INTERDEPENDENCIES IN MICRO-CREDIT GROUP: EVIDENCE FROM REPAYMENT DATA*

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ABSTRACT

We use repayment data from Grameen Bank groups to study mutual dependence in behavior among participants. Such dependence is a measure of group cohesion, and is interpreted as evidence for the existence of inter-connectedness among members at the group level. Results from a dynamic fixed-effects probit model demonstrate that individual repayment outcomes are significantly influenced by own lagged repayment behavior, and by averages of lagged repayment behaviors for the remaining members of a group. Simulations of own and cross effects between participants provide further support for strong inter-dependencies at the group level in repayment outcomes. By strengthening mutual support networks, such inter-dependencies may be crucial for poverty alleviation in developing countries such as Bangladesh.

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INTRODUCTION

This paper uses data on loan repayments to examine interactions among women in micro credit groups. In particular, it studies how patterns of missed payments translate into changes of behavior at the group level. By testing for changes in behavior in the repayment data, this paper provides evidence for the existence of inter-dependencies among members in group settings. Such inter-dependencies strengthen ties among group participants, and by laying the foundation for support networks at the village level, are crucial in the fight against poverty.

The inter-dependencies in repayment patterns that we measure in this research may originate due to the presence of joint liability and/or social capital. As is well known, micro lending organizations use innovative means to deliver credit. Making the group jointly liable for loans keeps default rates low and minimizes moral hazard in credit use. In the case of general loans (such loans have to be repaid within one year in equal weekly installments), joint liability implies that if average repayment in past weeks for others in the group is low, the probability that a participant repays this week is high. Such compensatory patterns are expected particularly in the weeks nearer to the end of loan cycles, since all loans must be repaid by the end of a loan cycle (one year) in order to avoid group default. These compensatory patterns are evident in the data used in this analysis.

Several researchers have analyzed the influence of joint liability on group repayment rates. Among them, Besley & Coate (1995) study the repercussions of this form of liability by formulating a "repayment game". They demonstrate that group lending leads to lower default rates since members with successful projects may repay the

loans of others in the group whose projects have yielded insufficient returns. However the authors also show that the whole group may choose to default ("strategic default") even when individual participants could have repaid their loans in the absence of joint lending. Besley & Coate (1995) is one of the earliest attempts to provide a theoretical explanation of the efficacy of group lending schemes, but the authors provide no empirical support of their theory. Others including Zeller (1998), Wydick (1999), and Ahlin & Townsend (2000), confirm that peer monitoring (which arises due to the presence of joint liability) has a favorable impact on repayment performance at the group level.

Another source of inter-dependencies among participants in credit groups is social capital. The notion of social capital captures common ties and a common cultural heritage that underlie interactions in rural environments. Micro lending programs tap into the social inter-connectedness of village life. In close-knit rural settings, the stigma associated with defaulting on a loan is a powerful tool in ensuring that loans are fully repaid on time. Anecdotal evidence suggests that participants often transfer their time, resources, and labor to assist others in their group. Such assistance is especially forthcoming during instances of ill-health, to fulfill child-care needs, or to compensate for sudden down-turns in consumption. Groups with high levels of reciprocative mutual assistance are considered to possess high levels of social capital. In studying repayment data, the presence of social capital may manifest itself in compensatory patterns of payments similar to those mentioned above.

Given its significance, recent research has highlighted the importance of social capital in explaining the success of micro lending programs. Zeller (1998) and Karlan (2004) have shown that the existence of common ties is correlated with improved repayment in micro lending schemes. Measures such as proportion of members who share the same ethnicity, the proportion of members who reside in the same village, and other measures of cultural homogeneity and geographic dispersion, positively influence repayment rates. Using data from FINCA Peru, Karlan (2004) is able to show that social capital causes higher repayment rates. He is able to circumvent the endogeneity problem[1] since the formation of groups in FINCA is decided using an exogenous rule. But the effect of social capital is not unambiguous as demonstrated by Wydick (1999) and Ahlin & Townsend (2000), who find no (or very weak) evidence that measures of commonality (level of sharing among non-relatives, years that participants have known each other before forming a group, and whether participants interact socially outside of group contexts) improve repayment performance.

This paper is the first to study inter-dependencies among group members using repayment data. These inter-dependencies are interpreted as measures of common ties and links within a group; hence, this study is among the few that can provide tangible empirical evidence for the presence of interactions between participants in group settings. The research uses variations in the repayment behavior of group members to provide information on group inter-connectedness. We acknowledge that group behavior need not be evident only in repayment data. As noted before, there is anecdotal evidence that members of a group assist one another with child care needs and during instances of sickness. Unfortunately, information on such mutual transfers of time and resources are absent in our data. Given this, we study inter-temporal patterns in repayment behavior at the group level. These patterns are then used as indicators of the inter-linkages and proxy measures of the mutual assistance support networks that exist among credit participants.

Using data from the Grameen Bank on 219 groups that encompass 966 women, we show that a participant's decision to meet weekly installment payments is significantly influenced by own repayment outcomes in the past, and by variables that measure average repayment history of other members in the participant's group (these variables are discussed in detail below). Our estimation technique controls for woman-specific heterogeneity and other confounding factors that could arise due to time, experience, and

age effects. Simulation results provide striking evidence of strong cross effects in repayment behavior among group participants.

Our results provide significant evidence that inter-dependencies exist. However, since joint liability and social capital have similar predictions in terms of repayment outcomes, it is difficult to identify which of these two is the source of the repayment patterns observed. Although it would be valuable to document whether joint liability or social capital (or both) is responsible for the repayment inter-dependencies we measure, lack of detailed data hinders us from disentangling their separate effects. For example, one of the variables used to measure social capital is a household's participation in social organizations and networks.[2] If we had information on the other associations that households belonged to over and above their membership in Grameen groups, then we could control for the former in our estimations. A significant effect of household membership in other social organizations and networks would signal that social capital is an important determinant of repayment behavior. Similarly, we could attribute repayment inter-dependencies to joint liability by studying a sample of Grameen members who did not belong to any outside social organization or network. Such members would not have access to social capital (if social capital originates from membership in other social organizations and networks), and thus for them, inter-connectedness in repayment outcomes may be due to joint liability alone. Unfortunately, our data lacks such detailed information.

We believe that although identifying the source of the inter-dependencies is important, documenting their existence is equally so. This is because the existence of inter-dependencies in repayment outcomes may lead to the creation of support networks for group members in areas that are unrelated to micro-credit. For example as noted above, members often transfer time and labor resources to assist others in their group when they fall ill or experience negative shocks to consumption. Such links among participants serve to strengthen informal support structures in rural environments, and may be crucially important from an insurance point of view. Whether an official rule (joint liability) or an unofficial commitment (social capital) on the part of members underlies the observed patterns, this research contributes to the literature by demonstrating empirically that repayment inter-dependencies exist among Grameen participants.

