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Vulnerability of Microfinance to Strategic Default and Covariate Shocks: Evidence from Pakistan

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Vulnerability of Microfinance to Strategic Default and Covariate Shocks: Evidence from Pakistan*

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Abstract

This paper investigates the repayment behavior of microfinance borrowers in Pakistan using a unique dataset of about 45,000 installments/repayments covering 2,945 microfinance borrower households over the period 1998–2007. In early 2005, the microfinance institution for these borrowers adopted a new system with strict enforcement of punishment against repayment delays/defaults. This reform led to a healthy situation with almost zero default rates, overcoming the previous problem of frequent defaults. We hypothesize that strategic default under the joint liability mechanism—if one group member is hit by a negative shock and faces difficulty in repayment, the other members who are able to repay may decide to default as well, instead of helping the unlucky member—was encouraged by weak enforcement of dynamic incentives and responsible for the pre-reform failure. As evidence for this interpretation, we show that a borrower's delay in installment repayment was correlated with other group members' repayment delays, beyond the level explained by possible correlation of project failures due to locally covariate shocks during the pre-reform period. The post-reform period is divided into two sub-periods by an earthquake in October 2005. Analysis of repayment behavior in the post-reform period yields the results that suggest that (1) the relative success under the new system was because of the suppression of strategic behavior among group members, thereby allowing joint liability schemes to function as individual lending schemes *de facto* and (2) the earthquake only marginally affected the new system in terms of repayment delays.

JEL classification codes: O16, G29, D82
Keywords: group lending, joint liability, contingent renewal, strategic default, covariate shocks

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1. Introduction

This paper empirically analyzes the repayment behavior of microfinance borrowers who were subject to high levels of idiosyncratic and covariate shocks and to subsequent reforms in the contract design concerning repayment installments and dynamic incentives. In the literature on microfinance, mechanisms that led to the success of Grameen Bank in maintaining high repayment rates have been the focus of research (Aghion and Morduch, 2010). While the first generation studies emphasize on various aspects of the role of joint liability in group lending, such as peer selection (Ghatak, 1999; 2000), peer monitoring (Stiglitz, 1990; Varian, 1990; Banerjee et al., 1994), and peer enforcement (Besley and Coate, 1995; Armendariz de Aghion, 1999), there has been a shift in emphasis in the second generation studies. Aghion and Morduch (2010) argue that joint liability is only one factor contributing to successful microfinance schemes and that there are other important aspects such as sequential financing, contingent renewal, dynamic incentives, frequent repayment installments, and public repayments.[1] Chowdhury (2005) theoretically shows that without sequential financing, group-lending schemes may suffer from under-monitoring, which might lead to borrowers investing in risky projects. In another theoretical paper, Chowdhury (2007) outlines that contingent renewal alone can resolve the moral hazard problem only when the discount rate is relatively low; however, a combination of sequential financing and contingent renewal can be successful even when the discount rate is relatively high.

The analysis of different theoretical mechanisms in literature notwithstanding, empirical evidence on the effectiveness of each continues to be limited,[2] although it has seen an increase in recent times (Hermes and Lensink, 2007). Kono (2006) reports the results of the Vietnamese experiment with microfinance games wherein contract designs are varied, and shows that joint liability *per se* leads to more frequent strategic default. Using the field experiment approach, Gine and Karlan (2009) evaluate the impact of removing group liability in the Philippines and find no adverse impact on repayment as long as public and frequent repayment systems are maintained.[3] At the same time, few empirical studies use non-experimental data while attempting to establish an explicit theoretical link. Using data from Peru,

[1]Sequential financing refers to group loans that are staggered within the same round. Contingent renewal means the exclusion of defaulting borrowers from future access to loans. Dynamic incentives refer to provision for larger loans to borrowers who successfully repay. Contingent renewal and dynamic incentives in this sense are sometimes combined as dynamic incentives in the broad sense. Public repayments refer to a system where borrowers make repayments to loan officers visiting villages in presence of others.

[2]The focus here is on empirical studies that attempt to establish an explicit link to theories. There are a large number of empirical and insightful studies that estimate the reduced-form determinants of group repayment behavior among microfinance borrowers (e.g., Hermes et al., 2005; Kritikos and Vigenina, 2005; Godquin, 2004; Paxton et al., 2000; Wydick, 1999; Sharma and Zeller, 1997). Among these, Wydick (1999) is one of the more influential ones as it employs the most extensive list of proxy variables to measure screening, monitoring, and enforcement within groups.

[3]See Cassar et al. (2007), McIntosh (2008), and Field and Pande (2008) for other applications of the experiment approach to analyze the mechanism underlying the repayment behavior.

Karlan (2007) finds evidence for the existence of peer monitoring under joint liability. Using data from Thailand, Ahlin and Townsend (2007) test theoretical models of joint liability lending, showing that the joint liability rate negatively affects repayment while the strength of local sanctions positively affects repayment. Interestingly, they show that the Besley and Coate model of strategic default has low explanatory power in general but that its explanatory power increases when applied to poor, low-infrastructure areas. These studies mostly support the view that mechanisms such as sequential financing, contingent renewal, dynamic incentives, frequent repayment, and public repayments are more important than joint liability is to the success of microfinance lending. However, they do not provide detailed empirical evidence for each theoretical mechanism, especially regarding the intra-group repayment dynamics that plays a key role in each model. More recently, Ahlin (2009) tests risk-matching and intra-group diversification of risk using Thai data and finds evidence of homogeneous sorting by risk and risk anti-diversification within groups.

To extend the empirical research in this direction, this paper investigates a unique dataset of about 45,000 installments/repayments covering 2,945 borrower households in Pakistan over the period 1998–2007, in order to offer empirical evidence that (1) strategic default is a serious problem for microfinance and (2) contingent renewal is a prerequisite for joint liability to prevent strategic default. Modern-style microfinance took root in Pakistan in the late 1990s; since then, there have been several examples of microfinance schemes that have failed despite following a group lending design on the lines of Grameen Bank in Bangladesh. Our dataset is unique not only in its level of disaggregation but also in its time coverage, which includes two important events. First, in early 2005, contract designs were changed to stress on improved enforcement of contingent renewal and more frequent repayment installments. Our dataset includes this break and enables us to analyze the outcome of contract design changes regarding repayment behavior. The second event occurred in October 2005 when a disastrous earthquake measuring 7.6 on the Richter scale struck Pakistan, killing more than 70,000 people. An earthquake is a strong covariate and an unexpected natural shock. Sample borrowers in our dataset lived in a radius ranging between 40 and 110 km from the epicenter. Therefore, our dataset enables us to analyze the impacts of covariate shocks of a high magnitude, whose impact on microfinance finds little mention in the literature (Shoji, 2010; Becchetti and Castriota, 2008).

Our analysis of the installment-level dynamics of repayment delays shows that a type of strategic default under the joint liability mechanism—wherein if one group member is hit by a negative shock and faces difficulty in repayment, other members who are capable of repayment may decide to default themselves as well, instead of helping out the unlucky member—was encouraged by weak enforcement of the contingent renewal rule. We ascribe the pre-2005 failure to this type of default. The delay in the unlucky member's repayment of each installment was correlated with other members' repayment delays beyond the level explained by the possible correlation of project failures due to locally covariate shocks. Although this type of strategic default has been shown to exist theoretically (e.g., Besley and Coate, 1995; Bhole and Ogden, 2010), this paper provides the empirical evidence lacking in the literature.

The rest of the paper is organized as follows. Section 2 provides a theoretical model to guide our empirical investigation. Section 3 describes the dataset and its background, providing the empirical definition of default and repayment delay adopted in this paper. Section 4 investigates the determinants of loan default and repayment delay under the old system at the borrower level, in order to show that the 2005 reforms were a step in the right direction. Section 5 documents the bulk of our empirical analysis, in which we examine the dynamics of installment repayments for loans made under the old system. Section 6 extends the analyses to loans made under the new system to show the decline in strategic default and demonstrate that the earthquake only marginally affected the new system in terms of repayment delays. Section 7 presents the conclusions.

2 A Theoretical Model of Group Lending with Imperfect Joint Liability

2.1 Overview

Joint liability or group liability can be defined as the mechanism wherein all group members are collectively responsible for loans made to group members in a manner such that all members lose their future access to loans if at least one borrower in the group fails to repay. In the first generation microfinance research, this mechanism was considered as the principal contributor to the success of Grameen Bank. Theoretical predictions show that the joint liability rule encourages peer selection (Ghatak, 1999; 2000), peer monitoring of project choice or efforts (Stiglitz, 1990; Varian, 1990; Banerjee et al., 1994), and peer enforcement with an aim to avoid strategic default (Besley and Coate, 1995; Armendariz de Aghion, 1999; Bhole and Ogden, 2010), which in turn may contribute to improved repayment rates among poor and collateral-less borrowers. At the same time, these theoretical studies also show that there might be a possibility of joint liability leading to high default rates, depending on structural parameters.

By construction, most of the abovementioned studies allow only two states: collective repayment or collective default. In order to simulate real life scenarios wherein even under joint liability schemes some members default while others in the same group repay their dues (but do not repay the dues of their defaulting peers), the assumption of perfect joint liability needs to be abandoned. We therefore extend a version (without social sanctions) of the repayment game proposed by Besley and Coate (1995), hereinafter referred to as the BC model, in order to allow the option of a group member repaying his/her due only. The BC model shows that borrowers who would repay under individual liability may not do so under group liability if they realize that they cannot repay as a group.

In this section, we build an extended model of repayment under imperfect joint liability to show that "peer correlation," which is the focus of the empirical analysis of this paper, reflects the intra-group interaction of borrowers. Models in the existing literature on group lending, however, cannot show this because the enforcement of joint liability is typically assumed to be perfect, which implies that repayment delay or default within a borrowers' group should be perfectly correlated. By assuming imperfect joint liability, we investigate the comparative statics of peer correlation with respect to the degrees of enforcement of the contingent renewal and the joint liability rules. The extended model predicts that strategic default may occur under imperfect joint liability. Under imperfect joint liability, "within-group cooperation" (a borrower who would not repay under individual liability is helped by another member to repay the debt) rarely occurs.

2.2 The model

There are two *ex ante* identical borrowers, each of whom has a project that requires one unit of capital. The project yields θ units of income. Before undertaking the project, the borrowers do not know θ but know that θ is distributed on $[\theta^{min}, \theta^{max}]$ according to the distribution function $F(\theta)$. Assuming the two borrowers form a borrowers' group, the bank lends each borrower one unit of capital, which is due at the end of the period with the amount to be repaid at the gross interest factor at r (>1). If both borrowers repay, each obtains the payoff of $\theta_i - r$, $i = 1, 2$ (the borrowers are assumed to be risk-neutral). These are exactly the same assumptions as those in the BC model.

If neither of the borrowers repay, each obtains the payoff of $\theta_i - \pi p(\theta_i)$, where $p(.)$ is the penalty on the defaulting borrowers, which is assumed to be increasing in θ. One way of justifying $p'(.)>0$ is that the main penalty is the loss of future access to microfinance loans and the net gain from having microfinance access increases in the realized value of θ. As in the BC model, the inverse of the penalty function $p(.)$ is denoted by the function $\varphi(.)$ ($\equiv p^{-1}(.)$). An additional parameter π is not included in the BC model. It is a fixed parameter in the range [0, 1] that captures the level of enforcement of the contingent renewal rule. By the contingent renewal rule, we refer to the mechanism analyzed by Chowdhury (2007), i.e., borrowers maintain their future loan access contingent on full repayment of their current loans. This rule is a prerequisite for dynamic incentives to function in the narrow sense (borrowers who have successfully repaid will be given a larger amount of credit). In reality, this rule may not be enforced strictly. We thus assume that the defaulters will maintain their future loan access with a probability of $1-\pi$.[4]

[4] In the context of strategic default, Armendariz de Aghion (1999) shows a theoretical model in which the probability of penalty lies in the range [0, 1], which corresponds to π in our model. In her model, this parameter is chosen by the lender and its optimal value for the lender turns out to be 1; hence, the problem of partial enforcement of the

If borrower i repays his/her due (but does not repay his/her partner's due[5]) and borrower j defaults, the payoff for the former is $\theta_i - r - \gamma\pi p(\theta_i)$, and that for the latter is $\theta_j - \pi p(\theta_j)$, where γ is a fixed parameter in the range [0, 1] that captures the level of enforcement of the joint liability rule. By the joint liability rule, we refer to the rule that all non-default members lose their future loan access if at least one borrower in the borrowers' group fails to repay the current loan. In reality, this rule may not be enforced strictly. We assume that the peer of the defaulting borrower may maintain his/her future loan access with a probability of $1-\gamma$.

In accordance with the BC model, we consider the extensive form game depicted in Figure 1. At the time the game is played, the returns from both borrowers' projects are assumed to have been realized. These returns are denoted by θ_1 and θ_2 and are assumed to be common knowledge within the group. In the first stage of the game, both borrowers decide simultaneously whether to contribute their shares. The two options are labeled as c (contribute) and n (not contribute). If both borrowers make the same decision, the outcome is straightforward: either both repay their individual dues or both default.

However, if the borrowers choose different strategies in the first stage, then the borrower who has played c now has to choose from three options: *GR* (repay the total group dues), *IR* (repay individual dues only), or *D* (default). The second choice of *IR* is our addition to the BC model. The payoffs for various combinations of strategies are shown in the bottom rows of Figure 1. For example, if borrower 1 plays n and borrower 2 plays c in the first stage, borrower 2 gets to choose from three options, resulting in one of the following payoffs: $\theta_2 - 2r$ (playing *GR*), $\theta_2 - r - \gamma\pi p(\theta_2)$ (playing *IR*), or $\theta_2 - \pi p(\theta_2)$ (playing *D*).

