \ of \ the \ borrower’s \ loan)\}, \ i = 1, ..., N , \ j = 1,2$. The borrower’s demand function is derived by maximizing her expected profit. The demand function is same for all types of borrowers. If there are multiple offers, the borrower chooses the best offer which presents her with the maximum amount of profit.

Money Lenders

---

5 For the ease of calculation, I use $r_i = 1 + \{(the \ interest \ rate \ charged)\}$ following Hoff and Stiglitz (1997)
I assume that there are two symmetric moneylenders, ML1 and ML2, at the ends of a social distance line. Field research shows that moneylenders' funds are coming from self-funding, formal bank loans, and loans from other informal lenders (Aleem 1990). This model assumes that moneylenders have unlimited access to formal banking with a flat interest rate ($\rho$). The marginal costs for moneylenders’ loans are given as $\rho$.

Moneylenders can see the borrower’s type ex ante without any cost. Meanwhile, they cannot automatically observe whether their clients’ projects are a failure or success. Therefore, some borrowers, whose projects experience success, will strategically avoid repayment, and act as if they are failing (strategic default). Moreover, even if the moneylenders figure out the outcome level, the borrowers still can take the money and run.

Accordingly, moneylenders expend effort on enforcement ($e_i$) in order to monitor their project outcomes and to collect money from their borrowers. As moneylenders spend more on enforcement, they can more precisely see their outcomes, and they can collect additional money. Thus, the likelihood of strategic defaults by borrowers and the probability of runaways decrease. However, higher enforcement is more costly. Therefore, the optimal level of an enforcement effort is determined endogenously by the balance of its costs and benefits in the moneylenders' profit maximization problem.

Moneylenders have their own subjective probability about each borrower’s repayment, $P_{e\theta}(e_{i\theta},d_i)$: the moneylender’s subjective probability about a type $\theta$ in the location $d_i$. This probability of repayment consists of the prospect of the project's success, $p_{e\theta}$, which is known to the lender, and the moneylender's subjective, strategic default rates. I assume that borrowers are more likely to do a strategic default if they are away from their moneylenders. And if moneylenders spend more on enforcement, borrowers have a harder time to cheat their outcome. Thus, the probability of borrower’s repayment decreases with distance, and increases with enforcement effort, $P_{d_i} < 0$, $P_{e\theta} > 0$.

$EC(e_{i\theta},d_i)$ is an enforcement cost function. The expense increases as the lenders expend greater enforcement effort. And also, a cost of enforcement increases with distance because loan collection is harder for a far-away borrower, i.e. $EC_{e\theta} > 0$ and $EC_{d_i} > 0$. Thus, the moneylender j's expected profit function of lending to the borrower
i can be written as, \( r^I_i X \left( r^I_i \right) \cdot P^\theta \left( e^I_i, d^I_i \right) - \rho X \left( r^I_i \right) - EC \left( e^I_i, d^I_i \right) \), where \( r = 1 + \{\text{the interest rate}\}, i = 1, \ldots, N, j = 1, 2 \).

Moreover, the marginal increase in the probability of repayment from an additional enforcement effort is lower or the same for far away borrowers \( P_{e_{i\theta d_i}} \leq 0 \). The marginal increase of enforcement cost from an additional effort is higher or same for far away borrowers \( EC_{e_{i\theta d_i}} \geq 0 \).

2.3.3.2 Equilibrium

In the above settings, two symmetric moneylenders simultaneously decide their interest rates, the amount of their enforcement efforts, and the boundaries of their operations.

Firstly, the monopolistic interest rate, the enforcement cost, and the boundary of moneylenders' operations are derived for both lenders from their profit maximization. Given the boundaries by symmetric lenders, the market structure will either be among three types: two monopolistic regions, two monopolistic regions and one contestable market, or a whole segment that is a contestable market. Then, given the market structure, optimal interest rates are derived. In a monopolistic region, both moneylenders charge their own monopolistic interest rates. In the contestable market area, ML1 and ML2 strategically compete against the lenders. ML1 charges an interest rate which is slightly lower than ML2’s offer, and ML2 charges a slightly lower interest rate than ML1. Therefore, it works as Bertrand-type price competition.

The credit demand to MLj (\( j=1,2 \)) by borrower i is a reaction function of the opponent’s interest rate in the contestable market:

The borrower i’s demand for ML1,

\[
X^1_i (r_1, r_2) = \begin{cases} 
X (r_1) & \text{if } r_1 < r_2 \\
\frac{1}{2} X (r_1) & \text{if } r_1 = r_2 \\
0 & \text{if } r_1 > r_2 
\end{cases}
\]

The borrower i’s demand for ML2,

\[
X^2_i (r_1, r_2) = \begin{cases} 
X (r_2) & \text{if } r_1 > r_2 \\
\frac{1}{2} X (r_2) & \text{if } r_1 = r_2 \\
0 & \text{if } r_1 < r_2 
\end{cases}
\]
In this Bertrand-type price competition, moneylenders reduce the interest rate to a level in which the opponent cannot make a positive profit. Therefore, the market interest rate in the contestable market is the level of the opponent’s zero-profit interest rate.

Now I solve for the moneylenders' problem. ML1’s profit maximization problem is:

\[
\max_{r_{i\theta}, e_{i\theta}} r_{i\theta} X(r_{i\theta}) \cdot P_\theta(e_{i\theta}, d_i) - \rho X(r_{i\theta}) - EC(e_{i\theta}, d_i), \theta = h, l, i = 1, ..., N.
\]

s. t. \( r_{i\theta} X(r_{i\theta}) \cdot P_\theta(e_{i\theta}, d_i) - \rho X(r_{i\theta}) - EC(e_{i\theta}, d_i) \geq 0, \forall i, \theta \)

\( p_\theta(R(X(r_{i\theta})) - r_{i\theta} X(r_{i\theta})) \geq 0, \forall i, \theta \)

\( e_{i\theta} = \arg\min_{e_{i\theta}} r_{i\theta} X(r_{i\theta}) \cdot (1 - P_\theta(e_{i\theta}, d_i)) + EC(e_{i\theta}, d_i) \)

\( r_{i\theta}^1 \leq r_{i\theta}^2, \forall i, \theta, in \ a \ contestable \ market \)

Moneylenders choose their interest rates and enforcement efforts in order to maximize their profits subject to each borrower’s location \( d_i \) for which the moneylenders can make a positive profit. The fist condition tells the non-negativity constraint of the moneylenders’ profit. The second condition is the participation constrains of the borrowers. The borrowers participate as long as they receive the positive net return from their investment. The third condition rewrites the profit maximization to the cost minimization. The optimal level of an enforcement effort, derived from the maximization problem, is equal to the amount of enforcement that minimizes the cost, that is the loss from a strategic default plus the enforcement cost. The last constrain is for a contestable market. In it, a moneylender charges an interest rate as low as her opponent’s level.

To hold a maximum solution for \( r_{i\theta} \) and \( e_{i\theta} \): the demand function should be twice differentiable and concave with respect to \( r_{i\theta} \), \( (X' < 0 \ and \ X'' < 0) \), the probability of repayment is concave (or quasi-concave) with respect to \( e_{i\theta} \), \( (P_{e_{i\theta}} > 0 \ and \ P_{e_{i\theta} e_{i\theta}} \leq 0) \), and the enforcement cost is convex (or quasi-convex) with respect to \( e_{i\theta} \), \( (EC_{e_{i\theta}} > 0 \ and \ EC_{e_{i\theta} e_{i\theta}} \geq 0) \).

\[ 6 \]

\[ 7 \]
From the above assumptions, the demand function, the probability of repayment, and the enforcement cost function satisfy the following conditions, \( X' < 0 \) and \( X'' < 0 \), \( P_{\epsilon_{i\theta}} > 0 \), \( P_{e_{i\theta}e_{i\theta}} < 0 \), \( E_{\epsilon_{i\theta}} > 0 \), \( E_{C_{e_{i\theta}e_{i\theta}}} \geq 0 \) and \( E_{C_{e_{i\theta}d_{i}}} > 0 \).

The monopoly level of an enforcement effort and the interest rate, \( (e_{\epsilon_{i\theta}}^{m}, r_{\epsilon_{i\theta}}^{m}) \), is derived from first-order conditions, (A1) and (A2) in APPENDIX 2A. \( e_{\epsilon_{i\theta}}^{m} \) is chosen at the level for which a marginal loss from strategic default equals the marginal cost of additional enforcement cost. \( r_{\epsilon_{i\theta}}^{m} \) is chosen to equalize marginal revenue from an increasing interest rate and the marginal cost of funds.

Given \( (e_{\epsilon_{i\theta}}^{m}, r_{\epsilon_{i\theta}}^{m}) \), the boundaries of the moneylenders’ operation are derived. It settles the market structure. In the overlapping area, the two moneylenders start a Bertrand-type price competition. At the equilibria, moneylenders charge a monopolistic interest rate in the monopolistic region. They work at the level of their opponent’s zero-profit interest rate in the contestable region.

Next, I examine a relationship with the distance, \( d_{i} \), and the monopoly interest rate, \( r_{\epsilon_{i\theta}}^{m} \). The impact of distance on the interest rate can be decomposed into two channels, the impact for the probability of default (in the first term of the equation (1)) and the impact of the enforcement cost (in the second term of the equation (1)).

\[
\frac{\Delta r_{\epsilon_{i\theta}}^{m}}{\Delta d_{i}} = \frac{dr_{\epsilon_{i\theta}}^{m}}{dd_{i}} + \frac{dr_{\epsilon_{i\theta}}^{m}de_{i\theta}}{dd_{i}} \tag{1}
\]

Table 2.2 The Total Effect of the Distance to the Monopoly Interest Rate

<table>
<thead>
<tr>
<th>( \frac{\Delta r_{i}}{\Delta d_{i}} )</th>
<th>( \frac{dr_{i}}{dd_{i}} )</th>
<th>( \frac{dr_{i}de_{i}}{dd_{i}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>the total effect</td>
<td>the effect through the probability of repay</td>
<td>the effect through the enforcement cost</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>( \frac{dr_{i}}{de_{i}} ) / ( \frac{de_{i}}{dd_{i}} )</td>
</tr>
</tbody>
</table>

Therefore, \( X'' < 0 \), \( P_{\epsilon_{i\theta}e_{i\theta}} < (\leq)0 \), \( E_{C_{e_{i\theta}e_{i\theta}}} \geq (>)0 \).
As summarized in Table 2.2, the monopoly interest rate increases with distance. First channel is through the probability of repay. Moneylenders regard borrowers, who live far away, as customers with lower probabilities of repay. On the other hand, nearby borrowers have higher probabilities of repay \( P_{d_i} < 0 \). Thus, moneylenders try to collect higher total revenues from borrowers with closer relationships. Because of the elastic demand in monopoly, moneylenders reduce interest rates in order to increase the size of their loans and total revenues for short distance borrowers. Meanwhile, moneylenders charge higher interest rates for borrowers with weaker social relationships in order to reduce their loan demands \( \frac{dr_i}{dd_i} > 0 \). The second channel is through an enforcement cost. Moneylenders abandon their enforcement activity for far away people due to the high cost \( \frac{de_i}{dd_i} < 0 \).

Since an additional enforcement effort increases the cost, moneylenders need to boost their total revenue in order to pay for the greater enforcement. Under the elastic demand, moneylenders decrease the interest rates in order to increase the total revenue \( \frac{dr_i}{de_i} < 0 \).

Thereby, in the second channel, moneylenders put out a greater enforcement effort for their nearby people. It leads to lower interest rates in order to increase their total revenue. To conclude, the monopolistic interest rates increase with distance.

To summarize this section, moneylenders charge monopolistic interest rates in the monopoly region. And monopoly interest rates increase with distance. In the overlapping region, they charge rates as low as their opponents’ competitive rates.

2.3.3 Numerical Example

This section shows a numerical example of two moneylenders’ models.

Two types of borrowers, a high type and a low type, are located in 9 locations, \( d_i = 0.1, \ldots, 0.9 \) \(^8\). There are 18 borrowers in total. Assume everyone has a project which produces a 300% return when it succeeds, and 0 return if it fails. The high type borrower always succeeds, and the low type borrower succeeds with 60% probability. The borrower’s demand is \( X(r_i) = 100 - 10r^2 \). This demand function satisfies the concavity assumption \( (X' < 0 \text{ and } X'' < 0) \).

---

\(^8\) I exclude \( d_i = 0 \) and 1 in order to avoid a case where the denominator becomes 0.
There are two moneylenders in this market. They are located on the edge of the social distance map. Moneylenders need to lay on some enforcement effort in order to prevent a “take the money and run”. The moneylenders' subjective probability of repayment is \( P_{e_i d_i} = 1 - d_i + 2e_i \), where \( P_{d_i} < 0 \), \( P_{e_i} > 0 \), \( P_{e_i d_i} = 0 \), and \( P_{e_i d_i} = 0 \). The enforcement cost is \( EC(e_i) = 2000e_i^2d_i \), \( EC_{d_i} > 0 \), \( EC_{e_i} > 0 \), \( EC_{e_i d_i} > 0 \), and \( EC_{e_i d_i} > 0 \). Since the demand function is concave with respect to \( r_i \), and the enforcement cost is convex with respect to \( e_i \), there is an optimal solution for \( e_i \) and \( r_i \).

The formal interest rate of moneylender’s fund is \( \rho = 1.1 \). Since lenders can see the borrowers' type, they offer a market interest rate for each one. First, I solve for the monopolistic interest and zero-profit rates for both lenders. Given the interest rate, I figure out the monopolistic region and the overlapping area, and I derive the market equilibrium interest rate.

(1) Market equilibrium interest rate for a high type

The first-order conditions for the monopoly interest rate for the high type are 
\[
\begin{align*}
0.15r_i^* - \frac{2}{d_i} r_i^*^3 &- 30(1 - d_i)r_i^*^2 + \left(22 + \frac{5}{d_i}\right)r_i^* + 100(1 - d_i) = 0.
\end{align*}
\]

Given the above equations, I calculate the monopolistic interest rate and the zero-profit interest rate for both types of the lenders in 9 locations (d= 0.1, 0.2, … ,0.9). Table 2.3 lists the interest rates for 9 locations. And Figure 2.2 demonstrates the monopolistic interest rate in the solid line and the zero-profit interest rate in the dashed line for ML1 (the blue color) and ML2 (the red color).

The monopolistic interest rate increases with distance. After the distance \( > 0.6 \), the moneylenders' profits are negative. So, the first three borrowers in \( d_i \leq 0.3 \) receive a monopolistic interest rate from ML1. And, last three borrowers after \( d_i \geq 0.7 \), receive a monopolistic rate from ML2. Two moneylenders compete in \( 0.4 \leq d_i \leq 0.6 \). A borrower in \( d_i = 0.4 \) is offered the monopolistic rate still, because ML2 cannot provide a cheaper loan than ML1. At \( d_i = 0.5 \), the interest rate is at the zero-profit level.
The market interest rate for the high type is in the last row of Table 2.3 and in dots in Figure 2.2. The interest rate shaded by blue in Table 2.3 is the interest rate offered by ML1. The red shade presents ML2, and the purple means both lenders. Now, the high type borrowers receive a 300% return with 100% probability, so all high type borrowers can make a positive return with the offered interest rate, i.e. the borrower’s participation constraint is not binding.

Table 2.3 Interest Rates for High Type

<table>
<thead>
<tr>
<th>Distance from ML1</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monopoly rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML1</td>
<td>2.09</td>
<td>2.19</td>
<td>2.29</td>
<td>2.40</td>
<td>2.6</td>
<td>2.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML2</td>
<td>2.82</td>
<td>2.6</td>
<td>2.40</td>
<td>2.29</td>
<td>2.19</td>
<td>2.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero-Profit rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML1</td>
<td>1.10</td>
<td>1.19</td>
<td>1.39</td>
<td>1.63</td>
<td>1.963</td>
<td>2.51</td>
<td>3.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML2</td>
<td>3.16</td>
<td>2.51</td>
<td>1.963</td>
<td>1.63</td>
<td>1.39</td>
<td>1.19</td>
<td>1.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equilibrium Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.09</td>
<td>2.19</td>
<td>2.29</td>
<td>2.40</td>
<td>2.40</td>
<td>2.29</td>
<td>2.19</td>
<td>2.09</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* the blue cells is ML1’s interest rate, the red cells represent ML2, purple show both MLs.

Figure 2.2 MLs’ Interest Rate for High Type

Note. Dark blue dots = the market interest rate in a contestable market with two MLs.

Blue (Red) line = ML1 (2)’s monopolistic interest rate
Blue (Red) dashed line = ML1 (2)’s zero-profit line.

(2) Market equilibrium interest rate for a low type
The first-order conditions for the low type are, $e_i^* = 0.6(100r_i^* - 10r_i^{*3}) / (2000d_i)$ and $0.6(100 - 30r_i^{*2})(1 - d_i + e_i^*) + 22r_i^* = 0$. Similar to the way we solved the interest rate for the high type in (1), we calculate the monopolistic and zero-profit interest rates for 9 locations (Table 2.4, Figure 2.3). The people far away from both lenders, who are in the middle area of the segment, are excluded from the credit transactions.

Low type borrowers earn a 300% return with 60% probability, and the borrowers do not need to repay when their project fails. Thus, the borrower’s participation constraint is $r=3$. The borrowers' participation constraint is binding in $d=0.4$, so the moneylenders provide an interest rate of 3 for the borrowers.

Table 2.4 Interest Rate for Low Type

<table>
<thead>
<tr>
<th>Distance from ML1</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monopoly rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML1</td>
<td>2.40</td>
<td>2.60</td>
<td>2.80</td>
<td>3.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.08</td>
<td>2.80</td>
<td>2.60</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>Zero-Profit rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML1</td>
<td>1.70</td>
<td>2.06</td>
<td>2.45</td>
<td>3.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.00</td>
<td>2.45</td>
<td>2.06</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>Equilibrium Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML1</td>
<td>2.40</td>
<td>2.60</td>
<td>2.80</td>
<td>3.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.00</td>
<td>2.80</td>
<td>2.60</td>
<td>2.40</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* the blue cells is ML1’s interest rate, the red cells represent ML2.

Figure 2.3 ML’s Interest Rate for Low Type

MLs Interest Rate for Low Type
Note. Dark blue dots = the market interest rate in a contestable market with two MLs.
Blue (Red) line = ML1 (2)’s monopolistic interest rate
Blue (Red) dashed line = ML1 (2)’s zero-profit line.

In the numerical example, we demonstrate that low-type borrowers who live far away are excluded from the informal credit market. Regarding high-type borrowers, a person who lives at an equal distance from both moneylenders may enjoy a lower interest rate due to competition between two moneylenders. However, nearby borrowers tend to be stuck in monopolized markets and thus receive higher interest rates, because of the entrance barrier generated from the high enforcement costs, or the low probability of repayments. To conclude, this example shows that social ties make segmentations between each of the lenders in informal credit market.

2.4 Model with MFI

This section adds an MFI into the model of the informal credit market with the two moneylenders from the last section in order to analyze how the entrant of the MFI changes the rural credit market where informal moneylenders dominate. I also discuss the impact of subsidies on an MFI by comparing the welfare changes of the entire rural credit market from the entrant of a non-subsidized MFI and the entrant of a subsidized MFI. I demonstrate how the welfare changes with various levels of subsidies.

A distinguished characteristic of an MFI is the reduction of transaction costs with its lending mechanisms, and as a consequence, it can operate apart from personal ties. I model an MFI by incorporating these aspects, and I show that an MFI can break market segmentation, enhance competition, and provide downward pressure on the interest rate in the rural credit market.

I also show how moneylenders, who can screen for their borrowers’ types, pick high type borrowers, and MFIs end up lending to low type borrowers and some high type borrowers who live in a long distance away from the moneylenders. Finally, the welfare analysis of various levels of subsidies to MFIs show that even a non-subsidized, for-profit MFI plays a critical role in improving financial inclusion, and also has a positive impact on the rural credit market by enhancing competition between the moneylenders.
2.4.1 Model Framework

Two moneylenders and one MFI are the lenders in this model. This model adopts the same framework for the moneylenders as in the previous model in Section 2.3. In the last model, two moneylenders are on the edge of a social distance line. And moneylenders can see the type of borrowers, but they cannot see the outcome of the project. So, they have to expend energy on an enforcement effort. Since the enforcement is costly to the borrowers that live far away, there is a natural segmentation in the market between the lenders.

I now add an MFI into the model. Firstly, the MFI is not located on the social distance line of the borrowers and MLs. I assume that an MFI come from outside of the village community, and allows borrowers to form groups by themselves and to apply for loans, which enables the MFI to operate outside of personal ties of borrowers. In this way, the MFI conveys the cost of enforcement and monitoring to group members, and successfully achieves a high repayment rate without a high enforcement cost for the MFI. As such, an MFI expands outside of social ties, and includes people that have been excluded from the informal credit market.

Secondly, I assume a for-profit MFI that maximizes its profit instead of maximizing the number of borrowers as a non-profit MFI does. This result, which I derived from this assumption, will contribute to a discussion on the role of for-profit MFIs, which is controversial regarding the trade-off between outreach and financial sustainability.

Finally, I demonstrate cases of various degrees of subsidies for the administrative costs of microfinance lending, and the results from the numerical examples enable a comparison of the impact on the interest rate, outreach, and social welfare of the rural credit market through the various degree of subsidies to the MFIs. To the best of my knowledge, this work will be the first to show how to evaluate the impact of MFI subsidies in the rural credit market, and it will shed light on further discussions for the impact evaluation of subsidies to MFIs.

2.4.2 Model

---

Administrative costs include salaries, rent, utilities, travel and transportation, office supplies, etc. Other costs are the cost of the funds that the MFI borrows and the costs from loan losses. (Joanna Ledgerwood 2002).
2.4.2.1 Assumptions

The assumptions about borrowers and moneylenders are similar to the last section.

MFIs

In contrast to the moneylenders, I assume that an MFI can collect repayments without enforcement activities, while the MFI cannot see the types of borrowers\textsuperscript{10}. Commonly, an MFI uses the group lending mechanism\textsuperscript{11}. It requires potential borrowers to form a group, and they must attend weekly group meetings\textsuperscript{12}. Because of the information advantage with the same villagers, group members can monitor the outcome and enforce repayment easily. Therefore, the MFI conveys the enforcement activities to the borrowers through the group lending mechanism\textsuperscript{13}. On the other hand, the MFI cannot see the types of borrowers since the MFI itself is not close to the borrowers. I assume that the MFI knows only the distribution of high and low type borrowers. Moreover, I assume that the MFI cannot see the offer by the moneylenders which easily permits the MFI to guess what type the lenders are. For that reason, an MFI offers the same interest rate for both types of borrowers.

MFIs take advantage of subsidies from a variety of sources, such as governments, international donors, NGOs, and social investors. In this paper, I compare the welfare impact via varied degree of subsidies. In general, subsidies to MFIs take the forms of either a direct payment of the administrative costs or lower costs for funding from the donors than the market interest rates (Armendariz de Aghion and Morduch 2005). In this model, I assume that there are subsidies for the MFI’s administrative costs, which include expenses for salaries, rent, utilities, travel and transportation, office supplies, etc, and in the numerical example, I demonstrate the welfare changes in the rural credit market

\textsuperscript{10} Bryan and Zinman’s (2014) field experiment on consumer credit supported these assumptions. They estimated the peer effects on loan repayment, and they found no evidence for screening types, but they found large effects on enforcement from peers.