Section 2 provides a brief discussion of the Grameen Bank and highlights the structure of repayment schedules. Section 3 presents the empirical model and explains the various components of the dynamic fixed-effects probit framework. Section 4 describes the data and provides summary statistics of the dependent and independent variables. Results of two specifications of the model in section 3 are outlined in section 5, and estimates from the models of section 5 are used in the simulations of section 6. Section 7 discusses why the documented repayment inter-dependencies matter from a poverty alleviation perspective. Section 8 concludes with policy implications and directions for future research. Tables and figures are embedded in the body of the paper.

THE GRAMEEN BANK

The Grameen Bank is the most widely known micro-credit institution in the world. It provides credit for non-agricultural self-employment purposes, and only those who own less than half an acre of (cultivable) land are eligible to participate. Credit is provided to groups under joint liability - under such a scheme, default by a member disqualifies all others in her group from future loans. Coupled with progressive lending (obtaining a larger loan in the future is conditional on successfully repaying one's current loan), joint liability is a powerful substitute for collateral. Grameen specifically targets women (over 90% of the participants are women), although there are some male groups as well.

Loans from Grameen are of three types - general, seasonal, and housing. General loans carry an interest rate of 20% and have to be repaid within one year in equal weekly installments. These repayments are made at public village meetings, and it is immediately evident who in the group has not been able to repay that week. There are very few instances in which participants pay nothing at all. In cases where they cannot fully repay that week, participants usually pay some partial amount. Default is avoided by over-compensating in the weeks nearer to the end of loan cycles.[3] Seasonal loans are of shorter duration (6 months) and have an interest rate of 16%. Housing loans carry an interest rate of 8-10% and can be repaid over several years. This study focuses on general loans only.

Several insurance mechanisms are built into the structure of Grameen loans. In most cases, 5% of a woman's loan is a mandatory contribution to a group savings fund. Members can use resources of the savings fund for consumption and other non-productive purposes, subject to the approval of all other group members. Additionally, 1% of every loan must be donated to an emergency fund. The emergency fund is used to make payments to the families of members who expire. Grameen lending also has certain non-credit aspects. These are referred to as the "sixteen decisions", and involve principles such as sending female children to school, not paying dowries for daughters at the time of marriage, and consuming food items that are nutritious.

EMPIRICAL MODEL

In order to gauge the extent to which repayment behaviors are linked within a group, we formulate an empirical model in which current repayment outcomes are determined by past repayment of the individual and average past repayment of the remaining individuals in a group. Inter-linkages in repayment behaviors across time are evident if lagged indicators of repayment (for both the individual and her group members) have power in predicting current repayment outcomes. These inter-linkages provide evidence that cross dependencies among group participants exist. The stronger the effect of lagged repayment behaviors on current outcomes, the stronger the level of connectedness within a group.

The model that is estimated is of the following form:

$$y_{ijt} = \beta X_{ijt} + \gamma X_{ijt_l} + \delta Z_{-ijt_l} + \alpha\tau_{ijt} + \lambda M_{ijt} + \mu_{ij} + \varepsilon_{ijt} \quad \text{--- (1)}$$

where *i* denotes a specific woman, *-i* denotes other group members excluding woman *i*, *j* denotes a group, and *t* indicates time, which is measured in weeks in these data.

The variables in equation (1) are as follows: y_{ijt} = 1 if a woman paid her installment in week *t*; y_{ijt} =0 otherwise. X_{ijt} is a matrix that includes measures on individual-specific characteristics such as the square of the participant's age and the number of months since the participant joined the Grameen program. The latter variable is a proxy for experience. X_{ijt_l} is a set of individual-specific variables from past weeks including whether a repayment was made last period, two periods ago, and a summation of the total number of times a repayment was made in weeks 3 to 52. Thus X_{ijt_l} includes a set of measures for the individual's lagged repayment performance. Z_{-ijt_l} consists of averages of the variables in X_{ijt_l} for the remaining members in group *j*. The influence of Z_{-ijt_l} on the dependent variable in equation (1) captures the existence of cross effects in repayment behavior within a group. τ_{ijt} measures calendar time in months from 1960[4] until the week *t* in which a particular repayment is made. This variable accounts for time effects across all participants in the data. M_{ijt} is a dummy variable that corresponds to the month in which a repayment is made by woman *i*. Month dummies are included in the estimation to correct for patterns in the repayment data that may vary systematically across seasons of the year. For example, repayment probabilities may be higher during or after the harvest season. μ_{ij} is a woman-specific fixed effect that controls for heterogeneity among participants. This variable allows us to address concerns related to self-selection at the individual level. ε_{ijt} is an independent

and identically distributed error term that follows the normal distribution. Given its formulation, equation (1) is a dynamic fixed-effects probit model.

Table 3 presents results for specification 1, which corresponds to equation (1). Specification 2 (results in table 4) expands the set of variables in X_{ijt_1} and Z_{-ijt_1} to include further details on individual and cross effect repayment histories. Thus lagged individual repayment extends up to four weeks in the past, and the variable that summarizes repayment in a cumulative measure is disaggregated to capture effects from weeks 5 to 26 and from weeks 27 to 52. The corresponding averages of these variables for other group members are created in order to measure inter-dependencies. We estimate specification 2 in addition to the model of equation (1) for two reasons: first, it can be demonstrated that results are not contingent on a particular format of equation (1), and are robust to alternative formulations. Second, with its finer and more detailed breakdown of variables, specification 2 allows a closer analysis of the time lags across which inter-dependencies persist.

DATA

Data used in this research were collected from villages in Bangladesh that had a Grameen credit program. These data were gathered in 2000 by Grameen officials working under our guidance. The data span 18 branches, 35 centers, 219 groups, and 966 women. Information is available on weekly repayment histories for each woman from her very first loan cycle. However only information on general loans were collected. General loans are the most common category of loans and must be repaid within one year in 52 weekly installments. Summary statistics for the variables included in the estimations are provided in table 1.

Table 1 shows that on average there are five women in each group. Individual women appear in these data for an average of approximately 374 weeks, a little over seven years. The average age of a woman in these data is 29 years, and experience in Grameen (as measured by months since joining) varies from less than 1 month to 276 months (23 years).

