Joint-liability borrowing decisions under risk: Empirical evidence from rural microfinance in Ethiopia

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Abstract- **This paper investigates borrowing decisions of rural households from a microfinance in Tigray, Ethiopia using household panel data on 5 years and a dynamic panel probit model. The theoretical model takes two types of risk involved in joint-liability lending explicitly into account: risk of partner failure and the risk of losing future access to credit. Empirical results show that these risks are important in explaining borrowing decisions. Another finding is that the probability of repeat-borrowing is higher than the probability of new participation, with possible implications that perceived joint-liability threats deter participation and easing stringent punishments might help poor households' access to credit.**

Keywords- **Microfinance, risk, dynamic panel probit**

I. INTRODUCTION

The microfinance revolution is hailed for its innovative approaches to mitigate classical incentive problems that hinder lending, in poor rural areas. One most celebrated approach in microfinance is the joint-liability contract often combined with some dynamic incentives involved in borrowing [1]. The approach requires borrowers to form self-selected groups in which they are jointly responsible for a group loan. In most microfinance institutions (MFIs), while successful borrowers are successively rewarded with increased loan amounts, *strategic defaulters*, at times including their village, are punished by denying future access to credit. This is believed to help lenders, even those operating in poor remote villages, by inducing borrowers to use local information and *discipline* their partners in repayment. Several theoretical papers appeal to efficiency and aggregate welfare gains from this design [2]. Microfinance has thus convinced donors and governments on its potential to solve the credit access problem for the poor. As a result, microfinance is seen as a key policy ingredient of poor countries, such as Ethiopia, where considerable amount of government as well as donor resources have been devoted in the last two decades [3].

A major assumption in most theoretical work that emphasize on aggregate (social) efficiency gains from the new approaches in microfinance is that potential borrowers are risk-neutral and optimize over their expected incomes, regardless of contractual risks associated with joint-liability and subsequent lose of future access to credit. Aggregate gains from borrower disciplining are often considered under static incentive and participation constraints and without due regard to dynamic effects of contractual risks on long-term individual borrower decisions under uncertainty, given the risk environments under which borrowers operate.

Given access to joint-liability credit, an important empirical question is if such contractual risks matter for households to participate in borrowing given the uncertain environment they operate in. With the intricate workings of the contract and its dynamic incentives in one hand and the erratic economic environment under which borrowers operate on the other, the contractual risk involved and its dynamic interplay with other household variables may matter more than physical availability of credit. Empirical evidence on the performance of MFIs, and particularly with regard to contractual risk considerations of borrowing is however scarce mainly due to rigorous data requirements or evidences are too localized and mixed [4]. This paper studies farm households' borrowing decisions in rural Ethiopia, where the risk involved in the joint-liability contract and the risk of losing future access to credit are explicitly taken into account. A five-wave panel data spanning over ten years of two-year interval (1997-2006) from 402 borrowing and non-borrowing farm households is used. Results from dynamic probit indicate that, other things remaining the same, contractual risk and weights given to future access to credit matter for participation in risky environments where production is subject to the vagaries of nature and consumption variability after a shock is not insured. A full-fledged set of financial products, including credit for consumption might be essential to

insure ex-post production risk. Section 2 develops the theoretical framework. Section 3 and 4 present the empirical model, estimation approach and data. Section 5 summarizes the results and section 6 concludes.

II. JOINT-LIABILITY LENDING AND INTERTEMPORAL HOUSEHOLD BORROWING DECISIONS

Consider household i with endowment W_t and access to a joint-liability based MFI. Assume no strategic interactions between borrowers and that a borrower is willing to repay if able. The MFI forgives defaults it consider as non-strategic. Nevertheless, MFIs are imperfectly informed about borrowers' income realizations and may mistakenly punish non-strategic defaults. This occurs with probability τ. Households' value of future access to credit, *v*, is part of their welfare valuations. Let i and j form contract $ij=(r,c)$, where *r* is interest payment and *c* is the joint-liability.