\textsuperscript{11} Recent literatures (Ahlin and Townsend 2007, Gine et. al. 2006) consider dynamic incentive as a key mechanism for the high repayment rate. Yet, this model is only for one-time loans. So I focus exclusively on the group lending aspect of the mechanism.

\textsuperscript{12} I did not assume group liability in this model, because to set up this type of cooperation with the group requires a more detailed borrower’s problem. Nevertheless, this set up is still reasonable, because many MFIs, such as Grameen bank’s new policy, Grameen 2, initiated the removal of group liability from their group lending mechanism.

\textsuperscript{13} Yet, it is still possible to think theoretically that a group itself can take the money and run. However, this kind of strategic default by a group has not been reported, which Banerjee and Duflo 2010 mention as a puzzling aspect.
according to varied levels of subsidies. Regarding the costs of funding, same as moneylenders, the MFI has access to unlimited amounts of funds from the government banks with the market interest rate of, $\rho$.

2.4.2.2 Equilibrium

I assume a for-profit MFI that maximizes its own profit. When I assume no strategic interaction between an entrant MFI and the existing moneylenders, at the equilibrium, the MFI offers the monopoly interest rate and borrowers just take the cheapest loan compared to the existing moneylenders. In this case, an MFI maximizes the expected profit as below, subject to the MFI’s participation constraint as in the first condition and the borrowers’ participation constraint as in the second condition. Since I assume that an MFI neither tells the type of borrowers, nor relies on social ties, the MFI provides uniform interest rates to the whole market.

$$\max_{r_{MFI}} r_{MFI}X(r_{MFI}) \cdot p(\theta_{MFI}) - \rho X(r_{MFI}) - AC$$

s.t. $r_{MFI}X(r_{MFI}) \cdot p(\theta_{MFI}) - \rho X(r_{MFI}) - AC \geq 0$

$p^\theta \left(R(X(r_{MFI})) - r_{MFI}X(r_{MFI})\right) \geq 0, \ \theta = h, l$

The MFI does not screen each type of borrower, but it knows the distribution of both types and the probability of success for each type. So, $p(\theta_{MFI})$ is the expected probability of a borrower’s success. $\theta_{MFI}$ is the share of high type borrowers who request loans from the MFI. Then, $p(\theta_{MFI}) = \theta_{MFI}p^h + (1 - \theta_{MFI})p^l$, where $p^h$ and $p^l$ are probabilities of success for high and low types respectively. $AC$ is the administrative cost which is uniform across the borrowers. To hold a maximum solution for $r_{MFI}$, the demand function should be twice differentiable and concave with respect to $r_{MFI}$, ($X' < 0 \ and \ X'' < 0$).

It should be noted that the composition of the type of borrowers who receive loans from the MFI, $\theta$, varies depending on the moneylenders’ interest rates. And the moneylenders’ interest rates are lower for the high types than for the low types who stay at the same social distance. Therefore, as the MFI increases its interest rates, the high type borrowers begin to switch back to the moneylenders, and the share of the high type borrowers falls, which pushes down the expected probability of a borrower’s success, $p(\theta_{MFI})$.  

28
In order to find a stable rate for the borrowers’ composition, I assume that the MFI first starts with guesses regarding the tentative composition rate equal to the composition of the total population in the model, \( \theta = 1/2 \), and I calculate the interest rate and the numbers of each type of borrower who chooses the MFI. And in the second round, the MFI modifies the guess equal to the realized composition from the first guess, and recalculates the numbers of each type of borrower who receives loans from the MFI. In this way, the MFI keeps modifying its guesses on the composition rate until the realized rate equals the guess. The composition rate derived from this process is the stable rate of the borrowers’ composition who receive credits from the MFI.

In this manner, the MFI solves for the monopoly interest rate. As shown in APPENDIX B, the moneylender’s monopoly rate may be lower than the MFI’s monopoly interest rate for nearby borrowers, and the MFI’s rate may be lower for the far away borrowers.

Next, if there are strategic interactions between the moneylenders and the MFI, at the market equilibrium, a lender charges an interest rate that is a little lower than the opponent’s break-even interest rate, but it’s still profitable. Thus far, when ML1 (ML2)’s zero-profit interest rate is lower than the MFI’s zero-profit rate, at the market equilibrium, ML 1 (ML2) charges the interest rate slightly lower than the MFI’s zero-profit rate. Furthermore, when an MFI’s zero-profit interest rate is lower than the one of ML1 (ML2), the MFI charges the interest rate slightly lower than the ML1 (ML2)’s zero-profit rate. The MFI’s zero-profit interest rate is derived from the following equation:

\[
\hat{r} X \theta - \rho X (\hat{r}) - AC = 0.
\]

Same with the above MFI’s maximization problem, the MFI finds the stable composition of the types of the borrowers, \( \theta_{MFI} \), by making a guess.

### 2.4.3 Numerical Example with an MFI

Following the numerical example of the previous section, 2.3.3, I add an MFI in the example. First, I assume an entrant of a non-subsidized MFI and examine how the market interest rate changes, and how much it impacts on social welfare. Second, I assume a subsidized MFI and demonstrate how the market equilibrium and social welfare changes.

All assumptions are the same as the last section. Every borrower has the same demand function \( D(r) = 100 - 10r^2 \) toward all of the lender types. Here, \( r = 1+ \{ \text{the interest rate charged} \} \). Borrowers have a project with a 300% return. There are two types of borrowers: a high type that always succeeds, and a low type that succeeds 60% of the
time. The both types are in 9 locations in \( d_i \in [0.1, 0.9] \). Thus, there are 18 borrowers in total, and the share of the high type borrowers, \( \theta \), is \( \frac{1}{2} \). Two moneylenders and one MFI exist in this market. The MFI cannot see the type, also it cannot use a offer by moneylenders as a signal for the type. The cost of fund is equal to the formal interest rate, which is \( \rho = 1.1 \). The administrative cost (AC) is the subject of a subsidy in this example. And without a subsidy, AC=15. In the later discussion, I compare cases of various levels of subsidy (s), a 1/3 subsidized MFI (AC-s=10), a 2/3 subsidized MFI (AC-s=5), a full-subsidized MFI (AC-s=0), a 4/3 subsidized MFI (AC-s=-5), a 5/3 subsidized MFI (AC-s=-10), a 200% subsidized MFI (AC-s=-15), and 7/3 subsidized MFI (AC-s=-20). Theoretically, the MFI can be subsidized more than the AC. With this example, I will demonstrate the level of subsidy at which social welfare starts to decrease.

(1) A Non-subsidized MFI

This section analyzes the MFI’s interest rate when the MFI pays the full administrative expense: AC=15. First, I show a case where there is no strategic interaction between the MFI and moneylenders. In this case, the MFI offers its monopolistic interest rate. Second, I allow for strategic interactions between the moneylenders and the MFI. In this case, the MFI charges an interest rate that is slightly lower than the opponent’s zero-profit interest rate but still profitable for the MFI.

As I assumed, the MFI does not screen the types of borrowers, but they know the distribution of types. Thus, the MFI’s interest rate varies by the composition of borrower types who loan from the MFI. The borrower composition for the MFI is derived as follows. First, the MFI assumes its borrower composition equal to the distribution of the types in the entire community, \( \theta_{MFI}^1 = 1/2 \), and derives the tentative interest rate and the number of each type of borrower under the rate. From the first estimate, the tentative interest rate is \( r_{MFI}^{m1} = 2.34 \) with 2 high types and 9 low types. Thus, the share of the high-type borrower is 18%. In the second round, the MFI adjusts its estimate to \( \theta_{MFI}^2 = 0.18 \). Under the second estimate, the interest rate is \( r_{MFI}^{m2} = 2.45 \) with 0 high types and 7 low types. Therefore, the share of high types is 0%. For the third round, the MFI modifies its estimate to \( \theta_{MFI}^3 = 0 \). The market interest rate is \( r_{MFI}^{m3} = 2.54 \) with 0 high-type borrowers and 5 low-type borrowers. Here, borrower composition matches the previous estimate. Therefore, MFI’s monopoly interest rate is \( r_{MFI}^m = 2.54 \). Furthermore, following the same steps of estimation and modifying the borrower composition, the zero-profit interest rate is \( r_{MFI}^0 = 2.5 \) with 3 low types.
Figure 2.4 Market Equilibrium Interest Rates after Entrance of an MFI without Subsidy

Note. Light Blue dots = the market interest rate in a contestable market with two MLs without an MFI.
Green line = MFI’s monopolistic interest rate.
Green dashed line = MFI’s zero-profit interest rate.
Blue (Red) line = ML1 (2)’s monopolistic interest rate.
Blue (Red) dashed line = ML1 (2)’s zero-profit line.

Figure 2.4 displays the MFI’s monopolistic interest rate (green line) and the MFI’s zero-profit interest rate (green dashed line) for the high types in the left figure and for the low-type borrowers in the right figure. Blue dots represent the market interest rate in the previous example with only two moneylenders. By comparing the original equilibrium in blue dots and the MFI’s monopoly rate, the chart shows that the low-type borrowers, except those who live near the moneylenders, have incentive to take out loans from the MFI. On the other hand, none of the high-type borrowers have incentive to move to the MFI.

Once the strategic interaction between moneylenders and the MFI starts, moneylenders will reduce their interest rates, which will result in a price competition for the entire market area. For the high-type borrowers, the MFI’s zero-profit interest rate is far above the moneylender’s competitive rate. Therefore, the equilibrium interest rate does not change even after the entrance and interaction between lenders. For the low-type
borrowers, the moneylenders serve the borrowers that live close to them, and the MFI serves the borrowers who live far away from both moneylenders. The green dot in Figure 2.4 depicts the interest rate after the interaction between moneylenders and the MFI.

Table 2.5 summarizes the market interest rates and type of lender for each villager prior to the entrance of an MFI and after competition between moneylenders and an MFI with various amounts of subsidy. The interest rate shaded by green in Table 2.5 is the interest rate offered by MFI. The blue shade represents ML1. The red shade represents ML2, and the purple means both moneylenders.

In the numerical example involving overlapping moneylenders without an MFI, the moneylenders’ interest rate is non-monotonic. First, the moneylenders charge monopolistic interest rates to borrowers within certain proximity and these rates increase with distance. And then, the interest rates decrease in overlapping areas due to competition. Moneylenders also exclude some low-type borrowers at a distance.

When an MFI without any subsidy enters a market, the moneylender’s interest rate for high-type borrowers does not change because its rate falls below the MFI’s break-even interest rate. However, when an MFI’s administrative cost is subsidized, its break-even rate decreases, meaning that the moneylender’s interest rate decreases as well—namely, to one slightly lower than the MFI’s zero-profit level. As the amount of the subsidy increases, the moneylender’s rate drops even further. Meanwhile, since the MFI's break-even interest rate becomes lower than the moneylender’s zero-profit rate, the MFI begins to lend to high borrowers. Eventually, in the case of a 200% subsidized administrative cost, the MFI serves all high-type borrowers.

For low-type borrowers, when an MFI without any subsidy enters a market, the MFI lends to distant borrowers at a monopolistic interest rate. At the same time, moneylenders decrease the rate for the nearest borrowers to a level slightly lower than the MFI’s zero-profit interest rate. When an MFI becomes subsidized, MFI’s zero-profit rate dips below the moneylender’s rate, inciting the MFI to start providing loans to the nearest borrowers as well. In time, all low-type borrowers receive loans from the MFI at a 100% subsidy. Moreover, despite the MFI's being subsidized, the MFI’s interest rate to distant low-type borrowers maintains the monopolistic rate.

Table 2.5 Market Equilibrium Interest Rate with Varied Levels of Subsidy

| a: High Type |
Note. The rate in this table is \(1 + \text{Interest Rate}\).

The green cells represent MFI, the blue cells represent ML1’s interest rate, the red cells represent ML2, and the purple cells show both MLs.

(2) A subsidized MFI

Next, I discuss a case in which a government subsidizes MFI’s administrative cost (AC) in various levels, demonstrating the effect of subsidy on the market equilibrium interest rate and the social welfare. Theoretically, a government can subsidize above the cost of AC. In this example, I demonstrate the impact on social welfare by gradually increasing the level of subsidy. I display seven cases of subsidy: a 1/3 subsidized MFI (AC+s=10), a 2/3 subsidized MFI (AC+s=5), a 100% subsidized MFI (AC+s=0), a 4/3 subsidized MFI (AC+s=-5), a 5/3 subsidized MFI (AC+s=-10), a 200% subsidized MFI (AC+s=-15), and a 7/3 subsidized MFI (AC+s=-20). The MFI’s zero-profit interest rates and the number of
borrowers are derived in the same manner of the above discussion. Table 2.5 summarizes the equilibrium interest rates and the type of lender for each villager under various degrees of subsidy.

The 1/3 subsidized MFI expands its operation against the low types, and it also serves one high-type borrower at the midpoint. In addition, the interest rate for the high types drops from the monopoly rate. The interest rate for the high types decreases further as the amount of subsidies increases. Yet the interest rate against the low types rarely changes from the 1/3 subsidy due to the high interest rate of moneylenders. When full administrative cost is subsidized, MFI increases its clients, all low-type borrowers, and three high-type borrowers at the midpoints. The number of high type borrowers gradually increases as the subsidy expands, and at the 7/3 subsidy, all high-type and low-type borrowers switch to the MFI.

The first finding from this exercise is that for the case of the high-type borrower, the subsidy to the MFI promotes price competition against moneylenders and decreases the interest rate significantly. Thus the subsidy to the MFI creates price competition against the high-type borrowers. Additionally, a small amount of subsidy to the MFI can rapidly increases micro loans among the low-type borrowers, given the very high interest rate of the moneylenders. However, the interest rate for low-type borrowers is not dramatically influenced by the subsidy.

(3) Welfare Analysis with Numerical Example

Table 2.6 summarizes the changes of coverage between borrowers, consumers’ surplus, producers’ surplus, and social welfare before and after the introduction of the MFI. Further, I discuss different levels of subsidy to the MFI.

First of all, the example shows that even the non-subsidized MFI can increase borrower outreach. On entrance of the nonsubsidized MFI, the low-type borrowers, who have been

\[\text{At 1/3 subsidy, } r_{\text{MFI}}^c = 1.94 \text{ with 1 high type and 7 low types. At 2/3 subsidy, } r_{\text{MFI}}^c = 1.81 \text{ with 1 high type and 7 low types. At full subsidy, } r_{\text{MFI}}^c = 1.57 \text{ with 3 high types and 9 low types. At 4/3 subsidy, } r_{\text{MFI}}^c = 1.48 \text{ with 3 high types and 9 low types. At 5/3 subsidy, } r_{\text{MFI}}^c = 1.32 \text{ with 5 high types and 9 low types. At 200\% subsidy, } r_{\text{MFI}}^c = 1.24 \text{ with 5 high types and 9 low types. At 7/3 subsidy, } r_{\text{MFI}}^c = 1.09 \text{ with 9 high types and 9 low types.} \]

In this paper, I omit the borrower’s cost of monitoring under MFI lending mechanisms.
previously excluded, start receiving loans. Additionally, consumers’ surplus and social welfare slightly increase.

Second, the surplus of high-type borrowers significantly increases with the introduction of the subsidy, because severe competition between the subsidized MFI and moneylenders significantly decreases the interest rate. On the other hand, the surplus of low-type borrowers stays almost constant as the amount of subsidy increases, because moneylenders’ break-even interest rate for low-type borrowers is so high that the MFI can fix their interest rate very high as well.

Third, as subsidy increases, eventually the subsidy reaches a point where the moneylender cannot afford to offer loans, which means that all borrowers loan from the MFIs. Thus, MFI’s surplus increases but the moneylenders’ surplus decreases. As for social welfare, which is total surplus minus cost of subsidy, increased subsidy increases social welfare up to the level of 200% subsidy, after which it starts decreasing. Therefore, in this simple calculation, the socially optimal size of subsidy is 200% of administrative cost. Consequentially, up to 200% of subsidy, MFI’s producer surplus is bigger than the cost of subsidy, which means that the MFI can pay back the subsidy from their surplus and the total welfare is greater under subsidy.

Overall, the subsidy to the MFI is justified from the view that it breaks the monopolistic interest rate of moneylenders and increases the competition against the high-type borrowers in a rural credit market. Moreover, even without the subsidy, the MFIs can expand access to credit for the low-type borrowers, who are formally excluded from ML’s market.
Table 2.6 Social Welfare before and after MFI’s Entrance

<table>
<thead>
<tr>
<th>Number of borrowers</th>
<th>MFI</th>
<th>MLs</th>
<th>High Type</th>
<th>Low Type</th>
<th>MLs</th>
<th>High Type</th>
<th>Low Type</th>
<th>MLs</th>
<th>High Type</th>
<th>Low Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition w/ MFI</td>
<td>w/o MFI</td>
<td>Zero-subsidy</td>
<td>1/3subsidy</td>
<td>2/3subsidy</td>
<td>100% subsidy</td>
<td>4/3subsidy</td>
<td>5/3subsidy</td>
<td>200% subsidy</td>
<td>7/3subsidy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AC=15</td>
<td>AC+s=10</td>
<td>AC+s=5</td>
<td>AC+s=0</td>
<td>AC+s=-5</td>
<td>AC+s=-10</td>
<td>AC+s=-15</td>
<td>AC+s=-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer's Surplus (CS)</td>
<td>High Type</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Low Type</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Producer's Surplus (PS)</td>
<td>MLs</td>
<td>264</td>
<td>264</td>
<td>202</td>
<td>217</td>
<td>217</td>
<td>233</td>
<td>233</td>
<td>233</td>
<td>233</td>
</tr>
<tr>
<td></td>
<td>a MFI</td>
<td>-</td>
<td>0</td>
<td>64</td>
<td>104</td>
<td>104</td>
<td>270</td>
<td>396</td>
<td>466</td>
<td>563</td>
</tr>
<tr>
<td>Sum of CS + PS</td>
<td>718</td>
<td>730</td>
<td>1060</td>
<td>1180</td>
<td>1266</td>
<td>1554</td>
<td>1752</td>
<td>1839</td>
<td>1967</td>
<td></td>
</tr>
<tr>
<td>Total Cost of Subsidy</td>
<td>-</td>
<td>0</td>
<td>40</td>
<td>80</td>
<td>180</td>
<td>240</td>
<td>350</td>
<td>420</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>Total Surplus - Cost of Subsidy (Social Welfare)</td>
<td>718</td>
<td>730</td>
<td>1020</td>
<td>1100</td>
<td>1086</td>
<td>1314</td>
<td>1402</td>
<td>1419</td>
<td>1337</td>
<td></td>
</tr>
</tbody>
</table>

Note. AC=Administrative Cost, s=Subsidy

2.5 Conclusions and the Direction of Future Research

This paper examines how an MFI’s entrance into an informal credit market of monopolistically competitive moneylenders changes informal lenders’ outreach of credit access and market interest rates. I construct a theoretical framework to which I apply a numerical example in order to compare interest rates, coverage, and social welfare for a market with and without a subsidized MFI and a non-subsidized MFI. I first establish a sorting model\(^\text{16}\) with moneylenders and borrowers, to which I add an MFI with varied levels of subsidy.

This paper assumes that two types of borrowers exist: one with high human capital, the other with low human capital. Moreover, they are distributed spatially by social distance from moneylenders, which affects moneylenders’ costs of collecting loans and borrowers’ probability of strategic default. Though moneylenders can learn the type, it can be costly

\(^{16}\) Though this model may be called a matching model, this paper uses the term sorting (Udry and Conning 2005) to demonstrate the systematic sorting of borrowers across different financial institutions, according to borrowers’ characteristics.
to collect money from borrowers. In contrast, an MFI does not know borrower type, but can collect repayment without any costs.

Under this assumption, I find a solution for the explicit rules of segmentation between informal lenders. In the numerical example involving overlapping moneylenders without an MFI, the moneylenders’ interest rate is non-monotonic. First, the moneylenders charge monopolistic interest rates to borrowers within certain proximity and these rates increase with distance. And then, the interest rates decrease in overlapping areas due to competition. Moneylenders also exclude low-type borrowers at a distance.

When an MFI without any subsidy enters a market, the moneylender’s interest rate for high-type borrowers does not change because its rate is far below the MFI’s break-even interest rate. However, when an MFI’s administrative cost is subsidized, MFI’s break-even rate decreases, meaning that the moneylender’s interest rate decreases as well. As the amount of the subsidy to an MFI increases, the moneylender’s rate drops even further.

For low-type borrowers, entrance of an MFI without subsidy lends to distant borrowers at a monopolistic interest rate. At the same time, moneylenders decrease the interest rate for the nearest borrowers. When an MFI becomes subsidized, an MFI starts providing loans to the nearest borrowers as well. Moreover, despite the MFI being subsidized, the MFI’s interest rate to distant low-type borrowers maintains the monopolistic rate.

This numerical example shows that an MFI’s entrance into a rural credit market affects interest rates and coverage for borrowers in several ways. Firstly, distant, low-type borrowers who were previously excluded from the moneylender credit market receive access to credit from the MFI even without a subsidy. High-type borrowers benefit from reduced interest rates due to increased competition between the MFI and moneylenders. The larger the subsidy to the MFI, the lower the interest rates, which increases the surplus of high-type borrowers.

Compared according to social welfare, an MFI’s entrance enhances borrowers’ surplus, since more low-type borrowers have access to credit after the entrance of an MFI—even non-subsidized ones. A subsidized MFI intensifies the competitive environment and reduces interest rates for high-type clients, which consequently increases the surplus of high-type borrowers dramatically. Due to the loss of monopolistic profit, moneylenders’ surplus lessens. Yet, a large increase in the welfare of borrowers more than offsets the
loss of the lenders’ welfare. A comparison of different levels of subsidy reveals that the socially optimal size of subsidy is 200% of administrative cost.

This model is based on strong assumptions and has several limitations. It excludes the fact that participation in an MFI requires substantial transaction costs for borrowers, including those for monitoring, screening, and managing group members. If these costs are too taxing to borrowers, then more of them will remain with their moneylenders. Therefore, a subsidy to the MFI will produce lower social welfare than the costs of subsidy.

Secondly, I can extend this model to incorporate any externality effect from competition between lenders in the informal credit market. As in Hoff and Stiglitz’s model, if an increased number of available lenders weakens people’s incentive to repay, the enforcement costs of and probability for strategic defaults are higher. Under these settings, higher competition will deteriorate MFIs’ loan portfolio, therefore MFI’s interest rates should be higher, and the outreach of MFIs should shrink. This extension of the model will contribute to the growing discussion about MFI competition and its loan portfolio—topics that my next chapter will empirically discuss.

This model also omits MFI’s effort to collect loans and screen borrowers. In reality, MFIs also pay their effort on screening and enforcement, for example, by holding a weekly meeting in a village. In this setting, as subsidy to the MFI increases, MFI will input less effort in enforcement and screening. As such, the optimal level of subsidy will be smaller than the current result due to a moral hazard for the MFI.