Table 1 also shows the means and standard deviations of the various measures of repayment on outstanding installments. On average, 73% of the current period installment payments were met in these data. Averages of the lagged measures of individual repayments from past weeks are of a similar magnitude. While 76% (there are 50 installments between weeks 3 and 52, of these 38 are met) of installments on loans outstanding for the individual are met in weeks three to 52, this percentage falls from 73% for weeks five to 26 to 62% for weeks 27 to 52. The means of the variables that measure average repayment for remaining group members from last week and the week before are similar in magnitude. The average of these variables from three and four weeks ago differ in size by a factor of ten (average of repayment three weeks ago for others in group is scaled by 10^{-3}, whereas the average of repayment four weeks ago for others in group is scaled by 10^{-4}). The mean of the averages of the repayment histories

TABLE 1
SUMMARY STATISTICS - ALL VARIABLES EXCLUDING MONTH DUMMIES DATA FOR 966 WOMEN IN 219 GROUPS

Variable	Mean	Standard Deviation	Min.	Max.	Obs.
No. of women in a group	4.815	1.321	2	10	271630
No. of weeks each woman appears	374.189	223.823	14	1672	271630
[@]Repay this week?	0.73	0.444	0	1	271630
Repay last week?	0.732	0.443	0	1	271630
Repay two weeks ago?	0.732	0.443	0	1	271630
Repay three weeks ago?	0.733	0.442	0	1	271630
Repay four weeks ago?	0.733	0.442	0	1	271630
Sum of own repay from weeks 3 to 52 ($x10^{-3}$)	0.038	0.024	0	0.155	271630
Sum of own repay from weeks 5 to 26 ($x10^{-3}$)	0.016	0.009	0	0.044	271630
Sum of own repay from weeks 27 to 52 ($x10^{-3}$)	0.016	0.01	0	0.04	271630
Average of repayment last week for others in group ($x10^{-2}$)	0.007	0.004	0	0.01	271630
Average of repayment two weeks ago for others in group ($x10^{-2}$)	0.007	0.004	0	0.01	271630
Average of repayment three weeks ago for others in group ($x10^{-3}$)	0.007	0.004	0	0.01	271630
Average of repayment four weeks ago for others in group ($x10^{-4}$)	0.007	0.004	0	0.01	271630
Average of own repay from weeks 3 to 52 for others in group ($x10^{-4}$)	0.004	0.002	0	0.0122	271630
Average of own repay from weeks 5 to 26 for others in group ($x10^{-4}$)	0.002	0.001	0	0.003	271630
Average of own repay from weeks 27 to 52 for others in group ($x10^{-4}$)	0.002	0.001	0	0.004	271630
Age of woman ($x10^{-3}$)	0.029	0.006	0.01	0.066	271630
Age of woman squared ($x10^{-4}$)	0.087	0.039	0.01	0.4356	271630
Calendar time in months since 1960 ($x10^{-4}$)	0.04	0.004	0.0242	0.0481	271630
Months since joining Grameen Bank program ($x10^{-4}$)	0.006	0.005	0	0.0276	271630

[@] Denotes dependent (endogenous) variable

for remaining group members disaggregated by various weeks are also depicted in Table 1.

Equation (1) includes dummies for the months in which members make repayments. This is done to control for systematic differences in repayment probabilities that may arise due to seasonality of income (repayment probabilities are likely to be high in the harvest season or immediately thereafter). The month dummies, particularly those from June to October, also control for the effect of the expectation of floods in Bangladesh on repayment probabilities. Table 2 shows the means and standard deviations of the month dummies that are incorporated in the estimations.

TABLE 2
SUMMARY STATISTICS - MONTH DUMMIES
DATA FOR 966 WOMEN IN 219 GROUPS

Variable	Mean	Standard Deviation	Min.	Max.	Obs.
January	0.088	0.283	0	1	271630
February	0.077	0.266	0	1	271630
March	0.082	0.275	0	1	271630
April	0.08	0.272	0	1	271630
May	0.083	0.276	0	1	271630
June	0.081	0.272	0	1	271630
July	0.085	0.278	0	1	271630
August	0.086	0.28	0	1	271630
September	0.084	0.278	0	1	271630
October	0.086	0.281	0	1	271630
November	0.085	0.279	0	1	271630
December	0.083	0.275	0	1	271630

RESULTS

Specification 1

Results from the first specification of the dynamic fixed-effects probit model are reported in table 3. This specification includes women fixed-effects, indicators of own repayment history, cross repayment effects within the group, the age of the participant squared, calendar time measured in months from 1960, the number of months since the participant joined the Grameen program, and month dummies for when repayments are made. Since there are 966 women in these data, estimates for the 966 women fixed-effects are not reported in table 3. The dependent variable is an indicator for whether the participant repaid in the current period - if inter-dependencies are present within a group, then lagged repayment history of other group members should have predictive power (the variables should be significant) in explaining current individual repayment.

Estimates in table 3 show the expected patterns. The three measures of own lagged repayment behavior have strong positive effects on whether or not a repayment is made this period. If the participant met a weekly installment payment two weeks ago, she is likely to pay in the current period also. The positive effects on meeting an

installment payment this week are even stronger if a repayment was made last week, controlling for other variables in the specification. A variable that summarizes the participant's repayment history in the previous 50 weeks also has the predicted effects. Evidently, in the absence of individual and village-level shocks, women who have regularly met their installment payments in past weeks are likely to continue on that path in the current week.

Of most interest in table 3 are variables that measure effects across group members in terms of repayment behavior (the fourth, fifth, and sixth variables in table 3). The average of repayments last period for others in the group has a significant and negative effect on the probability that a repayment is made this period. Thus, if average repayment for the group was low last period, then results suggest that participants are more likely to meet their installments this period. Intuitively, this is logical given the presence of joint liability and the severe penalties associated with loan default. If past averages of repayments have been low, then members are likely to ensure that subsequent payments are met on time in order to avoid reneging on their loans. If the group as a whole is falling behind in their payments, then members may even over-compensate (pay more
than their due) nearer to the end of loan cycles in order to avoid group default (instances of over-compensation are evident in the data). Such compensatory actions (in which the past repayment outcomes of other group members influence a particular member's current outcome) support the notion of inter-linkages among group participants in repayment behavior.

TABLE 3
DYNAMIC FIXED EFFECTS PROBIT MODEL - SPECIFICATION 1
DEPENDENT VARIABLE - REPAY THIS WEEK?

Variable	Coefficient	T- statistic[#]
Repay last week?	1.707	73.864***
Repay two weeks ago?	0.97	41.433***
Sum of own repay from weeks 3 to 52 ($x10^{-3}$)	33.098	68.839***
Average of repayment last week for others in group ($x10^{-2}$)	-27.175	-7.601***
Average of repayment two weeks ago for others in group ($x10^{-2}$)	12.279	3.466***
Average of own repay from weeks 3 to 52 for others in group ($x10^{-4}$)	59.071	9.916***
Age of woman squared ($x10^{-4}$)	-8.9054	-4.456***
Calendar time in months since 1960 ($x10^{-4}$)	109.66	5.683***
Months since joining Grameen Bank program ($x10^{-4}$)	-15.42	-0.871
January	3.06E-04	0.011
February	1.84E-02	0.617
March	1.81E-02	0.616
May	3.69E-02	1.265
June	3.97E-02	1.343
July	6.84E-03	0.234
August	9.14E-02	3.059***
September	-6.95E-02	-2.370***
October	8.33E-03	0.281
November	9.52E-03	0.315
December	4.30E-02	1.415

[#]Inverse hessian t-statistics. *** Denotes significance at the 1% level; ** Denotes significance at the 5% level, and * Denotes significance at the 10% level.