Two *ex ante* contractual outcomes influence borrowing: (1) conditional on own success, the contract entails an extra risk of partners' default; (2) conditional on being declared *strategic default*, borrowers are subject to lifetime credit access punishment. However, the contract brings symmetrical benefits to partners. So, assessing the contractual risk effect is not straightforward. To clarify, suppose the MFI disburses loan to the group where i's share is L_{it}. Given shocks, household i's probability of success S is p, otherwise F with prob. $1-p$. Possible states of ij are $\{SS, SF, FS, FF\}$, which occur, respectively, when i and j succeed (prob. $p_i p_j$), when i and j fail (prob. $(1-p_i)(1-p_j)$), and when i succeeds but j fails (prob. $p_t(1-p_j)$) and vice-versa. i's income realization less of stochastic repayment $R_{it+1}=(1+r)L_{it}$ introduces income risk.

Borrowing decisions are related to (intertemporal) production, consumption and wealth accumulation. A budget identity relating consumption (C_t), W_t and investment (x_t) and subsistence consumption ($\overline{C}$) is:

$$C_t = W_t - x_t \geq \overline{C}, \text{ and } 0 < x_t < W_t \qquad (1)$$

In the absence of credit, (1) is binding, dictating households 1. to deplete its productive endowments in bad years and 2. to seek for external finance if additional investment is required. Borrowing relaxes the budget through its liquidity effect in year *t* as well as through additional productivity gains of *x*, which affects endowments in next periods. This makes borrowing a dynamic variable bridging liquidity gaps between periods. The decision to borrow is therefore evaluated in a stochastic dynamic framework that falls into the general family of optimal stopping problems [5]. With borrowing option *Z*, the household maximizes time separable well-behaved utility $U(.)$ derived from consumption, which can be summarized by a Bellman equation:

$$V_t(W_t, v_t, Z_t) = \max_{C_t, z\in\{B,NB\}} \left[V_t^B(W, v, Z), V_t^{NB}(W, v)\right] \qquad (2)$$

The value function $V_t(W_t, v_t, Z_t)$ is the maximum attainable value of current and expected lifetime rewards. $V_t^B(.)$ and $V_t^{NB}(.)$, respectively, are expected discounted utilities if the household borrows $Z=B$ or does not borrow $Z=NB$ defined as:

$$\begin{aligned} V_t^B(W, v; Z) &= U(C_t, v_t, Z_t) + \beta E_t(V_{t+1}(W_{t+1}, v_{t+1})) \\ &= U(W_t - x_t + L_t) + \beta E V_{t+1}(Y_{t+1} - R_{t+1} + v_{t+1}) \\ V_t^{NB}(W, v) &= U(C_t, v_t) + \beta E_t(V_{t+1}(W_{t+1}, v_{t+1})) \\ &= U(W_t - x_t, v_t) + \beta E V_{t+1}(Y_{t+1} - R_{t+1} + v_{t+1}) \end{aligned} \qquad (3)$$

β is the discount factor, *E* is the expectation operator, and *Y* is income, which under the stochastic realization of two states is redefined as maximum $\overline{Y}$ and $\underline{Y}$ and minimum $\overline{y}$ and $\underline{y}$, with and without borrowing respectively. Due to additional contractual risk, we assume, $\overline{Y} > \overline{y}$ and $\underline{Y} < \underline{y}$. Substituting *E* by respective probabilities and writing the joint-liability substituting for R_{t+1}:

$$\begin{aligned} V_t^B(W, v; Z) &= U(W_t - x_t + L_{it}, v_t) \\ &+ \beta V_{t+1}\Big\{\Big[p_{it+1}(\overline{Y}_{t+1} - (1+r)L_{it+1})\Big] \\ &+ \Big[\big(p_{it+1}(1-p_{jt+1})\big)\big(\overline{Y}_{t+1} - (1+r)L_{it+1} - c_{t+1}\big)\Big] \\ &+ \big[(1-p_{it+1})\underline{Y}_{t+1}\big] \\ &+ v_{t+1}\Big[\big(1-(1-p_{it+1})(1-p_{it+1})\big) + \big((1-\tau)(1-p_{it+1})(1-p_{jt+1})\big)\Big]\Big\} \\ V_t^{NB}(W, v) &= U(W_t - x_t, v_t) \\ &+ \beta V_{t+1}\Big\{\big(p_{it+1}(\overline{y}_{t+1})\big) + \big((1-p_{it+1})\underline{y}_{t+1}\big) + v_{t+1}\Big\} \end{aligned} \qquad (4)$$