The choice of each borrower depends on the realization of (θ_1, θ_2) and the level of enforcement of the rules characterized by (π, γ). As in the BC model, the extensive form of the game outlined in Figure 1 has many Nash equilibria. Therefore, following the BC model, we use subgame perfection to refine these and assume that the borrowers can achieve the Pareto-superior equilibrium if there are two equilibria of mutual contribution and mutual non-contribution.

2.3 Characterization of the solution

Using Figure 1, we search for the Pareto-superior subgame perfect equilibria. Our model is a generalization of the BC model in the sense that it becomes an individual lending model if $\gamma = 0$ and a

contingent renewal rule does not occur. In our model, we assume that the lender cannot enforce the rule with a probability of 1 because of enforcement inability.

[5]Following Besley and Coate (1995), we assume that in order to avoid joint liability penalty, a non-defaulting borrower needs to fully repay his/her defaulting partner's dues. Armendariz de Aghion (1999) shows that the lender optimally chooses the full repayment of the defaulting peer even when he/she can choose a fraction of it. Her theoretical result justifies our assumption. On the other hand, Bhole and Ogden (2010) show that allowing partial liability improves the efficiency of a flexible group lending scheme. Allowing for partial liability in our model is left for further study.

joint liability model if $\gamma = 1$. If $\gamma = 0$, the player who chooses *c* in the first stage does not choose *GR* in the second stage since the payoff under *GR* is always smaller than that under *IR*. In other words, when $\gamma = 0$, the choice of *GR* is always dominated by the choice of *IR*. Therefore, this situation is equivalent to the individual lending model analyzed by Besley and Coate (1995). The resulting pattern of equilibria is shown in Figure 2. In the top right region, both borrowers repay; in the bottom left, both default; in the top left, borrower 1 defaults; and in the bottom right, borrower 2 defaults.

Similarly, if $\gamma = 1$, the player who chooses *c* in the first stage does not choose *IR* in the second stage since the payoff under *IR* is always smaller than that under *D*. In other words, when $\gamma = 1$, the choice of *IR* is always dominated by the choice of *D*. Therefore, this situation is equivalent to the without-social-sanctions case analyzed by Besley and Coate (1995). When $\gamma > 1/2$, the pattern of equilibria is the same as that in the BC model. The resulting pattern of equilibria is shown in Figure 3. In the top right region where $\theta_1 > \varphi(2r/\pi)$ and $\theta_2 > \varphi(2r/\pi)$, we observe that the group dues are repaid successfully. However, this is achieved by the non-symmetric equilibria of either {(*c*, *GR*), *n*} or {*n*, (*c*, *GR*)}. As explained by Besley and Coate (1995), since both borrowers have lucrative projects that make it possible for either to repay the group loan unilaterally, {*c*, *c*} cannot be an equilibrium. When {(*c*, *GR*), *n*} is achieved as the equilibrium, for instance, borrower 2 free-rides on borrower 1's decision to repay the group dues. This is one case of strategic default predicted in the BC model. In contrast, in the middle portion where $\varphi(r/\pi) < \theta_i < \varphi(2r/\pi)$, $i = 1, 2$, loans are successfully repaid as in the top right region without any free riding, i.e., both borrowers repay their dues. Another case of strategic default predicted in the BC model occurs when $\theta_1 < \varphi(r/\pi)$ and $\varphi(r/\pi) < \theta_2 < \varphi(2r/\pi)$ or when $\theta_2 < \varphi(r/\pi)$ and $\varphi(r/\pi) < \theta_1 < \varphi(2r/\pi)$. In this case, under individual liability, the relatively favored borrower repays while the other defaults, but the joint liability drives the relatively favored borrower to default as well.[6]

When $\gamma < 1/2$, it is possible to encounter a situation as shown in Figure 4. In four top-right regions where $\theta_1 > \varphi(r/\pi)$ and $\theta_2 > \varphi(r/\pi)$, loans are repaid successfully by the group. Since the rule of joint liability is not strong enough, in no case does one borrower repay the group dues while the other repays nothing. This is in sharp contrast to the prediction made in the BC model's prediction. For instance, when $\theta_1 < \varphi(r/\pi)$ and $\theta_2 > \varphi(2r/\pi)$, or when $\theta_2 < \varphi(r/\pi)$ and $\theta_1 > \varphi(2r/\pi)$, the BC model predicts within-group cooperation (a borrower who would not repay under individual liability is helped by another member to repay the debt), while our model predicts that such cooperation cannot be achieved because γ is not large enough. On the other hand, the second case of strategic default predicted in the BC model is replicated in our model. See the two regions in Figure 4 where $\theta_1 < \varphi(r/\pi)$ and $\varphi(r/\pi) < \theta_2 < \varphi(2r/\pi)$ or when $\theta_2 < \varphi(r/\pi)$ and $\varphi(r/\pi) < \theta_1 < \varphi(2r/\pi)$. The incomplete joint liability model predicts group default ({*n*,

[6] This may be avoided if informal social sanctions are effective. See Besley and Coate (1995).

$n\}$). In this paper, we focus on this type of strategic default, wherein a borrower who would repay under individual liability does not do so under group liability if he/she realizes that they cannot repay as a group.

When γ is sufficiently small, the type of strategic default outlined above (without group cooperation) does not occur and the pure individual liability mechanism prevails. The threshold value is determined by the equality $\gamma = 1 - r/\{\pi p(\theta_i)\}$, which is increasing with π.

2.4 Comparative statics analysis of peer correlation with respect to the degree of rule enforcement

Figure 5 shows the possible regimes under different combinations of (π, γ). Of the four segments in the figure, the left segment is characterized by very low enforcement of the contingent renewal rule (π is low), resulting in a situation where loans are not repaid. In this area, peer correlation is not defined.

The bottom right region is characterized by low enforcement of the joint liability rule (γ is low), resulting in a situation where the pure individual liability mechanism prevails. Borrower 1 defaults if $\theta_1 < \varphi(r/\pi)$ and borrower 2 defaults if $\theta_2 < \varphi(r/\pi)$, as shown in Figure 2. Therefore, if individual projects in the same borrowers' group are independent, the peer correlation coefficient is zero. If individual project risks are locally covariate, then peer correlation purely reflects this covariance.[7]

The top right region is characterized by high values of γ, resulting in a situation where *IR* is never chosen in the second stage of the repayment game. Under this regime, we observe two cases depending on the realization of (θ_1, θ_2): Both loans are repaid or neither of the loans is repaid, as shown in Figure 3. Therefore, regardless of the correlation of individual projects in the same borrowers' group, the peer correlation coefficient is unity.

The middle right region characterized by middle values of γ is the area of interest. In this case, we never come across a situation where the whole group dues are repaid by one of the two group members. When group dues are paid successfully, both borrowers pay their individual dues. On the other hand, if we look at situations where loans are not repaid at all, we find cases in which a borrower who would repay under individual liability does not do so because of the weak but non-negligible group liability. In Figure 5, such cases fall in the "GR-IR mixed region," wherein individual repayment behavior dominates in case of payment of dues, while group repayment behavior dominates in case of default. Because of the latter effect, the peer correlation coefficient is strictly between 0 and 1 when individual project risks are independent. The level of peer correlation reflects the frequency of strategic defaults.

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[7] See Armendariz de Aghion (1999) for the theoretical impact of the covariance of intra-group microfinance returns on repayment when strategic default occurs, and see Ahlin and Townsend (2008) for an example of empirical modeling of the covariance.

On the basis of this argument, the peer correlation coefficient is expected to increase with γ. This expectation is confirmed numerically in the case where θ_1 and θ_2 are jointly distributed as an independent uniform distribution in the range [θ^{min}, θ^{max}].

The impact of π on the peer correlation coefficient depends on the level of γ. We investigate the case where θ_1 and θ_2 are jointly distributed as an independent uniform distribution in the range [θ^{min}, θ^{max}]. If initially γ is low enough for the situation to fall in the middle right region while the new situation falls in the bottom right region (a move from point A to A' in Figure 5), the peer correlation coefficient should decline. On the other hand, if both the initial and new points are located in the middle right region (a move from point B to B' in Figure 5), the sign of the change in the peer correlation coefficient is indeterminate. Our numerical results indicate that the change in the coefficient is negative when γ is low and the change is positive above a threshold value of γ.

Our strategic default model thus predicts that better enforcement of the contingent renewal rule will result in lower default rates and a lower level of peer correlation because of the less frequent occurrence of strategic defaults. On the other hand, most models focusing on adverse selection or moral hazard predict the opposite. For example, if the joint liability model solves the adverse selection problem through assortative matching (Ghatak, 1999; 2000), in the imperfect joint liability model, project outcomes are uncorrelated when individual projects' returns are uncorrelated since there is little assortative matching. At the same time, in a model with improved joint liability, more peer correlation and fewer defaults are observed, owing to the high prevalence of assortative matching.[8] This is exactly the opposite of the predictions made in the model derived in this section. In the following sections we show that the empirical characteristics found in Pakistani data are more consistent with the strategic default model where π increases with γ remaining almost constant at a low level, than they are with other models.

3 Data and Background

3.1 Microfinance in Pakistan

Pakistan is one of the low income countries in South Asia where poverty is rampant and the majority of the poor face difficulties in getting access to efficient sources of credit (World Bank, 2002). Microfinance is still relatively new to Pakistan, both from a conceptual and a practical point of view. The country is among the largest potential microfinance markets in the world with a conservative estimate of the potential borrower base at 10 million adults. This figure is likely to expand dramatically given Pakistan's high population growth rate.

[8]See Ahlin (2009) for other theoretical models on borrowers' risk matching.

Modern-style microfinance in Pakistan began only in the late 1990s. At that time, the main providers of microfinance were NGOs and government-supported rural support networks. Microfinance was declared a priority in the official Poverty Alleviation Strategy in 1999 and a regulatory framework for the promotion of microfinance was established in 2001. The result was a massive investment of at least US$400 million in the period 1999–2005, largely from multilateral sources such as the World Bank and the Asian Development Bank. Among the various microfinance providers today, Khushhali Bank, the flagship institution established by the Pakistani government in 2000, served more clients than the collective client base of all the NGOs and rural support programs before 2001 (Montgomery, 2005).

Microfinance institutions (MFIs) in Pakistan now comprise a voluntary network called Pakistan Microfinance Network (PMN). With the passage of time, the country has not only moved forward but also benefited from the experience of countries that were ahead of it on the microfinance front. However, it must be said that although the impact of microfinance services in Pakistan has been positive, their outreach has been limited, with many of the poor untouched by them (Montgomery, 2005).

During the 1990s, the economy of Pakistan registered moderate growth; however, due to rising economic inequality, poverty did not decline proportionately (World Bank, 2002). The macroeconomic scene in the country has not changed much during the 2000s as far as macroeconomic indicators are concerned. Because of the lack of sustained high growth, the absolute level of real per capita income is still very low, standing at US$2,678 in 2008 after PPP adjustment (UNDP, 2010). In this backdrop, transferring the benefit of growth equitably across board, especially among the poor, remains a challenge.

3.2 Primary data of microcredit borrowers and their repayment

We utilize micro-level information maintained for the purpose of financial monitoring of microcredit intervention. The information is obtained from a member of PMN. The names and identities of the participating households are replaced by computer-generated numbers to safeguard privacy. The sample is taken from a district in the North-West Frontier Province (NWFP),[9] Pakistan, which was severely affected by the earthquake. Four primary datasets were collected in August 2006 and subsequently updated in July 2009. They were converted into a pooled cross-sectional dataset for empirical analysis.

(1) Borrowers' Data: There are 2,950 borrowers in this dataset collected in August 2006, comprising those who borrowed between May 1, 1998, and July 8, 2006. Since installment and repayment

[9] In April 2010, the constitution of Pakistan was amended and the former NWFP was renamed "Khyber Pakhtunkhwa." In this paper, since all data correspond to a period before this constitutional amendment, the expression NWFP is used to refer to the current province of Khyber Pakhtunkhwa.

records were missing for five borrowers in this dataset,[10] we analyzed 2,945 borrowers in this paper. Approximately 30% of the borrowers are females. Information regarding the household to which the borrower belonged was collected and made part of the borrower dataset.

(2) Data on Borrowers' Community Organizations: To be eligible for microfinance loans in the study area, borrowers need to form a community organization (CO) with joint liability. Information of COs to which the above borrowers belonged was collected. There are 870 COs in the CO dataset, comprising those established between March 11, 1997, and April 10, 2006. Female borrowers usually belonged to COs designated as "female COs," which accounted for 22.4% of the sample COs. COs maintain their own savings account, with the balance ranging from Rs.0 to Rs.99,000 and the average being Rs.6,348.[11]

(3) Data on Installments: For each borrower, records were kept for each installment, such as due date, amounts due as principal and as service charges or process fee,[12] installment repaid, and outstanding debt after repayment. For the 2,945 borrowers in the borrower dataset, there are 44,931 installment records. Their due dates range from June 1, 1998 to October 2, 2007.

(4) Data on Repayment Receipts: When a borrower repays, a receipt is issued and relevant information such as the time and amount of repayment and the amount of penalty is recorded in this dataset. To the 2,945 borrowers in the borrower dataset, 32,695 receipts were issued. The receipts are dated between June 5, 1998 (the first repayment in our sample was made four days after the due date) to October 22, 2007 (the last repayment in our sample was made 20 days after the due date).