In table 3, the average of repayment two weeks ago for others in the group has a significant and positive effect on current repayment probabilities (the same is true for the average of repayment history from weeks three to 52 for others in the group). This suggests that if lagged repayment for the group was low two weeks ago, then participants are less likely to repay in the current week. The reversal in sign of the two variables (average repayment last week and two weeks ago for others in the group) is explained by noting that additional time allows participants to distinguish the actual cause of low

payments. In the very short run (a week), the cause of low payments (whether moral hazard or genuine inability to repay) may not be immediately obvious. Members may thus display compensatory behavior from week to week. But two weeks is a sufficient length of time for participants to discern whether the cause of low payments by others is due to moral hazard. Their behavior in the current week is thus likely to be positively correlated with the average repayment outcomes of others in the group two weeks ago. For example, if remaining members decide not to repay their loans, it is unlikely that an individual participant will continue to repay her loan once she realizes their intentions. As noted before, Besley & Coate (1995) provide theoretical evidence for such "strategic default" strategies. The repayment patterns evident in table 3 provide further support that mutual intra-group dependence exists.

The other variables in table 3 measure time effects associated with age and experience in the program. The negative and significant coefficient on the age-squared variable suggests that although probabilities of repayment may increase with age of the participant, such increases do not continue indefinitely (the relationship is non-linear). A separate age coefficient could not be estimated due to collinearity.[5] Experience in the program has a negative (but insignificant) effect on repayment probabilities. This is consistent with previous work (Menon 2004a and Menon 2004b), which documents that diminishing returns to the benefits of participating in micro-credit programs are evident for experienced members. Where benefits of participation are measured in terms of the ability to buffer consumption against seasonal shocks, members who have participated for longer stretches of time experience smaller changes in inter-seasonal consumption. More experienced members are thus better able to withstand seasonal shocks to consumption. Although this signals that micro-credit organizations such as the Grameen Bank have succeeded in reducing the vulnerability of the poor to seasonal shocks, it also implies that experienced participants may have developed the means to survive independently on their own. For example, experienced members may have accumulated assets with which to smooth consumption, finance alternate activities, and so on. Given costs of membership, such participants may depend less on Grameen loans.

Month dummies are also included in the specification of table 3. As mentioned above, this is done to de-trend the repayment data of patterns that are consistent across specific months of the year. The August and September month dummies are significant. August corresponds to the third rice harvest of the year (Aus season), and repayment probabilities are evidently higher during that time. The season of most hardship is late September to early October, and repayment probabilities, as measured by the negative September month dummy, appear to be lower during that time.

Specification 2

The second specification includes more detailed repayment histories for the individual participant and for her other group members. Results of this specification are reported in table 4. The dependent variable is the same as in table 3, and specification 2 also controls for 966 women specific effects (these are not reported).

As is evident, a participant's repayment record from the past week (and from two and three weeks ago) has strong positive effects on the probability of a repayment this period. Lagged repayment from a month ago is insignificant. The averages of these measures for others in the group have similar impacts to those found in table 3. If average repayment for the remaining group members was low last week, then individual repayment probabilities are higher this period. As discussed before, this indicates the presence of compensatory behavior and provides evidence that group-level inter-dependencies exist. Averages of repayment for others in a group from two, three, and four weeks ago, have positive but insignificant effects on the likelihood of a repayment in the current period.

TABLE 4
DYNAMIC FIXED EFFECTS PROBIT MODEL - SPECIFICATION 2
DEPENDENT VARIABLE - REPAY THIS WEEK?

Variable	Coefficient	T-statistic[#]
Repay last week?	1.435	56.871***
Repay two weeks ago?	0.587	19.087***
Repay three weeks ago?	0.239	7.087***
Repay four weeks ago?	-2.11E-02	-0.664
Sum of own repay from weeks 5 to 26 ($x10^{-3}$)	81.239	45.484***
Sum of own repay from weeks 27 to 52 ($x10^{-3}$)	23.071	15.644***
Average of repayment last week for others in Group ($x10^{-2}$)	-42.99	-10.602***
Average of repayment two weeks ago for others in Group ($x10^{-2}$)	2.708	0.575
Average of repayment three weeks ago for others in Group ($x10^{-3}$)	1.087	0.21
Average of repayment four weeks ago for others in Group ($x10^{-4}$)	4.775	0.977
Average of own repay from weeks 5 to 26 for others in group ($x10^{-4}$)	535.88	19.729***
Average of own repay from weeks 27 to 52 for others in group ($x10^{-4}$)	-285.09	-12.535***
Age of woman squared ($x10^{-4}$)	-4.509	-2.140**
Calendar time in months since 1960 ($x10^{-4}$)	97.915	4.608***
Months since joining Grameen Bank program ($x10^{-4}$)	-60.369	-3.066***
January	9.18E-03	0.306
February	2.44E-02	0.784
March	2.90E-02	0.946
May	5.02E-02	1.646*
June	5.42E-02	1.755*
July	3.01E-02	0.985
August	0.129	4.130***
September	-3.57E-02	-1.166
October	2.68E-02	0.867
November	3.27E-02	1.038
December	9.46E-02	2.972***

[#]Inverse hessian t-statistics. ***Denotes significance at the 1% level; **denotes significance at the 5% level, and * denotes significance at the 10% level.

Variables measuring own and cross repayment history from weeks 5 to 26 and from weeks 27 to 52 have predicted effects. Disaggregated own repayment history has significant and positive effects on the probability of repayment in the current period. The average repayment history from weeks 5 to 26 for others in a group also has significant positive effects on the dependent variable. This differs from the effect of average repayment history from weeks 27 to 52 for others in a group, which is negative and significant. The reversal in sign during the latter half of loan cycles suggests that participants may adopt a compensatory pattern of payments as the end of the loan term nears. The sum of the coefficients for average of own repay of others in the group from weeks 5 to 26 and for weeks 27 to 52, is positive. Thus, over the complete loan cycle, there is a positive correlation between current individual repayment probabilities and average of repayment outcomes of the remaining members in a group. As noted above, this positive relationship is explained by the fact that participants have adequate time to discern the underlying cause of average repayment patterns for others in the group. They thus adjust their repayments accordingly.

The effects of age squared and calendar time in months are the same as in specification 1 of table 3.[6] Experience of the participant also has similar impacts as in table 3, although the effect in table 4 is strongly significant. This is explained as above. Of the month dummies in table 4, those for May, June, August, and December are positive and significant. These months roughly coincide with the three rice harvests in Bangladesh (Aman harvest in December, Boro harvest in May/June, and Aus harvest in August), where repayment probabilities are expected to be high. Note that although we are looking at the same target population in specifications 1 and 2, different month dummies are significant. This is because specification 2 includes other variables (as compared to specification 1) that allow a more detailed analysis of the inter-dependencies that exist in these repayment data. With the inclusion of these other variables in specification 2, a different set of month effects become evident (as compared to the results for the month dummies in specification 1) since a different set of correlations are being controlled for. This is true even though the target population for the two specifications is the same. We would expect that repayment probabilities are high in post-harvest times; this is what we find with the finer analysis of specification 2. Given the more "aggregate" form of specification 1, positive effects are evident only for the August month dummy.