Lastly, in this model, the loan contract contains interest rates only. Yet, it could be extended to a set including both interest rates and loan sizes. Under this new model construction, an MFI hiding its borrowers’ types would offer its contract menu of interest rates and loan sizes and, in turn, could screen borrowers by contract type. For example, high-type borrowers would choose higher interest rates and larger loans, while low-type borrowers would choose lower interest rates and smaller loans at a separating equilibrium. These settings would reduce the MFI’s loss due to its inability to observe borrower type. As such, social welfare would increase.

To conclude, this paper shows that, even without a subsidy, an MFI can still improve the welfare of the poor previously excluded from credit access. This result clarifies that, even for-profit MFIs without any subsidy can increase outreach and induce competition in the
rural credit market, which adds another angle to the controversy of for-profit MFIs, such as Compartamos in Mexico or BRI in Indonesia. Moreover, the model shows that subsidies to an MFI creates higher competition in the rural credit market and increase the surplus of high-type borrowers. Altogether, this simple model provides the first step for an analysis of an MFI's entrance from the perspective of the informal credit market.
Appendix 2A

From FOC,
ri: $F^1(r_i,e_i,d_i) = X(r_i) \cdot P(e_i,d_i) + r_iX'(r_i) \cdot P(e_i,d_i) - \rho X'(r_i) = 0$, \hspace{1cm} (A1)
iei: $F^2(r_i,e_i,d_i) = r_iX(r_i) \cdot P_{e_i}(e_i,d_i) - EC_{e_i}(e_i,d_i) = 0$, \hspace{1cm} (A2)

Totally differentiate (A1) and (A2),
d$F^1 = F^1_rdr_i + F^1_edie_i + F^1_ddi$
d$F^2 = F^2_rdr_i + F^2_edie_i + F^2_ddi$

Express in a matrix form, given $dF^1 = 0$ and $dF^2 = 0$,
\[
\begin{pmatrix}
F^1_{ri} \\
F^2_{ri}
\end{pmatrix}
\begin{pmatrix}
\frac{dr_i}{d_i} \\
\frac{de_i}{d_i} \\
\frac{dd_i}{d_i}
\end{pmatrix} = 0
\]
\hspace{1cm} (A3)

(A3) can be rewritten as follows,
\[
\begin{pmatrix}
F^1_{ri} \\
F^2_{ri}
\end{pmatrix}
\begin{pmatrix}
\frac{dr_i}{dd_i} \\
\frac{de_i}{dd_i} \\
\frac{dd_i}{dd_i}
\end{pmatrix} = - \begin{pmatrix}
F^1_{ri} \\
F^2_{ri}
\end{pmatrix}
\]
\[
|A| = \begin{vmatrix}
F^1_{ri} & F^1_{ei} \\
F^2_{ri} & F^2_{ei}
\end{vmatrix} = F^1_{ri}F^2_{ei} - F^1_{ei}F^2_{ri} = (2X'P + (r_iP - \rho)X')r_iXP_{e_i} - EC_{e_i} - (X + r_iX')^2e_i < 0,
\]
\hspace{1cm} (\because the concavity assumption of the objective function, see footnote 6)
\[
|B| = \begin{vmatrix}
F^1_{di} & F^1_{ei} \\
F^2_{di} & F^2_{ei}
\end{vmatrix} = -F^1_{di}F^2_{ei} + F^1_{ei}F^2_{di} = - (X + r_iX')(P_{e_i}(r_iXP_{e_i} - EC_{e_i}) - P_{e_i}(r_iXP_{e_id_i} - EC_{e_id_i})) > 0
\]
\hspace{1cm} (\because (X + r_iX') < 0^{17}, P_{e_i} > 0, P_{di} < 0, P_{e_id_i} < 0, P_{e_id_i} < 0, EC_{e_id_i} > 0, EC_{e_id_i} > 0 )

\[
^{17} \text{The sign of } X + r_iX' \text{ relates to the price elasticity of the loan demand. Let } \varepsilon_i \text{ be the elasticity of demand, where } \varepsilon_i = \frac{r_iX'}{X} = \frac{r_i}{\frac{dr_i}{dr_i}}. \text{ Since the loan demand is elastic in monopoly, } -\varepsilon_i > 1, \text{ thus } (X + r_iX') < 0.
\]
$$|C| = \begin{bmatrix} F^2_{r_l} & -F^2_{d_l} \\ F^2_{r_l} & -F^2_{d_l} \end{bmatrix} = -F^2_{d_l} F^1_{r_l} + F^1_{d_l} F^2_{r_l} = -\left(2X'P + (r_i P - \rho)X''\right)\left(r_i X P_{e, d_i} - E C_{e, d_i}\right) + \left(X + r_i X\right)^2 P_{e, d_i} > 0$$

$$\therefore \begin{cases} \frac{dr_i}{dd_i} = \frac{B}{|A|} > 0 \quad (A4) \\ \frac{de_i}{dd_i} = \frac{C}{|A|} < 0 \quad (A5) \end{cases}$$

(A3) can also be rewritten as follows,

$$\begin{bmatrix} F^1_{r_l} \\ F^2_{r_l} \end{bmatrix} \begin{bmatrix} \frac{dr_i}{de_i} \\ \frac{dd_i}{de_i} \end{bmatrix} = \begin{bmatrix} F^1_{e_i} \\ F^2_{e_i} \end{bmatrix}$$

$$|D| = \begin{bmatrix} F^1_{r_l} & F^1_{d_l} \\ F^2_{r_l} & F^2_{d_l} \end{bmatrix} = F^1_{r_l} F^1_{d_l} - F^1_{d_l} F^1_{r_l} = \left(2X'P + (r_i P - \rho)X''\right)\left(r_i X P_{e, d_i} - E C_{e, d_i}\right) - \left(X + r_i X\right)^2 P_{e, d_i} > 0$$

(\because \text{the concavity assumption of the objective function, see footnote 6})

$$|E| = \begin{bmatrix} -F^1_{e_i} & F^1_{d_i} \\ -F^2_{e_i} & F^2_{d_i} \end{bmatrix} = -F^1_{e_i} F^2_{d_i} + F^1_{d_i} F^2_{e_i} = (X + r_i X)\left\{-P_{e_i}\left(r_i X P_{e, d_i} - E C_{e, d_i}\right)\right\} + P_{d_i}\left(r_i X P_{e, d_i} - E C_{e, d_i}\right) < 0$$

(\because \left(X + r_i X\right) < 0, P_{e_i} > 0, P_{d_i} < 0, P_{e, d_i} < 0, P_{e, d_i} < 0, E C_{e, d_i} > 0, E C_{e, d_i} > 0)

$$\therefore \frac{dr_i}{dd_i} = \frac{D}{|D|} < 0 \quad (A6)$$

Appendix 2B

F.O.C.

$$r_{\text{MFI}}: \quad X (r_{\text{MFI}}) \cdot p(\theta_{\text{MFI}}) + r_{\text{MFI}}X (r_{\text{MFI}}) \cdot p(\theta_{\text{MFI}}) - \rho X'(r_{\text{MFI}}) = 0 \quad , \quad (A3)$$

From (A3), the MFI’s interest rate is

$$r_{\text{MFI}} = \frac{\rho}{p(\theta_{\text{MFI}})} \frac{X}{X'}$$

From (A1), the ML’s interest rate for a type $\theta$ is

$$r^0_{\text{ML}} = \frac{\rho}{p^0(\theta_{e, d_i})} \frac{X}{X'}$$
Therefore,
If $p^\theta P(e_i,d_i) > p(\theta_{MFI})$, then $r_{ML}^{\theta} < r_{MFI}$
If $p^\theta P(e_i,d_i) < p(\theta_{MFI})$, then $r_{ML}^{\theta} > r_{MFI}$

where $\theta = h, l$ and $p(\theta_{MFI}) = \theta_{MFI}p^h + (1 - \theta_{MFI})p^l$.

$p^\theta$ is the probability of project’s success by type $\theta$, and $P(e_i,d_i)$ is the money lender’s subjective probability of a non-strategic default. $p(\theta_{MFI})$ is the expected probability of success by a borrower who receives loans from the MFI.

First, if a borrower is the high type, and has a very close relationship with a moneylender, for the borrower, the moneylender’s interest rate will be lower than the MFI’s interest rate because the moneylender has an advantage in screening for high types, and provides a lower interest rate. In addition, for a borrower with close social distance, the enforcement costs and probability of strategic default are very low. By contrast, the MFI is incapable of screening for the borrowers’ types. Therefore, it can be written as follows: if $\theta = h$ and $d_i$ is close to zero, then $r_{ML}^h < r_{MFI}$. \( p^h P(e_i,0) > \theta_{MFI}p^h + (1 - \theta_{MFI})p^l = p(\theta_{MFI}) \). Because the probability of the project’s success is higher with a high type borrower, $p^h > p^l$. Plus, a borrower, who lives within a close distance to the moneylender, is less likely to default strategically. For example, a borrower who resides at zero distance from the moneylender, $d_i = 0$, will have a zero probability of strategic default, $P(e_i,d_i) = 1$. In this case, $p^h P(e_i,0) = p^h > \theta_{MFI}p^h + (1 - \theta_{MFI})p^l = p(\theta_{MFI})$, therefore $r_{ML}^h < r_{MFI}$.

By contrast, if a borrower is the low type and lives at zero distance from the moneylender, $d_i = 0$, the moneylender’s interest rate for the low type will be higher than the MFI’s interest rate, $r_{ML}^l > r_{MFI}$. \( p^h P(e_i,0) = p^h > \theta_{MFI}p^h + (1 - \theta_{MFI})p^l = p(\theta_{MFI}) \).

Furthermore, for the person who resides far away from the moneylender, the interest rates will be higher, $r_{ML}^0 > r_{MFI}$, the moneylender suffers from the high probability of strategic default.

To summarize the above, the moneylender’s monopoly rate may be lower than the MFI’s monopoly interest rate for the nearby high type borrower, and the MFI’s rate may be lower for the nearby low type and far away borrower.
Chapter 3 Competition and Microfinance: Interaction effects between MFIs and Banks

Abstract

This chapter estimates how many default risks in the microfinance sector can be explained to have resulted from within-sector competition and the sector’s competition with the formal banking sector. Since MFIs’ enforcement method renders them especially vulnerable to increased competition, I empirically examine competition–stability linkage with country-level data from 75 countries from 2000–2010. This study adds empirical evidence to the current dearth of literature addressing microfinance competition and stability.

Results show that the microfinance sector’s within-sector competition and competition with the formal banking sector negatively influence MFI portfolio risks, but it varies by countries’ income levels. In lower- and upper-middle–income countries, bank competition increases MFI portfolio risks, while there is no effect on MFI portfolio risks in low-income countries. MFI competition uniformly increases MFIs’ default risk across all income groups. Results from further investigation support that the greater negative impact of bank competition in upper-middle–income countries is that banks become more likely to compete directly with MFIs. By contrast, in LICs, bank competition does not affect MFI portfolio risks since banks and MFIs operate in a vertical relationship.

3.1 Introduction

Microcredit has long achieved a high repayment record, and this characterizes the success of MFIs compared to the former financial policies in developing countries. Given MFIs’ widely perceived success, their expansion has become central to many developing countries’ policies for reducing poverty and increasing people’s access to finances.
Moreover, because some private banks and investors regard microfinance to constitute profitable investment opportunities, the number of new entrants by pro-profit MFIs has risen (Cull et al. 2009)). As such, microcredit markets have become highly saturated and competitive in the last decade (World Bank 2012).

However, in recent years, when average MFI portfolio quality started to deteriorate worldwide, MFIs had to perform write-offs. The portion of portfolios at risk (e.g., with payments more than 30 days overdue) plateaued at approximately 2–3% in the early 2000s and has increased to 4–5% since 2007 (Deutsche Bank, 2012). And many countries have reported repayment crises.18,19 The recent trend of increasing risk has raised concerns that microfinance may not be robust in highly competitive environments. MFIs rely on specific lending methods such as progressive lending, which converts a small loan to larger loan given a good payment record. However, as more MFIs become available, borrowers become disincentivized to repay as a means to future access because they can borrow from other MFIs. Moreover, some borrowers fall into multiple debt (Chen, Rasmussen, & Reille 2010).

This chapter first examines how much portfolio risk in the microfinance sector can be influenced by competition within the sector. As I discuss in the following section, theoretical studies have shown that increased competition between MFIs can work either way: Higher competition can weaken enforcement mechanisms, which results in borrowers’ decreased repayment rates, while higher competition can reduce MFIs’ interest rates, which increases the borrower’s profit, reduces their risky investments, and raises their repayment rates. In this sense, the chapter assesses the relationship between competition and stability in the microfinance sector with cross-country data.

This chapter also seeks to identify the impact of the formal banking market’s competitiveness on MFI portfolio risks. Given the success of MFIs, formal banks have also begun to extend their services to previously unbanked people as a means to secure new customers. At the same time, to promote greater financial inclusion, governments have encouraged commercial banks to operate in previously isolated areas (CGAP 2011). As a result, borrowers of MFIs and borrowers of formal banks have begun to overlap.


19 The impact of global financial crisis on the recent microfinance crisis should not be significant. Microfinance is essentially informal and commonly directed to micro-businesses and household consumption that are not linked to the global economy (Constantinou and Ashta 2011).
From this, this chapter examines the impact of the expansion of the formal financial sector upon MFIs. With cross-country data, in this chapter I demonstrate the relationship between high bank competition and MFI stability.

Results will contribute to the assessment of how policies directed toward the formal financial market influence MFIs. It will also provide a picture of the entire financial market regarding whether MFIs exit as formal financial institutions enter the market. Therefore, the results will contribute to discussions concerning whether microfinance should be seen to complement or replace the formal financial market. Such a contribution will inform the assessment of the role of microfinance in overall financial development, which has become increasingly necessary as government involvement in financial inclusion policies grows.

This chapter aims to identify factors of microfinance default risks from the perspective of the competition–stability relationship within the microfinance sector and between microfinance and the formal banking sector. Microfinance crises can significantly and negatively impact the livelihoods of clients, who live with tight budgets. Even one-time financial drops can cause substantial declines in their spending on consumption, business, education, health, and home improvement (MicroSave 2012). On this point, this chapter offers empirical evidence on competition and stability in the microfinance sector that can contribute to discussions of future microfinance policies toward building a stronger microfinance industry and avoiding the large costs of MFI instability.

It should be noted that Chapter 3 focuses on one aspect of the impact of competition. Competition within the financial market enhances specialization of lending, which allows a variety of financial institutions to operate and reach out to new clients (i.e. higher outreach). For example, Love and Martínez Pería (2012), using firm-level data for 53 countries from 2002 to 2010, found that bank competition substantially increases firms’ access to finance. The result of this chapter describes only one effect of competition and does not tell whether competition is good or bad.

Literature that examines the competition–stability relationship in the microfinance sector is scarce. McIntosh et al. (2005) examine the effects of competition among MFIs on borrower behavior in a Ugandan microfinance market by using the data of clients in FINCA, the largest MFI in Uganda. Their findings show that higher competition, measured as the number of accessible MFIs, raises multiple borrowing and reduces repayment rates. Later, Assefa, Hermes, and Meesters (2010) use MFI-wise data from 67
countries and examine the impact of competition on MFI performance, especially focusing on outreach and loan repayment rate. Estimating with the MFI-specific fixed effects model, their results show that higher competition among MFIs, measured by Lerner indexes calculated by the authors, is associated with lower loan repayment and decreased outreach to the poor.

This study uses cross country panel data and aims to show the influence of competitiveness in a country’s microfinance sector on MFI portfolio risks. The results will add evidence to this thin area of study. At the same time, this chapter aims to identify how the formal financial market’s competitiveness impacts repayment rates in the microfinance sector, which is not entirely isolated from other financial markets in a country.

There are a few studies that have discussed the influence of formal financial institutions on the MFIs but most of the papers focus on the impact on MFI’s outreach. Cull et al (2013) examined the impact of formal bank penetration on the MFI outreach. They used MFI-level data combined with country-level data on bank penetration. Their sample contained 238 MFIs from 38 countries. They used a number of commercial bank branches as indicators for bank penetration, and average loan sizes and shares of female borrowers as indicators for outreach. They estimated with OLS regressions. They found that greater bank penetration was associated with greater MFI outreach, as reflected in smaller average loan sizes and greater shares of women. They also discovered that higher bank penetration reduced the profitability of MFIs. Furthermore, combining the data for MFIs’ sources of funding and lending methods, they showed that their evidence was stronger for commercially-oriented MFIs with bilateral lending contracts. Thus, they discussed that competition from commercial banks pushed MFIs into poorer markets.

Vanroose and D’Espallier (2013) also came across a similar story. They also used MFIs level data coupled with country-level variables for financial depth from 1073 MFIs in 77 countries from 1997 to 2006. They used the number of ATMs for their bank penetration measure. They employed random-effect, panel data regressions. Their finding showed that a higher penetration of the formal banking sector was associated with lower MFI profitability. Moreover, they found that MFIs had less numbers of clients and smaller sizes of loan portfolios in countries with higher penetrations of the formal banking sector.

Additionally, Hermes et al. (2009) examined the relationship between the levels of financial depth, measured by private credit to GDP ratio and interest rate spread, and the
efficiency of MFIs. The efficiency measure was derived from production frontier analysis. Their sample covered 435 MFIs over the period 1997-2007. Their findings demonstrated the positive effect of financial development on the cost efficiency of MFIs. They also found that the MFIs with bank borrowings have higher efficiency.

This paper also shares the same objective as that of Ahlin et al. (2010). Ahlin et al. (2010) demonstrates that the success of MFIs depends on the country’s macroeconomic context and institutional environment with data from 373 MFIs in 74 countries from 1996 to 2007. Their evidence showed that macroeconomic environments complemented the MFIs’ performances. Higher macroeconomic growth was associated with lower default rates and the faster growth of MFIs. They also found that microfinance substitutes for weak institutions.

As far as I know, there have been no reports on how the market structure of the formal banking sector has influenced the stability of MFIs. This will be the first paper to discuss the effect of competition from both MFIs and formal banks on the MFIs stability.

The reminder of this chapter is organized as follows. Section 3.2 presents an overview of the theoretical discussions on relationship between competition and the portfolio risks of MFIs. Section 3.3 discusses the data we use in the analysis and my empirical methodology. Section 3.4 shows the results of the empirical investigation of the relationship between competition and the MFI’s portfolio risks. Section 3.5 provides conclusions and future work.

3.2 Theoretical Discussion

Competition and Stability in the Microfinance Market

The impact of competition in the banking sector can go either way (Beck 2013). On the one hand it can increases banks’ efforts to reduce costs and to provide more services, and on the other hand it can erode banks’ expected future profits and may increase banks’ incentives for making risky loans under limited liability. This paper extends the traditional competition-stability discussions into the microfinance sector. This same argument will be applicable to the effect of competition in the microfinance sector.

Considering the positive effects, competitive pressure in financial markets increases banks’ efforts to reduce costs and to provide more services. Moreover, competition
reduces monopoly interest rates, which reduces the entrepreneurs’ costs of borrowing and increases their expected profits. Therefore, entrepreneurs are less likely to choose risky investments. This in turn increases the probability of projects’ successes and reduces the default rates (Boyd and De Nicolo (2005)). On the other hand, high competition may erode banks’ expected future profits and may increase banks’ incentives for making risky loans under limited liability (Keeley (1990)). In addition, under extensive competition, banks earn fewer informational rents from their relationships with borrowers, reducing banks’ incentives for the proper screening of borrowers, which increases the risks of default (Allen and Gale (2004)).

In addition, there will be MFI-specific effects from competition. As the microfinance market becomes more saturated and more competitive, a borrower’s likelihood of getting loans from other MFIs becomes higher. As a consequence, MFIs enforcement mechanisms for the denial of future access to loans will no longer be effective (Hellman et al (2000)). In addition, with a lack of credit bureaus, extensive competition increases informational asymmetry between lenders and borrowers, and it becomes difficult for MFIs to know the total debt levels of their clients (McIntosh and Wydick (2005)). As such, the impact of competition in the microfinance sector can be both positive as well as negative.

Sorting Borrowers According to MFIs and Formal Banks

There are broadly three types of financial institutions: formal financial institutions, informal financial institutions, and MFIs. The microfinance market is not entirely isolated from other financial markets in a country. In this chapter, I focus on the relationship between MFIs and formal financial institutions.

According to Berger and Udell (2006), large formal financial institutions have a comparative advantage in lending technology based on hard information such as collaterals, while small MFIs have a comparative advantage in lending technology based on soft information, such as screening and monitoring by group members. In general, the financial market in developing countries is naturally segmented, formal financial institutions and people who have collaterals, and MFIs and people without collaterals (Conning and Udry 2005). However, as the success of MFIs’ high repayment rates and high profitability has become more widely recognized, many formal banks have started to enter the microfinance market to seek new customers. Banks use other types of hard
information, such as asset-based lending\textsuperscript{20}, and extend credit to many opaque borrowers (Berger and Udell (2006)).

Under increasing competition in the microfinance market, the MFI’s lending mechanisms will become less effective. In contrast, the lending methods of formal banks with hard information will have comparative advantages. As such, higher competition will shift the economy from one where informal and MFIs are dominant to one where formal banks are dominant. However, the negative effect of competition on MFIs is not a “bad” thing because it creates opportunities for more efficient MFIs to enter the market and opportunities for banks that have higher comparative advantages in a competitive market. This paper will contribute to a discussion of how the financial market develops and the role of microfinance.

\textit{Interaction between the Microfinance and the Formal Banking Sectors}

There are broadly two types of interactions between MFIs and banks, which are vertical and horizontal (Floro and Ray (1997)). In the vertical relationship, MFIs borrow their funds from banks. Bank borrowing occupies approximately a quarter of the total funds (Cull et al 2009). For the horizontal relationship, MFIs and banks target the same base of borrowers and compete against each other for clients.

The flow chart below shows multiple routes regarding how bank competition influences MFIs’ repayment rates. In the vertical relationship, higher competition in the formal banking sector is associated with lower interest rates, which means lower costs for funds for the MFIs. Therefore, MFIs’ expected profits increase, and MFIs’ risk taking behaviors will weaken. Thus, higher competition will reduce MFIs default risks.

Figure 1, Flow Chart: The Effect of Competition from the Banks on MFIs’ Repayment Rates

\textsuperscript{20} Asset-based lending permits using disposable assets as collateral.
In the horizontal relationship, if the formal banks and MFIs are substitutes; they directly compete against each other. Therefore, the effects from bank competition are simply the same as the effects from increased competition within the microfinance market. Higher competition in the microfinance market could weaken MFIs’ enforcement abilities and reduce the repayment rates. On the other hand, higher competition could reduce the interest rates of MFIs, which would reduce borrowers’ risky investments and increase their projects’ successes and repayment rates. Finally, if the formal banks and MFIs are complementary, higher bank competition might encourage a push among MFIs to poorer borrowers. The repayment rates of MFIs could either go up or down depending on the types of projects chosen by the poorer borrowers, their financial environments, and whether they have access to other financial sources.