The household participates in borrowing if $V^B \geq V^{NB}$. The difference compares utility from borrowing today and discounted expected flow of future effects against not borrowing today and avoiding the stochastic income flow in the future.

III. EMPIRICAL MODEL AND ESTIMATION

Based on the theoretical model a latent variable 'tendency to borrow' Z_{it} is defined and modelled as a dynamic random effect (RE) Probit model:

$$Z_{it} = 1\left(\gamma Z_{it-1} + x_{it}^{'}\beta + \alpha_i + \varepsilon_{it} \geq 0\right) \quad (5)$$
$$(i = 1,..., N; t = 1,..., T)$$

$Z_{it}=B$ as defined before, x_{it} is a vector of regressors determined in (4), Z_{it-1} is lagged independent implicit in the endowment transition; β, γ, α, and ε are parameters to estimate where α_i is time-invariant individual heterogeneity and ε_{it} is the error term. Identification requires assumptions on the initial conditions problem as well as autocorrelation, which render ML estimation of RE probit model difficult. Following Stewart [6], we estimate the Heckman model [7], using maximum simulated likelihood (MSL) which solves both initial conditions and extends it to the autocorrelation problem to simulate the integrals based on the GHK algorithm. A first-order autoregressive error structure is considered.

IV. MICROFINANCE IN ETHIOPIA AND DATA USED

The panel data used comes from 402 randomly selected rural households in Tigray, northern Ethiopia, observed over five years (1997-2006). Tigray is located in the semi-arid zone of the Sub-Sahara belt. Erratic rainfall, decades of civil-war and conflicts, coupled with overpopulation severely degraded its natural resources and characterize its subsistence rural economy, generally classified as food-deficient. Smallholder agriculture, the main stay of 775 thousand rural household, is unpredictable and subject to the vagaries of nature hard felt by inhabitants. Efforts to increase productivity by introducing new technologies such as high-yielding crops and fertilizer are often hindered by income shocks because formal insurance schemes to smooth consumption after shock are absent and informal risk-sharing is limited. Food aid and 'cash-for-work' safety nets are instituted recently to insure against income shocks.

A recent effort to rehabilitate the region included the provision of financial services to farmers. The *Dedebit Credit and Saving Institution* (DECSI) is one of biggest and pioneer MFI in Ethiopia operating in the region providing working capital credit to smallholder farmers that are literally out of the horizons of traditional banking. DECSI started in 1994 and expanded from 67,057 to nearly 424,000 borrowers and average loan size from USD 111 to USD 217 between 1997 and 2006, encroaching to almost all parts of the region. Lending interest rate ranges between 12.5 and 15 per cent per year, one of the lowest in the world. Maximum loan size is 5000 ETB (close to USD 500). Loan duration ranges 1-2 years.

DECSI followed a Grameen style joint-liability credit contract and implemented it in its stricter sense. A credit application is made by group of 3-7 self-selected borrowers screened by credit committee composed of credit officers and local officials. Initially, DECSI started with a criteria of owning "at least two-oxen" for credit eligibility but has never been implemented strictly (Mees, 2000). If approved, individually requested amounts are awarded for which they become responsible as a group and repayment is strictly made conditional on full-group amount. Any thing less is considered default and consequently, all group members, some times even their village, is denied of future credit. In some instances, contrary to the 'limited liability' assumption in the microfinance literature, DECSI followed a policy of tracking down defaulters to jail or local courts regardless of realized outcome, in which case local leaders play a role. DECSI enjoys the benevolence of local leaders because its credit services are often synchronized with the state's extension programs. The latter made the perceived threat of future access to credit more stringent and borrowing decision more difficult.