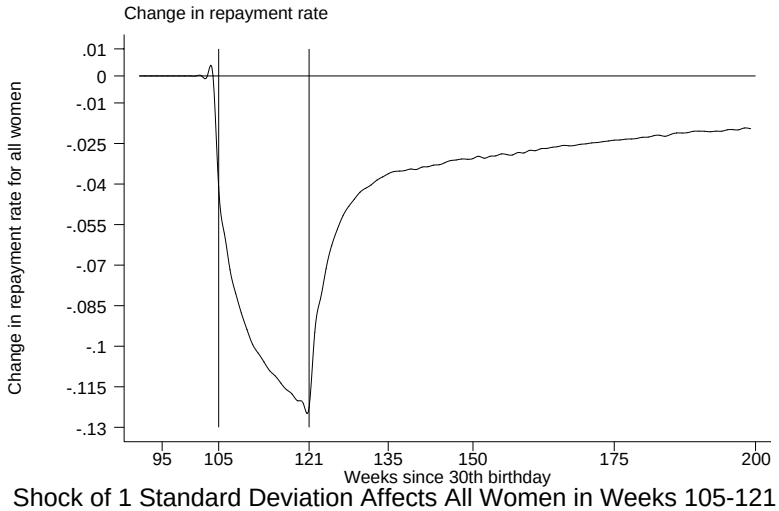
SIMULATIONS

The results in tables 3 and 4 show that repayment probabilities in the current period are significantly influenced by a participant's own repayment behavior in past periods, and by averages of lagged repayment behaviors of the remaining group members. Estimates from the two specifications of equation (1) are used in simulations to provide graphical descriptions of dynamics as reflected in the repayment data. These simulations are presented in figures 1 through 8.

Figures 1-4 correspond to specification 1. A repayment shock which lasts for four months (17 weeks) is simulated to begin in the first week of the third year (week 105). This shock may be of various magnitudes. Figure 1 depicts the case where a repayment shock of one standard deviation affects all women for four months from week 105 to week 121. The change in the repayment rate (as compared to a situation of no shocks) is plotted. As evident, repayment probabilities decline through the 17 weeks of the shock, and then begin to asymptote back to the pre-shock level (change=0 level) after week 121. Although not shown on the graph, change in the repayment rate returns to its pre-shock level (change=0 level) only after the 500th week as measured along the x-axis. Figure 2 is the same as figure 1, except that the magnitude of the shock is increased to two standard deviations. As is clear, the decline in repayment probabilities is even steeper through the weeks of the shock, and a return to pre-shock levels takes even longer

(almost 550 weeks as measured along the x-axis). Figure 3 facilitates a comparison between these two cases by plotting figures 1 and 2 together. Shocks that affect all women in the data may have impacts that are akin to large "negative" phenomena such as floods. Figures 1 through 3 show that
in the event of such aggregate shocks, not only do repayment rates decline during the weeks of the shock, but they take a considerable amount of time to return to their pre-shock levels.

