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MICRO-LENDING FOR SMALL FARMERS IN BANGLADESH: DOES IT AFFECT FARM HOUSEHOLDS' LAND ALLOCATION DECISION?

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ABSTRACT

It has long been hypothesized that lack of access to credit is the main reason why, despite higher profitability of High Yielding Varieties (HYVs), farmers in developing countries continue to allocate a portion of their land to traditional crop varieties. The empirical testing of this hypothesis has generated a large body of literature with differing conclusions. This paper re-examines the issue in the context of a specially designed group based lending programs for small farmers in Bangladesh, who neither have access to formal sources of credit nor do they qualify to become members of other micro-credit organizations. Two measures of access to credit, *credit limit* and *amount borrowed* at a given point in time, are used to analyze the determinants of farm households' land allocation decision. Under a variety of model specifications, formulated within Heckman's two-step method, the results show that credit limits from the lending programs and informal sources are significant determinants of small farmers' decision to cultivate HYV.

JEL Classification: D13; C25; O16.
Key Words: Micro-credit programs, Access to Credit, Credit Limit, Land Allocation Decision, Selection Bias, Bangladesh.

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MICRO LENDING FOR SMALL FARMERS IN BANGLADESH: DOES IT AFFECT FARM HOUSEHOLDS' LAND ALLOCATION DECISION?

Shahidur Rashid[1], Manohar Sharma[2], and Manfred Zeller[3]

1. INTRODUCTION

Despite significant expansion in institutional credit provision to agriculture, and the remarkable success of micro-credit institutions in recent years, small farmers in Bangladesh and elsewhere in South Asia continue to lack access to financial markets[4]. They neither have access to formal institutional credit nor do they generally qualify to participate in the micro-lending institutions, administered by the non-governmental organizations (NGOs). The empirical evidence on limited access to formal credit by small farmers is overwhelming (see, for example, Lipton 1976; Gonjalez-Vega 1984; Khalili and Meyer 1993, Binswanger and Khandker 1995). On the other hand, since micro-lending programs target women and the poorest section of the population, small farmers are often screened out through eligibility restrictions, such as those requiring that the households be female headed or own less than 0.50 acres of land[5].

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[4] For a review of limited access to credit by small farmers in Bangladesh, see Sen (2000); for India, see Binswanger and Khandker (1995); for a broad review in the context of South Asia, see Faruqee and Carey (1997).
[5] Both of these eligibility conditions are commonly practiced by the micro-lending organizations in Bangladesh.

However, there are some scattered initiatives to extend financial services to small and marginal farmers in Bangladesh[6]. The *Marginal and Small Farm Crop Intensification Project*, funded by the German Agency for Technical Cooperation (GTZ) and the International Fund for Agricultural Development (IFAD), is one of them. In terms of both eligibility conditions and operational structure, this program differs significantly from other micro-lending institutions in the country. Farmers owning up to 1.5 acres of land, which roughly fits the definition of small farmers in Bangladesh, can join the program and, unlike other micro-lending operations, its members conduct banking transactions directly with a commercial bank. A local NGO, called Rangpur Dinajpur Development Services (RDRS), acts as a facilitator and is responsible for forming farmer groups, providing them with training, and finally linking them with a commercial bank to conduct banking transactions. Therefore, in addition to credit, this program brings small farmers closer to the formal banking system, which has been a long-standing policy challenge in the country.

This paper examines whether access to credit through this innovative program has significantly altered farm households' decision to cultivate high yielding varieties (HYVs) of rice. In particular, it investigates the significance of access to credit in explaining why, despite higher profitability, farmers in developing countries continue to allocate a portion of their land to traditional crop varieties. There are a number of competing microeconomic theories to explain this observed behavior of farm households. One of the theories, known as *input fixity*, is based on the argument that if farmers are credit constrained, inputs that are considered variable (such as labor,

[6] The Hortex Foundation, a pilot project of the Ministry of Agriculture, Government of Bangladesh, is also experimenting with similar ideas as part its effort to promote export of horticultural crops.

fertilizer, and pesticides) may actually be quasi-fixed in the short run[7]. Therefore, if traditional varieties outperform modern varieties at low levels of input use, a credit-constrained farmer may choose to cultivate both traditional and modern crop varieties.