Sample households include those that borrowed repeatedly, those that participated at least once but dropped out, and those that never participated over the years. Besides, the initial survey contains some pre-survey information regarding borrowing and household characteristics. The proportion of borrowers joining the MFI has slightly increased from 1997 to 2002 but declined in 2004, again with a slight increase between 2004 and 2006, modestly approximating trend in the population. The highest percentage of dropouts was in the year 2002-04, perhaps, due to the major draught occurred in 2003 in the country. When asked 'why a household decided not to borrow while there was a need for credit', majority (59 %) of them reported had feared failure to repay and sliding down into debt-trap. Very few of them reported had other

sources of credit. Descriptive information summarizing the above statistics can be obtained from the authors.

V. Results and Discussion

Results of the reduced form Heckman model estimated by dynamic RE probit model with AR(1) using MSL for the t>1 period variables of interest are reported. For comparison, the same model is estimated using pooled probit and simple dynamic random effect probit. The Heckman model is also estimated with and without autocorrelation. The simulated model is run with number of replications R= 150. All results are in the table below. The estimate for lagged dependent is significant in all models confirming the need for the dynamic specification. A significant lagged dependent means those who at least borrowed once are likely to borrow again (state dependence). Results show, compared to other estimators, the pooled estimate for the lagged dependent is larger than estimates all other models and with comparable significance level to the simple RE as well as Heckman with no autocorrelation, but more significant than Heckman model with autocorrelation. As expected, after making the required normalization, all other pooled estimates are (in absolute value) smaller than the estimates of the other three models. The random effect estimator results in reduction in the estimate for the lagged dependent compared to the pooled, especially when the normalization is taken into account but still higher than when autocorrelation is allowed. Most other parameter estimates of the simple random effect estimator are comparable to the Heckman model with no autocorrelation but greater than the Heckman estimates with autocorrelation.

Table 1. Dynamic probit estimates of participation in joint-liability borrowing

Variable names	Description	Pooled (probit)	Simple RE (xtprobit)	MSL RE (no auto)	MSL RE AR (1), R=150
	t > 1	$\beta(std.err)$	$\beta(std.err)$	$\beta(std.err)$	$\beta(std.err)$
L_crdtdum	1 if borrowed from DECSI group credit	.2937***	.2729***	.2729***	.2511*
		(0.0968)	(.1043	(0.1043)	(0.1036)
hhage	Age of household head (years)	.0455*	0.0490*	.0490*	.0476*
		(0.0245)	(0.0263)	(.0263)	(0.0256)
hhage2/100	Age-squared (scaled by 100)	-.0469**	-0.0500*	-.0500*	-0.0485*
		(0.0224)	(0.0241)	(0.0241)	(0.0235)
oxen	Number of oxen	-.0062	-0.0117	-.0115	-0.0123
		(0.0506)	(0.0535)	(.0536)	(0.0520)
landsize	Size of land used (*tsimad* =0.25 ha.)	.0097	0.0096	.0096	0.0093
		(0.0166)	(0.0174)	(.0174)	(0.0170)
mrkt	Proximity to nearest market	.3337***	0.3430***	.3429 ***	.3346***
		(0.1034)	(.1117)	(.1118)	(.1086)
conflct_dum	1 if affected by war	-.4726***	-.5029***	-.5031***	-0.4774**
		(.1719)	(0.1819)	(.1820)	(0.1772)
accss_value	1 if losing future access to credit worst punishment	.5397***	0.5846***	.5842***	0.5792***
		(0.1449)	(.1633)	(.1636)	(.1586)
Nointerest	1 if never participated in extension by choice	.3012***	-.3318***	-.3320***	-.3228***
		(0.0932)	(.1030)	(.1031)	(0.1002)
Othersourc	*1 if other sources of credit were available*	-0.0361	-.0328	-0.0326	-0.0247
		(0.1029)	(.1111)	(0.1112)	(0.1080)
Shock_id	If shock (death of animals, poor yield, death of household head) occurred in the year t=1 (initial cond.)	-4.89e-06 (0.1032)	-	-0.0044 (0.1082)	-0.0020 (0.1046)
crdt_exp	1 if experienced borrowing before the first survey	0.7712***		.7713***	0.7832**
		(0.2794)		(.2794)	(0.2798)
Lnhhexp	log of household expenditure (t=1)	-0.9570***		-.0957	-0.0931
		(0.0920)		(.0920)	(0.092)
Partner	1 if unable to find a partner when DECSI was available	-0.6920		-.6919***	-0.6595*
		(0.2605)		(0.2605)	(0.2618)
trust	1 if believed "trust" deteriorated has been deteriorated in the community	-0.5619		-0.5619*	-0.5437*
		(0.2440)		(0.2440)	(0.2433)
	Wald $\chi2(11)$	75.95***	$\chi2(10)$, 0.55***	60.53***	55.63***
	LR test of rho= 0: $\chi2$ (1)	-	1.51	1.51	-
	Log likelihood	-526.30558		-525.55202	-524.8016
	Pseudo R2	0.2884	-	-	-
	Number of obs.	2010	1608	2010	2010