FIGURE 1
EFFECT OF A 1 STANDARD DEVIATION REPAYMENT SHOCK - SPECIFICATION 1



Shock of 1 Standard Deviation Affects All Women in Weeks 105-121

FIGURE 2
EFFECT OF A 2 STANDARD DEVIATIONS REPAYMENT SHOCK - SPECIFICATION 1

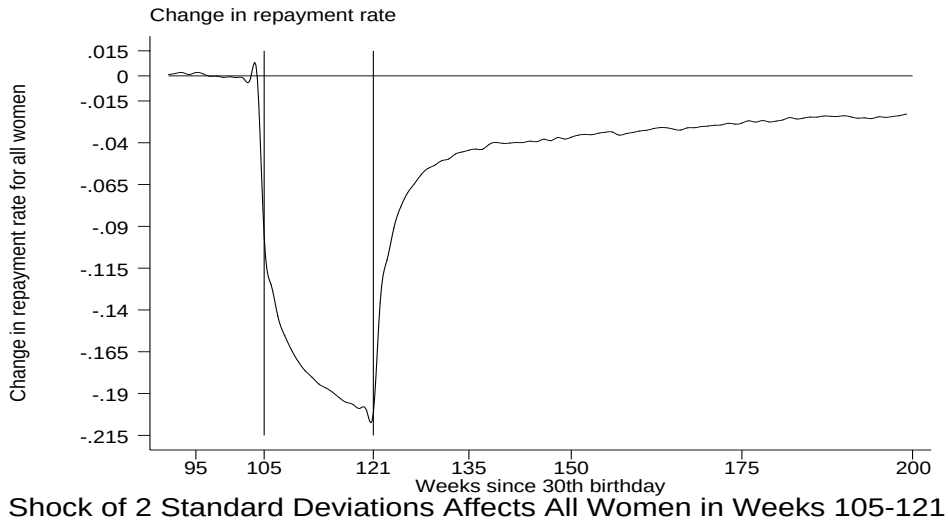


FIGURE 3
PREVIOUS REPAYMENT SHOCKS PLOTTED TOGETHER - SPECIFICATION 1

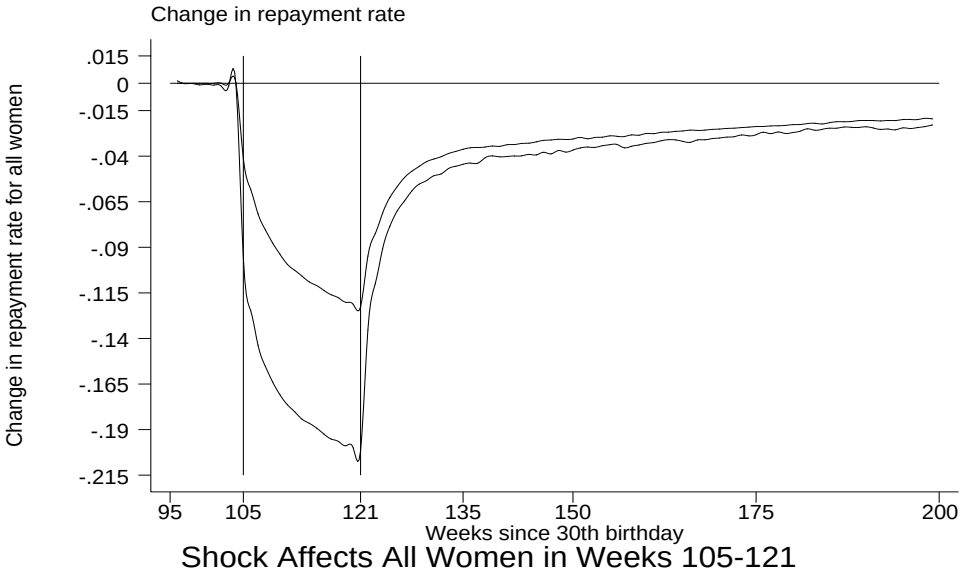


FIGURE 4
CROSS EFFECT OF A 3 STANDARD DEVIATIONS
SHOCK - SPECIFICATION 1

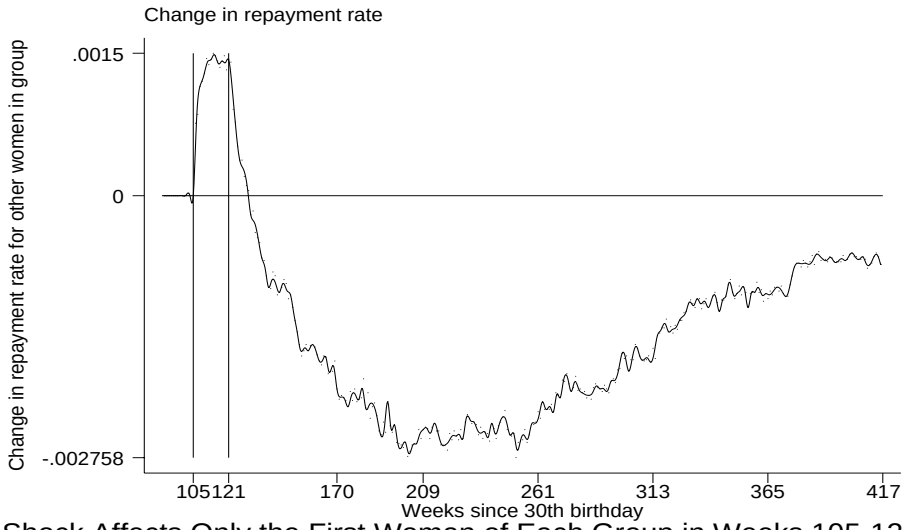
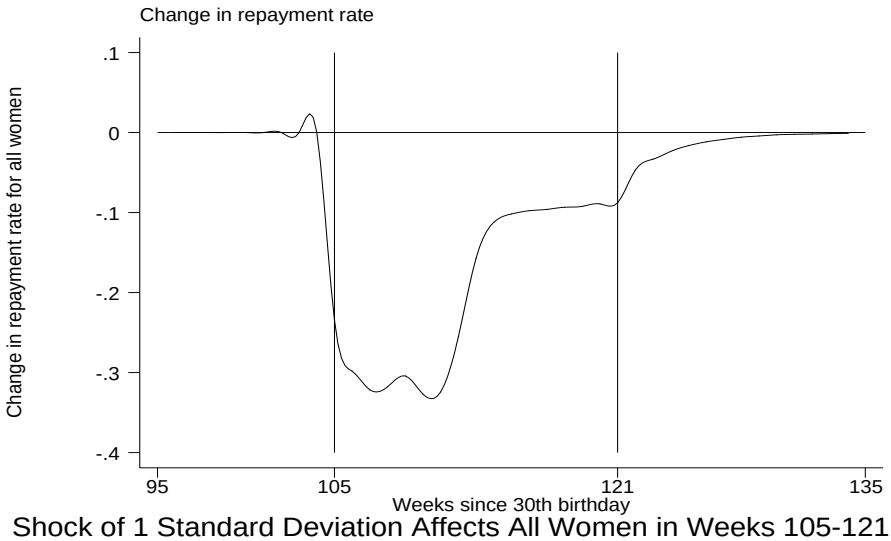


Figure 4 captures the effects of an idiosyncratic shock that is particular to only the first woman of each group (for example, the first woman of each group may become ill for an extended period of time). In order to simulate the effects of an idiosyncratic shock which is quite severe, the first woman of each group was subjected to a shock of three standard deviations for 17 weeks (from week 105 to week 121). Figure 4 plots the effects on the remaining group members of such a shock, under specification 1. It can be seen that during the weeks of the shock, other individuals in the group increase their repayments to compensate for the fact that one of their members is unable to repay. In fact, the increased repayment rate of the remaining group members persists into the weeks immediately following the end of the shock (beyond week 121). This trend does not continue indefinitely; as figure 4 shows, the change in the repayment rate for the other group members eventually becomes negative. This pattern in which the remaining members pay less than their due extends for several weeks, and may correspond to a case in which the burden of subsidizing a sick member has repercussions on the repayment probabilities of others in the group.

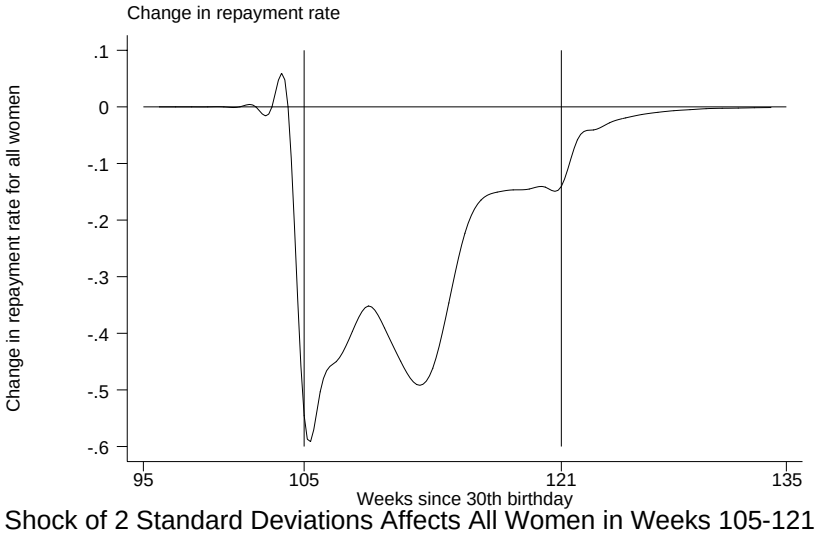
Figures 5-8 correspond to specification 2. Similar to the instances above, figure 5 shows changes in the repayment rate when a shock of one standard deviation affects all women for four months. Figure 6 shows the corresponding case in the event of a larger shock of two standard deviations. Figure 7 plots figures 5 and 6 together. Recall that specification 2 has a more detailed disaggregation of own and cross repayment outcomes from past periods, as compared to specification 1. With more "memory", figures 5, 6, and 7 show that although the repayment rate falls during the weeks of the shock, it begins to move back to its pre-shock level (but does not attain its pre-shock level) even before the aggregate shock ends in week 121. Pre-shock levels of