3.3 Methodology

3.3.1. Data

The source of data on MFIs is the MIX. It is a widely used database in the microfinance literature that is publicly available on the company’s Web site and contains information on more than 1,400 MFIs. The downside of the dataset is that it is voluntarily reported by MFIs, which would bias the data to larger MFIs. For our regression, we include the whole samples reported in the MIX. I use the weighted average by country because our interest is the country-level regressions. The MIX automatically converts to the country-wide data. The indicators of bank competition are from Clerides et al. (2013). The source of other
bank variables is the Financial Index by the World Bank. In total, our sample contains data from 2000 until 2010 for up to 83 countries.

The dependent variable in our analysis is the default risk of MFI loans. Appendix Table A1 summarizes the variables in the regressions. The main indicator for a risk of default in this paper is portfolio-at-risk (PAR). PAR captures the quality of an MFI's portfolio and is the measure of risk-exposure. Portfolio-at-risk, > 30 days (PAR30) is calculated as the total value of outstanding balance of loans in arrears by 30 days or more as a percentage of total outstanding loans. Portfolio-at-risk, > 90 days (PAR90) is the percentage share of delinquent loans by 90 days or more. I also use the loan loss reserves rate and the loan loss rate. The loan loss reserve represents the amount that MFIs set aside to cover expected bad debt. The amount of the loan loss reserve is calculated by multiplying the total portfolio of past due portfolio by the likelihood of default based on number of days in arrears. The loan loss rate is the percentage of loans that have been removed from the balance of the gross loan portfolio because they are unlikely to be repaid.

The independent variable of our interest is an indicator for competition. In this paper, I use the Lerner index, the adjusted-Lerner index as a competition measure for formal banks. These are adopted from Clerides et al. (2013). And I use the Lerner index as a competition measure for MFIs, which I calculated with data from MIX21.

The Lerner index is defined as \( L = \frac{p - mc}{p} \), where \( p \) is output price and \( mc \) is the marginal cost. The Lerner index determines the extent of competition by the extent of disparity between output price and marginal cost of production. The Lerner index ranges between 0 and 1, with zero corresponding to perfect competition. And the lower values of the Lerner index represent higher bank competition.

The adjusted-Lerner index is defined as \( \text{adj}\,L = \frac{\pi + tc - mc \cdot q}{\pi + tc} \), where \( \pi \) is the profit of bank, \( tc \) is the total cost, \( mc \) is the marginal cost and \( q \) is the total output. Like the standard Lerner index, the adjusted Lerner ranges from 0-1, with larger values indicating greater market power.

To control for income growth, I include the real GDP per capita growth rate. I also include

---

21 Appendix A describes the detailed estimation methods of the Lerner index for MFIs by using the data of the MIX.
the number of commercial bank branches per 1,000 km², the number of bank account per 100,000 adults, and the ratio of private credit to GDP. These variables measure the outreach of formal bank, and I include these variables to investigate how the impact of competition varies depending on countries’ financial outreach.

It should be noted that increased competition is characterized by decreases in the Lerner index. As such, the negative coefficients for the Lerner index indicate that increased competition, expressed in lower value in the Lerner index, increases MFI portfolio risks. Therefore, the negative coefficients mean that MFIs’ portfolio risks are more likely to be higher when country’s banking sector and MFI’s sector are more competitive.

3.3.2 Empirical Model

I employ both OLS regression with cross-country data and country-fixed-effect regression with panel data. Lerner indexes and MFI PAR show large variance between countries despite little within-country differences. However, since the competitiveness of a formal banking or MFI sector in a country does not change much year after year, a fixed effects model might be unable to assess the effect of Lerner indexes. Therefore, I use both OLS regression with cross-country variables and fixed-effect estimation with panel data.

I start with a simple OLS regression with cross-country data. I use a country’s average from 2000 to 2010, or else the latest year with available data. The following model captures between-country variation:

\[ Y_i = \alpha + \beta_1 X_i + \beta_2 \text{Growth}_i + u_i \]  
(1)

in which \(Y_i\) is country \(i\)’s average MFI PAR, loan loss reserves, and loan loss rate from 2000 to 2010, \(X_i\) is country \(i\)’s average of its bank Lerner index and MFI Lerner index from 2000 to 2010, \(\text{Growth}_i\) is country \(i\)’s average real GDP per capita growth rate from 2000 to 2010; and \(u_{i,t}\) is the error term.

Second, I use a country-fixed effects model with a panel data as follows:

\[ Y_{i,t} = \alpha + \beta_1 X_{i,t} + \beta_2 \text{Growth}_{i,t} + v_i + u_{i,t} \]  
(2)

in which \(Y_{i,t}\) is the MFI PAR, loan loss reserves, and loan loss rate in country
During time $t$, $X_{i,t}$ is country $i$’s formal banks’ Lerner index and MFI Lerner index during time $t$, $Growth_{i,t}$ is the real GDP per capita growth rate; $v_i$ is the time-invariant fixed effect, and $u_{i,t}$ is the error term. Year dummies are included in all fixed-effect regressions.

This fixed effects model controls for the average differences across countries in any observable or unobservable predictors, including differences in property rights and strength of social networks. Since fixed effect coefficients absorb all cross-country differences, the model can greatly reduce the threat of omitted variable bias.

I assume that formal bank competition variables are exogenous. According to Cull et al. (2013) and Vanroose and D’Espallier (2013), the number and size of portfolios of MFIs remain too small to exert any substantial effect on the mainstream banking sector.\(^{22}\) I have also performed regressions with lagged variables in order to reduce any possible reverse causality effect.

### 3.4 Results

In what follows, Section 3.4.1 reports the baseline results for all countries. Section 3.4.2 breaks down the effect of competition by country income levels, including low-income countries (LICs), lower-middle-income countries, and upper-middle-income countries. Lastly, Section 3.4.3 examines the effect of the formal banking sector’s coverage on the relationship of competitiveness and MFI portfolio risks.

All regressions in this chapter include bank competition measures (i.e., Lerner indexes and adjusted Lerner indexes) and the MFI Lerner index. Dependent variables are the logs of PAR 30, PAR 90, the loan loss rate, and loan loss reserves.

It should be noted that increased competition is characterized by decreases in Lerner indexes. As such, the negative coefficients for the Lerner indexes indicate that increased competition also increases MFI portfolio risks. If signs are positive, then increased competition lowers MFI portfolio risks.

\(^{22}\) As of 2012, the percentage share of outstanding loans from MFIs to GDP was 0.99, while the percentage share of outstanding loans from commercial banks (%GDP) was 34.3. These values are the averages of low- and middle-income countries according to International Monetary Fund (IMF) data.
Fixed-effect regressions include year dummies to control for time variation due to changes in the external economic environment common across countries. In Section 3.4.3, I include the interactions of competition and the number of branches per 1,000 adults, the number of accounts per 1,000 adults, and the share of private credit to GDP.

3.4.1 Baseline Results

Figure 2A in Appendix shows the negative relationship between MFI portfolio risks measured by PAR 90 and both the formal banks’ and MFIs’ Lerner indexes for all countries. I thus expect a result supporting that MFI portfolio risks tend to be greater in any country with more competitive formal banking and MFI sectors.

Table 3.1 reports the results of cross-country OLS estimation for all countries. These results show significant, negative relationships between MFI Lerner indexes and MFI portfolio risks, which indicate that MFIs in countries with greater competition are more likely to face greater risks of default. Formal banks’ Lerner and adjusted Lerner indexes report mostly negative but statistically insignificant signs. Growth rates in real GDP per capita reveal significantly negative coefficients, meaning that growth rates in real GDP per capita tend to reduce MFIs’ risk of default, which supports the findings of Ahlin et al. (2011).

Table 3.2 reports fixed-effect regression for all countries. The upper part of the table shows results from using current variables among competition indicators, while the bottom part shows results from using lagged variables. The results of bank adjusted Lerner index in column 7, the lagged bank Lerner index in columns 2 and 7, and the lagged adjusted Lerner index in column 6 show statistically significant negative coefficients. This finding indicates that a microfinance sector that operates in a country with a highly competitive formal banking sector is more likely to face a greater risk of default. However, the negative effects of MFI Lerner indexes are muted in fixed effects models, possibly because within-country variance is smaller for MFI Lerner indexes.

3.4.2 Results by Income Group

Tables 3.3 and 3.4 break down the impact of bank and MFI competition by country according to income group: low-income countries (LICs), lower-middle-income countries, and upper-middle-income countries. Figure A2 in Appendix shows that the
negative relationship between MFI PAR and the formal banks’ Lerner index is stronger for upper-middle–income countries than LICs. Meanwhile, the MFI Lerner index shows clear negative slopes for all income groups.

Table 3.3 reports the results of cross-country OLS estimation. Regarding formal bank competition indicators of the Lerner index and adjusted Lerner index, the effect on MFI default rate is significantly negative in lower- and upper-middle–income countries. The negative effects are larger for upper-middle–income countries except for the result shown in column 1. These findings support the idea that bank competition is significantly associated with higher MFI PAR especially for lower- and upper-middle–income countries, which is consistent with the pattern shown in Figure A2. For the MFI Lerner index, results indicate that any MFI operating in a country with greater competition among MFIs is more likely to face greater portfolio risks across all income groups.

Table 3.4 reports results from countries’ fixed-effect estimations with current Lerner indexes and lagged Lerner indexes. Formal banks’ Lerner and adjusted Lerner indexes show significantly negative effects on MFI portfolio risks in upper-middle–income countries. The results using lagged variables are not significant but show the same signs, which supports the finding’s robustness. By contrast, the results of the MFI Lerner index are neither significant nor robust. Similar with results shown in Table 3.2, such weakness might be caused by little within-country variation in MFI Lerner indexes.

In sum, estimations by income groups reveal that the effect of formal bank competition is greater in upper-middle–income countries. A possible explanation for this finding is that in a higher-income country, MFIs and formal banks are more likely to operate in a horizontal relationship than a vertical one, meaning that they directly compete for the same pool of borrowers. In a higher-income country with better property rights protection and contract enforcement, many people already have access to formal banks compared to people in LICs. Thus, in a higher-income country, increasing competition in the formal financial sector may push banks to target new customers previously excluded from the formal financial sector by, for example, allowing more flexible collateral requirements.\footnote{Cull \textit{et al.} (2013) also mention this possibility but without offering any statistical evidence.} Therefore, in a higher-income country, MFI portfolio risks are more likely to be influenced by competitiveness in the formal banking sector.

For LICs, by contrast, the extent of formal financial development is lower with poorer property rights protection and contract enforcement, meaning that access to formal banks
is limited to very few wealthy people with enough collateral. In these cases, MFIs’ target borrowers and formal banks’ borrowers have never overlapped, suggesting that the relationship between MFIs and formal banks is more likely to be vertical. As such, for LICs the pressure of competition from the formal banking sector does not affect MFI portfolio risks.

3.4.3 Interaction Results

Findings presented in the previous section show a larger influence of bank competition on MFI portfolio risks in upper-middle–income countries, because formal banks are more likely to compete directly with MFIs in upper-middle–income countries. This section investigates the hypothesis that the impact of bank competition is greater given wider coverage by banks in the upper-middle income countries, since banks are thus more likely to compete directly with MFIs.

Table 3.5 summarizes the coverage of formal banks and MFIs across income groups in mean values. Bank coverage is greater in lower- and upper-middle–income countries, while LICs show wider coverage by MFIs. Such results underscore the possibility that banks in higher-income countries directly compete with MFIs. By bank and MFI coverage, LICs have greater coverage by MFIs, while upper- and lower-middle–income countries have greater coverage by formal banks.

To test this hypothesis, I include variables that measure coverage by formal banks as well as interaction terms of each bank coverage variable and Lerner indexes. I employ the number of bank branches per 1,000 adults (Table 3.6), the number of accounts per 1,000 adults (Table 3.7), and the share of private credit to GDP (Table 3.8).

Tables 3.6, 3.7 and 3.8 show a similar pattern for coefficients: positive but insignificant signs regarding bank Lerner and adjusted Lerner indexes, negative significant signs on interaction terms, and positive significant signs on banks’ coverage variables. The negative, significant signs on the interaction terms indicate that in a country of greater financial development, the negative effect of bank competition on MFI portfolio risks is greater.

Tables 3.6, 3.7 and 3.8 also show positive significant signs on interaction terms with the

---

24 Upper-middle–income countries are only Brazil, Mexico, and Peru. Though they have the largest coverage according to the number of MFI branches per 1,000 adults, this value is skewed due to the rapid increase of MFIs in Peru, meaning that the value may not represent the general trend of upper-middle–income countries.
MFI Lerner index, which indicates that the negative impact of MFI competition is smaller in a country with greater coverage by formal banks. This result corresponds with the greater coverage of banks and less coverage of MFIs in upper- and lower-middle-income countries shown in Table 3.5.

Table 3.9 shows the size of the marginal effect of formal banks’ Lerner index on PAR 30 across income groups. Coefficients are adopted from column 1 in Tables 3.6, 3.7 and 3.8. For each income group, I assign an average value of the number of bank branches, number of accounts, and amount of private credit to GDP shown in Table 3.5. Results show that the marginal effect of formal banks’ Lerner index is more negative in upper-middle-income countries, which is driven by higher values of bank branches, accounts, and private credit to GDP. Results thus support the hypothesis that in higher-income countries, due to formal banks’ wider coverage in targeting borrowers, competitive pressure from a formal banking sector tends to create greater portfolio risks for MFIs.

3.4 Conclusion and Future Work

This study has been motivated by the rapid expansion of MFIs and the ensuing increase of MFI portfolio risks reported worldwide in recent years. Theoretically, the impact of competition regarding repayment rate can either increase banks’ efforts to reduce costs or increase banks’ incentives for making risky loans, though not much empirical study has been performed on the topic. The present study estimates the impact of competition with a country-wise dataset from 2000 to 2010 and adds new evidence to the present scarce literature. It also examines the impact of competitiveness in the formal banking sector upon MFI portfolio risks. As MFIs expand, MFIs and formal banking sectors’ borrowers start to overlap, which underscores the importance of examining whether MFIs complement or replace formal banks. The results of this can contribute to discussions about the role of MFIs in a country’s financial development.

The findings in this chapter contribute to the very limited literature concerning MFI competition and stability. The estimation for default risks of MFIs from the perspective of both MFI and bank competition is especially new. I find that both bank and MFI competition are critical factors for MFI default risk. MFI portfolio risks are negatively influenced by competition within the MFI sector and between the MFI and banking sectors. I also find that negative impact varies according to countries’ income levels. The
negative effect of bank competition is greater in upper-middle–income countries, while MFI competition uniformly influences all income groups. Further investigation of the interaction terms supports the hypothesis that the impact of bank competition is greater in upper-middle–income countries, where banks have greater coverage and are thus more likely to compete directly with MFIs. These findings illustrate that formal banks and MFIs can be substitutes in upper-middle–income countries and operate in a vertical relationship in LICs.

These results also underscore the importance of comprehensive financial policies that include formal banks, MFIs, and informal financial institutions. For example, the discussion of recent government interaction in expanding commercial bank operations to remote areas should include such expansions’ impact on the microfinance sector. Results also call for designing ways to minimize the negative effects of fierce competition, which include initiatives on promoting information-sharing systems, promoting financial literacy among clients, and improving financial regulations. To further inform policy discussions, future research should identify policies that are more effective in reducing the negative impact of increased competition. Lastly, increasing MFI exits due to increased competition could be natural part of financial development. As a country’s finance develops, the economy may shift from an economy where MFIs have advantage to the one that formal banks have advantage. As such, my future research will investigate the role of MFIs in the processes of financial development.
Table 3.1 The Effect of Competition on MFI’s Default Risks, Cross-country data, OLS Regression

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
</tr>
<tr>
<td>Bank Lerner Index</td>
<td>-1.046</td>
<td>-1.172</td>
<td>-0.360</td>
<td>-0.0762</td>
<td>-1.046</td>
<td>-1.172</td>
<td>-0.360</td>
<td>-0.0762</td>
<td>-1.046</td>
<td>-1.172</td>
<td>-0.360</td>
<td>-0.0762</td>
</tr>
<tr>
<td></td>
<td>(-0.765)</td>
<td>(-0.864)</td>
<td>(-0.365)</td>
<td>(-0.0551)</td>
<td>(-0.765)</td>
<td>(-0.864)</td>
<td>(-0.365)</td>
<td>(-0.0551)</td>
<td>(-0.765)</td>
<td>(-0.864)</td>
<td>(-0.365)</td>
<td>(-0.0551)</td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-3.602)</td>
<td>(-4.904)</td>
<td>(-3.597)</td>
<td>(-4.391)</td>
<td>(-3.744)</td>
<td>(-5.212)</td>
<td>(-3.711)</td>
<td>(-4.439)</td>
<td>(-2.960)</td>
<td>(-5.233)</td>
<td>(-3.102)</td>
<td>(-3.795)</td>
</tr>
<tr>
<td>N</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>73</td>
<td>80</td>
<td>80</td>
<td>78</td>
<td>80</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.246</td>
<td>0.276</td>
<td>0.171</td>
<td>0.292</td>
<td>0.253</td>
<td>0.287</td>
<td>0.173</td>
<td>0.294</td>
<td>0.360</td>
<td>0.383</td>
<td>0.205</td>
<td>0.444</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
### Table 3.2 The Effect of Competition on MFI’s Default Risks, Panel data, Country Fixed Effect Regression

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log (PAR30)</td>
<td>0.619</td>
<td>0.332</td>
<td>-0.702</td>
<td>-0.014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (PAR90)</td>
<td>-1.049</td>
<td>-0.406</td>
<td>-1.058</td>
<td>-0.0139</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Loan Loss Rate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Loan Loss Reserve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Bank Lerner Index</td>
<td>-5.908***</td>
<td>-6.937***</td>
<td>-2.323</td>
<td>-3.975*</td>
<td>-3.065**</td>
<td>-1.982*</td>
<td>-1.113</td>
<td>-1.616</td>
<td>-1.019</td>
<td>-1.982*</td>
<td>-1.113</td>
<td>-1.616</td>
</tr>
<tr>
<td>L. Bank Adjusted Lerner Index</td>
<td>-6.660</td>
<td>-2.999</td>
<td>-1.066</td>
<td>-1.733</td>
<td>-3.392</td>
<td>-2.778</td>
<td>-0.585</td>
<td>-1.914</td>
<td>-1.019</td>
<td>-1.982*</td>
<td>-1.113</td>
<td>-1.616</td>
</tr>
<tr>
<td>R-squared</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of country</td>
<td>75</td>
<td>74</td>
<td>73</td>
<td>74</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
</tbody>
</table>

### Lagged VARIABLES

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log (PAR30)</td>
<td>-1.101</td>
<td>-2.503</td>
<td>0.486</td>
<td>-2.065</td>
<td>-1.019</td>
<td>-1.982*</td>
<td>-1.113</td>
<td>-1.616</td>
<td>-1.019</td>
<td>-1.982*</td>
<td>-1.113</td>
<td>-1.616</td>
</tr>
<tr>
<td>Log (PAR90)</td>
<td>-0.848</td>
<td>-2.503</td>
<td>0.355</td>
<td>-2.002</td>
<td>-1.108</td>
<td>-1.781</td>
<td>-1.062</td>
<td>-1.437</td>
<td>-1.108</td>
<td>-1.781</td>
<td>-1.062</td>
<td>-1.437</td>
</tr>
<tr>
<td>Log (Loan Loss Rate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Loan Loss Reserve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>year dummy</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>580</td>
<td>476</td>
<td>557</td>
<td>480</td>
<td>577</td>
<td>477</td>
<td>554</td>
<td>481</td>
<td>594</td>
<td>588</td>
<td>567</td>
<td></td>
</tr>
<tr>
<td>Number of country</td>
<td>73</td>
<td>73</td>
<td>72</td>
<td>73</td>
<td>73</td>
<td>72</td>
<td>73</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td></td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Log (PAR30)</th>
<th>(2) Log (PAR90)</th>
<th>(3) Log (Loan Loss Rate)</th>
<th>(4) Log (Loan Loss Reserve)</th>
<th>(5) Log (PAR30)</th>
<th>(6) Log (PAR90)</th>
<th>(7) Log (Loan Loss Rate)</th>
<th>(8) Log (Loan Loss Reserve)</th>
<th>(9) Log (PAR30)</th>
<th>(10) Log (PAR90)</th>
<th>(11) Log (Loan Loss Rate)</th>
<th>(12) Log (Loan Loss Reserve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Lerner Index</td>
<td>-1.794 (-1.525)</td>
<td>-2.301** (-1.826)</td>
<td>-1.205 (-1.203)</td>
<td>-1.223 (-1.014)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Lerner Index * Lower-middle Income Country</td>
<td>-2.973*** (-2.918)</td>
<td>-2.215** (-2.070)</td>
<td>-1.471 (-1.475)</td>
<td>-2.286** (-2.109)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Lerner Index * Upper-middle Income Country</td>
<td>-2.814*** (-3.434)</td>
<td>-2.648** (-2.350)</td>
<td>-1.047 (-1.182)</td>
<td>-3.164*** (-3.218)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td></td>
<td>-1.236 (-0.990)</td>
<td>-1.993 (-1.933)</td>
<td>-0.781 (-0.646)</td>
<td>-0.702 (-0.573)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adj. Lerner Index * Lower-middle Income Country</td>
<td>-3.558*** (-3.103)</td>
<td>-2.805** (-2.308)</td>
<td>-1.580 (-1.302)</td>
<td>-2.796** (-2.240)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adj. Lerner Index * Upper-middle Income Country</td>
<td>-3.611*** (-3.138)</td>
<td>-3.511** (-2.194)</td>
<td>-1.507 (-1.172)</td>
<td>-4.068*** (-2.942)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner Index * Lower-middle Income Country</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner Index * Upper-middle Income Country</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real GDP per capita growth rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>81</td>
<td>81</td>
<td>79</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.142</td>
<td>0.101</td>
<td>0.037</td>
<td>0.110</td>
<td>0.145</td>
<td>0.111</td>
<td>0.030</td>
<td>0.112</td>
<td>0.306</td>
<td>0.253</td>
<td>0.139</td>
<td>0.308</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
Table 3.4 The Effect of Competition on MFI’s Portfolio Risks by Income Groups, Panel data, Country Fixed Effect Regression