The number of receipt-level observations is considerably smaller than that of installment-level observations for two reasons. First, some installments were not repaid—clear cases of default. Second, when the borrowers paid amounts more than the amounts due in an installment, one receipt was issued. To reduce the transaction costs of monthly repayment, many borrowers preferred to pay a single installment worth several months' amount at one go. On the other hand, when the borrower could not pay a monthly installment, he/she often repaid the amount worth two months' dues in the following month. All installment dues associated with loans provided after January 2005 were already repaid by the time the dataset was updated in July 2009. Therefore, the right-censoring problem for installments is not a

[10] These borrowers obtained loans on October 6, 2005, two days before the earthquake.

[11] In this paper, "Rs." refers to nominal Pakistani rupees. The exchange rate between Pakistani rupees and US dollars was stable at around Rs.60/$ during the study period. The government estimates for inflation rates inside Pakistan were in the range from 3.1 to 7.9% per annum.

[12] Under Islamic law, no interest is charged on microfinance loans but borrowers have to pay service charges or process fee in addition to the principal. In effect, these charges are equivalent to interest (the interest rate charged on these loans was 20% per annum under the old system).

cause for concern.[13]

There are two important time breaks in our data. First, from January 2, 2005, the MFI began to provide microcredit under a new system offering improved accountability. The last loan under the old system was issued on October 4, 2003. There was a gap of more than 13 months without new loans, during which period the MFI continued to collect dues from old loans while it formulated a new system. The second time break occurred on October 8, 2005, when Pakistan was hit by a severe earthquake.

3.3 Reforms in January 2005

There are a number of differences in the contract characteristics of microfinance loans issued under the old and new systems (Table 1). First, the average loan size was almost halved. It was Rs.16,300 (about US$270) under the old system and Rs.9,000 (about US$150) under the new system. This drop is attributable to the drop in the minimum allowable amount of a standard loan from Rs.10,000 to Rs.5,000 and to the abolishment of loans exceeding Rs.15,000 under the new system.

Second, the number of installments and length of credit duration decreased by 25%. Under the old system, there were several types of loans on offer. The most common was a 19-month loan to be repaid in 18 monthly installments (42.3% of the sample), followed by a 31-month loan to be repaid in 30 monthly installments (18.3%). Approximately 8.3% of the sample loans were not to be repaid monthly but in a single installment with the loan period of 6, 9, 12, or 18 months. Under the new system, only two standard types of loans were offered: a 12-month loan to be repaid in 12 monthly installments or a 15-month loan to be repaid in 15 monthly installments. The first type accounted for 92.3% of the sample, and the second type 7.2% (there are three exceptional cases where the loans were repaid in a single installment one month after the loan was issued).

The third change between the two systems was that interests (service charges) for all loans were collected in advance as processing fee under the new system, whereas under the old system, service charges were collected over the repayment period along with the principal in each installment. In addition, under the old system, there was a grace period of one month before repayment began. This one-month grace period was abandoned under the new system.

The fourth change pertained to the enforcement of penalty against non-repayment. Under the old system, there was a rule that no new loans would be given to a borrower unless his/her entire group repaid. However, the rule was not enforced stringently. The new system promised better accountability, which called for stricter enforcement of the non-repayment rule. This positive change is reflected in Table 1:

[13] Our dataset updated in July 2009 includes information for those borrowers who borrowed after our initial data collection in August 2006 and were still in the repayment schedule in July 2009. To avoid the right-censoring problem, this paper employs the subset of our dataset that corresponds only to the borrowers included in the initial data collected in August 2006.

Under the new system, the ratio of borrowers with a national identity information record (NIC information) is 100%. Additionally, the ratio of female borrowers also increased under the new system.

The fifth change involved linking development projects at the community level with repayment rates of COs in the region. In Pakistan, several initiatives were introduced in the 2000s to strengthen community-based development (Kurosaki, 2005). Under the new system, the implementation of infrastructure or human resource development projects became contingent on the repayment record of the community. This change is another example of improved dynamic incentives for repayment.

3.4 Earthquake in October 2005

The second time break in our dataset is demarcated on October 8, 2005. On this day, an earthquake measuring 7.6 on the Richter scale rocked Kashmir. The calamity caused widespread destruction and heavy loss to human life, killing at least 73,000 people, severely injuring another 70,000, and leaving 2.8 million people homeless. Social service delivery, commerce, and communications were either severely weakened or destroyed. Beyond the human toll, the overall cost of the earthquake was staggering. A joint damage and needs assessment by a group of experts from Asian Development Bank and World Bank put the value of direct damage due to the earthquake at US$2.3 billion, resulting indirect losses at US$576 million, and estimated the total costs for relief, livelihood support for victims, and reconstruction cost at approximately US$5.2 billion (Asian Development Bank and World Bank, 2005).

The earthquake also adversely affected the macroeconomy, particularly the fiscal deficit. The overall fiscal deficit as a percentage of the GDP rose by about 1% point after the earthquake. Given the magnitude of resources needed for the rehabilitation of earthquake-affected areas, the government was not able to fully absorb the fiscal impact of the earthquake without significantly compromising on public sector development. Therefore, the poor in areas not affected by the disaster (i.e., the vast majority of the poor in Pakistan) were adversely affected as well on account of increased allocation of public resources to the earthquake-affected areas at the expense of the rest of the country.

The characteristics of borrowers and loan contracts under the new system are shown in Table 1. Figures corresponding to borrowers who were issued loans before the earthquake are indicated separately from those issued loans after. Overall, however, both sets of figures show close similarity. None of the variables in Table 1 showed statistically significant differences except the ratio of borrowers with income sources outside the region. Table 1 thus proves that the critical change pertaining to the characteristics of loan contracts and borrowers was the system change in January 2005, and not the earthquake in October 2005.

3.5 Data compilation for loan default and repayment delay

From the primary data described above, we compile several variables for loan default and repayment delay, since these are the two pressing concerns of the MFI (Table 2). Aggregating the number of loans fully repaid by the time of our survey, we obtain the borrower-level variable *Default*, which is plotted in Figure 6. As can be seen clearly from the figure, all the 670 borrowers under the new system repaid fully (*Default* = 0). In contrast, out of 2,275 old borrowers, only 1,119 had completed the repayment by the time of our survey, implying a default rate of 50.8% (Table 2).[14]

In Figure 6, the predicted probability from a probit model is also plotted for samples under the old system, in which *Default* was regressed on the date of loan issue and its polynomials. Polynomials of the fifth order and above did not have statistically significant coefficients. The default rates show a highly nonlinear pattern over the period.

The default rate for the old loans, nevertheless, underestimates the cost for the MFI because some bad loans were repaid much after the last due date. For instance, in our sample, a borrower who obtained a credit of Rs.25,000 on May 7, 1998, had paid only about two-thirds of his/her due by November 7, 1999 (the due date of the last installment) and paid the rest on July 19, 2001. Such cases are not counted as defaults.

Therefore, in order to accurately measure the quality of repayment by the 1,119 borrowers with *Default* = 0, a variable named *Avg_delay*, i.e., the average delay in days of repayment relative to the due date for each installment, was calculated. Table 2 shows the average of *Avg_delay* for the 1,119 borrowers at 100.0 days, ranging from -552.0 to 1014.0 (standard deviation [SD] at 145). If we exclude 5 outliers who made early repayment (*Avg_delay* < -200) and 4 outliers who made very late repayment (*Avg_delay* > 1000), the average of *Avg_delay* becomes 98.5 (SD = 131.6).[15]

Similar variables can be defined at the installment level. The first one, *No_repay*, is a dummy variable that takes the value of one when the installment is not paid. For installments that are paid, another variable *Delay* (delay in days of repayment from the due date for the installment) is computed. In addition to these two, a third variable, *Problem*, is a dummy variable assuming the value of one if the installment is not repaid within 31 days from the due date. Since early repayment is not a concern for MFIs, the variable *Problem* ignores early repayments. Since late repayment and no repayment are concerns for MFIs, *Problem* aggregates the late and no repayment information into one variable. As

[14]For loans provided under the old system, the due date of the last installment for the 2,275 borrowers ranged from July 7, 1999, to October 4, 2004. Given that our data was collected more than 57 months after the last of these due dates, it is safe to ignore the possibility of future repayments. Therefore, the right-censoring problem for the old loans can be ignored.

[15]The borrower with *Avg_delay* at -552 borrowed Rs.20,000 on September 2, 2002; this amount was due on April 2, 2004, without installments. However, since the borrower repaid the entire amount on September 28, 2002, i.e., 552 days before his due date, his *Avg_delay* was -552 days.

shown in Table 2, all three variables have very high average values for loans provided under the old system. About 21% of all installments were never repaid, the average delay of repaid installments was about 101 days, and 65% of all installments suffered from late repayment or non-repayment.

In sharp contrast, for all 670 borrowers under the new system, *Default* = 0 and *No_repay* = 0 (Table 2), whether the loan was made before or after the earthquake. We calculate *Avg_delay*, *Delay*, and *Problem* for for these borrowers as well. The average of *Avg_delay* and that of *Delay* are slightly negative before the earthquake and slightly positive after the earthquake, suggesting the possibility that the earthquake led to more delays (3.4 days on average) in repayment. However, a simple *t* test of the equal means cannot reject the null hypothesis that the means are the same. Therefore, it appears that no serious delay occurred under the new system and the adverse impact of the earthquake was not statistically significant.[16] However, to confirm this conclusion, a multivariate regression is conducted in Section 6.

4 Why Did the Old System Fail? A Borrower-Level Analysis

4.1 Empirical models

At the outset of our analysis, we investigate the determinants of loan default and repayment delay under the old system. Two dependent variables—*Default* and *Avg_delay*—and four groups of explanatory variables are employed.

1. Borrowers' characteristics (including those of the household to which the borrower belonged): gender, family type, income sources, physical conditions of the house, status in the borrowers' group, etc.

2. Credit characteristics: amount of credit, number of installments, period of credit in months, etc.

3. CO characteristics: number of CO members, value of CO savings, age of the CO when the loan was issued, etc.

4. Location and time effects: time effects and union fixed effects.

Regarding group 4, unobservable heterogeneity that is specific to a region is controlled by union fixed effects.[17] Unobservable macro effects are controlled by the date of issue of each loan. In one specification, *D_issue* (measured in the number of days elapsed since May 1, 1998) and its higher order polynomials are adopted. In another specification, year dummies corresponding to the date of issue are

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[16] All five borrowers whose repayment records were completely missing belonged to the same borrower group and borrowed just two days before the earthquake. They lived in an area 106 km from the epicenter of the earthquake. With these five borrowers added to the list of repayment delays or defaults, the adverse impact of the earthquake on repayment would have been slightly more serious than what is indicated in Table 2.

[17] In Pakistan, a union is the smallest administrative unit that comes under the jurisdiction of the union council. Usually, 10–20 villages make a single union council. Although there are 47 union councils in the dataset, only 9 had multiple borrowers' groups. Therefore, we compiled union dummies for these nine councils and merged the remaining councils into one category of "small unions." Union fixed effects in the regression analyses below correspond to these 10 dummies.

included. As shown in Figure 6, no monotonic trend is observed between *Default* and *D_issue* under the old system, but some fluctuations exist over time. Therefore, controlling macro effects in a flexible manner is important.

There are several selection problems in investigating the reduced-form determinants focusing on these explanatory variables. First, *Avg_delay* is defined only when *Default*=0. To control for this selection bias, we adopted Heckman's two-step procedure. Second, contract type is not randomly chosen but is partly decided by the borrowers themselves. Therefore, if we do not control for this self-selection, the coefficients on the credit characteristics listed above cannot be interpreted as showing the causal effects of contract design on repayment (Aghion and Morduch, 2010). One way to control is to adopt the matching approach employed by Gomez and Santor (2003) in the context of microfinance. Instead of correcting the self-selection bias corresponding to the contract type, we report non-corrected results with explanatory variables in groups 2 and 4 only (subsection 4.2.1). The motivation of this exercise is to capture the net effects on repayment, including the causal effects of contract design and selection effects. This specification is informative in characterizing the problems that occurred under the old system. After controlling for the self-selection of contract type, we estimate a more reduced-form model with explanatory variables in groups 1, 3, and 4 only (subsection 4.2.2). In this specification, the choice of contract type is treated as endogenous so that variables in group 2 are excluded.

4.2 Estimation results

4.2.1 Default/delay and credit contract design

Table 3 reports estimation results with *Default* (dummy for borrower-level default) or *Avg_delay* (average delay in days in installment repayment by a borrower with *Default* = 0) as dependent variables. The explanatory variables are contract types, time effects, and union fixed effects.

In the regression results for *Default*, the period of credit duration and the dummy for non-monthly installments show positive and statistically significant coefficients. For instance, in Model 1, the probability of default would be higher by 18.5% if the credit duration became six months longer and the probability would be higher by 20.8% if monthly installments were replaced by installments with a longer interval in between. The regression results for *Avg_delay* show a very strong effect of the dummy for non-monthly installments, indicating that the delay would be 84 days longer if monthly installments were replaced by installments with a longer interval. These results demonstrate the appropriateness of the reforms introduced in early 2005—making all installments monthly and reducing the maximum loan duration to 15 months. As predicted by the estimation results in Table 3, these reforms successfully reduced repayment delays, resulting in zero default rates under the new system (Table 2). The success of frequent repayment in minimizing default and delay has been seen in microfinance schemes worldwide, and attributed to the early warning mechanism, the lender's capture of non-microfinance income flow of the borrower, and the borrower's commitment to save regularly (Aghion and Morduch, 2010). On the other hand, a recent study based on a randomized experiment in India by Field and Pande (2008) shows no differences between microfinance schemes with weekly and monthly repayment frequencies. Considering these findings in conjunction, it appears that monthly repayment is the optimal frequency that can be stipulated to avoid repayment delays and reduce the transaction costs of too frequent repayment.