FIGURE 5
EFFECT OF A 1 STANDARD DEVIATION REPAYMENT SHOCK - SPECIFICATION 2



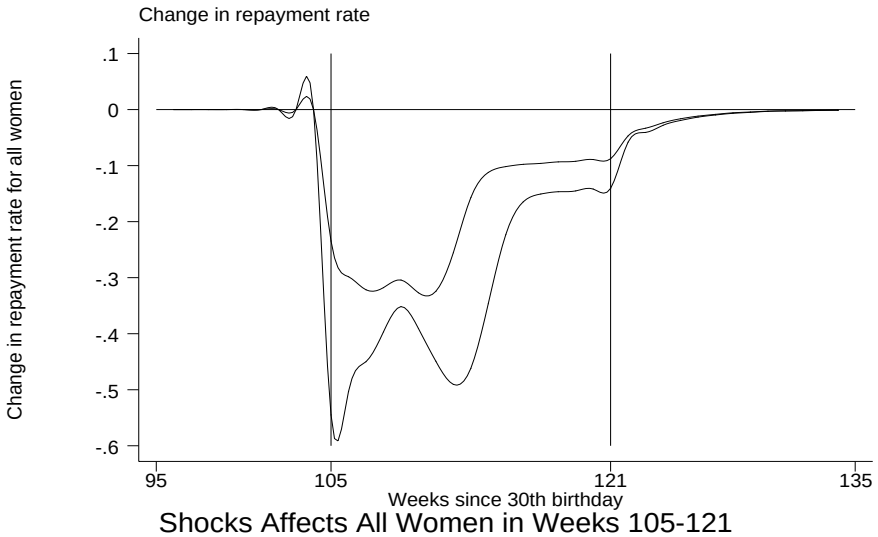
Shock of 1 Standard Deviation Affects All Women in Weeks 105-121

FIGURE 6
EFFECT OF A 2 STANDARD DEVIATIONS REPAYMENT SHOCK - SPECIFICATION 2



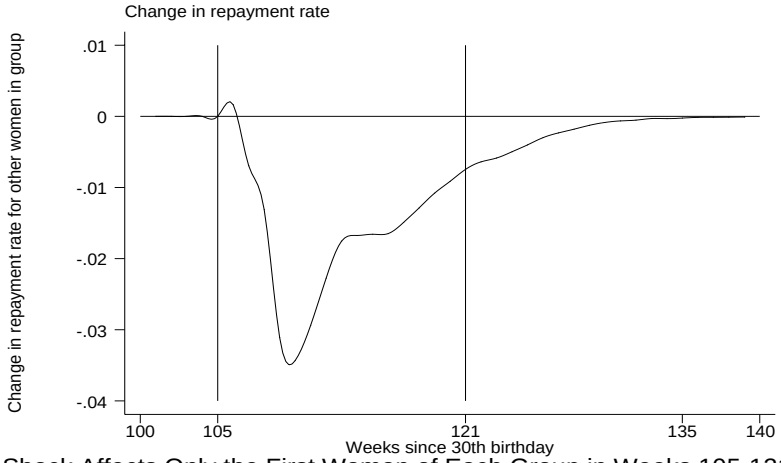
Shock of 2 Standard Deviations Affects All Women in Weeks 105-121

FIGURE 7
PREVIOUS REPAYMENT SHOCKS PLOTTED TOGETHER - SPECIFICATION 2



Shocks Affects All Women in Weeks 105-121

FIGURE 8
CROSS EFFECT OF A 3 STANDARD DEVIATIONS SHOCK - SPECIFICATION 2



Shock Affects Only the First Woman of Each Group in Weeks 105-121

the rate (change in the rate returns to 0) are re-attained within a mere three and a half months (14 weeks after the end of the shock). Explanations for positive movements in the repayment rate during the weeks of the shock may hinge on the fact that aggregate negative phenomena such as floods are expected in Bangladesh every year.[7] Thus, participants may plan ahead for such contingencies by saving during the non-flood weeks, in order to meet installment payments during the weeks of the flood. Although the occurrence of floods is expected, the actual magnitude may vary from year to year. Hence, it need not be the case that in the weeks of the flood, the repayment rate remains unaffected. Rates may still decline in the event that the flood is particularly severe, although access to savings implies that rates need not fall continuously while the flood lasts. We have no information on participants' savings to provide empirical support for the subsequent rise in repayment rates during weeks 105-121 of figure 7.

Figure 8 is the counterpart to figure 4 for the case of specification 2. With a more detailed history of own and cross repayment outcomes there is an initial increase in the repayment rate of other group members, but this increase does not persist through weeks 105-121 (as before, these are the weeks in which an idiosyncratic shock affects the first woman of each group). In fact, figure 8 shows that the change in the repayment rate for the remaining group members becomes negative before returning to its pre-shock levels. This may be because with finer details on individual and cross repayment histories, the group is able to distinguish true instances of debilitating shocks from moral hazard behavior. Because the shock lasts for four months, there is enough time for other members to verify the cause behind a member's inability to pay. In the presence of moral hazard behavior, remaining group members may choose not to subsidize the person who is unable to repay. Furthermore, as noted in Besley and Coate (1995), remaining group members may opt to miss some of their own installment payments. Figure 8 also shows that, similar to the previous figures of specification 2, repayment rates for other individuals in the group converge back to their original level within a short period of time (by week 140, which is 19 weeks after the end of the shock).

INTER-DEPENDENCIES AND POVERTY ALLEVIATION

The two specifications estimated in this paper provide empirical evidence that substantial inter-dependencies in repayment behavior exist at the group level. But the crucial question is how these inter-dependencies matter from a poverty alleviation perspective. Although there may be several channels that link inter-dependencies in repayment behavior to reduced indigence, we focus on three ways in which such inter-linkages between Grameen participants, as captured in repayment data, may contribute to poverty reduction and improved welfare.

First, in the context of the Grameen program, interactions in repayment outcomes, particularly compensatory interactions, imply that groups are less likely to default on outstanding loans. Therefore, they are more likely to remain members for longer periods of time. Several studies have shown that participation in micro-credit programs such as the Grameen Bank is associated with improved well-being. In particular, Pitt and Khandker (1998) find that household per capita consumption, an overall measure of welfare, increases as a consequence of participating in credit programs such as the Grameen Bank.[8]

Second, as noted before, there is anecdotal evidence that participants transfer their time and resources to assist others in their group. This often happens at instances unrelated to the need to meet weekly installment payments, and may be particularly important from an insurance point of view. Thus for example, group members may assist one another during times of ill-health, to fulfill child-care needs, or to compensate for sudden down-turns in consumption. Groups with high levels of such reciprocative mutual assistance are often considered to possess high levels of social capital. Studies such as Grootaert (2001) have reported that the presence of social capital reduces the

likelihood of being poor. In this research, inter-linkages in repayment behavior may lead to the creation of mutual assistance networks (as seems to be the case from anecdotal evidence), which, in turn, strengthens social capital. Social capital contributes to the eradication of poverty.