The concept of a *credit limit*,[8] defined as the amount of credit that a farm household is able to borrow if needed, is used as a measure of access to credit. This concept is significantly different from commonly used measures of access to credit, such as amount borrowed at a given point in time. For example, suppose a researcher observes that the amount-borrowed by a farmer at the time of interview is equal to zero. Without further information, one can draw two very different implications from this observation. It can imply either that the farmer wanted credit but did not get any (i.e., lacked access to credit) or that the farmer did not need any credit. By contrast, if credit limit is observed to be zero, one can unambiguously conclude that the farmer lacked access to credit. The household survey data used for this study contains detailed information on both measures of access to credit, enabling us to empirically test how the two measures differ in explaining farm households' land allocation decisions in rural Bangladesh.

[7] Other major theories include: portfolio selection, safety first, and farmer experimentation. As Smale, Just, and Leathers (1994) point out, it is likely that other theoretical explanations are nested within a general model. However, as we have argued in section II, such concerns are minimal for the sample we have studied.

[8] Asking households about their credit limits presents pitfalls. First, credit limit depends on the price borrowers are willing to pay for credit, and the interest rate borrowers are willing to pay depends on the potential payoff of the project they intend to finance. Second, those who have borrowed close to their credit limits (at any given interest rate) or have actually hit it are likely to have a better knowledge of their credit limits than those who do not. However, credit limits in many NGO credit programs are well publicized and are set under clear-cut institutional rules, and borrowers or prospective borrowers know quite accurately the maximum they can borrow at a known, constant interest rate. Hence, extracting quite accurate formal credit limits from households in program villages is possible. This is what the IFPRI survey in Bangladesh did.

Under a variety of model specifications within Heckman's two-step framework, our results suggest that access to credit, defined as *credit limits* from lending institutions and informal sources, is a significant determinant of farm households' decision to allocate land to HYV. On the other hand, when *amount-borrowed* is considered to be an indicator of access to credit; micro-lending becomes an insignificant determinant of HYV cultivation. This implies that if access to credit is assumed to be the same as the amount that a household has borrowed at a given time, there are potentials for drawing misleading conclusions about the role of credit. The remainder of the paper is organized as follows. The next section provides a description of data and study setting, which is followed by a formal description of the econometric models. The estimation methods and underlying assumptions are outlined in section IV. Results of the econometric models, as well some descriptive statistics on key variables, are discussed in section V. The paper concludes with a summary of the analyses and potential implications for policies.

2. DATA AND STUDY SETTING

The data set used in this study comes from a household survey conducted by the International Food Policy Research Institute (IFPRI) during 1994 –1995, under its multi-country research program titled, *Rural Finance and Food Security.* Using a multi-stage sampling method, seven survey villages were selected from five different geographic locations (Thana or Sub-district) in such a way that each village had at least one of the following micro-lending programs: *Rangpur Dinajpur Rural Development Services* (RDRS), *Bangladesh Rural Advancement Committee* (BRAC), *Association of Social Advancement* (ASA).

Instead of attempting wider coverage and larger sample, the survey was carried out with 350 households in a closely supervised environment to ensure quality of data. While selection of survey villages was random, selection of households was choice-based, i.e., members of RDRS, ASA, and BRAC were over sampled. In order to capture seasonal variations in income, consumption, and indebtedness, the survey was conducted in three rounds covering a period of 13 months from January 1994 to January 1995. Thus it contains data for all three cropping seasons in Bangladesh, namely A*man* (crop harvested during November-December), *Aus* (crop harvested during July-August), and *Boro* (crop harvested during April-May)[9].

Data for the Boro season of 1994 have been used in this analysis. Selection of this agricultural season is motivated by two factors. First, agricultural activities during the other two seasons are highly weather dependent. In particular, HYV cultivation decisions during those cropping seasons are critically determined by whether land elevation is sufficient enough to avoid flooding and water logging. In fact, in low-lying lands, which constitute significant portion of the total cultivable lands in some districts, HYV cultivation is not even an option during these seasons. This suggests that analyzing determinants of HYV cultivation without detailed data on land characteristics, as many past studies have done, can be seriously misleading. By contrast, Boro cultivation relies almost entirely on mechanical irrigation and the probability of flooding is also very low. Thus the analysis can be carried out without data on land elevation and other land characteristics.