With regard to the coefficient on the dummy for loan size larger than Rs.15,000, the coefficient is negative, which is contrary to our expectations.[18] It is negative in all four models reported in Table 3, with the coefficient on *Avg_delay* being statistically significant. This appears to reflect selection bias. Only those borrowers with characteristics associated with higher probability of on-time repayment applied for and were granted large loans. Given the strong selection effect, the potential negative effect of loan size on repayment cannot be observed in Table 3.

Significantly positive coefficients of the period of credit duration and the dummy for non-monthly installments could also reflect selection effects. The regression results show that loans with longer repayment periods and fewer installments are detrimental to repayment because of the negative causal effects on repayment behavior and the selection effect of such contracts attracting more risky borrowers.

In all specifications, both union fixed effects and time effects are jointly significant at the 1% level. It is not qualitatively important whether the time effects are controlled by *D_issue* and its higher-order polynomials or by year dummies (compare Models 1 and 2 in Table 3). This applies to other regression results as well. Therefore, the tables below report only the estimation results using *D_issue* and its higher-order polynomials.

4.2.2 Default/delay and borrowers' characteristics

As a more reduced-form approach, *Default* or *Avg_delay* is regressed on explanatory variables, including borrowers' individual characteristics, borrower households' characteristics, CO characteristics, and location and time effects (Table 4). The explanatory variables are jointly significant and those with individual statistical significance show expected signs. The results are summarized in four observations.

First, borrowers who reported their NIC information and female borrowers were less likely to default. When female borrowers repaid their loans, they did so on time. The finding of the higher

[18] We employ this variable instead of loan size for two reasons. First, loan size is highly correlated with loan duration. Therefore, to avoid the multicollinearity problem, we employ this dummy variable. Second, as part of 2005 reforms, the issue of loan contracts larger than Rs.15,000 was stopped. This dummy variable is used to examine the efficacy of this change.

repayment rate by female borrowers is consistent with those of other empirical studies on microfinance in South Asia (Aghion and Morduch, 2010). This may reflect difference in preferences and alternative sources of credit availability. The result pertaining to NIC information shows that NIC information made it more difficult for a defaulting borrower to re-apply for a loan in the future. In other words, this shows that the enforcement of the contingent renewal rule was imperfect under the old system. The dummy for chairman or secretary of the CO has a negative coefficient, which is as expected since such borrowers are more credible; however, the coefficient is not statistically significant.

Second, to control the resource availability of a borrower, several household-level variables characterizing household income sources are included and all of them have significant coefficients. Households with more income sources and households with income originating outside their residential areas were less likely to default, and when borrowers from these households repaid loans, they did so on time. This shows the importance of income diversification in avoiding default.

The third observation is that the dummy variable for a female-headed household has a negative coefficient and that coefficient is statistically significant for the *Default* regression. If this variable mainly captures the income and wealth effects, we expect the opposite sign since female-headed households in Pakistan tend to be poorer than male-headed households. The negative coefficient implies that female-headed households have fewer alternative credit sources because of which they tend to default less.

Last, several variables characterizing the CO to which the borrower belonged have significant effects on repayment. COs' savings have a negative coefficient, implying that either the savings accumulated at the CO serves as a buffer against default or borrowers in COs with higher savings tend to be safer investors. COs with incomplete records were more likely to default. The age of the CO at the time when the loan was issued has a positive coefficient, suggesting that older COs were less successful at repayment, which in turn points to group fatigue (Sharma and Zeller, 1997). Among the CO characteristics, the number of CO members has a positive coefficient and it is statistically significant in the *Avg_delay* regression. We attribute this result to the difficulty faced by larger COs in coordinating within the group and to the need to avoid the free rider problem.[19]

The regression results in Table 4 thus appear to indicate a limited role played by COs in preventing default and repayment delays; instead, our field observations indicate that COs functioned as a collusive forum that was counterproductive under the old system. This inference will be further

[19] In a different context in Pakistan, Kurosaki (2005) reports a positive effect of the size and diversity of a community-based organization (CBO) on the level of collective action. His interpretation is that while larger and more diverse CBOs may face difficulty in coordinating within the group and avoiding the free rider problem, the advantage they enjoy in terms of technical skills required for the particular type of collective action he analyzes outweighs the difficulty.

investigated in the next section.

5 Repayment Dynamics and Intra-Group Interactions under the Failed System: An Installment-Level Analysis

5.1 Example

Figure 7 plots the pattern of repayment for five sample borrowers who belonged to the same CO and borrowed under the same conditions. They borrowed Rs.20,000 on November 7, 2000, which was to be repaid in 18 monthly installments after a grace period of one month. In the figure, the cumulative amounts of repayment are plotted for the borrowers, and the scheduled repayment is traced in a blue line with solid diamond dots. For each borrower, a marker on the curve represents the cumulative amount repaid at that date.

If the curve lies below the scheduled line, it implies a delay in repayment. The figure shows that borrowers 401, 403, and 405 made delayed repayments, while borrowers 402 and 404 paid before the due date (*Avg_delay* for these two borrowers is negative). If a curve plateaus before reaching the level of Rs.23,490 (the total amount that should be repaid), it implies that the loan was defaulted. From the figure, borrowers 401, 403, and 405 can be said to have defaulted (*Default* for these three borrowers is 1; hence, *Avg_delay* is not defined). Borrower 405 repaid the amounts corresponding to the first ten installments, although the repayments were delayed. Therefore, the installment-level variables for borrower 405 for the first ten installments are calculated as *No_repay* = 0 and *Delay* > 0, and for the last eight installments as *No_repay* = 1 and thereby *Delay* is not defined for the last eight installments for borrower 405.

Figure 7 provides two interesting insights. First, borrowers with repayment problems have linear or slightly concave curves. This implies that once a borrower makes a delayed repayment, it becomes difficult for him/her to catch up with the scheduled repayment by the next installment; instead, it is more likely that the borrower will be delayed again by a similar or longer margin. In other words, *Delay* appears to be positively auto-correlated.

Second, the curves for some of the borrowers closely resemble each other. When borrower 402 repaid more than the required amount for the third installment, borrower 404 followed suit. Further, borrowers 401 and 405 missed the first two due dates but paid the amount due for one installment on the due date of the third installment, and while they repaid some amount when the fourth installment was due, it was not enough to clear their outstanding dues. In other words, *Delay* appears to be positively correlated among the CO members (we call this peer correlation).

Since members of a CO reside in the same village, they are subject to village-level covariate shocks. If it can be shown that borrowers 401 and 405 (or borrowers 402 and 404) have suffered from such covariate negative shocks, peer correlation between them is expected. It is expected that microenterprise project returns are more correlated if borrowers invest in similar investments. However, the actual investments do not match our expectations: borrower 402 invested in a small grocery shop, while borrower 404 invested in buffaloes; further, borrower 401 invested in buffaloes, while borrower 405 invested in a small grocery shop. Therefore, it is difficult to explain the observed peer correlation by village-level covariate shocks.

By analyzing more cases and holding discussions with program participants and MFI officers in the field, we infer that the mismatch mentioned above may be reflective of a kind of strategic default. Because the dynamic incentives were weak under the old system, if one group member was hit by a negative shock and faced difficulty in repayment, the other members who were able to repay might have decided to default themselves as well, instead of helping the unlucky person make his/her repayment. As mentioned in Section 2, the peer correlation coefficient should be 1 if joint liability is perfectly enforced, and less than 1 under imperfect joint liability. The value of the coefficient increases with the frequency of strategic default. Using our detailed dataset at the installment level, we investigate whether this hypothesis is supported empirically.

5.2 Empirical strategy

We begin with an installment-level model for *Delay*, because most cases of *No_repay* = 1 occur after several instances of repayment delay. By definition, for each borrower, the variable *No_repay* switches only once from zero to one, after which, it continues to take the value of one. Therefore, after analyzing the determinants of *Delay*, we analyze the determinants of transition probability from *No_repay* = 0 to *No_repay* = 1.

To focus on the installment-level dynamics and to avoid additional complications caused by differences in repayment schedules, we use the subset of our installment-level data with 18 monthly installments. Out of 36,777 installments under the old system (see Table 2), 17,316 installments comprise the subset used in the analysis below. A larger subset is used in the robustness check. Each credit contract is denoted by subscript i and the order of its monthly installment is denoted by subscript t ($t = 1, 2, \ldots, 18$). The following model is estimated to investigate the determinants of $Delay_{it}$:

$$Delay_{it} = a_1 Delay_{i,t\text{-}1} + a_2 Delay^C_{it} + u_i + u_t + e_{it}, \qquad (1)$$

where $Delay^C_{it}$ is the average over j of $Delay_{jt}$ where j is a member of the CO to which borrower i belongs and is a borrower whose due falls on the same date as borrower i's due. In calculating $Delay^C_{it}$, borrower i is excluded to avoid the spurious correlation between $Delay_{it}$ and $Delay^C_{it}$ due to construction. This variable captures the extent of peer correlation. u_i is a borrower-specific unobservable factor, u_t is an unobservable factor specific to the installment order, e_{it} is an independently identically distributed (iid) error term, and a_1 and a_2 are parameters to be estimated.

Equation (1) is estimated by a two-way fixed effect (FE) panel regression model, with individual credit contract as "group" and the installment number as "time" for the FE specification. The borrower-level determinants of repayment such as gender, NIC information, income sources, CO characteristics, and others, which have already been investigated in the previous section, are jointly controlled by u_i. In addition, u_i controls the macroeconomic factors because each credit contract is associated with the date of the credit issue so that the i-fixed effect controls unobserved factors associated with the date. The common dynamics in a repayment cycle (e.g., a borrower may have a higher motivation to repay on time for the first and the last installment, but may have lower motivations for payment of installments in between) is controlled by u_t.

Since $Delay^C_{it}$ does not reflect the information of No_repay_{jt}, a variant of equation (1) is also estimated:

$$Delay_{it} = a_1 Delay_{i,t\text{-}1} + a_2 Problem^C_{it} + u_i + u_t + e_{it}, \quad (2)$$

where $Problem^C_{it}$ is defined in a way similar to $Delay^C_{it}$, but using $Problem_{jt}$ (dummy for non-repayment until 31 days after the due date; see Table 2). To investigate the determinants of transition probability from No_repay=0 to No_repay=1, we compile a variable $No\_repay^C_{it}$, which is calculated from No_repay_{jt} in a way similar to $Delay^C_{it}$. We then estimate the following equation for the subsample with $No\_repay_{i,t\text{-}1}$=0:

$$No\_repay_{it} = a_1 Delay_{i,t\text{-}1} + a_2 No\_repay^C_{it} + u_i + u_t + e_{it}. \quad (3)$$

Equations (2) and (3) are also estimated by a two-way FE model, with individual credit contract as group and the installment number as time. In all three equations, parameter a_1 captures the extent of auto correlation, and parameter a_2 captures the extent of peer correlation. The robustness of our results to other econometric specifications is discussed in a separate subsection.

If the estimate for a_2 is significantly positive, it implies the existence of peer correlation, which is consistent with the predictions of the imperfect joint liability model discussed in the theoretical section. It is possible, however, that peer correlation simply reflects the ill-effects of covariate shocks that hit microenterprise projects run by microcredit borrowers. To examine this possibility, we divide the sample observations into those belonging to a CO with very homogeneous microenterprise projects and those belonging to a CO with heterogeneous microenterprise projects. If the main reason for the significance of a_2 is the covariance of microenterprise project returns, we expect the estimate for a_2 among homogeneous groups to be larger than that among heterogeneous groups. If the estimate for a_2 is similar for both groups, we interpret that peer correlation stems mainly from strategic default under imperfect joint liability.

For this investigation, we compile a CO-level variable, *Homogeneity*, which is a dummy variable for the same project purpose.[20] It is an indicator of the homogeneity of microenterprise projects. If *Homogeneity* = 1, the borrowers are presumably subject to greater covariate risk in microenterprises than if *Homogeneity* = 0. We split the sample on the basis of *Homogeneity* and estimate equations (1), (2), and (3) using smaller subsamples. We then compare the estimates for a_2, testing the statistical significance of the difference using regression based on the pooled sample with a full set of cross-terms of explanatory variables with *Homogeneity*.

5.3 Estimation results

The FE estimation results for equations (1), (2), and (3) are reported in Table 5. Coefficient a_1 on $Delay_{i,t-1}$ is positive and statistically significant in all three equations. Therefore, the existence of auto-correlation in repayment delay is confirmed quantitatively. The size of the coefficient in equations (1) and (2) is smaller than unity with statistical significance at the 1% level, allowing us to conclude that the dynamic path is stable.

Coefficient a_2 on the peer-average variable is also positive and significant in all three equations. This means that peer correlation exists. The size of these coefficients is rather large. A 10-day delay among the peers led to a delay of 3.19 days; a 10 percentage-point increase in the number of non-repaying borrowers until 31 days after the due date led to a delay of 3.06 days; and a 10 percentage-point increase in the number of fellow borrowers with *No_repay* = 1 increased the probability for a borrower to reach the status of *No_repay* = 1 by 4.89 percentage points.