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
</tr>
<tr>
<td>Bank Lerner Index</td>
<td>2.705**</td>
<td>2.384</td>
<td>0.773</td>
<td>2.721</td>
<td>(2.128)</td>
<td>(0.700)</td>
<td>(0.349)</td>
<td>(0.755)</td>
<td>2.721</td>
<td>(2.128)</td>
<td>(0.700)</td>
<td>(0.349)</td>
</tr>
<tr>
<td>Bank Lerner Index * Lower-middle Income Country</td>
<td>-3.151</td>
<td>-2.378</td>
<td>0.430</td>
<td>-1.718</td>
<td>(-1.497)</td>
<td>(-0.594)</td>
<td>(0.133)</td>
<td>(-4.418)</td>
<td>-1.718</td>
<td>(-1.497)</td>
<td>(-0.594)</td>
<td>(0.133)</td>
</tr>
<tr>
<td>Bank Lerner Index * Upper-middle Income Country</td>
<td>-7.060***</td>
<td>-11.19***</td>
<td>-2.114</td>
<td>-10.45***</td>
<td>(-3.641)</td>
<td>(-2.732)</td>
<td>(-0.694)</td>
<td>(-2.656)</td>
<td>-10.45***</td>
<td>(-3.641)</td>
<td>(-2.732)</td>
<td>(-0.694)</td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td>0.869</td>
<td>-0.381</td>
<td>-1.259</td>
<td>0.571</td>
<td>(0.893)</td>
<td>(-0.189)</td>
<td>(-0.845)</td>
<td>(0.317)</td>
<td>0.571</td>
<td>(0.893)</td>
<td>(-0.189)</td>
<td>(-0.845)</td>
</tr>
<tr>
<td>Bank Adj. Lerner Index * Lower-middle Income Country</td>
<td>-1.389</td>
<td>1.224</td>
<td>-0.0520</td>
<td>1.244</td>
<td>(-0.700)</td>
<td>(0.430)</td>
<td>(-0.0194)</td>
<td>(0.497)</td>
<td>1.244</td>
<td>(-0.700)</td>
<td>(0.430)</td>
<td>(-0.0194)</td>
</tr>
<tr>
<td>Bank Adj. Lerner Index * Upper-middle Income Country</td>
<td>-5.021***</td>
<td>-8.659***</td>
<td>-1.225</td>
<td>-5.913*</td>
<td>(-3.130)</td>
<td>(-2.816)</td>
<td>(-0.537)</td>
<td>(-1.532)</td>
<td>-5.913*</td>
<td>(-3.130)</td>
<td>(-2.816)</td>
<td>(-0.537)</td>
</tr>
<tr>
<td>MF Lerner Index</td>
<td>0.229</td>
<td>-1.125</td>
<td>0.0949</td>
<td>-2.220**</td>
<td>(0.253)</td>
<td>(-0.968)</td>
<td>(0.0923)</td>
<td>(-2.370)</td>
<td>0.0949</td>
<td>(0.253)</td>
<td>(-0.968)</td>
<td>(0.0923)</td>
</tr>
<tr>
<td>MF Lerner Index * Lower-middle Income Country</td>
<td>0.926</td>
<td>2.233</td>
<td>-1.372</td>
<td>3.642***</td>
<td>(0.654)</td>
<td>(1.277)</td>
<td>(-0.844)</td>
<td>(2.110)</td>
<td>3.642***</td>
<td>(0.654)</td>
<td>(1.277)</td>
<td>(-0.844)</td>
</tr>
<tr>
<td>MF Lerner Index * Upper middle Income Country</td>
<td>0.214</td>
<td>2.904</td>
<td>-1.234</td>
<td>3.477***</td>
<td>(0.175)</td>
<td>(1.310)</td>
<td>(-0.929)</td>
<td>(2.018)</td>
<td>3.477***</td>
<td>(0.175)</td>
<td>(1.310)</td>
<td>(-0.929)</td>
</tr>
<tr>
<td>year dummy</td>
<td>(-12.35)</td>
<td>(-10.01)</td>
<td>(-7.899)</td>
<td>(-11.17)</td>
<td>(-12.52)</td>
<td>(-13.01)</td>
<td>(-7.873)</td>
<td>(-14.68)</td>
<td>(-18.81)</td>
<td>(-14.95)</td>
<td>(-15.68)</td>
<td>(-10.78)</td>
</tr>
<tr>
<td>N</td>
<td>638</td>
<td>495</td>
<td>595</td>
<td>499</td>
<td>636</td>
<td>497</td>
<td>593</td>
<td>501</td>
<td>674</td>
<td>668</td>
<td>637</td>
<td>674</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.100</td>
<td>0.277</td>
<td>0.034</td>
<td>0.236</td>
<td>0.095</td>
<td>0.278</td>
<td>0.042</td>
<td>0.218</td>
<td>0.104</td>
<td>0.220</td>
<td>0.102</td>
<td>0.204</td>
</tr>
<tr>
<td>Number of country</td>
<td>75</td>
<td>74</td>
<td>73</td>
<td>74</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>75</td>
<td>81</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses.
### Table 3.4 (Lagged Variables)

<table>
<thead>
<tr>
<th>Lagged VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.Bank Lerner Index</td>
<td>1.425</td>
<td>-3.984</td>
<td>-0.395</td>
<td>-3.097</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Bank Lerner Index + Lower-middle Income Country</td>
<td>(-0.863)</td>
<td>(-1.481)</td>
<td>(-0.225)</td>
<td>(-1.083)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Bank Lerner Index + Upper middle Income Country</td>
<td>-1.573</td>
<td>3.022</td>
<td>2.403</td>
<td>3.417</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Bank Adj. Lerner Index</td>
<td>0.491</td>
<td>-1.696</td>
<td>-1.358</td>
<td>-1.223</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Bank Adj. Lerner Index + Lower-middle Income Country</td>
<td>(-0.430)</td>
<td>(-0.950)</td>
<td>(-0.950)</td>
<td>(-0.687)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Bank Adj. Lerner Index + Upper middle Income Country</td>
<td>-1.194</td>
<td>1.551</td>
<td>0.511</td>
<td>1.292</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.MF Lerner Index</td>
<td>1.316*</td>
<td>-0.414</td>
<td>1.240</td>
<td>0.691</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.MF Lerner Index + Lower-middle Income Country</td>
<td>(1.741)</td>
<td>(-0.377)</td>
<td>(1.258)</td>
<td>(0.699)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.MF Lerner Index + Upper middle Income Country</td>
<td>0.262</td>
<td>2.463</td>
<td>-1.572</td>
<td>1.600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year dummy</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
</tr>
<tr>
<td>N</td>
<td>580</td>
<td>476</td>
<td>557</td>
<td>480</td>
<td>577</td>
<td>477</td>
<td>554</td>
<td>481</td>
<td>594</td>
<td>588</td>
<td>567</td>
<td>592</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.094</td>
<td>0.278</td>
<td>0.046</td>
<td>0.236</td>
<td>0.091</td>
<td>0.263</td>
<td>0.049</td>
<td>0.219</td>
<td>0.109</td>
<td>0.174</td>
<td>0.115</td>
<td>0.137</td>
</tr>
<tr>
<td>Number of country</td>
<td>73</td>
<td>73</td>
<td>72</td>
<td>73</td>
<td>73</td>
<td>72</td>
<td>73</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses.
Table 3.5 Coverage by formal banks and MFIs across income groups

<table>
<thead>
<tr>
<th></th>
<th>LICs</th>
<th>Lower-middle income countries</th>
<th>Upper-middle income countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Bank account per 1,000 adult</td>
<td>162.18</td>
<td>448.84</td>
<td>787.82</td>
</tr>
<tr>
<td>Bank branch per 1,000 adult</td>
<td>2.89</td>
<td>12.12</td>
<td>22.91</td>
</tr>
<tr>
<td>MF branch per 1,000 adult</td>
<td>7.54</td>
<td>2.76</td>
<td>8.3</td>
</tr>
<tr>
<td>Bank branch per km2</td>
<td>4.45</td>
<td>8.76</td>
<td>14.71</td>
</tr>
<tr>
<td>MF branch per km2</td>
<td>11.56</td>
<td>0.85</td>
<td>1.11</td>
</tr>
<tr>
<td>Private Credit / GDP</td>
<td>0.1642</td>
<td>0.2798</td>
<td>0.4613</td>
</tr>
</tbody>
</table>

*Source.* Data regarding MFI branches per 1,000 adults and MFI branches per km² are from the International Monetary Fund’s Financial Access Survey; all other data are from the World Bank’s Global Financial Inclusion Database.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
</tr>
<tr>
<td>Bank Lerner Index</td>
<td>3.244**</td>
<td>1.901</td>
<td>1.455</td>
<td>1.451</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.191)</td>
<td>(0.748)</td>
<td>(0.719)</td>
<td>(0.522)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Lerner Index * Bank Branch</td>
<td>-0.472***</td>
<td>-0.448***</td>
<td>-0.112</td>
<td>-0.278**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-3.617)</td>
<td>(-3.163)</td>
<td>(-1.238)</td>
<td>(-2.037)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td>1.680*</td>
<td>0.0821</td>
<td>0.250</td>
<td>0.753</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.727)</td>
<td>(0.0522)</td>
<td>(0.192)</td>
<td>(0.519)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner * Bank Branch</td>
<td>-0.209***</td>
<td>-0.169***</td>
<td>-0.109**</td>
<td>-0.108*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.828)</td>
<td>(-2.801)</td>
<td>(-2.302)</td>
<td>(-1.960)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lemer Index</td>
<td>0.181***</td>
<td>0.159***</td>
<td>0.0573</td>
<td>0.0820*</td>
<td>0.0952***</td>
<td>0.0707**</td>
<td>0.0522*</td>
<td>0.0275</td>
<td>0.00148</td>
<td>-0.0289</td>
<td>-0.0161</td>
<td>-0.0257</td>
</tr>
<tr>
<td></td>
<td>(3.880)</td>
<td>(2.970)</td>
<td>(1.585)</td>
<td>(1.780)</td>
<td>(2.818)</td>
<td>(1.998)</td>
<td>(1.820)</td>
<td>(0.958)</td>
<td>(0.102)</td>
<td>(-1.549)</td>
<td>(-1.092)</td>
<td>(-1.381)</td>
</tr>
<tr>
<td>MF Lemer * Bank Branch</td>
<td></td>
<td></td>
<td></td>
<td>0.0422*</td>
<td>0.0909**</td>
<td>0.0400</td>
<td>0.0750**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.841)</td>
<td>(2.584)</td>
<td>(1.146)</td>
<td>(2.173)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Bank Branch</td>
<td>0.1849</td>
<td>0.159***</td>
<td>0.0573</td>
<td>0.0820*</td>
<td>0.0952***</td>
<td>0.0707**</td>
<td>0.0522*</td>
<td>0.0275</td>
<td>0.00148</td>
<td>-0.0289</td>
<td>-0.0161</td>
<td>-0.0257</td>
</tr>
<tr>
<td></td>
<td>(3.880)</td>
<td>(2.970)</td>
<td>(1.585)</td>
<td>(1.780)</td>
<td>(2.818)</td>
<td>(1.998)</td>
<td>(1.820)</td>
<td>(0.958)</td>
<td>(0.102)</td>
<td>(-1.549)</td>
<td>(-1.092)</td>
<td>(-1.381)</td>
</tr>
<tr>
<td></td>
<td>(-0.860)</td>
<td>(-1.649)</td>
<td>(-0.610)</td>
<td>(-0.454)</td>
<td>(-0.853)</td>
<td>(-1.606)</td>
<td>(-0.218)</td>
<td>(-0.534)</td>
<td>(-1.681)</td>
<td>(-2.146)</td>
<td>(-1.565)</td>
<td>(-1.171)</td>
</tr>
<tr>
<td></td>
<td>(-10.07)</td>
<td>(-7.155)</td>
<td>(-8.672)</td>
<td>(-6.794)</td>
<td>(-11.19)</td>
<td>(-9.574)</td>
<td>(-12.93)</td>
<td>(-11.31)</td>
<td>(-11.45)</td>
<td>(-9.293)</td>
<td>(-10.80)</td>
<td>(-6.701)</td>
</tr>
<tr>
<td>Year dummy</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
</tr>
<tr>
<td>N</td>
<td>413</td>
<td>398</td>
<td>397</td>
<td>401</td>
<td>415</td>
<td>400</td>
<td>399</td>
<td>403</td>
<td>565</td>
<td>561</td>
<td>537</td>
<td>566</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.171</td>
<td>0.270</td>
<td>0.044</td>
<td>0.168</td>
<td>0.133</td>
<td>0.240</td>
<td>0.048</td>
<td>0.155</td>
<td>0.101</td>
<td>0.178</td>
<td>0.110</td>
<td>0.153</td>
</tr>
<tr>
<td>Number of country</td>
<td>68</td>
<td>68</td>
<td>67</td>
<td>68</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>77</td>
<td>77</td>
<td>77</td>
<td>77</td>
<td>77</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
Table 3.7 Interaction w/ Bank Accounts per 1000 adults, Panel data, Country Fixed Effect Regression

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Lerner Index</td>
<td>4.106*</td>
<td>3.928</td>
<td>3.232</td>
<td>5.198</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.864)</td>
<td>(1.035)</td>
<td>(1.115)</td>
<td>(1.344)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Lerner Index * Account</td>
<td>-0.00758***</td>
<td>-0.00895**</td>
<td>-0.00383</td>
<td>-0.0103***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-3.091)</td>
<td>(-2.504)</td>
<td>(-1.112)</td>
<td>(-2.803)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td>3.971***</td>
<td>3.045</td>
<td>2.513</td>
<td>4.445*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.738)</td>
<td>(1.099)</td>
<td>(1.208)</td>
<td>(1.729)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner * Account</td>
<td>-0.0110***</td>
<td>-0.0102***</td>
<td>-0.00628*</td>
<td>-0.0108***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-5.088)</td>
<td>(-3.315)</td>
<td>(-1.878)</td>
<td>(-3.673)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.507</td>
<td>-0.749</td>
<td>-0.0443</td>
<td>-0.438</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-0.417)</td>
<td>(-0.476)</td>
<td>(-0.0547)</td>
<td>(-0.253)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF Lerner * Account</td>
<td>0.00349***</td>
<td>0.00317**</td>
<td>0.00134</td>
<td>0.00253**</td>
<td>0.00353***</td>
<td>0.00266**</td>
<td>0.00156**</td>
<td>0.00166</td>
<td>-0.000472</td>
<td>-0.00144**</td>
<td>0.000465</td>
<td>-0.00169**</td>
</tr>
<tr>
<td>Number of Account</td>
<td>0.00349***</td>
<td>0.00317**</td>
<td>0.00134</td>
<td>0.00253**</td>
<td>0.00353***</td>
<td>0.00266**</td>
<td>0.00156**</td>
<td>0.00166</td>
<td>-0.000472</td>
<td>-0.00144**</td>
<td>0.000465</td>
<td>-0.00169**</td>
</tr>
<tr>
<td>Real GDP per capita growth rate</td>
<td>-1.943</td>
<td>-5.116</td>
<td>-1.268</td>
<td>-1.857</td>
<td>-0.999</td>
<td>-4.052</td>
<td>-0.485</td>
<td>-1.259</td>
<td>-2.511</td>
<td>-5.131**</td>
<td>-1.173</td>
<td>-2.151</td>
</tr>
<tr>
<td></td>
<td>(-0.821)</td>
<td>(-1.568)</td>
<td>(-0.765)</td>
<td>(-0.607)</td>
<td>(-0.430)</td>
<td>(-1.273)</td>
<td>(-0.313)</td>
<td>(-0.427)</td>
<td>(-1.454)</td>
<td>(-2.339)</td>
<td>(-0.785)</td>
<td>(-0.948)</td>
</tr>
<tr>
<td></td>
<td>(-9.368)</td>
<td>(-5.019)</td>
<td>(-6.319)</td>
<td>(-5.311)</td>
<td>(-11.54)</td>
<td>(-5.526)</td>
<td>(-8.546)</td>
<td>(-6.695)</td>
<td>(-8.788)</td>
<td>(-6.019)</td>
<td>(-11.36)</td>
<td>(-5.927)</td>
</tr>
<tr>
<td>y ear dummy</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>209</td>
<td>205</td>
<td>210</td>
<td>214</td>
<td>209</td>
<td>205</td>
<td>210</td>
<td>214</td>
<td>209</td>
<td>205</td>
<td>210</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.187</td>
<td>0.257</td>
<td>0.048</td>
<td>0.211</td>
<td>0.220</td>
<td>0.251</td>
<td>0.058</td>
<td>0.194</td>
<td>0.165</td>
<td>0.226</td>
<td>0.030</td>
<td>0.175</td>
</tr>
<tr>
<td>Number of country</td>
<td>39</td>
<td>39</td>
<td>38</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>38</td>
<td>39</td>
<td>44</td>
<td>44</td>
<td>43</td>
<td>44</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
Table 3.8 The Interaction Effect of Competition and Financial Development, Panel data, Country Fixed Effect Regression

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
<td>Log (PAR30)</td>
<td>Log (PAR90)</td>
<td>Log (Loan Loss Rate)</td>
<td>Log (Loan Loss Reserve)</td>
</tr>
<tr>
<td>Bank Lerner Index</td>
<td>2.450**</td>
<td>-0.497</td>
<td>-0.640</td>
<td>0.107</td>
<td>(2.076)</td>
<td>(-0.298)</td>
<td>(-0.357)</td>
<td>(0.0658)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Lerner Index * Fin Dev</td>
<td>-0.114***</td>
<td>-0.0824*</td>
<td>0.0329</td>
<td>-0.0760</td>
<td>(-3.295)</td>
<td>(-1.728)</td>
<td>(0.621)</td>
<td>(-1.647)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.937*</td>
<td>0.425</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.884)</td>
<td>(0.260)</td>
<td></td>
</tr>
<tr>
<td>Bank Adjusted Lerner * Fin Dev</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.106***</td>
<td>-0.0941**</td>
<td>0.0218</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-3.383)</td>
<td>(-2.328)</td>
<td>(0.473)</td>
</tr>
<tr>
<td>MF Lerner Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.0667</td>
<td>0.0701</td>
<td>-0.0372</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.595)</td>
<td>(-1.316)</td>
<td>(1.794)</td>
</tr>
<tr>
<td>MF Lerner * Fin Dev</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.00208</td>
<td>0.0701</td>
<td>-0.0372</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-0.0667)</td>
<td>(1.595)</td>
<td>(-1.316)</td>
</tr>
<tr>
<td>Financial Development</td>
<td>0.0664***</td>
<td>0.0846***</td>
<td>0.0161</td>
<td>0.0765***</td>
<td>0.0559***</td>
<td>0.0816***</td>
<td>0.0173</td>
<td>0.0749***</td>
<td>0.0346*</td>
<td>0.0165</td>
<td>0.0422***</td>
<td>0.0108</td>
</tr>
<tr>
<td></td>
<td>(5.192)</td>
<td>(5.151)</td>
<td>(1.056)</td>
<td>(5.555)</td>
<td>(5.018)</td>
<td>(5.259)</td>
<td>(1.288)</td>
<td>(5.669)</td>
<td>(1.879)</td>
<td>(0.721)</td>
<td>(2.723)</td>
<td>(0.532)</td>
</tr>
<tr>
<td>Real GDP per capita growth</td>
<td>-4.437***</td>
<td>-4.584**</td>
<td>-1.255</td>
<td>-1.797</td>
<td>-4.007***</td>
<td>-4.004*</td>
<td>-0.422</td>
<td>-1.677</td>
<td>-3.567**</td>
<td>-5.341***</td>
<td>-2.662*</td>
<td>-3.255*</td>
</tr>
<tr>
<td></td>
<td>(-3.047)</td>
<td>(-2.104)</td>
<td>(-0.637)</td>
<td>(-0.882)</td>
<td>(-2.751)</td>
<td>(-1.903)</td>
<td>(-0.212)</td>
<td>(-0.861)</td>
<td>(-2.129)</td>
<td>(-3.048)</td>
<td>(-1.833)</td>
<td>(-1.822)</td>
</tr>
<tr>
<td></td>
<td>(-11.98)</td>
<td>(-12.10)</td>
<td>(-6.459)</td>
<td>(-13.12)</td>
<td>(-11.11)</td>
<td>(-12.41)</td>
<td>(-6.769)</td>
<td>(-15.69)</td>
<td>(-8.343)</td>
<td>(-8.130)</td>
<td>(-12.17)</td>
<td>(-8.555)</td>
</tr>
<tr>
<td>Year dummy</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
<td>(yes)</td>
</tr>
<tr>
<td>N</td>
<td>593</td>
<td>454</td>
<td>555</td>
<td>458</td>
<td>591</td>
<td>456</td>
<td>553</td>
<td>460</td>
<td>578</td>
<td>572</td>
<td>552</td>
<td>576</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.161</td>
<td>0.365</td>
<td>0.053</td>
<td>0.315</td>
<td>0.164</td>
<td>0.364</td>
<td>0.061</td>
<td>0.312</td>
<td>0.142</td>
<td>0.286</td>
<td>0.072</td>
<td>0.255</td>
</tr>
<tr>
<td>Number of country</td>
<td>71</td>
<td>70</td>
<td>69</td>
<td>70</td>
<td>71</td>
<td>71</td>
<td>69</td>
<td>71</td>
<td>79</td>
<td>79</td>
<td>79</td>
<td>79</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1. Robust t-statistics in parentheses
Table 3.9 Marginal Effect of Lerner Index by Income Group

<table>
<thead>
<tr>
<th>Table</th>
<th>LICs</th>
<th>Lower-middle income countries</th>
<th>Upper-middle income countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 6: Bank Branches</td>
<td>1.88</td>
<td>-2.48</td>
<td>-7.57</td>
</tr>
<tr>
<td>Table 7: with Accounts</td>
<td>2.88</td>
<td>0.70</td>
<td>-1.87</td>
</tr>
<tr>
<td>Table 8: Private credit / GDP</td>
<td>0.58</td>
<td>-0.74</td>
<td>-2.81</td>
</tr>
</tbody>
</table>

Note: The marginal effect of the Lerner index is calculated by using the coefficients shown in Tables 6–8 by inputting the average value of each income group into the number of bank branches, number of accounts, and ratio of private credit to GDP. The average value appears in Table 5.
Appendix Table A1 Variable Description and Summary Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
<th>Source</th>
<th>N</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR30</td>
<td>The ratio of portfolio at risk (&gt; 30 days) to gross loan portfolio</td>
<td>MIX market</td>
<td>745</td>
<td>3.800</td>
<td>1.520</td>
<td>0.320</td>
<td>12.120</td>
</tr>
<tr>
<td>PAR90</td>
<td>The ratio of portfolio at risk (&gt; 90 days) to gross loan portfolio</td>
<td>MIX market</td>
<td>560</td>
<td>4.680</td>
<td>1.780</td>
<td>0.540</td>
<td>12.130</td>
</tr>
<tr>
<td>Loan Loss Rate</td>
<td>Write-offs - Value of Loans Recovered / Gross Loan Portfolio</td>
<td>MIX Market, Author's calculation</td>
<td>712</td>
<td>0.120</td>
<td>1.620</td>
<td>0.030</td>
<td>40.270</td>
</tr>
<tr>
<td>Loan Loss Reserve Rate</td>
<td>Loan Loss Reserves / Gross Loan Portfolio. Loan loss reserves is a weighted average of delinquency rate. We assign a likelihood of default based on # of days in arrears. 10% for 1-30 days past due, 50%, for 31-60 days, 75% for 61-90 days, and 100% for over 90 days.</td>
<td>MIX Market, Author's calculation</td>
<td>564</td>
<td>0.090</td>
<td>0.050</td>
<td>0.000</td>
<td>0.291</td>
</tr>
<tr>
<td>Loan Loss Reserve Rate</td>
<td>Loan Loss Reserves / Gross Loan Portfolio. Loan loss reserves is a weighted average of delinquency rate. We assign a likelihood of default based on # of days in arrears. 10% for 1-30 days past due, 50%, for 31-60 days, 75% for 61-90 days, and 100% for over 90 days.</td>
<td>MIX Market, Author's calculation</td>
<td>564</td>
<td>0.090</td>
<td>0.050</td>
<td>0.000</td>
<td>0.291</td>
</tr>
<tr>
<td>Bank's Competition Indicators</td>
<td>Lerner index</td>
<td>Clerides et al. (2013)</td>
<td>659</td>
<td>0.2845797</td>
<td>0.1003376</td>
<td>0.001</td>
<td>0.65</td>
</tr>
<tr>
<td>Bank's Competition Indicators</td>
<td>Adj. Lerner index</td>
<td>World Bank</td>
<td>654</td>
<td>0.2279434</td>
<td>0.1066233</td>
<td>0.003</td>
<td>0.637</td>
</tr>
<tr>
<td>Real GDP per capita growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFI's Lerner Index</td>
<td>see Appendix 2</td>
<td>MIX Market, Author's calculation</td>
<td>561</td>
<td>0.380</td>
<td>0.120</td>
<td>0.030</td>
<td>0.850</td>
</tr>
<tr>
<td>Bank Branch Account</td>
<td>The number of bank branch per 1,000 adult</td>
<td>World Bank</td>
<td>432</td>
<td>12</td>
<td>14.8</td>
<td>0.31</td>
<td>92.68</td>
</tr>
<tr>
<td>Private Credit / GDP</td>
<td>The number of accounts per 1,000 adult</td>
<td>World Bank</td>
<td>236</td>
<td>411.47</td>
<td>459.06</td>
<td>7.32</td>
<td>2861.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>728</td>
<td>29.320</td>
<td>25.590</td>
<td>0.770</td>
<td>167.540</td>
</tr>
</tbody>
</table>