Second, using data for the Boro season enables us to consider the theory of *Input Fixity* as a single maintained hypothesis. As Smale, et. al. (1994) point out, it is

[9] For a detailed description of the sampling methodology, see Zeller et. al (2001).

likely that other theoretical explanations (such as *portfolio selection* and *farmers' experimentation)* are nested within a general model. That is, a combination of theories can provide a better explanation why the farmers allocate their land to various crop varieties. Considering the agro-climatic conditions and availability of indigenous crop varieties, this argument is readily applicable for Aman and Aus seasons. By contrast, as farmers can reduce risks by cultivating traditional and modern varieties, assuming high profitability of HYV and availability of irrigation, it can be safely assumed that farmers cannot reduce overall risks by choosing a portfolio of crops during the Boro season.[10] Therefore, the concerns for theories being nested within a general model should be minimal.

Another data-related issue deserves some explanations. The organization and operational structure of the micro-lending programs surveyed for this study are different. While both BRAC and ASA operate under similar organizational frameworks, with the main objective of serving households owning less than 0.50 acres of land, RDRS focuses on small and marginal farmers, who own up to 1.5 acres of land. Moreover, unlike ASA and BRAC, RDRS does not manage its members' fund. Instead, after receiving training, RDRS members transact directly with the nationalized commercial banks at prevailing market interest rates. Our initial objective was to carry out the analysis exclusively with the sample of RDRS members, but due to the insufficiency of degrees of freedom (small sample), ASA and BRAC members, who cultivated more than one acre of land (own plus rented), are also included to implement the empirical methodology. As a result, there is a

[10]Profitability of HYV is well documented in Bangladesh. According to Hossain (1988*)*, while cost of production per acre is about 40% higher, profits per acre of HYV is almost 2.5 times more than per acre profit from local varieties. Thus higher profitability at all net return ranges can be assumed safely, which is an additional condition necessary to rule out portfolio selection theory being nested.

likelihood of downward bias in the regression coefficients, especially the ones measuring the credit impacts.

3. THE ANALYTICAL FRAMEWORK

The paper attempts to model two household decisions: (i) the decision to participate in the micro-lending programs and (ii) the decision to cultivate modern rice variety. The second decision can be further disaggregated. For example, the farmers may first decide whether to adopt the technology and then, all else constant, decide how much land to allocate to HYV. These decisions can be defined as *propensity to adopt* and *intensity to adopt*[11] respectively. Formally, suppose that A^* and C^* are two latent variables determining adoption of HYV and participation in one of the micro-lending programs. If H denotes the amount of land allocated to HYV, the full model can be outlined by the following set of equations:

$$A_i^* = \alpha_0 + X_{1i}'\alpha_1 + \alpha_2 C_i + u_{1i} \quad (1)$$

$$C_i^* = \beta_0 + X_{2i}'\beta_1 + u_{2i} \quad (2)$$

$$H_i = \delta_0 + X_i\delta_1 + \delta_2 C_i + u_{3i}; \quad \text{if } \left(C_i^* > 0,\ A_i^* > 0\right) \quad (3a)$$

$$= \delta_0 + X_i'\delta_1 + u_{3i}; \text{ if } \left(C_i^* \le 0, A_i^* > 0\right) \quad (3b)$$

$$= 0 \text{ otherwise.} \quad (3c)$$

Where X_i is a vector that, in addition to household specific characteristics and regional dummies, includes *credit limit* (amount-borrowed) from informal sources, C_i

[11] Hossain (1988) treated these two decisions as independent and estimated a probit model for first stage decision and a Tobit model for the second stage decision. However, as variables that affect first stage decision can also affect second stage decision, error terms of the two equations are likely to be correlated.

represents *credit limit* (amount-borrowed) from micro-lending institutions in natural logarithms, and $u_i's$ are error terms.

The primary interest of this analysis is in equation 3(a), which specifies the amount of land allocated to HYV by adopter-cum-member farmers. Estimation is carried out in two stages. In the first stage, the joint probability of joining lending institutions and adopting HYV is estimated through reduced form specifications of equations (1) and (2). In the second stage, equation 3(a) is estimated with *inverse mills ratios* included as explanatory variables. That is, our final estimating equation can be specified as,

$$E(H_i \mid A^* > 0, C^* > 0) = \delta_0 + X_i \delta_1 + \delta_2 C_i + E(u_{3i} \mid A^* > 0, C^* > 0) \qquad (4)$$