This signals the number of replications used (R=150) is sufficient. In general, the inclusion of autocorrelation in the simulated Heckman model improves efficiency of the random effect specification.

All of the pre-survey instruments are significant at acceptable critical levels. The indicator for reluctance to adopt new methods, which also captures risk-perception (*nointerest)*, and the indicator for future access to credit (*accss_value*) are both highly significant and with expected parameter sign. Those uninterested to adopt new ways of doing things such as the agricultural extension program are less likely to borrow; and those who think losing future access due to default is the highest punishment and hence value future access to credit most are more likely to keep their relationship with the MFI by continuing to borrow. This is in line with the state dependence implied by the significance of the lagged dependent parameter. Parameters for availability of a reliable partner and the general perception on trust are also significant. Both capture the 'income risk' associated with joint-liability contract. The higher the chances of obtaining a reliable and trusted partner, the more likely to joint a joint-liability contract. Age has non-linear relationship with the probability of borrowing: age and age-squared are both significant but age-squared is with negative parameter sign indicating that the probability of being in a borrowing relationship declines with age.

Another important variable of interest is proximity to market (*mrkt*), which is positively highly significantly influencing the probability borrowing. This variable takes up not only market proximity but also geographical (infrastructural) differences among villages because our coding for market access coincidentally correlates with these geographic differences among zones. Besides, the shocks related to the conflict with Eritrea had significant effects on borrowing probability. The further away a village from the conflict zone, the more likely to borrow.

In sum, other things remaining the same, households' valuations of future access to credit, perceptions on risk of exogenous shocks and resilience to cope with shocks, availability of trusted and reliable partner significantly influence participation in borrowing.

VI. Conclusions

This paper dealt with what explains the probability of borrowing from a joint-liability based MFI. The novelty in this paper is that credit contract is seen within a whole mark of dynamic household production-consumption-wealth accumulation decisions rather than singled out as a separate household decision variable. An important finding in this paper is that the contractual risk of borrowing does matter in borrowing and ensuring physical availability of credit through MFIs without improving its contractual risks may be a necessary but not sufficient condition to improve credit access in poor and risky environments. Providing a full-fledged credit services, including credit for consumption, might help to cope with risk after shock and thus encourage households to use credit as a tool to tackle poverty. Another important finding is that household who happened to participate tend to repeat borrowing than other wise. It might be that the perceived threat of punishment and perceived risks are higher than are in reality. The implication is that policies that ease these risks and threats might help to encourage households to come forward and use credit. Use of extensive panel data and recent panel data techniques help to overcome estimation difficulties often faced in estimating dynamic panel probit models.

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