Appendix Table A2 Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>Log (PAR30)</th>
<th>Log (PAR90)</th>
<th>Log (Loan Loss Reserves)</th>
<th>Log (Loan Loss Rate)</th>
<th>Lerner Index</th>
<th>Adj. Lerner Index</th>
<th>MFI Lerner Index</th>
<th>Real GDP pc growth rate</th>
<th>Bank Branch</th>
<th>Accounts</th>
<th>Private Credit / GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log (PAR30)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (PAR90)</td>
<td>0.792</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Loan Loss Reserves)</td>
<td>0.319</td>
<td>0.2773</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Loan Loss Rate)</td>
<td>0.2229</td>
<td>0.2803</td>
<td>0.0625</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lerner Index</td>
<td>-0.0518</td>
<td>-0.147</td>
<td>0.0419</td>
<td>0.1686</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. Lerner Index</td>
<td>-0.0368</td>
<td>-0.1321</td>
<td>0.0826</td>
<td>0.0862</td>
<td>0.8511</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFI Lerner Index</td>
<td>-0.0072</td>
<td>-0.0739</td>
<td>-0.1452</td>
<td>0.0281</td>
<td>-0.0159</td>
<td>-0.0417</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real GDP pc growth rate</td>
<td>-0.303</td>
<td>-0.3631</td>
<td>-0.1021</td>
<td>-0.0491</td>
<td>0.2122</td>
<td>0.1789</td>
<td>0.1934</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Branch</td>
<td>-0.0838</td>
<td>0.0471</td>
<td>-0.0882</td>
<td>0.2318</td>
<td>-0.225</td>
<td>-0.2455</td>
<td>0.2016</td>
<td>0.107</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounts</td>
<td>-0.1725</td>
<td>0.0173</td>
<td>-0.119</td>
<td>0.0507</td>
<td>-0.2156</td>
<td>-0.2208</td>
<td>0.157</td>
<td>0.0265</td>
<td>0.3797</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>credit /GDP</td>
<td>-0.1428</td>
<td>0.0697</td>
<td>-0.1377</td>
<td>0.1008</td>
<td>-0.2941</td>
<td>-0.2409</td>
<td>0.08</td>
<td>-0.0178</td>
<td>0.4547</td>
<td>0.6776</td>
<td>1</td>
</tr>
</tbody>
</table>
### Appendix Table A3 List of Countries

<table>
<thead>
<tr>
<th>Low-income economies</th>
<th>Lower-middle-income economies</th>
<th>Upper-middle-income economies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Armenia</td>
<td>Albania</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Bolivia</td>
<td>Argentina</td>
</tr>
<tr>
<td>Benin</td>
<td>Cameroon</td>
<td>Azerbaijan</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Cote d'Ivoire</td>
<td>Bosnia and Herzegovina</td>
</tr>
<tr>
<td>Burundi</td>
<td>Egypt</td>
<td>Brazil</td>
</tr>
<tr>
<td>Cambodia</td>
<td>El Salvador</td>
<td>Bulgaria</td>
</tr>
<tr>
<td>Chad</td>
<td>Georgia</td>
<td>Chile</td>
</tr>
<tr>
<td>Comoros</td>
<td>Ghana</td>
<td>Colombia</td>
</tr>
<tr>
<td>Democratic Republic of the Congo</td>
<td>Guatemala</td>
<td>Costa Rica</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Honduras</td>
<td>Dominican Republic</td>
</tr>
<tr>
<td>Guinea</td>
<td>India</td>
<td>Ecuador</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>Indonesia</td>
<td>FYR Macedonia</td>
</tr>
<tr>
<td>Haiti</td>
<td>Iraq</td>
<td>Jamaica</td>
</tr>
<tr>
<td>Kenya</td>
<td>Kosovo</td>
<td>Jordan</td>
</tr>
<tr>
<td>Kyrgyz Republic</td>
<td>Lao P.D.R.</td>
<td>Kazakhstan</td>
</tr>
<tr>
<td>Madagascar</td>
<td>Moldova</td>
<td>Lebanon</td>
</tr>
<tr>
<td>Malawi</td>
<td>Mongolia</td>
<td>Mexico</td>
</tr>
<tr>
<td>Mali</td>
<td>Morocco</td>
<td>Montenegro</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Nicaragua</td>
<td>Panama</td>
</tr>
<tr>
<td>Nepal</td>
<td>Nigeria</td>
<td>Peru</td>
</tr>
<tr>
<td>Niger</td>
<td>Pakistan</td>
<td>Romania</td>
</tr>
<tr>
<td>Rwanda</td>
<td>Paraguay</td>
<td>Russia</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>Philippines</td>
<td>Serbia</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>Republic of Congo</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>Senegal</td>
<td></td>
</tr>
<tr>
<td>Togo</td>
<td>Sri Lanka</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>Sudan</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Syria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ukraine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uzbekistan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yemen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zambia</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* Income classifications from the World Bank. Outliers, China, South Africa, and Suriname, are excluded.
Appendix Figure A1 Histograms of Variables

- PAR30, Log
- PAR90, Log
- Loan loss reserve, Log
- Loan loss rate, Log
- Lerner Index
- Adj. Lerner Index
- MF Lerner Index
- Real GDP pc growth rate
- Number of Account per 1,000 adult
- Bank Branch per 1,000 adult
- Private Credit / GDP
Appendix Figure A2 Plot Figures

Appendix Figure A2 plots the relationships between MFI’s PAR90 and the banks’ Lerner Indexes and MFIs’ Lerner Indexes across income groups. The scattered points are labeled with country codes, and the points represent countries’ averages from the year 2000 to the latest available year.
Appendix 3B

*Estimation of the Lerner Index*\(^{25}\)

The Lerner index is computed to investigate the competitive behavior of MFIs, which is defined by: 

\[ L = \frac{p - MC}{p} \]

\(p\) is output price and \(MC\) is marginal cost. The output price is calculated as the ratio of total operating income (interest income plus other operating income) to total assets.

The marginal cost is derived from estimating the following trans-log cost function.

\[ \log C_{it} = \alpha_0 + \alpha_1 \log y_{it} + \alpha_2 \frac{1}{2} (\log y_{it})^2 + \beta_1 (\log w_{1it} + \log w_{2it}) \]

\[ + \beta_2 \frac{1}{2} (\log w_{1it}^2 + \log w_{2it}^2) + \gamma_1 \log y_{it} (\log w_{1it} + \log w_{2it}) \]

\[ + \gamma_2 \log w_{1it} \log w_{2it} + \delta_1 \text{trend} + \delta_2 \frac{1}{2} \text{trend}^2 + \delta_3 \log y_{it} \text{trend} \]

\[ + \eta (\log w_{1it} + \log w_{2it}) \text{trend} + \epsilon_{it} \]

\(C_{it}\) is the sum of financial and operating costs of MFIs. I use total assets for output, \(y\). I assume two inputs, labor and capital. The cost of labor (\(w_{1it}\)) is a ratio of personnel expense to number of employees. The cost of capital (\(w_{2it}\)) is the ratio of operating expense (minus personnel expenses) to net fixed assets. The cost function is estimated by including a time trend to capture the effect of technological change. Once I estimate the cost function, marginal cost (\(MC\)) is obtained by taking the derivative of the cost function with respect to \(\log y_{it}\).

Figures A3 and A4 show trends in both MFI and bank Lerner indexes. The bank Lerner indexes show an upward trend in early 2000, after which the Lerner indexes are constant. LICs have the least competitive banking sectors. By contrast, MFI Lerner indexes show steady declines during the entire period, and especially LICs show intense competition among income groups.

Figure A3 Bank’s Lerner Index by Income Group

---

\(^{25}\) Assefa, Hermes and Meesters (2010)
Source: The World Bank

Figure A4 MFI’s Lerner Index by Income Group

Source: MIX Market and author’s estimation
Chapter 4: Optimizing the timing of fertilizer applications

Abstract

Recent recommendations for fertilizers aim to match nutrient supplies with the varying nutrient demands of plants across time. From this perspective, agronomists have proposed two splits of nitrogenous fertilizer application: once at active tillering and again at panicle initiation. However, most field farmers apply nitrogen once or twice during early production stages, which results in the rice plant’s increased nitrogen loss and reduced nitrogen uptake. On the other hand, said recommendations do not account for all economic costs (e.g., labor costs involved in application). From this, it may be hypothesized that farmers are well-advised to ignore the recommendations.

To explore this question, I combine agronomic and economic considerations regarding the optimal timing of nitrogenous fertilizer. In light of knowledge of crop science, I set up a farmer’s profit maximization, and numerically determined the optimal splits, timings, and amounts of fertilizer applications while considering the extra labor costs for additional rounds of fertilizer. The model serves two objectives. First it allows me to explore specific hypotheses that may explain the reluctance to split. But the model also provides a prescriptive framework for generating fertilizer recommendations regarding timing as well as total quantity to be applied.

The results show that the fixed (labor) cost of fertilizer application does not explain why farmers typically do not split the nitrogen into two applications. The increase of yield from the additional split is larger than the additional cost of labor, except for the very small amount of N input. The numerical example also shows that splitting nitrogen equally is suboptimal. Applying more nitrogen at the time of panicle initiation than at the active tillering stage increases yield over an equal split of the same amount of nitrogen.

I also discuss how the price of credit changes the optimal fertilizer practice. The higher price of credit causes farmers to apply more nitrogen at panicle initiation because shorter loan durations can save interest payments. Lastly, I discuss the optimal fertilizer practices with damages on rice production function. Production damages reduce the optimal rates of nitrogen.
These findings will contribute to the improvement of the current NM software program. First, it is important to incorporate cost of labor and cost of credit into the programming of NM. Second, more split to panicle initiation is better than current equal splits by NM. Third, given the weather shocks or low agricultural input in real field, it will fit farmers’ actual field practices to allow damages on production function.

This chapter is the first analysis to combine agronomic knowledge of nitrogen dynamics with a rice production function specified by stages. This also helps to identify an area of future research that is necessary to improve fertilizer recommendations.

4.1 Introduction

4.1.1 Policy Problem

This chapter aims to model the optimal timing of nitrogen (N) fertilizer. Chemical fertilizer is a critical input for modern agricultural production. During the green revolution that began in the late 1960s in Asian countries, one of governments’ main policy goals was to increase fertilizer inputs (Pingali et al (1998)). However, the uniform recommendations failed to include the large heterogeneity among the farms’ conditions and the highly stochastic weather conditions, which are critical to derive the optimal fertilizer levels for the highly heterogenous field conditions (Roumasset (1976)). Recent fertilizer recommendations aim to match nutrient supplies with the varying nutrient demands of plants across time and farm sites (Buresh (2010), Dobermann (2004), Cassman (2002)).

Nitrogenous fertilizer, which is the most critical nutrient for plant growth, is subject to loss from soil immediately after application due to ammonium volatilization, de-nitrification, immobilization, and leaching\(^{26}\) (Buresh (2008), Choudhury (2005)).

---

\(^{26}\) Applied N fertilizer is converted to nitrate or ammonium ions in the soil and the plant absorbs them. During the transformation of N, they run off into the air or groundwater. First, applied N fertilizer accumulates in the floodwater. High concentrations of N, together with high floodwater pH and temperature, cause the loss of added fertilizer N into the atmosphere, which is called volatilization. De-nitrification occurs in the soil after the transformation of N to nitrate. Nitrate is reduced to nitrogen gases and then released into the atmosphere. Immobilization converts organic compounds into inorganic compounds through micro-organisms. Leaching moves the soil’s ammonium and nitrate out...
Moreover, the rate of N uptake in plants varies corresponding to the speed of plant growth. In general, the N intake of rice plants is at a maximum during their rapid vegetation period, which are the active tillering and panicle initiation times (Sheehy et al (2004a), (2004b)).

By feeding the plant at its most productive time, farmers can prevent N loss and increase N uptake in the plant. Therefore, IRRI (International Rice Research Institute)’s new fertilizer recommendations, which we are discussing in this paper, refer not only to the amount of fertilizer but also to the kinds of fertilizer and the timings for the applications (De Datta, Buresh (1989) Fairhurst et al (2007)). Moreover, these recommendations are tailored for each farm with farm specific information.

The underlying background of this new trial is world-wide concern and pressure regarding the growing demands for food, rapid increases in fertilizer needs (OECD/FAO (2011)), and the rising awareness of the risks of fertilizer pollution in the rivers and oceans (Ahrens et al (2007), (2010)). Given these problems, agronomist has been trying to meet the growing demands for food without doubling and tripling fertilizer inputs. The challenge for recent fertilizer practices has been to increase yield while also saving fertilizer use. Furthermore, if farmers can save fertilizer costs, then they will reallocate the money into other farming practices or they will just simply increase their net income by farming, which is important for most farmers because they suffer from poor economic conditions.

**Nutrient Manager**

For a help of tailoring recommendations to each farmer, the IRRI started a service of decision-support software that provides farmers with quick guidelines on the quantities and timing of fertilizer applications for rice plants after the farmers answer 10–15 questions. The software is called **Nutrient Manager** (NM). NM tailors fertilizer recommendations in the following steps. (Step 1) Farmers select a yield target. The IRRI generally place upper bound of yield target at about 75–80% of the yield potential.

of the root zone and sometimes into the groundwater through rain and irrigation.

27 Around 22 to 28 days after transplanting (DAT), which is called active tillering, the numbers of branches on each stem increase. At the panicle initiation time, around 40 DAT, the panicles start to form inside of every stem.

28 See Fairhurst et al (2007) for more details

29 This paper focuses on the use of N fertilizer. However, IRRI’s recommendation also guides farmers in the application of Phosphorus (P) and Potassium (K).
(Step 2) NM estimates the amount of endogenous nutrients in a soil from the farmers’ response to the questions, such as the crop residue management, the use of organic materials, or irrigation water. (Step 3) NM calculates the necessary fertilizer N rates and split them into optimal periods during the growth stage.

IRRI typically recommends 2 splits of N fertilizer at early application, at tillering time and panicle initiation time\(^{30}\). N is applied during the early to mid-tilling and at the panicle initiation stage (Brush 2010). On the other hand, from field observations, most farmers apply large amounts of N in the early stages, which causes a huge amount of N loss among the field farmers. This practice is far different from the one of NM.

Currently **Nutrient Manager** is available for the rice farmers in Bangladesh, China, India, Indonesia, Philippines, and West Africa. For example, in the Philippines, local agricultural extension technicians began to provide recommendations from **Nutrient Manager** to real farmers at 2008. And, since 2012, **Nutrient Manager** has become accessible over the Internet\(^{31}\). However, in contrast to the high publicity of **Nutrient Manager** in the agricultural technicians’ circle, the recognition of NM among small farmers is very low. None of the local farmers, who I interviewed, knew about the software.

### 4.1.2. Research Question

The objective of this chapter is to combine agronomic and economic considerations regarding the optimal timing of nitrogen fertilizer application to investigate whether a missing economic concept explains the gap between field farmers’ practices and the recommendations. In addition, I discuss how the recommendations should be modified in order to spread the use of NM among the farmers.

I focus on the labor costs of additional splits for fertilizer applications. NM suggests two splits at active tillering and at panicle initiation for the N fertilizer applications, however, as we describe in the next section, the many field farmers traditionally apply N fertilizer only once with a large amount of N at the early growing stages. NM’s recommendations, in most cases, create extra labor costs for the additional splits. However, the current programming for NM fails to combine the influence of the additional labor costs. I also examine the price of credit. Most farmers rely on credit to purchase fertilizer, and if the

\(^{30}\) Depending on the total amount of required N, the recommendations are no split sometimes and 3 splits other times.

price of credit is higher, the farmer will save interest payment by purchasing and applying fertilizer in later period.

In this chapter, I solve for the optimal number of splits of N application and the optimal timing of application including the extra costs of labor from the additional rounds of fertilizer. Firstly, I set up the farmers’ profit maximization model by integrating models of nitrogen dynamics. And then, given the costs for labor that the farmers reported in their field interviews, I numerically solve for the optimal timings for fertilizer applications, the numbers of splits, and the amounts of fertilizer. I also examine the impact of the cost of credit and uncertainty in agricultural production to fertilizer application. Then, I discuss how NM should modify its recommendations to increase the farmers’ overall economic efficiency.

As I discuss in the section 4.3, there is only one theoretical paper by Feinerman et al (1990) that has investigated the timing of fertilizer applications.\(^{32}\) This chapter is the first analysis that I know of which deals with combining agronomic knowledge of nitrogen dynamics and derives the optimal timing of fertilizer application. This trial reveals the area of future research that is necessary to improve fertilizer recommendations.

The rest of this chapter proceeds as follows. I first summarize statistics from a field survey of a Philippine village and document some of the factors associated with farmers deviating from the recommended timing of application (Section 4.2). Second, I establish a simple theoretical model to discuss the optimal timing of fertilizer application, number of splits, and amount of fertilizer in the trade-off between additional labor costs and the additional increase of net profit (section 4.3.1). For discussion, I provide numerical examples with data from field surveys (section 4.3.2). Since NM is an ongoing project, no studies have so far assessed new fertilizer recommendations from an economic perspective. Therefore, this study will contribute to produce directions for modifying NM’s recommendations for a wider spread among real farmers. Moreover, this is the first trial to analyze the optimal fertilizer application incorporating the detailed knowledge gained through crop science. This is the biggest contribution of this paper.

\(^{32}\) Duflo, Kremer and Robinson (2009) examine the effectiveness of a commitment device to increase fertilizer adoption among Kenyan farmers by offering them small discounts on fertilizer at the beginning of the season, when farmers are relatively liquid due to recent sales of harvests. Their plan is based on the idea that farmers are likely to procrastinate in regard to purchasing fertilizer until they need it, but when the time comes, they are often out of money. The researchers’ field experiment demonstrates that the commitment device was effective for increasing the use of fertilizer. Thus, their paper focuses on the timing of purchasing fertilizer but does not discuss the timing of application of fertilizer.
4.2 Discussion of Farmers Practice (FP) and NM’s recommendations using field data

This section discusses the differences between farmers’ conventional fertilizer practices and the NM recommendations. Comparing the timings for N-fertilizer applications in the FPs and NM, we investigate how much nitrogen the local farmers could save by adjusting their timings for the applications. Again, our focus is on nitrogen fertilizer.

The data in this section were collected through field interviews conducted in January 2013 at a village in the province of Pangasinan on Luzon Island in the Philippines. The data refer to a dry season of 2012. Fifty farmers were randomly selected among 387 households that comprised the village.

Table 4.1 reports the average timing for fertilizer applications and the amount of N for each number of splits. 9 of the 50 farmers applied it only once. 30 farmers applied the fertilizer twice, and 11 applied it more than three times during the season. The average amount of total N for each group of splits was 96 kg/ha for one-time applications, 133 kg/ha for two-times, 150 kg/ha for three-times, and 138 kg/ha for four-times. And farmers apply more N during the first round of application.

The last column of Table 4.1 summarizes NM’s recommendation. We derived the recommendation by setting the target yield at the same level that farmers achieved in the dry season in 2012. NM recommends 2-3 splits. The main timing of N input is at tillering time and panicle initiation time. The total amount of nitrogen by NM’s recommendation is much smaller than the amount of fertilizer by the farmers’ current practices. Especially, the recommended amounts for the first round are far below the amounts applied by the sample farmers.

One of the possible explanations for this apparent over-application in the first rounds is that farmers believe that rice plants should be raised like human children. Therefore, farmers apply more fertilizer to the young plants as if they are feeding infant children (Palis et al. (2007)). Moreover, according to informal talk with several farmers, they have been following what they have learned from their parents or neighbors. I guess that the procedures they follow have been affordable for the farmers and they’ve been fine with their yields. But this is my perception after talking with several farmers and their reasons.

33 In general, the recommendation has a five-day range for the timings of fertilizer-applications. I report the median date of the recommended range in Table 1 and Figure 1.
for their over-applications are unknown.

Table 4.1 Timing and Amount of N application by the number of fertilizer applications

<table>
<thead>
<tr>
<th>Total number of fertilizer-application</th>
<th>1 time application</th>
<th>2 splits</th>
<th>3 splits</th>
<th>4 splits</th>
<th>NM Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td># of farmers</td>
<td>9</td>
<td>30</td>
<td>9</td>
<td>2</td>
<td>45*</td>
</tr>
<tr>
<td>1st round</td>
<td>DAT kg/ha</td>
<td>DAT kg/ha</td>
<td>DAT kg/ha</td>
<td>DAT kg/ha</td>
<td>DAT kg/ha</td>
</tr>
<tr>
<td>1st round</td>
<td>13</td>
<td>96</td>
<td>9</td>
<td>69</td>
<td>9</td>
</tr>
<tr>
<td>2nd round</td>
<td>35</td>
<td>64</td>
<td>25</td>
<td>68</td>
<td>23</td>
</tr>
<tr>
<td>3rd round</td>
<td>48</td>
<td>39</td>
<td>33</td>
<td>55</td>
<td>34</td>
</tr>
<tr>
<td>4th round</td>
<td>45</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total N, kg/ha</td>
<td>96</td>
<td>133</td>
<td>150</td>
<td>138</td>
<td>89</td>
</tr>
</tbody>
</table>

* 5 farmers’ NM recommendations are missing due to their incomplete answers.

DAT = days after transplanting

Figure 4.1 plots the 50 local farmers’ actual nitrogen applications. The separate marks represent the different rounds of applications. Most farmers perform the first round of applications within 20 days after transplanting (DAT). On the other hand, the timings of the second and subsequent rounds are spread all over the growing stages of the rice plants.