Assuming the normality of u_{1i} , u_{2i} , and u_{3i}, equation (4) can be re-written as,

$$E(H_i \mid A^* > 0, C^* > 0) = \delta_0 + X_i \delta_1 + \delta_2 C_i + \sigma_{13}\lambda_{1i} + \sigma_{23}\lambda_{2i} \qquad (5)$$

where λ_{1i} and λ_{2i} are *inverse mills ratios* expressed by[12]

$$\lambda_{1i} = \Phi\left[\left(Z'_{1i}\alpha - \rho_{12}\left(Z'_{2i}\beta\right)\right)\Big/\sqrt{\left(1-\rho_{12}^2\right)}\right]\cdot\phi\left(Z'_{1i}\alpha\right)/\Phi\left(Z'_{1i}\alpha, Z'_{2i}\beta, \rho_{12}\right)$$

$$\lambda_{2i} = \Phi\left[\left(Z'_{2i}\alpha - \rho_{12}\left(Z'_{1i}\beta\right)\right)\Big/\sqrt{\left(1-\rho_{12}^2\right)}\right]\cdot\phi\left(Z'_{2i}\alpha\right)/\Phi\left(Z'_{1i}\alpha, Z'_{2i}\beta, \rho_{12}\right),$$

and

$$Z_{1i} = \begin{bmatrix}1 & X_{1i}\end{bmatrix}, \quad Z_{2i} = \begin{bmatrix}1 & X_{2i} & C_i\end{bmatrix},$$

$$\alpha = \begin{bmatrix}\alpha_0 & \alpha_1 & \alpha_2\end{bmatrix}', \quad \beta = \begin{bmatrix}\beta_0 & \beta_1\end{bmatrix}'.$$

The *inverse mills ratios*, λ_{1i} and λ_{2i} , are estimated by a *bivariate probit* estimation method applied to equation (1) and (2). In an intermediate step, predicted values of formal and informal credit limits (and amount-borrowed) are estimated through a

[12] The expressions for λ_{1i} and λ_{2i} are derived in Kochar (1997).

generalized Tobit method, which are used as instruments to control for the endogeneity of credit in the equation determining land allocation to HYV, i.e., equation (5).[13]

The general analytical framework outlined above is very flexible in terms of testing hypotheses under various assumptions about the error terms and access to credit. In particular, in addition to controlling for selectivity problem, this formulation allows testing the null hypothesis that decisions to adopt HYV and obtaining credit are jointly determined against the alternative that two decisions are independent. Furthermore, with these features incorporated, this analytical framework is able to address some of the econometric shortcomings of past empirical research on credit and HYV in Bangladesh.

For example, one of the most cited studies in Bangladesh, Hossain (1988), uses a Probit model to assess determinants of HYV adoption decisions and finds both formal and informal credit to be insignificant. However, using a Tobit specification, with proportion of land allocated to HYV as the dependent variable, the same study finds a significant relationship between credit and lands cultivated with HYVs.

There are two econometric problems in Hossain's methodology. First, his analytical method treats credit as exogenous variable, which can potentially generate inconsistent parameter estimates[14]. This paper addresses the problem by instrumenting credit with the predicted values, estimated with a generalized Tobit specification. Second, although a Tobit model controls for the censoring, it ignores

[13] Predicted values of credit limits are estimated using a generalized Tobit model. For a discussion on this methodology, see Amemiya (1986).
[14] This follows from the fact that obtaining credit is within the domain of households' choice and hence should be considered endogenous.

the self-selection bias arising from the farmers' decision to adopt HYV. This is similar to a common issue addressed in empirical labor economics, where the earning equation is estimated for those who actually work and earns an income. To draw the analogy, HYV is observed only if a farmer decides to adopt, just like earning is observed only if a worker decides to work.

4. ESTIMATION METHOD

The actual estimations are carried out in a sequential method that broadly involves three steps: i) estimation of a generalized Tobit specification to predict the probability of borrowing and loan amount, ii) estimation of reduced form probit models to determine the joint probability of adopting HYV and obtaining credit from one of the lending institutions, and iii) estimation of equation 5 by Instrumental Variable (IV) with $\lambda_{i's}$ and predicted credit amount as instruments. Note that, while estimations of first two steps are carried out with entire sample, step iii is based on the sample of adopter-cum-borrower households only. Household specific variables included in each stage of estimation—such as family size, age of the household head, highest level of education, ownership of land, etc.—are standard in micro-econometric analyses of household survey data. For example, in analyzing various impacts of micro-lending in Bangladesh, Pitt and Khandker (1998) and Morduch (1998) have used similar set of variables.