The regression results thus confirm the existence of strong auto- and peer correlation. The size of the peer correlation parameter can indicate the upper limit of the positive correlation among borrowers who delay/default owing to covariate shocks. To examine the extent to which the positive peer correlation can be attributed to strategic default, we split the sample by the value of *Homogeneity* and re-estimate equations (1), (2), and (3) using the smaller subsamples.

The summary regression results in Table 6 show that the estimates for a_2 are statistically significant in all specifications and their coefficients are very similar regardless of the choice of the sample. Coefficient a_2 in equation (1) is 0.320 for heterogeneous COs where some members invested in projects different from others, while it is 0.337 for homogeneous COs where all members invested in the same project. The difference is statistically insignificant. Similarly, the value of coefficient a_2 in equation (2) is 29.7 for heterogeneous COs and 30.7 for homogeneous COs. The difference again is statistically insignificant. In the *No_repay* regression (equation (3)), a_2 is 0.455 for heterogeneous COs and 0.526 for

[20] To compile this variable, project purposes are classified into 34 categories. For instance, "Livestock" shown under "Purpose of borrowing" in Table 1 is disaggregated into four categories of buffalo, cow, goat and sheep, and poultry.

homogeneous COs. Here, even though the difference is statistically significant, the absolute size of the difference is small enough for us to view the difference as economically insignificant.

The results in Table 6 do not support the view that the observed peer correlation was mainly due to the covariate shocks that hit borrowers; instead, they appear to corroborate the view that strategic default was (at least partially) responsible for peer correlation. In Section 6 of this paper, we estimate equation (1) using installment-level data under the new system. The results in Table 10 show that the estimate for a_2 in homogeneous COs is significantly larger than that for a_2 in heterogeneous COs. Given this contrast, it is reasonable to infer that the results in Table 6 support the view that the strategic default under the imperfect joint liability was a serious problem under the old system.

5.4 Robustness check

To check the robustness of the results in Table 6, we attempt four different specifications. First, instead of splitting the sample by *Homogeneity*, we compile the Herfindahl index for project purpose (the sum of shares squared) and add its cross-terms with the peer-average variables to the three equations. The Herfindahl index takes the maximum value of 1, and if all borrowers in a CO invest in different projects, the index takes the minimum value of $1/n$, where n is the number of members. If peer correlation is attributable to covariate shocks to microenterprises, we expect the coefficient on the cross-term to be positive. The regression results, shown in the last block of rows of Table 7, do not support this expectation. The cross-term has a negative and insignificant coefficient when the dependent variable is $Delay_{it}$, and a positive and marginally significant coefficient, but of an economically insignificant magnitude, when the dependent variable is No_repay_{it}.

Second, instead of limiting the sample to observations associated with 18 monthly installments, we employ a larger subset of observations associated with more than 5 monthly installments. Out of 36,777 installments under the old system (see Table 2), 36,306 installments are now included. The analysis may suffer from specification errors due to differences in repayment schedules, but it can gain in statistical efficiency from a larger number of observations. The results in Table 7 show qualitatively the same results as those in Table 6: Coefficient a_2 is slightly larger when observations associated with homogeneous COs are used than when those associated with heterogeneous COs are used, but the difference is not economically significant. The statistical significance level improved in the case of equation (1), possibly reflecting the larger number of observations used, but it deteriorated in the case of equation (3).

Third, we re-estimate equations (1) and (2) using the system generalized method of moments (GMM) approach proposed by Blundell and Bond (1998). In these two equations, the lagged variable $Delay_{i,t-1}$ is included in the right-hand-side, creating a dynamic panel data (DPD) structure. To avoid the potential endogeneity bias caused by the DPD structure, we employ the system GMM estimation method. The system GMM results in Table 7 show that coefficient a_2 is smaller (not larger) when observations associated with homogeneous COs are used than when those associated with heterogeneous COs are used, and the difference is statistically significant. Although a clear inference does not emerge from the results, it is beyond doubt that they do not support the view that the observed peer correlation was mainly due to covariate shocks that hit borrowers' microenterprises.

Fourth, considering the possibility of the reflection problem (Manski, 1993), we re-estimate the three equations using instrumental variable specifications, treating the peer-average variables as endogenous. Coefficients on the three variables proxying the peer effects, i.e., $Delay^{C}_{it}$, $Problem^{C}_{it}$, and $No\_repay^{C}_{it}$, are identified by the following instrumental variables: their lagged values ($Delay^{C}_{i,t\text{-}1}$, $Problem^{C}_{i,t\text{-}1}$, and $No\_repay^{C}_{i,t\text{-}1}$) and the lagged value of a variable proxying union-level repayment problems.[21] The regression results in Table 7 show that the extent of peer correlation is reduced and the difference in a_2 across the two subsamples distinguished by *Homogeneity* is insignificant in all three equations. This re-confirms the view that strategic default contributed to peer correlation.

In addition to conducting the robustness checks reported in Table 7, we re-estimate the model using *Delay* as the dependent variable after re-defining it as truncated at zero for payments made earlier than their due dates. This is because early payments do not damage MFIs. We also re-estimate the instrumental variable specification using two-period lags as the instrumental variables, considering the possibility that a borrower watches not only his/her peer's contemporary behavior but also his/her peer's one-time lagged behavior when deciding on the repayment decision. The results are qualitatively the same as those reported so far.[22] These results prove that a borrower's repayment delay for an installment is correlated with other members' repayment delays beyond the level explained by a possible correlation of project failures owing to locally covariate shocks. We therefore interpret this as evidence for the existence and seriousness of strategic default. Pakistani society historically has had limited experience with cooperative community-based development. It has been marked by the existence of strong local elites (e.g., see Kurosaki, 2005), which appears to underlie the limited success of community-based group lending. The following section investigates whether the system change in early 2005 can explain the relative success of the MFI under study.

[21]The union-level repayment problem variable is defined as the fitted value of $Problem^{C}$ on union fixed effects and year-month fixed effects for the repayment due dates.
[22]The estimations results are available on request.

6 Repayment Delays under the New System and Impact of the Earthquake

6.1 Empirical models

6.1.1 Borrower-level analysis

Table 2 shows no case of *Default* = 1 or *No_repay* = 1 after the adoption of the new system in early 2005. Therefore, we first estimate the borrower-level determinants of *Avg_delay* for the 670 borrowers who completed the repayment schedule, using a specification similar to the one reported in Table 4.

Given the severity of the 2005 earthquake in Pakistan, an observation of whether the natural calamity affected repayment patterns holds particular interest. To identify the earthquake impact, we adopt a standard difference-in-difference (DID) approach. First, we determine the distance between the borrower locality and the epicenter of the earthquake from the website of the Earthquake Reconstruction and Rehabilitation Agency (ERRA). We then create a dummy variable, *D_eq*, which takes the value of 1 if the household is located within a radius of 75 km from the epicenter of the earthquake, and 0 otherwise. The threshold radius of 75 km is chosen after consultation with seismologists at Pakistan Meteorological Department. The robustness of empirical results with respect to the choice of *D_eq* is discussed later.

To capture the possibility that repayment installments were adversely affected by the earthquake, we compile a borrower-level variable, *Time_t*1, which is the ratio of the number of installments due after the earthquake to the total number of installments. Variable *D_eq* captures the region-specific effect, while *Time_t*1 captures the effect of macroeconomic factors, so that their coefficients cannot be attributed to the earthquake. However, by adding *D_eq***Time_t*1, a cross-term for the two variables, we can identify the impact of the earthquake under the DID assumption that the region-specific effect affects only the base level of repayment delay, not its growth, and that the macroeconomic factors are homogeneous across regions.

Similarly, to capture the possibility that borrowers who obtained credit after the earthquake had difficulty in timely repayment, we introduce another borrower-level variable, *D_t*2, which is a dummy for loans made after the earthquake. The cross term *D_eq***D_t*2 shows the impact of the earthquake under a similar identification assumption. Since *Time_t*1 and *D_t*2 are positively correlated (the correlation coefficient was 0.657), we estimate three specifications: use both *Time_t*1 and *D_t*2 (specification A), *D_t*2 only (specification B), and *Time_t*1 only (specification C).

6.1.2 Installment-level analysis

To investigate the earthquake impact as well as the nature of peer correlation, we estimate an installment-level model corresponding to equation (1). To identify the earthquake impact under FE specifications, we compile an installment-level variable, *D_t*1, which is a dummy variable for installments due after the earthquake, and then include its cross term with *D_eq*. Under random effect (RE) specifications, we can add the borrower-level dummy variable *D_t2*, which is defined already, and its cross term with *D_eq*.

The cross-terms show the causal effect of earthquake on repayment delay under the DID assumption mentioned above. By investigating the coefficients on *D_eq*D_t1* (identified under both FE and RE specifications) and *D_eq*D_t2* (identified under RE specifications only), we can thus identify the impact of the earthquake.

6.2 Estimation results: Impact of the earthquake

Table 8 reports the estimation results for the borrower-level determinants of *Avg_delay* using 670 borrowers.[23] Among borrowers' and CO's characteristics, three variables have statistically significant coefficients. The effects of "Dummy for a female borrower" and "Number of income sources of the household" are significantly negative, indicating that female borrowers were more punctual in repayment and income diversification is beneficial for timely repayment. This is similar to our findings under the old system (Table 4). Contrary to expectation, "CO's savings" has a significantly positive coefficient but this is not robust (see Table 9).

The impact of the earthquake is marginally discernible through the coefficients on *D_eq*D_t2*. The borrower-average delay was 6.1 days longer as per specification A and 4.3 days longer as per specification B, if the borrower obtained the credit after the earthquake and he/she lived within a 75-km radius of the earthquake epicenter. The coefficients are statistically significant at the 5% level. Because of the multicollinearity, we prefer the estimate under specification B. The point estimate of a delay of 4.3 days is marginal if we compare it with repayment delays under the old system.

Table 9 reports the estimation results for the installment-level determinants of *Delay*.[24] First, all variables capturing auto- and peer correlation have positive and statistically significant coefficients. Second, the impact of the earthquake is not discernible in the installment-level analyses. The coefficients on *D_eq*D_t1* are insignificant in both models. The coefficient on *D_eq*D_t2*, which is identified in the RE specification only, is positive; however, its magnitude is extremely small and statistically insignificant. Third, most of the borrower-level variables, whose effects are identified only in the RE specification, are insignificant in explaining *Delay*, except for the female borrower dummy.

Table 10 reports results of the examination of the robustness of marginal or insignificant effects

[23]Some of the explanatory variables in Table 4 are excluded from Table 8 since they show no variation among the 670 borrowers.

[24]We use the subset of our installment-level data corresponding to observations with 12 monthly installments. Out of 8,154 installments under the new system (Table 2), 7,416 installments comprise the subset.

of the earthquake on repayment through different specifications. We obtain a positive (i.e., delay-increasing) and statistically significant coefficient on the cross-term *D_eq*D_t*2 only when we use the borrower-level regression models with *D_eq*, which is defined by a dummy variable associated with the threshold radius of 75 km. When we slightly change the value of the threshold radius (the definition of *D_eq*), the coefficients become insignificant or slightly negative. The coefficient on the cross-term *D_eq*Time_t*1 or *D_eq*D_t*1 is not significant. From the installment-level regressions, we are unable to find any positive and significant coefficient. Therefore, we conclude that the repayment delay was affected by the earthquake only marginally at best and the impact was not robust.

6.3 Estimation results: Nature of peer correlation

Regarding the nature of peer correlation, Table 9 shows that a_2 (the coefficient capturing peer correlation) remains highly significant under the new system, as was the case under the old system (Table 5). To investigate whether this means that the tendency to default strategically remains unaffected under the new system, we prepare Table 11, in which we examine whether a_2 is higher among borrowers who choose similar projects within their borrowers' group.

When equation (1) is re-estimated with the sample split by *Homogeneity*, a striking result emerges: a_2 is considerably larger when observations associated with homogeneous COs are used than when those associated with heterogeneous COs are used. The difference is not only statistically significant (the significance level is less than 0.1%), but also economically significant. The results under the default specification show that under the new system, coefficient a_2 is 0.292 in COs where some members invested in projects different from those of the others, while it is 0.656 in COs where all members invested in the same project.

In Table 11, we employ four types of robustness checks, as we did for the borrowers under the old system. When we identify the difference in COs' heterogeneity using the Herfindahl index for project purposes (last block of rows in Table 11), the cross-term has a highly positive and statistically significant coefficient (the significance level is less than 0.1%). When a larger subsample is employed, the results are very similar to those under the default specification. When we re-estimate equation (1) using the system GMM approach, the coefficients become slightly smaller, although the test for the hypothesis that a_2 is the same regardless of project homogeneity is rejected at the 0.1% level. When equation (1) is re-estimated with the peer-average $Delay^C_{it}$ treated as endogenous,[25] peer correlation among the less homogeneous groups disappears while that among the more homogeneous groups remains positive and

[25] Identifying instrumental variables are $Delay^C_{i,t-1}$ and the lagged value of the union-level repayment problem variable. The union-level repayment problem is defined as the fitted value of $Delay^C_{it}$ on union fixed effects and repayment-month fixed effects.

statistically significant at the 1% level.