Figure 4.1 Various N Fertilizer Applications Based on Farmers’ Field Practices

Source. Author’s field study

DAT= days after transplanting

Figure 4.2 demonstrates the amount of N inputs and the yield for the farmers’ practices (FPs). Farmers are ordered by their level of yield plotted in the straight line. The left axis measures the amount of N and the right axis measures the amount of yield. The corresponding bar graph is the total N inputs broken down into the total N loss and the total N uptake. The N uptake is calculated based on the N uptake and the N loss functions.
in my model. The detailed calculations are in section 4.3. This figure implies that the larger N loss in the farmers’ practices. The average percentage share of N loss in the total N input is 58 %.

Figure 4.2 Larger N loss within FP

Source. Author’s field study
Due to their incomplete answers, 5 farmers are omitted.

Figure 4.3 recalculates nitrogen loss in the FPs by modifying the timings of the N applications for the dates NM recommended. The amount of N uptake in Figure 4.3 is kept as it was in Figure 4.2. The revised N loss for NM’s recommending dates are in the green bar (“N loss (modified timing)”). The unfilled part of the bar is the saving of the N loss for applications with NM timing. In the other words, the N loss in the unfilled part is caused by the wrong timings of fertilizer applications by local farmers. The figure shows that some farmers can save a large amount of N just by adjusting the timing of the N applications.

Figure 4.3 N loss from Bad Timing

Source. Author’s field study
The conclusion of this section is that farmer's over apply fertilizer early in the planting season, relative to the recommendations of NM. In the following sections, I show that even the NM recommendation of an even split between tillering and panicle initiation is unwarranted and that a greater percentage applied at panicle initiation is indicated. I show that some farmers could save a large amount of N input by modifying their timings for N applications, and also by applying smaller amounts of N in the initial rounds.

4.3 Theoretical Discussions

This section sets up the farmers’ profit maximization problem (4.3.1). And then, I numerically solve for the optimal splits, timings, and amounts for the farmers’ fertilizer applications (4.3.2).

One theoretical paper has investigated the timing of fertilizer applications. Feinerman et al. (1990) examined the split application of nitrogen for corn production in the U.S. using a farmer’s decision-making model. Their study showed that pre-plant applications of nitrogen are subject to loss due to leaching and run-off, while nitrogen from late applications is entirely used for plant growth. However, late applications pose risks in the event of heavy rain, when soil becomes excessively wet, and nitrogen applications may become infeasible. Thus, to avoid missing opportunities for additional applications during all growth stages, farmers conventionally apply larger amounts of fertilizer at pre-planting, despite the potential for loss. Their study thus shows that a risk-averse farmer applies more nitrogen earlier than a risk-neutral farmer and thus more nitrogen in total.

Feinerman et al.'s (1990) model assumes two discrete periods of fertilizer application -- at pre-planting and at a later growth stage. Corn production depends on the sum of nitrogen at both the early and late applications, though part of the early application is lost during the later one. Given these assumptions, they solved farmers’ profit maximization problem and identified the optimal amount of nitrogen for both the early and late applications.

Yet, Feinerman et al.’s (1990) model omits the fact that a plant's nutrient intake also varies by growth stage. Since the original concept of NM was to match nitrogen application to a dynamics of a plant’s nitrogen uptake, I set up a model with dynamic equations for nitrogen uptake and loss across the maturity of the plant. In this sense, I focus on the dynamics of not only N loss, but also N uptake. At the same time, though their model assumes that plant production depends on the total nitrogen available after late application,
since NM recommends N application mainly at two different periods—at active tillering, and panicle initiation—I adopt a multiplicative production function consisting of the growth of tillers and panicles. I also assume that each part’s growth corresponds to the periods at active tillering, and panicle initiation, respectively. This aspect of the production function helps to explain the trade-off of nitrogen across each period.

To best of my knowledge, this paper is the first to integrate models of nitrogen dynamics with a sequential production function by stages and to discuss the optimal number of splits and timings according to the trade-off between labor costs for the additional applications and nitrogen saved due to on-time applications.

4.3.1 Optimal Number of Splits and Optimal Timing of N application

In splitting fertilizer, farmers face a trade-off between additional profit and cost of labor. This sub-section seeks to set up the farmers’ profit maximization problem to derive the optimal number of splits, the optimal timing of fertilizer application, and the optimal amount of fertilizer.

4.3.1.1 Production Function and Growth Calendar

The rice plant grown in the Philippines usually takes 3–4 months from germination to reach maturity depending on the variety. There are three distinct sequential growth stages: a vegetative stage (i.e., germination to panicle initiation), a reproductive stage (i.e., panicle initiation to heading/flowering), and a ripening stage (i.e., heading/flowering to harvest). Figure 4.4 shows the crop cycle for transplanted rice, which takes 100 days from transplanting to maturity.

The vegetative stage is characterized by active tillering, a gradual increase in plant height, and leaf emergence. The reproductive growth stage is characterized by panicle initiation, booting, heading, and flowering. Following fertilization, ripening is characterized by leaf senescence and grain growth, which increases the amount of starch in the

---

34 Yoshida (1981)
35 Heading refers to ‘panicle exsertion’ (exsertion of the panicle above the leaf sheath). Since flowering begins with panicle exsertion, heading is considered to be synonymous with flowering in terms of calendar days.
36 Leaf senescence is the loss of chlorophyll during a grain filling stage, which results in a decreases
spikelets\(^{37}\). Each stage corresponds to the growth of a different part, and the absorption and assimilation of nitrogen (N) varies according to stage. Since the purpose of this chapter is to examine the timing of fertilizer application, I therefore break down the yield function into parts corresponding with the three different stages.

Figure 4.4 Crop cycle for transplanted rice after 100 days of maturity

![Crop cycle diagram](source)

> **Source:** IRRI’s website (http://www.knowledgebank.irri.org/extension/growth-phases-and-growth-duration.html).

**Note:** Active tillering refers to the stage with a high tillering rate, roughly 20–28 days after transplanting (DAT).

**Rice Production Function by Components**

One method for examining rice yield performance is to break down the yield into its components, including number of panicles per plant and number of spikelets per panicle. These yield components are formed sequentially as the rice plant grows (see Table 4.2). In this chapter, I model rice production functions by component. Since the chapter focuses on the timing of the fertilizer application, examining the relationship between nitrogen in each stage and each yield component is crucial to deriving the optimal timing of the fertilizer application. However, research on the timing of the fertilizer application has used an ordinal blanket production function, which is the function of the total N input in the entire farming process and the rice yield at harvest. This chapter therefore builds upon this analytical framework to discuss the timing of the fertilizer input.

\[\text{in the photosynthetic energy conversion capacity (Choudhury 2005).}\]

\(^{37}\) Spikelets are rice grains before fertilization.
The grain yield of a rice plant can be expressed in multiplicative form according to its component parts as follows: 

\[
\text{Grain yield per plant} = \text{Number of panicles per plant} \times \text{Number of spikelets per panicle} \times \text{Percentage of filled grain} \times \text{Weight of grain}. 
\]

A panicle is a pyramidal, loosely branched flower cluster of the rice plant, formed from a node of the primary branches to the spikelets on top of the secondary branches (Figure 4.5). Typically, one panicle emerges from each tiller. However, since some tillers have no panicle (i.e., unfertilized tillers), I use the number of panicles instead of the number of tillers. Spikelets are the name of the rice grain before flowering, and fertilized spikelets are called rice grain.

Figure 4.5 Rice plant

Source: The Rice Hub (http://www.ricehub.org/RT/crop-establishment/-the-rice-plant/).

Each yield component is developed at a particular stage in the plant’s life (see Appendix).³⁸

Table 4.2 Period of yield component formation at certain growth stages

<table>
<thead>
<tr>
<th>Yield component</th>
<th>Planting</th>
<th>Active Tillering</th>
<th>Panicle Initiation</th>
<th>Flowering</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td># of panicles per m²</td>
<td>---------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td># of spikelets per panicle</td>
<td>---------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>Filled spikelets in %</td>
<td>---------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>Grain weight</td>
<td>---------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
</tbody>
</table>

Table 4.2 charts the development of each component according to the amount of nitrogen available at each stage of production. The number of panicles depends on the total nitrogen available per plant at active tillering and thus matches the farmer’s fertilizer application during active tillering. Meanwhile, the number of spikelets depends on the nitrogen available at panicle formation and thus corresponds with the farmer’s fertilizer application at panicle initiation. Finally, grain filling mostly depends on the amount of nitrogen redistributed from senescing leaves and newly assimilated nitrogen during the ripening stage.

From the above, I define the multiplicative rice production function by part as follows:

\[ Y = Y_{PAN}(X_{AT}) \times Y_{SP}(X_{P1}, Y_{PAN}) \times Y_{GF}(X_{GF}) \times GW \]  

(1)

In which \( Y \) = yield of rice grain (t/ha),
\( Y_{PAN} \) = the number of panicles per square meter (#/m²),
\( Y_{SP} \) = the number of spikelets per panicle (#/pan),
\( Y_{GF} \) = the share of filled spikelets (%),
\( GW \) = the weight of 1,000 grains (g)\( \times 10^{-7} \),
\( X_{AT} \) = the available N in the plant at active tillering time,
\( X_{P1} \) = the available N in the plant at panicle initiation time, and
\( X_{GF} \) = the available N in the plant at grain filling time.

Each yield component satisfies diminishing returns of yield to the amount of N, \( \frac{dY_{PAN}}{dX_{AT}} > 0, \frac{d^2Y_{PAN}}{dX_{AT}^2} < 0 \), \( \frac{dY_{SP}}{dX_{P1}} > 0, \frac{d^2Y_{SP}}{dX_{P1}^2} < 0 \) and \( \frac{dY_{GF}}{dX_{GF}} > 0, \frac{d^2Y_{GF}}{dX_{GF}^2} < 0 \). The number of spikelets is negatively associated with the number of panicles (\( \frac{dY_{SP}}{dY_{PAN}} < 0 \)). It is important to note that, unlike the ordinal production function, which uses an amount of applied N fertilizer
as an explanatory variable, this chapter uses the total N accumulated in the plant biomass \((X_t)\) as the variable for the amount of N. \(X_{AT}\) is the total assimilated N by active tillering, which influences the growth of panicles. \(X_{PL}\) is the amount of N available for use by developing spikelets, thus is the amount of N at panicle initiation. \(X_{GP}\) is the amount of N available during grain filling. As discussed in the following chapter, this value consists of newly absorbed N during grain filling as well as recycled N from that previously accumulated (Yoshida (1981) and Dobermann and Fairhurst (2000)).

4.3.1.2 Nitrogen Dynamics

This section discusses the dynamics of N in the rice plant. The amount of N varies over time according to the rate of N uptake, loss, and remobilization. This chapter applies knowledge of N dynamics in the farmer’s profit maximization model to derive the optimal timing of fertilizer application. Figure 4.6 shows the diagram of N fluxes into and out from the soil and rice plant.

Figure 4.6 Diagram of Nitrogen Dynamics

\[ N_t \]

- N fertilizer application
- Intrinsic soil N supply

\[ N \text{in soil (}Q_t\text{)} \]

\[ k^h Q_t \]

\[ N \text{ loss via denitrification and leaching.} \]

Available N in crop biomass \((X_t)\)

- Leaves
- Spikelets

N in detached dead biomass;

- 21% of N absorbed <45 DAT

Note: \(N^h_t\): The amount of N input from nitrogen fertilizer at \(t\). \(IN^h_t\): The amount of N supplied from indigenous and other environmental sources at \(t\). \(k^h\): The rate of N uptake at \(t\). \(k^l\): The rate of N loss. \(Q_t\): The stock of N in the soil at \(t\). \(X_t\): The accumulated N in the plant available to plant development at \(t\).

The amount of N in the soil at time \(t\) \((Q_t)\) is the sum of N from N fertilizer \((N^h_t)\), the amount of N supply from indigenous sources in the soil \((IN^h_t)\), and the N carried over from the previous period \((Q_{t-1})\). The N in the soil is absorbed by the rice plant at a varied
rate over time \( (k_t^h) \) and is also lost to the air or water at a constant rate over time \( (k_1^l) \). The plant also has an internal mechanism of recycling N from the old leaves to develop grain. About 30–40% of N is recycled. Finally, about 21% of N absorbed before 45 DAT is lost during leaf detachment (Sheehy et al. 2004 b). The following section details each mechanism.

**Nitrogen Uptake and Loss**

The rate of N uptake varies corresponding to the growth rate of the rice plant. For example, a plant needs more N during its rapid growth period. Figure 4.7 shows the growth of biomass over time for a rice plant of 100 days of maturity. The growth rate of the rice plant at 100 days of maturity peaks at around 40 DAT, which occurs during panicle initiation. Figure 4.8 shows the N uptake rate for a rice plant of 100 days of maturity. I therefore expect that N application at panicle initiation will most efficiently reduce loss and maximize uptake.

Figure 4.7 Growth of a rice plant’s biomass over time for 100 days of maturity

![Growth of a rice plant's biomass over time for 100 days of maturity](image)

*Source:* Sheehy and Mitchell (2013)

*Notes:* DAT = Days after transplanting. DAT adjusted from 120 days of maturity to a case with 100 days of maturity.
In what follows, I use the rate of N uptake at time \( t \) for a 100-day mature rice from Sheehy et al. (2005). This rate was taken during observations of the dry season in 2001 at IRRI, Los Baños, the Philippines.

\[
k^h_t = (\text{the rate of N uptake at time } t) = \frac{a \exp\left(-0.5\ln\left(\frac{1}{\beta}\gamma^2\right)\right)}{1-\exp\left(-0.5\ln\left(\frac{1}{\beta}\gamma^2\right)\right)} \times 0.1
\]

in which \( \alpha = 0.68 \pm 2.2 \), \( \beta = 43.3 \pm 1.2 \), and \( \gamma = 0.73 \pm 0.05 \). \( (2) \)

Nitrogen in the soil is subject to loss in the air and/or water due to ammonium volatilization, de-nitrification, immobilization, and leaching (Buresh 2010). Following Peng and Cassman (1998), I assume the rate of N loss, \( k^l \), to be constant over time (\( k^l = 0.105 \text{ per day} \)), which was the rate of N loss per day from the experimental farm at IRRI in Los Baños, the Philippines, in the dry season of 1995.

Finally, N is supplied from indigenous sources. Let \( \text{IN}_t \) be the amount of indigenous N in the soil. In the Philippines, N supplied from indigenous sources ranges from 0.3 kg/ha per day in poor soil to 1.2 kg/ha per day in fertile soil (ten Berge et al. 1997). In this chapter, I adopt the lower bound of supply, \( \text{IN}_t = 0.3 \text{ kg/day} \), which is 30 kg/ha of N supplied indigenously in one crop cycle. I also assume that the initial quantity of N in the soil is 12 kg/ha, \( \text{IN}_0 = 12 \) (Sheehy et al. 2005).

**Nitrogen Remobilization**
The rice plant is equipped with an internal mechanism of recycling N in older senescing organs for use in younger growing parts. Literature refers to this mechanism as *redistribution, reallocation, or remobilization*. It is reported that roughly 50–80% of N used for grain development in rice plants is reallocated from senescing organs, mostly leaves (Sheehy et al. 2004a; Tabuchi et al. 2007).

Remobilization works as follows. Before flowering, N is accumulated in leaves during protein synthesis, meaning that leaves act as a reservoir for N. After flowering, leaves start senescing and become a source of N. Protein in old leaves decomposes into glutamine, a form of amino acid, which is transported to the grains via phloem. The transported N in the grains is then reused for grain filling.

According to Tabuchi et al. (2007), too few studies have examined the allocation of N absorbed at different growth stages. In this chapter, I have adopted the results from Sheehy et al. (2004b) stating that 36% of N captured before panicle initiation is relocated to spikelets.

Following the above discussions and the diagram shown in Figure 4.6, the law of motion of N stock in the soil can be written as:

\[ Q_t = (Q_{t-1} + N_t + IN_t)(1 - k^h_t - k^l) \]  

in which \( Q_0 = N_0 + IN_0 \), \( Q_t \geq 0 \), \( N_t \geq 0 \), \( IN_t \geq 0 \), \( k^l = 0.105 \), \( k^h_t \) follows Eq. 2, and \( t = 0, \ldots, 100 \) DAT.

Using the stock of N in the soil \( (Q_t) \), and the rate of N uptake \( (k^p_t) \), I define the pool of N in the plant biomass available for growth of each component at each stage \( (X_{t=AT,PI,GF}) \) as follows:

\[ X_{AT} = X_{t=28} = \sum_{t=0}^{28} k^p_t Q_t \text{, in which } t \leq 28 \]

\[ X_{PI} = X_{t=45} = \gamma X_{37} + \sum_{t=38}^{45} k^h_t Q_t \text{, in which } 38 \leq t \leq 45 \]  

\[ X_{GF} = X_{t=80} = \gamma X_{45} + \sum_{t=46}^{80} k^h_t Q_t \text{, in which } 46 \leq t \leq 80 \]

in which \( \gamma \): the amount of recycled nitrogen for use in grains, \( \gamma = 0.3 - 0.4 \) (Sheehy et al. 2004b).
The N available for panicle growth and the sum of N uptake from transplanting to the end of active tillering, \( t = 28 \) DAT. \( X_{p i} \) is the nitrogen available for growth of spikelets, which is the sum of remobilized N accumulated prior to panicle initiation and the total N assimilated during panicle initiation from \( t = 38 \) to 45 DAT. \( X_{g f} \) is the N available for grain filling, which is the sum of remobilized N and current N uptake. Grain filling generally starts after panicle initiation and finishes at approximately 80 DAT.

4.3.1.2 The Farmer’s Profit Maximization Problem

Using the above rice production function and N dynamics, the farmer’s maximization problem can be written as follows:

\[
\max_{N_{at} \geq 0; N_{pi} \geq 0} \quad p_Y Y - p_N (N_{at} + N_{pi}) - p_L (L_{at} + L_{pi}) \quad (5)
\]

if \( N_{at} = 0, \) then \( L_{at} = 0, \) and if \( N_{at} > 0, \) then \( L_{at} = L. \)

if \( N_{pi} = 0, \) then \( L_{pi} = 0, \) and if \( N_{pi} > 0, \) then \( L_{pi} = L. \)

in which

\[
Y = Y_{PAN} (X_{AT}) \times Y_{SF} (X_{PI}, Y_{PAN}) \times Y_{GF} (X_{GF}) \times GW \quad \text{as in Eq.} \,(1)
\]

\[
X_{AT} = \sum_{t=0}^{28} k_t^h Q_t \quad \text{, in which } t \leq 28
\]

\[
X_{PI} = \gamma X_{37} + \sum_{t=38}^{45} k_t^h Q_t \quad \text{, in which } 38 \leq t \leq 45
\]

\[
X_{GF} = \gamma X_{45} + \sum_{t=46}^{80} k_t^h Q_t \quad \text{, in which } 46 \leq t \leq 80 \quad \text{as in Eq.} \,(4)
\]

\[
\gamma = 0.3
\]

\[
Q_t = (Q_{t-1} + N_t + 1N_t) (1 - k_t^h - k_t^l) \quad \text{as in Eq.} \,(3)
\]

Farmers chose the optimal amount of N input at active tillering \( (N_{at}) \) and at panicle initiation \( (N_{pi}) \) to maximize their net profit, which is \{Sales\} – \{Cost of Fertilizer\} – \{Fixed Cost of Labor per Application\}. Many field farmers hire workers to apply fertilizer, and farmers often supervise their work, meaning that there is a fixed cost per
time of fertilizer application. This fixed cost becomes critical when a farmer decides to switch from one-time application to split application.

As discussed in Section 4.3.1.1, the nitrogen uptake rate is maximized at panicle initiation. Therefore, I assume that application at panicle initiation is optimal for the case of one-time application and thus simplify the farmer’s problem in terms of timing the application to a choice between one-time application at panicle initiation and split application at both active tillering and panicle initiation.

Equation 6 shows the condition of a farmer who originally practices one-time application at panicle initiation but switches to two split applications at active tillering and panicle initiation.

\[ p_Y \frac{\Delta Y}{\Delta N_{AT}} - p_N - p_L \bar{L} > p_Y \frac{\Delta Y}{\Delta N_{P1}} - p_N \]  

(6a)

\[ p_Y \left( \frac{\Delta Y}{\Delta N_{AT}} - \frac{\Delta Y}{\Delta N_{P1}} \right) > p_L \bar{L} \]  

(6b)

\[ p_Y \left( \frac{\Delta Y_{PAN}}{\Delta Y_{PAN}} \frac{\Delta X_{AT}}{\Delta Q_{AT}} \frac{\Delta Q_{AT}}{\Delta N_{AT}} - \frac{\Delta Y_{SP}}{\Delta Y_{SP}} \frac{\Delta X_{P1}}{\Delta Q_{P1}} \frac{\Delta Q_{P1}}{\Delta N_{P1}} \right) > p_L \bar{L} \]  

(6c)

The right-hand side in Eq. 6a is the marginal increase of net profit when a farmer begins applying additional N at active tillering. The left-hand side is the marginal increase of net profit when a farmer continues to apply N at panicle initiation. Equation 6b indicates a farmer who switches to split application when the increase of marginal sales by switching application to active tillering from panicle initiation is greater than the fixed cost of labor.

Equation 6c further breaks down the marginal product of N input (\(\frac{\Delta Y}{\Delta N_{AT}}\)) into the marginal increase of the stock of N in the soil (\(\Delta Q_{AT}\)), the marginal increase of N in a plant (\(\Delta X_{AT}\)), and the marginal increase of yield by parts (\(\Delta Y_{PAN}\)).

The switching condition will be satisfied either when the diminishing marginal product of nitrogen is significant or when the fixed cost of labor (\(\bar{L}\)) is small. From Eq. 6c, because the N uptake rate at panicle initiation is higher than the uptake rate at active tillering, if the marginal productivity of N is the same during the yield of panicles and the yield of spikelets, then farmers initially prefer N application at panicle initiation. However, due to the diminishing marginal product of N, as N input at panicle initiation increases, the
incremental yield through the increase of the number of spikelets decreases. Thus, farmers would be more productive if they split N application between panicle initiation and active tillering. Moreover, farmers would prefer one-time application when the cost of labor is high.

The next condition is to derive the optimal level of N given the number of splits. The optimal level of N is determined when incremental sales from additional N input equal the cost of N.

\[
\frac{\Delta Y}{\Delta N_{P1}} = p_N \quad \text{for one-time application at panicle initiation} \quad (7)
\]

\[
\frac{\Delta Y}{\Delta N_{AT}} = \frac{\Delta Y}{\Delta N_{P1}} = p_N \quad \text{for two splits at active tillering and panicle initiation}
\]

4.3.2 Numerical Examples

This subsection numerically solves the farmer’s profit maximization model for deriving an optimal fertilizer application. To begin, I simulate the amount of N given various timing and splits of fertilizer application, after which I examine changes in optimal fertilizer application when farmers borrow credit to purchase fertilizer. Next, I examine the case of financial constraints, especially the relationship of labor costs and number of splits.