Depending on the assumptions about error terms and access to credit, four different specifications of the general model have been estimated. The first specification is based on the assumption that error terms in equations (1) and (2) are un-correlated and that the *credit limit* is the indicator of access to credit. The

assumption of uncorrelated error terms imply that the *inverse mills ratios*, λ_{1i} and λ_{2i} , can be estimated through an equation-by-equation probit regression. In the second stage, these *inverse mills ratios* along with *credit limit* and other household specific variables are included as explanatory variables.

One of the weaknesses of the above specification, however, is that it treats HYV adoption and borrowing as two independent decisions, which seems intuitively unrealistic as the set of variables that affect HYV adoption may also affect program participation and borrowing decisions. Statistically, this implies that the error terms of the first-stage probit equations are correlated and, if such assumption holds true, computing $\lambda's$ through equation-by-equation probit method will lead to inconsistent parameter estimates (Kochar 1997). In order to address this issue, the second specification of the model allows error terms of equations 1 and 2 to be correlated, but continues to assume credit limit as the measure of access to credit. In terms of estimation, the main difference between the two specifications is that the first stage probit equations are now estimated using *Full Information Maximum Likelihood* (FIML) method, instead of an equation-by-equation bivariate probit method.

Finally, to compare how the two measures of access to credit differ, the explanatory variable *credit limit* is replaced by *amount-borrowed* in the next two sets of regressions. Note that all other explanatory variables are identical to the previous specifications. Again, depending on the assumption about error terms in the probit equations, two different models are estimated. Notice that the results of these specifications, presented in Table 4, are in sharp contrast to the results reported in Table 3.

5. DISCUSSION OF RESULTS

While the focus of the study is on econometric analysis, some descriptive analyses have also been carried out in order to demonstrate how the sampled households differ in terms of key resource endowment and membership to various lending organizations[15]. The weighted means and standard deviations, reported in Table 1, clearly indicate that land allocation to HYV varies considerably by both farm size and whether or not households belong to one of the lending institutions. The proportion of irrigated land allocated to HYV varies within a range of 49 to 80 percent, with the lowest proportion corresponding to the poorest group of households. Among the poorest group of households, member households allocate 21 percent more land to HYV than non-members. For the other two land ownership groups, the differences in HYV land between member and non-member households are 9 percent and 11 percent respectively.

The other significant crops cultivated in irrigated land are local variety of Boro rice, wheat, and locally improved rice varieties. To check the reliability of the survey data, we have computed the mean proportion of land allocated to these crops from the national level data published by the Bangladesh Bureau of Statistics (BBS). As Table 2 shows, for three out of four survey districts, the descriptive results are in close proximity to nationally published statistics for 1994, the year this survey was conducted. The only exception is Sylhet district, where the national statistics of HYV as a proportion of irrigated land is substantially lower than estimates from the survey data. This apparent inconsistency is due to the fact that a large part of this district is

[15]These descriptive statistics are based on the households that had access to irrigation.

low-lying land (called *HAOR*), where water level increases during the Boro crop harvesting. As a result, because of its longer stem and more resilience to climatic adversities, local variety of rice is more suitable than modern HYV (Bera and Kelly 1990). Since our survey villages in this district were not in the *HAOR* area, proportion of HYV is naturally much higher than the district level average.

Before discussing the regression results, some general comments need to be made about potential inferential problems of including informal credit into the model. As Bell (1993) points out, access to formal credit may improve the likelihood of obtaining credit from the informal sources and hence formal and informal credit may be correlated. As joining one of the lending programs increases the probability of getting credit from informal sources, similar logic may be applicable for our sample. However, due to resulting omitted variable bias, exclusion of informal credit from the model is not a straightforward option in this analytical framework. In fact, as Davidson et al. (1978) point out, such exclusion can actually worsen the precision in the remaining explanatory variables, even when two variables are highly correlated. Therefore, despite potential collinearity, informal credit is also included into the model.

Table 1—Weighted Means and Standard Deviations of Selected Variables by Land Holding and by Group membership.