As done earlier, in addition to the robustness checks reported in Table 11, we re-estimate the model using *Delay* truncated at zero for the payments made earlier than their due dates, and the instrumental value specification using two-period lags as the identifying instrumental variables. The results are again qualitatively the same as those reported earlier in this section.[26]

These results confirm that the main reason for peer correlation in *Delay* under the new system is covariate shocks to microenterprises, and not strategic default. From our field observations, we received no indication that there occurred a substantial change in the covariance among microenterprises run by microcredit borrowers after early 2005. We therefore interpret this as evidence that the tendency to default strategically has reduced under the new system owing to improved dynamic incentives and more frequent repayment schedules. This interpretation is consistent with the prediction of our theoretical model in Section 2 that improvement in enforcement of the contingent renewal rule will result in lower default rates and a lower level of peer correlation due to the less frequent strategic default.

7 Conclusion

This paper analyzed an interesting case of microfinance in Pakistan in which an MFI successfully overcame the problem of frequent default by adopting a new system with strict enforcement of punishment against delayed repayments. We hypothesized that strategic default under the joint liability mechanism, which was encouraged by weak enforcement of dynamic incentives, was responsible for failure under the old system. Using a unique dataset of about 45,000 repayment installments covering 2,945 micro-borrower households over the period 1998–2007, we investigated the dynamics of repayment at the installment level. We found that a borrower's delay in the repayment of each installment was correlated with the repayment delays of other members in his/her group, beyond the level explained by possible correlation of project failures due to locally covariate shocks. Although peer correlation was evident under the new system as well, it was better explained by covariate shocks to microenterprises. Therefore, our interpretation is that strategic default occurred frequently and was a serious problem under the old system, while the new system was successful in suppressing collusion among group members. In terms of actual borrowers' data (not experimental data), this finding lends empirical support to the burgeoning literature on microfinance that insists that individual lending schemes are likely to be superior to joint-liability schemes when they are accompanied by dynamic incentives and frequent repayment installments.

Although the study area was hit by a disastrous earthquake in October 2005, the new

[26] The estimations results are available on request.

microfinance system was affected only marginally in terms of repayment delay. This does not necessarily imply that the earthquake did not pose any threat to MFIs; rather, it may reflect a change in the lending strategy in that the MFI became more selective about its clients and started monitoring borrowers more thoroughly, thereby undermining the gravity of the delay/default problem. As shown in Table 1, most borrowers' observable characteristics did not change after the earthquake, except for the ratio of households with income originating outside their residential areas (21% before the earthquake and 100% after the earthquake). This suggests that after the earthquake, the MFI tended to lend only to those households with outside income in order to avoid repayment problems. If borrowers in the earthquake-hit region faced stricter selection or monitoring after the earthquake, then it can be said that they suffered not only on account of the natural disaster but also from the inflexible repayment requirements of MFI—an inference that is corroborated in a similar finding reported by Shoji (2010) in the case of floods in Bangladesh, 2004. The net impact of the earthquake on borrowers' welfare is a topic that merits further investigation.

A novel implication of these findings in the context of understanding microfinance pertains to the concept of covariate shocks. Even in cases where shocks to microenterprises caused by borrowers of the same group are purely idiosyncratic from the viewpoint of an individual borrower, their effect on MFIs may be similar to that of covariate shocks if the tendency to default strategically exists. This paper shows that widespread strategic default affects the sustainability of microfinance more adversely than a purely covariate, negative shock such as the 2005 Pakistan earthquake.

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Table 1. Characteristics of Microfinance Loans

	Old system	New system: Borrowers who borrowed before the earthquake	New system: Borrowers who borrowed after the earthquake
Characteristics of credit			
First date of credit issued	01-May-98	02-Jan-05	16-Oct-05
Last date of credit issued	04-Oct-03	08-Oct-05	08-Jul-06
Amount of credit in Rs.			
Average	16,324	8,265	9,632
(SD: standard deviation)	(9,427)	(2,384)	(2,945)
Minimum	500	5,000	5,000
Maximum	50,000	10,000	15,000
Number of installments			
Average	16.17	11.90	12.42
(SD)	(8.98)	(1.07)	(1.04)
Minimum	1	1	12
Maximum	30	12	15
Credit duration in months			
Average	17.63	11.90	12.42
(SD)	(7.99)	(1.07)	(1.04)
Minimum	1	1	12
Maximum	31	12	15
Characteristics of borrowers			
Ratio of borrowers with NIC* information recorded	78.5%	100.0%	100.0%
Ratio of female borrowers	24.2%	50.5%	47.9%
Ratio of borrowers who are chairman or secretary of the CO	4.5%	18.0%	20.4%
Average number of income sources of the household	1.62	3.16	2.97
(SD)	(0.86)	(1.56)	(1.51)
Ratio of borrowers who had income sources outside the region	18.5%	21.1%	100.0%
Ratio of borrowers from female-headed households	8.0%	0.0%	13.9%
Ratio of borrowers from joint families	47.6%	36.6%	20.4%
Characteristics of COs (community organizations)			
Average CO's savings (in Rs.100000)#	0.173	0.056	0.041
(SD)	(0.160)	(0.105)	(0.075)
Average number of CO members#	36.0	24.3	22.1
(SD)	(12.4)	(9.0)	(8.2)
Ratio of COs with missing CO records#	0.165	0.032	0.014
Average CO's age in days at the time of loan issue	496.1	1204.2	1234.4
(SD)	(418.3)	(627.0)	(740.2)
Purpose of borrowing (total=100%)			
Agricultural crop	5.3%	0.3%	0.3%
Livestock	61.4%	6.9%	6.8%
Shops, business, workshops	30.4%	52.1%	58.1%
Others	0.6%	0.6%	0.9%
Domestic needs (consumption, education, housing, etc.)	2.3%	40.1%	34.0%
Number of sample borrowers	2275	317	353

Notes *: NIC stands for the "National Identity Card" issued by the Government of Pakistan.

"Savings" and "Number of CO members" were not reported for some of the sample COs under the old system. The reported averages consider only those COs with complete information.

Table 2. Defaults and Delays in Repayment of Microcredit

	Old system	New system: Borrowers who borrowed before the earthquake	New system: Borrowers who borrowed after the earthquake
Borrower-level variables			
Total number of observations	2275	317	353
Default (dummy for non-repayment)			
NOB: Number of observations for which this variable can be defined	2275	317	353
Average (ratio of defaults)	0.5081	0	0
Avg_delay (average delay in repayment)			
NOB	1119	317	353
Average (in days)	100.0	-1.3	2.1
SD	144.8	12.6	10.7
Minimum	-552.0	-93.8	-68.7
Maximum	1014.0	15.9	21.1
Installment-level variables			
Total number of observations	36777	3771	4383
No_repay (dummy for non-repayment)			
NOB	36777	3771	4383
Average (ratio of non-repayments)	0.2078	0	0
Delay (delay in repayment)			
NOB	29134	3771	4383
Average (in days)	101.1	-1.4	2.3
SD	176.1	18.8	16.1
Minimum	-552	-249	-208
Maximum	1560	28	77
Problem (dummy for non-repayment until 31 days after the due date)			
NOB	36777	3771	4383
Average	0.6549	0.0000	0.0046

Table 3. Borrower-level Defaults/Delays and Credit Contract Types

	Probit: *Default*			Two-stage Heckman: *Avg_delay*	
	Coef.		dF/dx	Coef.	
Model 1					
Dummy for loan size larger than Rs.15,000	-0.0182		-0.0073	-24.19	*
	(0.0952)			(12.76)	
Credit duration in months	0.0774	***	0.0309	0.63	
	(0.0072)			(1.01)	
Dummy for non-monthly installments	0.5414	***	0.2079	84.16	***
	(0.1340)			(18.83)	
Inverse Mills ratio				53.09	***
				(16.31)	
Union fixed effects	Yes			Yes	
Date of credit issued: linear, quadratic, cubic, quartic	Yes			Yes	
Number of observations used in the estimation	2275			1119/2275	
chi2(16), chi2(26) for zero slope	394.5	***		408.0	***
Pseudo R2	0.1251				
Model 2					
Dummy for loan size larger than Rs.15,000	-0.0403		-0.0161	-31.46	**
	(0.1007)			(13.03)	
Credit duration in months	0.0697	***	0.0278	0.57	
	(0.0072)			(1.02)	
Dummy for non-monthly installments	0.3639	**	0.1424	74.29	***
	(0.1523)			(20.32)	
Inverse Mills ratio				48.04	***
				(17.50)	
Union fixed effects	Yes			Yes	
Year fixed effects	Yes			Yes	
Number of observations used in the estimation	2275			1119/2275	
chi2(17), chi2(31) for zero slope	443.2	***		448.2	***
Pseudo R2	0.1406				

Notes: (1) The average of "Dummy for loan size larger than Rs.15,000" is 0.592 and that of "Dummy for non-monthly installments" is 0.129. For other variables, see Tables 1 and 2 for summary statistics.

(2) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.

(3) For the two-stage Heckman estimation, the first-stage model is the one reported in Table 4 for *Default* using 2275 observations. In other words, borrowers' and COs' characteristics are used as identifying instrumental variables. The number of uncensored observations is 1119.

Table 4. Borrower-level Defaults/Delays and Borrowers' Characteristics

	Probit: *Default*		Two-stage Heckman: *Avg_delay*
	Coef.	dF/dx	
Borrowers' individual characteristics			
Dummy for the availability of NIC information	-0.6548 ***	-0.2513	-142.41 ***
	(0.0901)		(36.15)
Dummy for a female borrower	-0.4779 ***	-0.1879	-78.40 ***
	(0.0772)		(25.86)
Dummy forCO chairman or secretary	-0.1922	-0.0764	-3.52
	(0.1383)		(26.72)
Borrower households' characteristics			
Number of income sources of the household	-0.3898 ***	-0.1555	-49.82 ***
	(0.0464)		(17.32)
Dummy for income sources outside the region	-0.3664 ***	-0.1447	-47.51 *
	(0.1154)		(27.49)
Dummy for a female-headed household	-0.8122 ***	-0.3004	-7.66
	(0.1757)		(49.25)
Dummy for a joint family	-0.0632	-0.0252	19.76
	(0.0714)		(14.72)
CO characteristics			
CO's savings (in Rs.100000)#	-0.4560 *	-0.1818	-40.51
	(0.2430)		(51.90)
Number of CO members#	0.0010	0.0004	1.57 ***
	(0.0027)		(0.51)
Dummy for missing CO records#	0.2393 **	0.0948	29.48
	(0.1026)		(23.74)
CO's age in days at the time of loan issue	0.00064 ***	0.00026	0.080 **
	(0.00010)		(0.038)
Inverse Mills ratio			-212.31 **
			(82.86)
Union fixed effects	Yes		Yes
Date of credit issued: linear, quadratic, cubic, quartic	Yes		Yes
Number of observations used in the estimation	2275		1119/2275
chi2(26), chi2(49) for zero slope	531.4 ***		603.2 ***
Pseudo R2	0.1685		

Notes: (1) # "Savings" and "Number of CO members" were not reported for approximately 15% of the sample COs. In such a case, "Dummy for missing CO records" takes the value of one, and the means of CO's savings and the number of members are included. The reported standard deviations for "Savings" and "Number of CO members" are based on the subsample for which these two variables were available.

(2) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.

(3) For the two-stage Heckman estimation, the first-stage model is the one reported in this table for *Default* . In other words, the model is identified only through the non-linearity of the inverse Mills ratio.

Table 5. Installment-level Dynamics of Delays and Defaults

	Determinants of *Delay*		Probability of transition from *No_repay* =0 to *No_repay* =1: Equation (3)
	Equation (1)	Equation (2)	
Lagged value of *Delay* : Parameter a_1	0.736 ***	0.842 ***	0.00019 ***
	(0.007)	(0.006)	(0.00001)
Peer effects: Parameter a_2			
Peer average of *Delay*	0.319 ***		
	(0.008)		
Peer average of *Problem*		30.571 ***	
		(2.133)	
Peer average of *No_repay*			0.4886 ***
			(0.0091)
Total number of observations	12630	12630	13092
Total number of borrowers	898	898	917
R2 within	0.712	0.681	0.260
R2 between	0.914	0.946	0.384
R2 overall	0.817	0.813	0.219
F-statistics for zero slope	1607.88 ***	1389.62 ***	237.02 ***
F-statistics for all u_i =0	2.48 ***	1.88 ***	2.39 ***
F-statistics for all u_t =0	1.35	5.57 ***	2.21 ***

Notes: (1) All three models are estimated by a two-way fixed effect panel regression model, with individual credit contract as "group" and the installment number as "time" for the fixed effect.
(2) F-statistics for zero slope have degrees of freedom (dof) at F(18,11714) for the determinants of *Delay* and F(18,12157) for the probability of transition. F-statistics for all u_i =0 have dof at F(897, 11714) for the determinants of *Delay* and F(916,12157) for the probability of transition. F-statistics for all u_t =0 have dof at F(16, 11714) for the determinants of *Delay* and F(16,12157) for the probability of transition.
(3) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.
(4) The subsample of installment-level data of borrowers associated with 18 monthly installments is used.

Table 6. Installment-level Peer Effects and Homogeneity of Microenterprise Projects

	Coefficient a_2 (extent of peer correlation) or its difference (addition for homogeneous groups)		
	Separate regression results using two subsamples		Regression results using pooled sample with cross-terms of all explanatory variables with *Homogeneity*
	Borrowers in a CO with less homogeneous projects (*Homogeneity* =0)	Borrowers in a CO with more homogeneous projects (*Homogeneity* =1)	
Delay on $Delay^C$ (equation (1))	0.320 ***	0.337 ***	0.018
	(0.011)	(0.013)	(0.019)
Delay on $Problem^C$ (equation (2))	29.684 ***	30.706 ***	1.022
	(2.788)	(3.126)	(4.591)
No_repay on No_repay^C (equation (3))	0.455 ***	0.526 ***	0.071 ***
	(0.012)	(0.015)	(0.019)
Number of observations	8493	4137	12630

Notes: (1) All nine models are estimated by a two-way fixed effect panel regression model, similar to the one in Table 5.