Third, there is direct evidence that micro-credit empowers women. Using data collected from rural Bangladesh in 1998-1999, Pitt, Khandker, and Cartwright (2003) find that participation in several micro-credit programs such as the Grameen Bank, Bangladesh Rural Advancement Committee (BRAC), and Bangladesh Rural Development Board's (BRDB) RD-12 project, ASA, Proshika, and others, leads to "…women taking a greater role in household decision making, having greater access to financial and economic resources, having greater social networks, having greater bargaining power vis-à-vis their husbands, and having greater freedom of mobility."[9] Although not explicitly tested for in the Pitt et. al. (2003) study, it is conceivable that the mutual assistance networks that originate from the presence of repayment inter-dependencies (which we document in this study) are important ingredients in empowering the women who participate in micro-credit programs. This empowerment of women contributes positively to poverty eradication. This is particularly true for households headed by female participants; as has been commonly noted, female headed households are often the most poverty-stricken and vulnerable in developing countries such as Bangladesh.

CONCLUSION AND POLICY IMPLICATIONS

A dynamic fixed-effects probit estimation of data from the Grameen Bank for approximately a thousand women provides evidence that strong inter-dependencies exist at the group level. Regression results demonstrate that individual repayment outcomes in the current period are significantly influenced by individual repayment histories from past periods, and by average measures of repayment histories of remaining individuals within a group. Inter-dependencies in repayment outcomes are interpreted as measures of group inter-connectedness. Such inter-connectedness strengthens ties among group participants. By laying the foundation for support networks, these ties are crucial from insurance and poverty alleviation points of view.

Estimated parameters are used in simulations, which yield striking results. Shocks of various magnitudes that affect all women are shown to decrease average repayment probabilities. As a result of such aggregate shocks, repayment rates return to their pre-shock levels only after a substantial amount of time. In the event of idiosyncratic shocks (shocks that affect only one woman of each group), there is evidence that remaining members compensate for the individual who is unable to meet installment payments (change in the repayment rate for remaining group members is positive while the idiosyncratic shock lasts). These simulations underline the results of the empirical model and provide further support for the substantial level of inter-linkages among participants of micro lending programs such as the Grameen Bank.

The results of this research have important policy implications. The inter-dependencies that exist in repayment behavior may be crucially important in developing mutual assistance support networks in village communities. In the rural areas of Bangladesh, such networks may already exist within *baris*. But participation in the Grameen program may potentially lead to the creation of support groups *across baris*. This is because as per Grameen rules, members of the same family cannot belong to the same Grameen group. Since groups consist of members from other households, the repayment inter-dependencies that we document may lead to the formation of support structures across *baris* in the village. These support structures play an important role from an insurance viewpoint. For example, during instances of ill-health, members may receive time and resource support from others in her group. Since others in her group belong to different households, they are less likely to be affected by the same illness.

Moreover, such support also ensures that installments are paid on time. Thus poor participants can continue to avail of the many benefits of membership in programs such as the Grameen Bank, and, in time, experience reduced poverty. As noted above, the presence of reciprocative assistance networks (for which this study finds empirical evidence in repayment data) is critical for strengthening social capital, empowering women, and contributing to poverty eradication by encouraging women's self-employment enterprises. Given these positive advantages, the results of this research further underline the importance of micro-finance as an innovative tool for poverty alleviation. In areas plagued by backwardness and marked by a lack of formal credit delivery mechanisms due to high information costs, screening costs, and monitoring costs, governments and non-government organizations should perhaps consider relying on micro-credit programs to foster prosperity and improve the status of women.

This study is unique in interpreting interactions in repayment outcomes as proxy measures of mutual dependence within groups, and thus contributes to the literature in the area. Yet endogenous group formation hinders our ability to make any causal statements about the relationship between better repayment rates and higher levels of inter-dependence. Our use of women fixed-effects helps us circumvent this problem, but the analysis could be enriched with data on group characteristics. The availability of other information such as who controls the loans obtained, membership in village associations over and above Grameen groups, and whether women have more bargaining power within the home as a consequence of participating in Grameen, would help us study the existing inter-linkages in a more multi-faceted manner. They would also aid in allowing us to decipher whether joint liability or social capital was responsible for the repayment patterns we observe in our empirical estimations. In future work, we hope to gather these data in order to address such considerations.

ENDNOTES

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[1] Previous research was hindered from making statements about causation due to the endogeneity of group formation. As argued by Ghatak (2000), when members self-select to form groups, it is likely that the resulting groups structures are homogeneous in terms of innate ability (for example, a high ability person is more likely to form a group with other high ability people). This is particularly feasible since individuals within village communities are likely to know each other's "types" beforehand. If groups form endogenously, then it is difficult to disentangle the role of common ties from the role of "group type" (whether of low or high ability) in deciding repayment outcomes. For example, a group composed of all high ability people with no ties in common could still depict high repayment rates.

[2] Grootaert, C., Narayan, D., Jones, V.N., and Michael Woolcock. (2004), "Measuring Social Capital: An Integrated Questionnaire," World Bank Working Paper No. 18, The World Bank, Washington D.C., p. 5.

[3] Grameen's rules regarding overdue loans are unconventional. A general loan is considered to be in default only one year after the end of the loan cycle (that is, two years after the date of loan disbursement).

[4] In these data, the most experienced participant joined Grameen in 1977. 1960 is an arbitrarily chosen year that precedes 1977.

[5] A different specification with age instead of experience was estimated. In this specification, age had a positive effect on repayment outcomes. An estimation with age and age-squared (instead of experience) yielded a significant positive effect of age and a significant negative effect of age-squared on repayment probabilities. Thus, repayment probabilities increase with age, but not indefinitely so. This is as expected. These results are not reported in the paper; they are available upon request.

[6] An alternate version of specification 2 with age instead of experience was estimated. In this estimation, age has a positive effect on repayment probabilities. With age and age-squared instead of experience, age has a positive and significant coefficient, whereas age-squared has a negative and significant coefficient. Thus age has a non-linear effect on repayment probabilities. These results are not reported; they are available upon request.

[7] Note that our estimations already take such expectations into account. The variables that capture the effect of these expectations in the two specifications we estimate are the month dummies that correspond to June, July, August, September, and October. Floods that are caused by the annual monsoons in Bangladesh commonly occur in these months (particularly in July, August, and September). The June-October month dummies control for the effect of the expectation of floods on repayment probabilities. Alternate versions of our models with flood dummies corresponding to these months were also estimated. These are not reported; they are available from the authors upon request.

[8] Pitt and Khandker (1998) report that for every 100 takas borrowed by a female participant, household per capita consumption increases by 18 takas. For every 100 takas borrowed by a male participant, household per capita consumption increases by 11 takas.

[9] Pitt, Khandker, and Cartwright (2003). p. 30.

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