Land Holding	Variables	Member Household		Non-member Household	
		Mean	Std. Dev	Mean	Std. Dev.
		(in decimals)			
0.0 - 50.0	Area cultivated	20.79	13.70	29.09	10.74
	Total irrigated land	27.31	17.68	48.20	46.09
	Amount of land allocated to HYV	16.31	13.58	17.61	14.43
	HYV land as a proportion of Irrigated land.	0.68	0.44	0.49	0.36
51.0 - 150.0	Area cultivated	81.89	16.02	95.31	25.06
	Total irrigated land	71.30	35.48	97.19	60.42
	Amount of land allocated to HYV	51.61	27.25	60.92	32.20
	HYV land as a proportion of Irrigated land.	0.80	0.29	0.71	0.31
151.0 - 250.0	Area cultivated	188.55	35.46	196.11	29.19
	Total irrigated land	196.51	110.42	181.59	106.2
	Amount of land allocated to HYV	141.41	64.71	117.36	71.71
	HYV land as a proportion of Irrigated land.	0.80	0.24	0.69	0.34
251.0 - 350.0	Area cultivated			292.39	25.47
	Total irrigated land			215.43	164.35
	Amount of land allocated to HYV			118.44	164.35
	HYV land as a proportion of Irrigated land.			.54	.32
350 +	Area cultivated			466.86	180.08
	Total irrigable land			403.64	212.55
	Amount of land allocated to HYV			228.58	99.17
	HYV land as a proportion of Irrigated land.			0.64	0.24

Source: Authors' computation based on IFPRI household survey 1994-95.

Table 2—Comparison of Survey Data with Nationally Published Statistics

Districts	Proportion of Land Allocated to HYV		
	Survey Data*		National Statistics**
	Mean	Standard Deviation	Mean
Dhaka	0.723	0.340	0.72
Mymansingh	0.573	0.356	0.70
Rangpur	0.611	0.319	0.62
Sylhet	0.794	0.353	0.30

* Author's calculation from IFPRI household survey 1994-95.
** Based on the data from the Bangladesh Statistical Yearbook for 1995.

Following the specifications of the previous sections, four sets of regression results are reported. Results of the specification that considers *credit limit* as the measure of access to credit is presented in Tables 3, where two columns of results are derived under the assumptions of correlated and uncorrelated error terms (in the probit equations) respectively. In other words, while the first column of the table hypothesizes decisions to adopt and decision to borrow to be interrelated; the other column treats two decisions as independent. Note that, although at different level of significance, both formal and informal *credit* limits are significant under these specifications. However, when decisions to adopt and decision to participate in lending program are treated independently, both the magnitude of the estimated coefficients and their significance levels decrease substantially. In particular, in addition to a 15 percent decrease in the estimated coefficient, formal credit limit becomes insignificant at five percent level of significance.

Table 3—*Credit Limit* As a Determinant of Farmer's Decision to Cultivate HYV

Explanatory Variables	Regression results[a]	
	HYV adoption decision and credit program participation decision interacted	HYV adoption decision and credit program participation decision are independent
Constant	240.323**	259.463**
	(2.24)	(3.03)
Age of the household head (in years)	-3.500	-4.301
	(-1.15)	(-1.56)
Age of the household head squared	0.031	0.049
	(0.95)	(1.57)
Total own land	0.713*	0.646**
	(1.66)	(2.23)
Total irrigated land***	0.366**	0.347**
	(3.96)	(4.30)
Total number of household members	-11.739**	-12.691**
	(-2.54)	(-3.52)
Highest grade completed by male member	5.827**	0.477
	(2.32)	(0.19)
Highest grade completed by female member	-2.666	-0.482
	(-0.75)	(-0.19)
Gender of the household head	-58.559**	-70.130**
	(-2.76)	(-3.73)
Dummy for geographic region 1	-6.729	6.751
	(-0.60)	(0.72)
Dummy for geographic region 2	15.240	58.159**
	(1.06)	(2.79)
Dummy for geographic region 3	10.323	27.336*
	(0.81)	(1.93)
Total adult male members	3.012	5.079
	(0.41)	(0.77)
Natural log of Informal credit limit $(\times 10^{-2})$	0.089**	0.095**
	(2.08)	(2.44)
Natural log of Formal credit limit $(\times 10^{-2})$	0.290**	0.249*
	(2.20)	(1.72)
Lambda-A (mills ratio from ADOPT Equation)	-27.813	-33.007*
	(-1.41)	(-1.86)
Lambda-B (mills ratio from PROGRAM Participation equation)	-69.422*	-89.052**
	(-1.77)	(-2.65)
Diagnostics[b]		
Log likelihood	-141.05	-137.59
Restricted Log likelihood		-202.07
Sample size	202	202
Adjusted R^2	0.871	0.89

Source: IFPRI household survey data 1994-95.