(2) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.

Table 7. Robustness of the Estimation Results Regarding Peer Effects

	Coefficient a_2 (extent of peer correlation)		Test for the hypothesis that a_2 is the same#
	Less homogeneous	More homogenous	
Split the sample by dummy variable *Homogeneity*	*Homogeneity* =0	*Homogeneity* =1	
0. Default (see Table 6)			
Delay on $Delay^C$ (equation (1))	0.320	0.337	n.s.
Delay on $Problem^C$ (equation (2))	29.684	30.706	n.s.
No_repay on No_repay^C (equation (3))	0.455	0.526	***
1. Larger sample whose installment number is more than 5			
Delay on $Delay^C$ (equation (1))	0.318	0.331	*
Delay on $Problem^C$ (equation (2))	30.456	33.989	n.s.
No_repay on No_repay^C (equation (3))	0.459	0.471	**
2. System-GMM estimates treating lagged *Delay* as endogenous			
Delay on $Delay^C$ (equation (1))	0.250	0.209	(**)
Delay on $Problem^C$ (equation (2))	128.613	79.677	(**)
3. Instrumental variable estimates treating peer variables as endogenous			
Delay on $Delay^C$ (equation (1))	0.094	0.103	n.s.
Delay on $Problem^C$ (equation (2))	10.522	-3.940	(n.s.)
No_repay on No_repay^C (equation (3))	0.214	0.204	(n.s.)
4. Cross-term with *Herfindahl* to identify the difference in a_2	*Linear term*	*Cross-term*	
Delay on $Delay^C$ (equation (1))	0.338	-0.021	(n.s.)
Delay on $Problem^C$ (equation (2))	30.832	-1.223	(n.s.)
No_repay on No_repay^C (equation (3))	0.379	0.146	*

Notes: All models include the lagged value of delay, borrower fixed effects, and time controls (time fixed effects for cases 1, 3, and 4) as explanatory variables in addition to the peer variable.

Case 1: The total number of observations is 25818 (equation (1) or (2)) and 26787 (equation (3)). The total number of borrowers is 1836 (equation (1) or (2)) and 1881 (equation (3)).

Case 2: Estimated by the system-GMM method proposed by Blundell and Bond (1998). Because of memory problem, the full list of time fixed effects were not included. Instead, the relative position of the installment and its higher order polynomials (to the fourth order) were included. This replacement did not affect the structural parameters for cases 1 and 2 reported in this table. In all specifications, Hansen's *J* test indicates that the overidentifying restrictions implied by this GMM procedure are not rejected. The AR(2) test for autocorrelation of order 2 indicates that the null hypothesis of no autocorrelation is not rejected.

Case 3: In the instrumental variable estimates, to avoid the simultaneity bias within a borrowers' group, the lagged values of the peer variables and the union-level shock indicators are employed as identifying instrumental variables for the peer variables.

Case 4: Coefficient in the first column shows the one corresponding to the mean level of *Herfindahl*. Coefficient in the second column shows the one on the cross-term. The average of *Herfindahl* is 0.697 and its standard deviation is 0.297.

The null hypothesis is rejected at 1%=***, 5%=**, 10%=*, and not rejected at 10%="n.s." When a_2 is larger in homogeneous COs than in heterogeneous COs, these are shown without parentheses; when a_2 is smaller in homogeneous COs, these are shown in parentheses.

Table 8. Borrower-level Delays under the New System and the Impact of the Earthquake

	Specification A	Specification B	Specification C
Controls to identify the earthquake impact			
D_eq : Dummy for location close to the epicenter	-2.061	-7.151 **	-5.665
	(5.592)	(2.944)	(5.375)
Time_t 1: Ratio of installments due after the earthquake	-20.935 **		-22.756 **
	(9.262)		(9.032)
D_eq * *Time_t* 1: Cross-term to identify the earthquake impact	-6.800		3.026
	(6.618)		(4.989)
D_t 2: Dummy for the loan made after the earthquake	0.017	2.139	
	(3.370)	(3.269)	
D_eq * *D_t* 2: Cross-term to identify the earthquake impact	6.092 **	4.339 **	
	(2.757)	(2.083)	
Borrowers' individual characteristics			
Dummy for a female borrower	-5.266 ***	-5.181 ***	-5.357 ***
	(0.998)	(0.991)	(0.992)
Dummy for CO chairman or secretary	1.215	1.191	1.272
	(1.086)	(1.089)	(1.088)
Borrower households' characteristics			
Number of income sources of the household	-1.265 ***	-1.306 ***	-1.291 ***
	(0.301)	(0.302)	(0.301)
Dummy for income sources outside the region	0.735	1.269	1.735
	(5.110)	(5.112)	(5.097)
Dummy for a joint family	2.517	2.529	0.414
	(2.655)	(2.662)	(2.495)
CO characteristics			
CO's savings (in Rs.100000)	11.657 *	12.298 **	13.515 **
	(6.029)	(5.925)	(5.988)
Number of CO members	0.083	0.066	0.063
	(0.058)	(0.056)	(0.057)
CO's age in days at the time of loan issue	-0.0012	-0.0009	-0.0013
	(0.0008)	(0.0008)	(0.0008)
Union fixed effects	Yes	Yes	Yes
Date of credit issued: linear, quadratic, cubic, quartic	Yes	Yes	Yes
Number of observations used in the estimation	670	670	670
F(20,649) or F(18,651) for zero slope	6.11 ***	6.40 ***	6.46 ***
R2	0.1584	0.1504	0.1515

Notes: Estimated by OLS.
(1) The dependent variable is *Avg_delay* . See Table 2 for its summary statistics. See Table 1 for the summary statistics of the explanatory variables.
(2) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.

Table 9. Installment-level Dynamics of Delays under the New System and the Impact of the Earthquake

	Fixed effect (FE) estimation	Random effect (RE) estimation
Controls to identify the earthquake impact		
D_eq		0.276
		(0.751)
D_t 1: Dummy for an installment due after the quake	-0.060	-0.259
	(0.670)	(0.598)
D_eq * *D_t* 1	-0.367	-0.235
	(0.907)	(0.831)
D_t 2: Dummy for the loan made after the earthquake		0.195
		(0.454)
D_eq * *D_t* 2		0.021
		(0.508)
Own and peer effects		
Lagged value of *Delay*	0.819 ***	0.983 ***
	(0.010)	(0.008)
Peer average of *Delay*	0.375 ***	0.233 ***
	(0.012)	(0.009)
Borrowers' characteristics		
Dummy for a female borrower		-0.549 **
		(0.263)
Dummy for CO chairman or secretary		0.062
		(0.285)
Number of income sources of the household		0.095
		(0.077)
Dummy for income sources outside the region		1.948
		(1.272)
CO's savings (in Rs.100000)		2.181
		(1.524)
Number of CO members		0.004
		(0.015)
CO's age in days at the time of loan issue		-0.0003
		(0.0002)
Total number of observations	6787	6787
Total number of borrowers	617	617
R2 within	0.622	0.609
R2 between	0.891	0.947
R2 overall	0.745	0.760
Statistics for zero slope	722.49 ***	21350.79 ***
F-statistics for all u_i=0	2.09 ***	
Statistics for all u_t=0	16.59 ***	225.55 ***

Notes: (1) Both models are estimated with individual borrower as a "group" for the fixed (random) effect and with the installment number as the fixed time effect.
(2) The effects of borrower-level variables including *D_eq* , *D_t* 2 and *D_eq***D_t* 2 are identified in the random effect specifications only.
(3) "Statistics for zero slope" are F(14,6156) and Gaussian Wald chi2(25). "F-statistics for all u_i=0" are F(616, 6156). "Statistics for all u_t=0" are F(10,3105) and chi2(10).
(4) The subsample of installment-level data of borrowers associated with 12 monthly installments is used.

Table 10. Robustness with Respect to the Earthquake Impact

	Specification A	Specification B	Specification C
Borrower-level regression			
D_eq = dummy (distance < 75 km)			
D_eq * *Time_t* 1	-6.800		3.026
	(6.618)		(4.989)
D_eq * *D_t* 2	6.092 **	4.339 **	
	(2.757)	(2.083)	
D_eq = dummy (distance < 70 km)			
D_eq * *Time_t* 1	-4.863		-8.894
	(7.665)		(5.476)
D_eq * *D_t* 2	-2.670	-4.070 *	
	(3.295)	(2.368)	
D_eq = dummy (distance < 80 km)			
D_eq * *Time_t* 1	3.986		5.353
	(8.790)		(6.085)
D_eq * *D_t* 2	0.378	1.358	
	(2.626)	(1.833)	
D_eq = 100/distance			
D_eq * *Time_t* 1	-4.091		-6.686
	(8.358)		(6.612)
D_eq * *D_t* 2	-1.999	-2.929	
	(3.292)	(2.629)	
Installment-level regression, FE specification: *D_eq* * *D_t* 1			
D_eq = dummy (distance < 75 km)			-0.367
			(0.907)
D_eq = dummy (distance < 70 km)			-0.854
			(1.006)
D_eq = dummy (distance < 80 km)			0.208
			(0.966)
D_eq = 100/distance			-0.656
			(1.110)
Installment-level regression, RE specification			
D_eq = dummy (distance < 75 km)			
D_eq * *D_t* 1	-0.235		-0.187
	(0.831)		(0.782)
D_eq * *D_t* 2	0.021	-0.062	
	(0.508)	(0.479)	

Notes: All models include the same set of explanatory variables that are shown in Table 8 (borrower-level regression) or in Table 9 (installment-level regression).
(2) Coefficient estimates are statistically significant at the 1% (***), 5% (**), and 10% (*) levels. Standard errors are in parentheses.

Table 11. Peer Effects and Homogeneity of Microenterprise Projects under the New System

	Coefficient a_2 (extent of peer correlation)		Test for the hypothesis that a_2 is the same#
	Less homogeneous	More homogenous	
Split the sample by the dummy variable *Homogeneity*	*Homogeneity* =0	*Homogeneity* =1	
0. Default			
Delay on $Delay^C$ (equation (1))	0.292	0.656	***
	(0.015)	(0.020)	
1. Larger sample whose installment number is 12 or 15			
Delay on $Delay^C$ (equation (1))	0.298	0.530	***
	(0.014)	(0.018)	
2. System-GMM estimates treating lagged *Delay* as endogenous			
Delay on $Delay^C$ (equation (1))	0.153	0.279	***
	(0.021)	(0.012)	
3. Instrumental variable estimates treating peer variables as endogenous			
Delay on $Delay^C$ (equation (1))	-0.041	0.227	***
	(0.022)	(0.040)	
4. Cross-term with *Herfindahl* to identify the difference in a_2	*Linear term*	*Cross-term*	
Delay on $Delay^C$ (equation (1))	-0.048	0.695	***
	(0.031)	(0.046)	

Notes: All models include the lagged value of delay and time controls (time fixed effects for cases 1, 3, and 4) as explanatory variables in addition to the peer variable.
Case 0: A pooled sample of 6787 is divided into Homogeneity=0 (4752 observations) and Homogeneity=1 (2035 observations).
Case 1: The total number of observations is 7452, divided into Homogeneity=0 (5308 observations) and Homogeneity=1 (2144 observations).
For cases 2, 3, 4, see notes in Table 7.
Figures in paretheses shows standard errors. The null hypothesis is rejected at the 1% level, which is denoted by ***. In all cases, a_2 is larger among more homogeneous COs.