With the example, I first set up the growth function of the rice plant by referring to summary statistics of field data by Siband et al. (2004). Figure 4.9 displays the rice production function by the plant’s parts, in which the blue line is the made-up yield relationship, while the red square represents the summary statistics adopted from Siband et al. (2004). The rice production function that corresponds to Figure 4.9 appears in Eq. 8. I assume a diminishing marginal product of N for production function in all parts. Figure 4.9a–c shows an upward function with decreasing slopes.

I also assume that the number of spikelets depends on the total N per panicle \(\left(\frac{X_{PI}}{Y_{PAN}}\right)\). I employ this form since it is perhaps the simplest way to capture the negative relationship between the number of panicles and the number of spikelets. Moreover, since the functional form of the relationship between the number of panicles and the number of spikelets...
spikelets remains unavailable in the literature, this assumption would be the second best solution.

The main constraint of this example is the lack of access to data of N input and plant growth by part. Moreover, to the best of my knowledge, very little research addresses the relationship between N uptake and plant growth by part. Thus, in this example, I form the production function by fitting the summary statistics (i.e., minimum, maximum, and quartiles) of N input and rice yield by component from Siband et al. (2004). As such, the production function in the example is hypothetical, not an estimation from field data. In addition, data from Siband et al. (2004) has been taken from an agricultural experimental station in the Philippines on dry season, meaning that the production function in the example should be considered to be the upper bound of rice production function, which assumes optimal farming practices for everything other than N fertilizer input. Nonetheless, the following analysis is meaningful in the sense that it demonstrates how to operationalize the optimal fertilizer application given the theoretical setting in the previous chapter.

Figure 4.9 Rice production function by part
(a) Number of panicles and N in the plant at active tillering

(b) Number of spikelets per panicle and N in the plant at panicle initiation
(c) Percentage of filled grain and N in the plant at grain filling

The rice production function is as follows:

\[
Y = Y_{PAN}(X_{AT}) \times Y_{SP} \left( \frac{X_{PL}}{Y_{PAN}} \right) \times Y_{GF}(X_{GF}) \times GW
\]  

(8)

\[Y_{PAN} = 150 + 6X_{AT} - 0.1(X_{AT})^2\]

\[Y_{SP} = 100 + 400 \left( \frac{X_{SP}}{Y_{PAN}} \right) - 400 \left( \frac{X_{SP}}{Y_{PAN}} \right)^2\]

\[Y_{GF} = 75 + 0.7X_{GF} - 0.007X_{GF}^2\]

\[GW = 23 \times 10^{-7}\]

\[X_{LT=AT,PLGF}\] is defined as Eq. (4), and \(\gamma = 0.3\) from Sheehy (2004b). \(Q_t\) follows Eq. (3) and the rate of nitrogen uptake and loss is as in Eq. (2).
I adopted my field sample averages of prices of rice and N fertilizer. The average rice price is 17 pesos/kg, $p_Y = 15419$ peso/t. The average price of N fertilizer ($p_N$) is 50.87 pesos/kg. I define fixed labor cost of fertilizer application as follows; $L_i = \{\text{Cost of Hired Labor}\} + \{\text{Cost of Lunch/Snacks}\} + \{\text{Cost of Supervising Hired Labor}\}$. Twenty-nine farmers out of 50 hired workers to apply fertilizer, and all of them said they supervise the performance. From my sample, farmers pay from 50 to 300 pesos per one time of fertilizer application plus snack or meals. For the cost of supervising, I use the farmer’s income from outside of farming as an opportunity cost, which is 250 pesos per day. Thus, the fixed cost of labor is 350 to 600 pesos per one time of fertilizer application.

Given these assumptions, I solve the numerical example and discuss: (1) Optimal fertilizer application without credit constraint, without production shocks: (2) Optimal fertilizer application with production shocks: (3) Optimal fertilizer application with credit borrowing: and (4) Optimal fertilizer application with credit constraint.

(1) Optimal fertilizer application without credit constraint, without production shocks

To solve for the optimal nitrogen application rates and optimal timing, I simulate yield and net profit for four different cases of application timing and splits. Figure 4.10 presents yield and net profit for: (1) One time application at active tillering (‘AT’ in the figure); (2) One time application at panicle initiation (‘PI’ in the figure); (3) Two splits at active tillering and panicle initiation with 50:50 splits (‘ATPI 50:50’ in the figure); and (4) Two splits at active tillering and panicle initiation with 40:60 splits (‘ATPI 40:60’ in the figure). Figure 4.11 shows N loss and N uptake throughout the crop growing period across four methods of application.
Figure 4.10 Yield and Net Profit with various timing of N application

Note: \( p_L = 600 \) peso, \( p_N = 50.87 \) peso/kg, \( p_N = 17 \) peso/kg. Net Profit = Sales – Cost of N – Fixed Cost of Labor
As expected, the splitting application performs better than the one time application. From the figure of yield, up to around 30 kg of N input, the yield is almost similar across four different cases. And then, the yield from splitting application grows rapidly afterward. Among one time applications, N input at panicle initiation presents higher yield, and application at active tillering presents the lowest performance. Among split applications, 40:60 split has higher yield. Net profit shows the similar trend.

In the figure of net profit, the optimal nitrogen rate is derived as the maximum point. All applications other than ‘PI’ indicate optimal rates larger than 250 kg/ha. For the case of one time application at panicle initiation, the optimal N input is 150 kg/ha.

The higher yield and net profit of input at panicle initiation than at active tillering can be explained by the smaller N loss and larger N uptake at panicle initiation. Up to 140 kg/ha of N input, one time application at panicle initiation holds the lowest N loss and largest N uptake. In contrast, N loss is largest and N uptake is smallest for ‘AT.’

N loss and N uptake are almost the same between one time application at panicle initiation and split applications, however, marginal yield of ‘PI’ starts diminishing after about 50 kg/ha of N. This is because diminishing marginal growth of spikelet as N input at panicle initiation increases. On the other hand, splits application can keep the higher marginal productivity for each component simply because it splits N input.

Among split applications, 40:60 split has higher yield. It suggests that the current recommendation by NM of equal split can be improved by allocating more nitrogen to panicle initiation. Finding the optimal ratio of split will be the future tasks to improve
(2) Optimal fertilizer application under uncertainty

The above fertilizer recommendations may strike the reader as quite high. This is in part because they abstract from yield-reducing damages. This subsection discusses the optimal fertilizer application with shocks in rice production, which have been omitted in the previous cases. Agricultural production in the field always encounters negative shocks from the natural environment. And also, unlike experimental farms, the field farms are not operated at the optimal level of all other inputs including fertilizer application, which makes field farmers more vulnerable to any shocks. Figure 4.12 plots the amount of yield calibrated from the production function using the field data of nitrogen input and the amount of yield observed in the field. Some farmers perform as good as the calibrated one, yet yield of low performing farmers is about 1/2 to 2/3 of the calibrated one. This difference can be explained by weather shocks or low agricultural input during plant growing season.

Figure 4.12 Yield from model calibration and yield from field observation

In this subsection, I assume that production shocks reduce yield to 1/2. In this paper, my objective is to show changes of optimal fertilizer application in conditions which are more similar to real farmers’ fields. And I avoid going into detailed discussions of uncertainty in this paper. So, I don’t assume timing of shocks, risk preference, and so on.

Figure 4.13 shows yield and net profit with the 1/2 damage factor on. From the figure of
net profit, the optimal dry season nitrogen application is 90 kg/ha for ‘AT’, 130 kg/ha for ‘PI’, 240 kg/ha for a 50:50 split, and 220 kg/ha for a 40:60 split. Corresponding yields are 2.83 t/ha, 3.52 t/ha, 4.80 t/ha, and 4.84 t/ha respectively. Comparing this with the previous case without production shocks, the optimal fertilizer rate is smaller. It suggests that incorporating damages in agricultural production to NM program will improve recommendations.

Figure 4.13 Yield and Net Profit allowing for field conditions

(3) Optimal fertilizer application with credit borrowing

In my field observation, 17 farmers out of 50 use credit to purchase fertilizer. One of the most popular informal credit schemes in the Philippines is called ‘5 to 7,’ wherein farmers borrow and repay at a five to seven ratio per month, i.e. 40% interest per month. Farmers usually borrow money just before the time of fertilizer application and pay back just after
harvest. So, the duration of loans when a farmer borrows for application at active tillering is two and a half months, with an interest payment of 100%. For application at panicle initiation, the duration of the loan is reduced to two months with interest payment of 80%.

Figure 4.14 shows the net profit with credit borrowing. I assume farmers use credit to purchase all N input with 100% and 80% of the interest payment for application at active tillering and panicle initiation respectively. The credit borrowing reduces the net profit function, thus it reduces the optimal N input. The optimal N input for ‘AT,’ ‘PI,’ ‘ATPI50:50,’ and ‘ATPI 40:60’ goes down to 90 kg/ha, 140 kg/ha, 240 kg/ha, and 230 kg/ha respectively. Corresponding yields are 5.66 t/ha, 7.11 t/ha, 9.61 t/ha, and 9.75 t/ha respectively. As before, the optimal N input for split applications is larger because it can avoid constraint by diminishing marginal productivity of one specific yield component. Higher interest payment for application at active tillering makes farmers better off by splitting more amounts to the panicle initiation time. Thus, by incorporating credit for fertilizer purchase, the optimal fertilizer application is to apply more fertilizer at panicle initiation.

![Figure 4.14 Net Profit with Credit Borrowing](image)

*Note: Interest rate = 40% per month.*

(4) Optimal fertilizer application with credit constraint

In the field, some farmers input very small amounts of N, for example 17 kg/ha, due to prohibitively high price to access credit or physically impossible access to financial institutions. For the case of smaller N input, the fixed cost of labor becomes a critical factor to decide the number of splits.
Table 4.3 compares net profit between one time application at panicle initiation and two splits with 40:60 ratio across various levels of fixed labor cost for the small amount of N input. L=350 and L=600 is the minimum and the maximum of fixed labor cost from the field observation respectively. L=1000 and L =2000 is the hypothetical situation if the labor cost increases.

For small amounts of N, a one-time application is better than two splits due to the fixed labor cost. For example, at L=600, a farmer is better off applying 20 kg/ha of nitrogen at once. One bag of urea contains 23 kg of nitrogen. So, a farmer who can purchase only one bag of urea and hold high cost of labor should apply all at one time. As labor cost increases, farmers are more likely to apply larger amounts of N at once.

Table 4.3 Net Profit with different levels of fixed labor cost of fertilizer application

<table>
<thead>
<tr>
<th>N input kg/ha</th>
<th>L=350</th>
<th>L=600</th>
<th>L=1000</th>
<th>L=2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PI</td>
<td>ATP1 40:60</td>
<td>PI</td>
<td>ATP1 40:60</td>
</tr>
<tr>
<td>10</td>
<td>59,201</td>
<td>58,993</td>
<td>58,951</td>
<td>58,493</td>
</tr>
<tr>
<td>20</td>
<td>65,937</td>
<td>66,032</td>
<td>65,687</td>
<td>65,532</td>
</tr>
<tr>
<td>30</td>
<td>72,223</td>
<td>72,828</td>
<td>71,973</td>
<td>72,328</td>
</tr>
<tr>
<td>40</td>
<td>78,022</td>
<td>79,376</td>
<td>77,772</td>
<td>78,876</td>
</tr>
<tr>
<td>50</td>
<td>83,297</td>
<td>85,672</td>
<td>83,047</td>
<td>85,172</td>
</tr>
</tbody>
</table>

Note: L= Labor cost per application. All values are in pesos.

To summarize this numerical example, split applications perform better than one-time applications. Due to the higher uptake of nitrogen during panicle initiation, larger amounts of nitrogen should be allocated at panicle initiation. The Nutrient Manager recommends equal splits, however, my discussion shows that more split toward panicle initiation is better. Moreover, higher cost of credit access pushes farmers to split more to panicle initiation. Labor cost does not matter except for a farmer faces a very strict credit constraint and applies only small amounts of N fertilizer.

These findings can contribute to the improvement of the current NM software program and other recommendations. First, it is important to incorporate cost of labor and cost of credit into the programming of NM. Second, given weather shocks or low agricultural input in real field, it will fit farmers’ actual field practices to allow damages on yield.

4.4 Conclusion and Discussion for Future Research
This chapter is motivated by the ongoing issue of improving fertilizer recommendations. The new feature of the recommendation is that it includes the timing of fertilizer application in order to match nutrient supplies with the varying nutrient demands of rice plants across time. In general, agronomists recommend applying nitrogenous fertilizer at active tillering and at panicle initiation in equal amounts. Through the field interviews, I realized that the conventional practices of field farmers are very different from the recommendations. The common practice among farmers is to apply large amounts of nitrogen once or twice in the early stage of rice production. To explain this gap, I set up the hypothesis that large, fixed costs of labor for the additional application prevent them from splitting the fertilizer application. NM omits an account of the fixed costs of labor for fertilizer application, even though many field farmers hire additional labor to apply fertilizer.

To examine this hypothesis, I tried to set up the rice production by components and integrate models of nitrogen dynamics. The production function by parts enables us to break down the production function sequentially. Thus, it allows for a more detailed discussion of the timing of fertilizer input. The result shows a large increase of yield and net profit as a result of splitting fertilizer application. Furthermore, the gain from splitting the application is far larger than the additional labor costs. Thus, it does not support my original hypothesis of trade-off from fixed labor costs. However, for the case of a small amount of N input, a one-time application is more profitable due to additional labor costs. The trade-off hypothesis may apply for some farmers who face strict credit constraints and who apply a small amount of nitrogen.

Another finding is that between two split applications, the one that allocates a larger amount to the panicle initiation produces a higher yield and thus a larger net profit. The current NM recommends equal splits, yet with this finding, the recommendation of NM can be improved by finding the best allocation between active tillering and panicle initiation.

This chapter also discusses the impact of the cost of credit. I find that higher costs of credit push farmers to apply more fertilizer at panicle initiation due to shorter loan durations and smaller amounts of interest repayment. I also discuss the optimal fertilizer practices with damages on rice production function to allow for field conditions. Production damages reduce the optimal rates of nitrogen.

These findings will contribute to the improvement of the current fertilizer recommendation. First, it is important to incorporate cost of labor and cost of credit into
fertilizer recommendations. Second, more nitrogenous fertilizer at panicle initiation is better than the common recommendation of splitting nitrogen equally between the tillering and PI stages (e.g. as recommended by NM).

However, these findings represent one result from one numerical example based on the strong assumptions about nitrogen dynamics and rice production function. First, this trial reveals missing data about nitrogen input in various timing and rice yield by each component. Research on a more-detailed relationship between the timing of nitrogen input and the growth of rice plants by parts, as well as the relationship between each component of the rice plants, is a future task for the area of crop science studies. In addition, the production function in this paper could be updated with more detailed observation. I adopt nitrogen dynamics mostly from a study by Sheehy et al (2004a b) (2005). However, their N uptake and N loss is from experimental farms. Therefore, for future work, I would try different examples with various levels of N uptake and N loss.

I also intend to expand this numerical example to incorporate the risk of moisture stress. Higher levels of nitrogen require more water, meaning that large nitrogen input will exacerbate moisture stress. Damage from moisture stress increases as N input increases. According to Figure 4.12 illustrating the relationship between total nitrogen input and yield, the field farmer’s yield declines with the larger amount of N more than the yield from calibration. Thus, the added damage from moisture stress due to N application will measure more accurately on actual observation.

This chapter demonstrates that the split application can improve farmers’ yields and economic profits, and even in a one-time application, farmers should apply N at panicle initiation rather than at active tillering. Furthermore, I rejected the hypothesis of trade-off of fixed labor costs of additional application and split application except for the very small amount of N input. Then, the question remains: Why do many farmers apply a large amount of fertilizer all at once at the beginning of production? Another hypothesis involves incorrect beliefs about fertilizer application. Palis et al. (2007) reported that Filipino farmers normally apply more fertilizer during the first round of application due to their belief that rice plants should be raised like human children and fostered in their early youth. Further research should focus on the adoption of new technology, in this case, the adoption of new fertilizer recommendations and more effective and efficient ways to provide agricultural extension services.

To conclude, this paper shows that, even with the strong assumptions and lack of data, farmers can improve their crops yields by following the recommendations of Nutrient
Manager. It also reveals that, in turn, Nutrient Manager can improve its recommendations by providing the optimal split between active tillering and panicle initiation, taking into consideration the agronomic factors reviewed above and farmers’ economic variables such as cost of labor and cost of credit.
Appendix 4A

Each yield component is developed at a particular stage in the plant’s life.

*Number of panicles per square meter (P(#/m²)):* This value is largely dependent on tillering performance because the number of panicles equals the number of tillers. Thus, the number of panicles is largely determined by the amount of N assimilated during the active tillering time.

*Number of spikelets per panicle (S(#/p)): Panicles start to differentiate spikelets inside of each stem at panicle initiation, which occurs approximately 40 days after transplanting (DAT). The amount of assimilated N at panicle initiation is thus an important factor for the number of spikelets. The larger the number of panicles per plant, the smaller the number of spikelets per panicle.

*Percentage share of filled grain:* Grain (or spikelets) start filling with starch after flowering during the ripening stage. As discussed in greater depth later, the rice plant recycles N from leaf senescence and returns it young organs. In general, since most N used to fill grains is remobilized from senescence, the performance of grain filling is determined by the remobilized N assimilated during earlier stages and by new uptake during the ripening stage.

*Grain weight (g)×10⁻⁷:* Grain weight is also determined during the ripening stage, yet is a stable varietal characteristic.

---


40 Tillers are branches that develop from the main stem.
Chapter 5 Conclusions

World Bank’s new development agendas for post-2015 emphasize poverty alleviation and inclusive growth. In this dissertation, I have looked at rural development policies, especially agricultural and financial strategies, as they are promising avenues to attain these goals. As a tool to improve financial access to the poor, microfinance has been at the center of rural financial policies over the past decade. However, in fact, many microfinance institutions (MFIs) have been depending on subsidies from governments and donors, therefore, assessments of the social benefits of MFIs are critical.

To contribute to discussions on subsidies for MFIs, Chapter 2 theoretically examines the impact of MFIs on the rural credit market. I model a monopolistically-competitive, informal credit market, which uses social ties as a key variable to sort borrowers among moneylenders, and I compare the market equilibrium before and after the entrance of the MFIs. I also examine the impact of subsidies on an MFI by comparing the welfare changes of the entire rural credit market.

The results show that, even without a subsidy, MFIs have substantial potential to improve the welfare of the poor, who are excluded from formal credit access. This result clarifies that, even for-profit MFIs without any subsidy can increase credit access and induce competition in the rural credit market. Furthermore, the subsidy to the MFI may be justified from the view that it breaks the monopolistic interest rate of moneylenders and increases the competition against the high-type borrowers in a rural credit market. Although it is necessary to compare MFI policies with alternative pro-poor policies for further discussions on subsidies, this chapter provides a first step for an impact evaluation of the entrance of MFIs from the perspective of the entire rural credit market.

In the model of chapter 2, the entrance of a single MFI is unambiguously welfare-increasing. This would not necessarily be the case with two or more MFIs. For future research, I intend to extend this model to incorporate any externality effect from competition between MFIs in the informal credit market. Higher competition will weaken people’s incentive to repay; thus, it will increase the MFI’s enforcement costs, therefore, it will increase MFIs’ interest rates.

In fact, the recent repayment crises raise concerns that MFIs are weak in competitive market environments. Financial crises may hinder the implementation of government
policies for financial inclusion and also set back the client living standards in both rural and urban areas. In addition, competition among MFIs, and between the formal banks and MFIs, is expected to increase in the future.

Therefore, Chapter 3 investigates the competition–stability relationship among MFIs and between the MFIs and formal banks. Its results show that the microfinance sector’s within-sector competition and competition with the formal banking sector both influence MFI portfolio risks, though effects vary among income levels. The negative effect of bank competition is greater in upper-middle–income countries, though MFI competition uniformly influences all income groups. These findings suggest that bank and MFI competition are substitutes in upper-middle–income countries and operate in a vertical relationship in LICs.

Findings from Chapter 2 and Chapter 3 imply that when a market is dominated by informal moneylenders, the subsidies to the MFI worth make the market more competitive. Still, subsidies should be temporary, since the MFI’s operating costs fall as learning by doing takes places. However, as a country’s financial sector develops, the MFI’s comparative advantage on their lending mechanisms will weaken, because borrowers can access alternative lenders even if they default, thereby making the use of collaterals by formal banks a more advanced lending scheme than that of the MFI. With that in mind, the recommended policies at this stage are to organize property rights and conduct contract enforcement, both of which facilitate the country’s transition from MFIs to formal banks. The results also support calls for expanding the coverage of credit reporting systems to MFIs to prevent over-indebtedness among borrowers as a result of fierce competition.

Chapter 4 focuses on the optimal timing of nitrogenous fertilizer and suggests how current recommendations derived from the computer software program Nutrient Manager (NM) can be improved. My field interviews in a Philippine village show that NM’s recommendations require some farmers to apply additional splits of fertilizer, which requires additional labor costs. In this chapter, I analyze rice production by components and integrate models of nitrogen dynamics, the results of which reveal that additional gain by splitting application is far greater than additional labor costs. These results do not support my original hypothesis that a trade-off from fixed labor costs would occur.

This chapter also discusses the impact of the cost of credit. I find that higher costs of credit push farmers to apply more fertilizer at panicle initiation due to shorter loan
durations and smaller amounts of interest repayment. Moreover, I find that more nitrogenous fertilizer at panicle initiation is better than the common recommendation of splitting nitrogen equally between the active tillering and PI stages.

It should be noted that these findings represent only one result from one numerical example that held strong assumptions about nitrogen dynamics and the rice production function. Due to these limitations, additional research is needed concerning the complex relationship between the timing of nitrogen input and the growth of rice plants by part, as well as the relationship between each component of the rice plant. Among other limitations, agronomic studies of nitrogen dynamics come from experimental farms, meaning that future work should involve applying different examples with various levels of nitrogen.

Finally, the original question still remains: Why do many farmers apply a large amount of fertilizer too early? An alternative hypothesis involves incorrect beliefs about fertilizer application, since Filipino farmers apply more fertilizer during the first round of application due to their belief that rice plants should be raised like children. Further research should focus on the adoption of new technology, in this case new fertilizer recommendations regarding timing.

This dissertation examines policies on microfinance and fertilizer practices in pursuit of the goal of poverty alleviation and inclusive growth through rural development. The results from each chapter help to improve ongoing development projects and policies, which should contribute to the achievement of the post-2015 goals—the “reduction of extreme poverty to no more than 3% globally by 2030” and the “promotion of shared prosperity by fostering the income growth of the bottom 40% of the population in each country” (World Bank 2013a).
References


Bose, Pinaki. 1998b. "Personal transactions and market activity in the informal sector" Economic Letters 59, 139-144.


Keeley, Michael, 1990, Deposit insurance, risk and market power in banking, American Economic Review 80, 1183–1200


MicroSave. 2012. “Andhra Pradesh MFI Crisis and its Impact on Clients” Center for Microfinance and Micro Save