Figure 1. Repayment Game with Imperfect Joint Liability

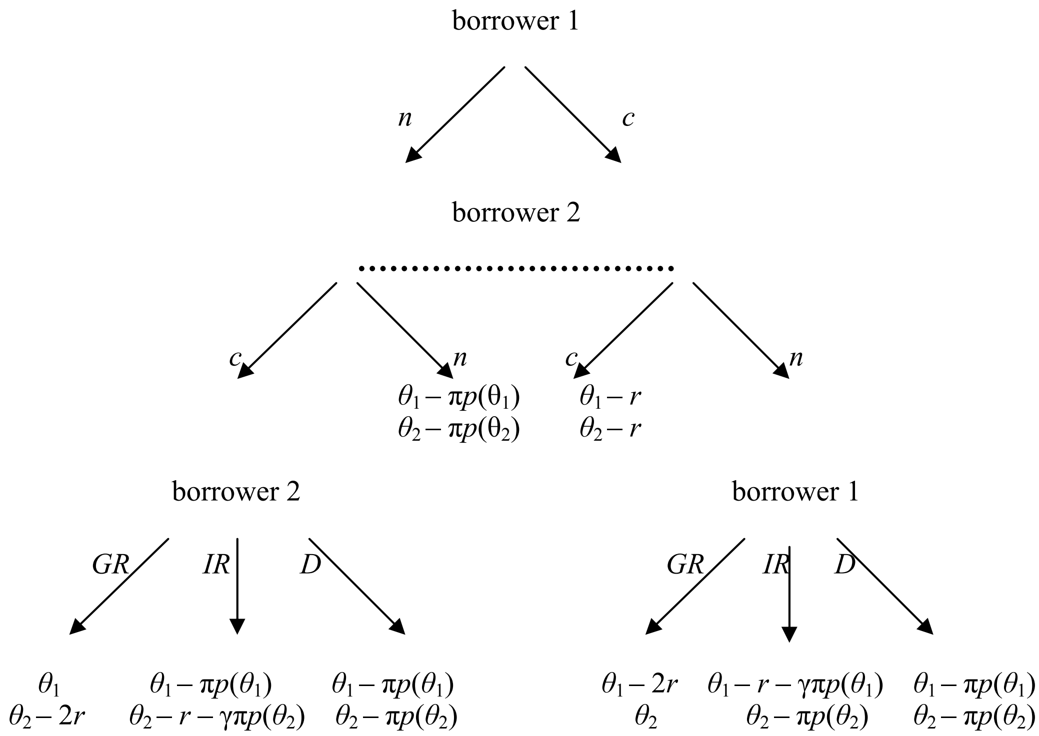


Figure 2. Equilibria Pattern and Project Returns: Individual Liability (γ = 0)

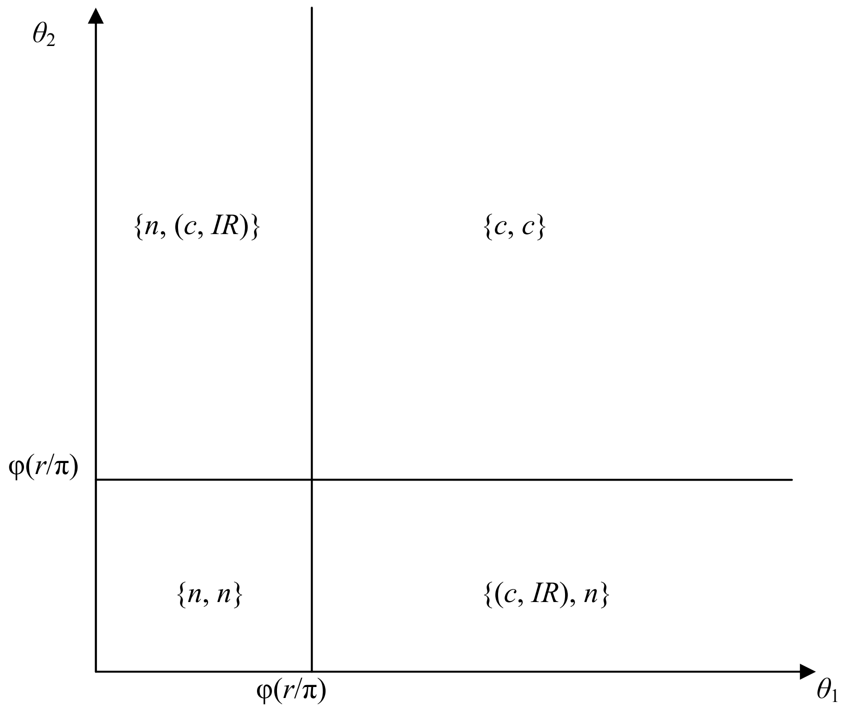


Figure 3. Equilibria Pattern and Project Returns: Perfect Joint Liability (γ > 1/2)

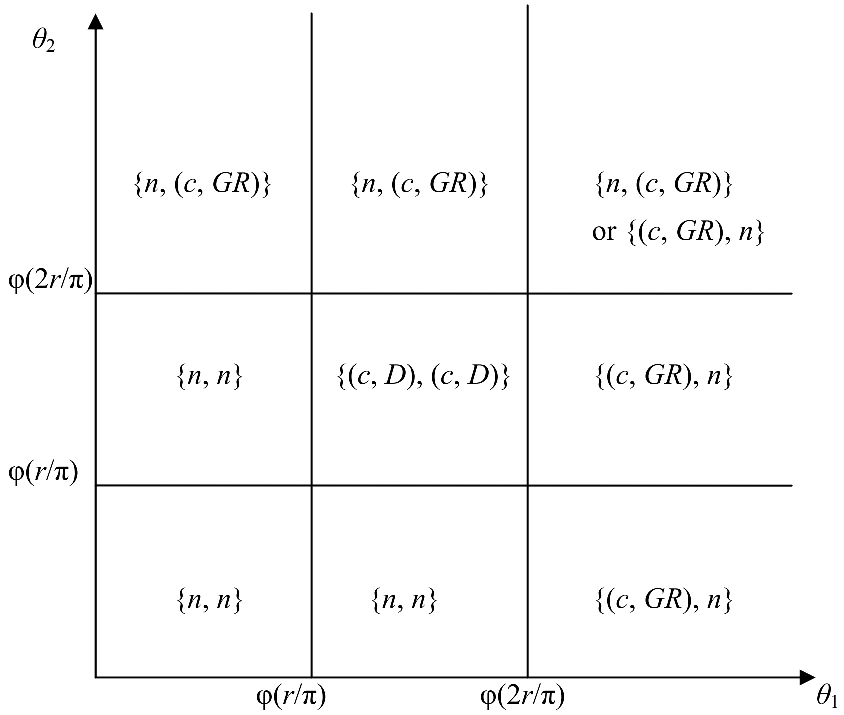
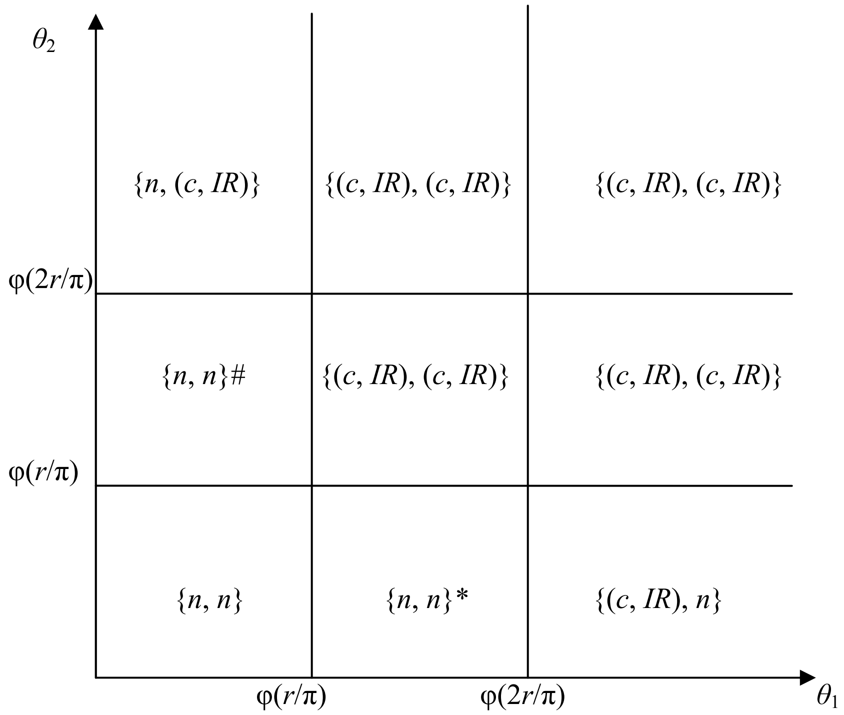


Figure 4. Equilibria Pattern and Project Returns: Imperfect Joint Liability (γ < 1/2)



Notes: # We assume that $1 - r/\{\pi p(\theta_1)\} < \gamma < 1/2$. Otherwise, $\{n, (c, IR)\}$ is the equilibrium.
* We assume that $1 - r/\{\pi p(\theta_2)\} < \gamma < 1/2$. Otherwise, $\{(c, IR), n\}$ is the equilibrium.

Figure 5. Equilibria Pattern and the Rule Enforcement Parameters

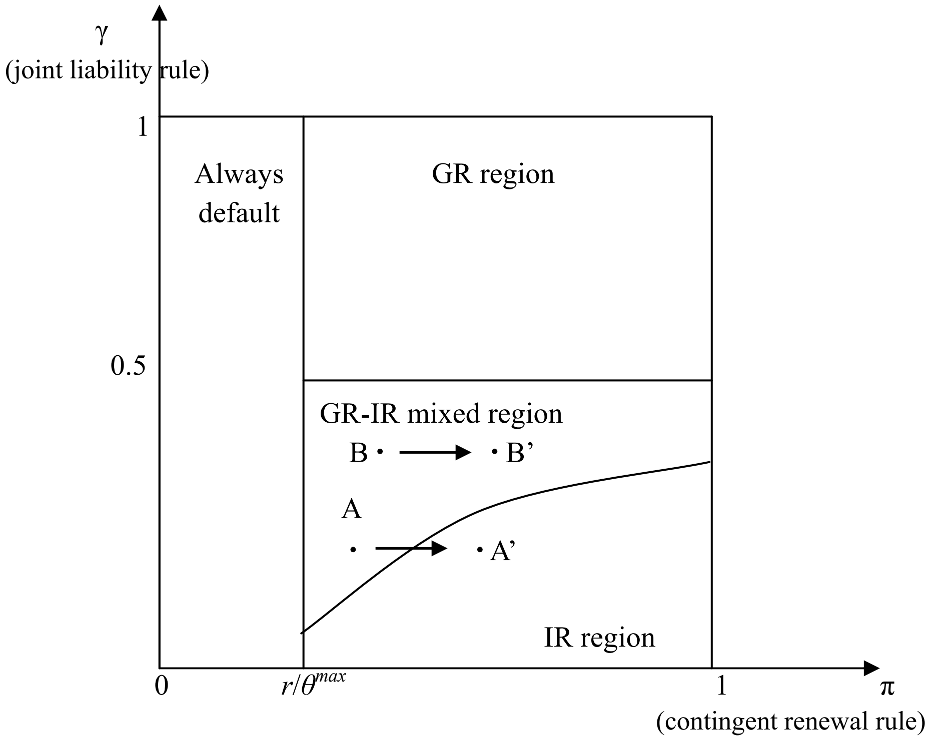


Figure 6. Borrower-level Default Rates

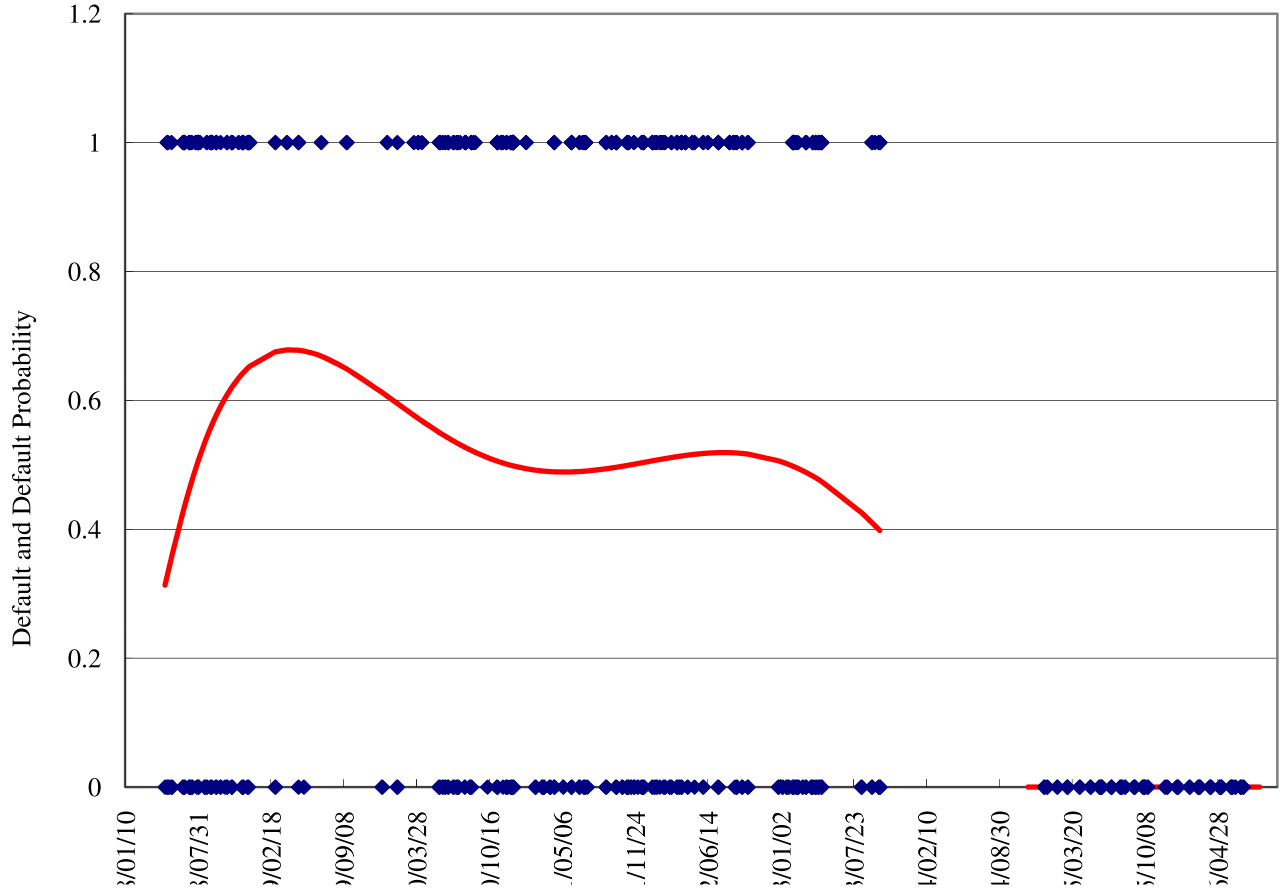


Figure 7. Examples of Repayment Dynamics in a CO (#415)