[a] Asymptotic t-ratios in parenthesis.

[b] Note that for the estimation method employed, R^2 is not bounded between o and 1. Also, since it remains same for all regressions, sample size is not reported with other results.

* Coefficients are significant at less than 10% level of significance

** Coefficients are significant at less than 5% level of significance

*** Irrigated land refers to mechanically irrigated land in all specifications and is measured in decimal (i.e., $1/100^{th}$ of an acre).

While credit variables are found significant, elasticities based on the regression estimates suggest that the responsiveness of farmer's HYV cultivation with respect to credit is low and becomes increasingly lower as land holding increases. For example, the estimated elasticity of HYV cultivation to credit limit for households owning less than 0.50 acres of land is estimated at 0.02; whereas the same estimate for the households owning more than one acre of land is only 0.002, implying that smaller farmers will derive the most benefit from credit services.[16] Given profitability from HYV is twice as high according to existing estimates, it follows that, by enabling small farmers to make profitable investment, credit programs can have significant beneficial impacts in terms of productivity growth and overall household well being.

Table 4 reports the results of the specification that assumes *amount-borrowed* as a measure of access to credit. Note that these results stand in sharp contrast to the results presented in Tables 3. In particular, *amount-borrowed* from lending programs now becomes highly insignificant, although loan from informal sources remains significant at 10 percent level of significance. Within our methodological framework, this result has a simple explanation. Although some households had membership in lending programs, they either borrowed less than their credit limit or did not borrow at all at the time of interview. In other words, while *credit limit* always received a positive value, *amount-borrowed* was reported either zero or a value that is less than the *credit limit* of the households. These differences between the two measures of

[16] These elasticity estimates are based on the regression estimates of Table 3 and mean HYV land, reported in Table 1. For example, household owning less than 0.50 acres of land allocated 0.163 acres of land (table 1) and the estimated coefficient for credit limit is 0.29×10^{-2}. Therefore, for this group of households, $\varepsilon_i = \frac{dH}{dC} \times \frac{C}{H} = \frac{\beta_c}{H} = \frac{.0029}{0.163} = .02$.

Table 4—*Amount Borrowed* As a Determinant of Farmer's Decision to Cultivate HYV

Explanatory Variables	Regression results[a]	
	Decision to adopt HYV's and decision to join credit program are interacted	Decision to adopt HYV's and decision to join credit program are independent
Constant	194.650*	231.257**
	(1.79)	(2.56)
Age of the household head (in years)	-3.705	-4.524
	(-1.12)	(-1.48)
Age of the household head squared	0.034	0.052
	(0.95)	(1.49)
Total own land	0.688	0.661**
	(1.49)	(2.03)
Total irrigated land	0.437**	0.408**
	(5.49)	(5.50)
Total number of household members	-10.650**	-12.067**
	(2.04)	(-2.74)
Highest grade completed by male member	5.855**	0.125
	(2.17)	(0.04)
Highest grade completed by female member	-0.509	0.906
	(-0.12)	(0.30)
Gender of the household head	-34.946*	-49.621**
	(-1.67)	(-2.55)
Dummy for geographic region 1	0.344	10.258
	(0.03)	(1.01)
Dummy for geographic region 2	25.116*	61.856**
	(1.67)	(2.68)
Dummy for geographic region 3	18.211	30.775**
	(1.30)	(1.96)
Total adult male members	4.984	4.696
	(0.63)	(0.65)
Natural log of amount borrowed from Informal sources $(\times 10^{-2})$	1.152*	1.122*
	(1.76)	(1.85)
Natural log of amount borrowed from formal sources $(\times 10^{-2})$	0.015	0.061
	(0.16)	(0.69)
Lambda-A (mills ratio from ADOPT Equation)	-11.462	-23.165
	(-0.69)	(-1.46)
Lambda-B (mills ratio from PROGRAM Participation equation)	-61.624	-84.020**
	(-1.49)	(-2.25)
Diagnostics[b]		
Log likelihood	-143.41	-140.540
Restricted Log likelihood		
Adjusted R^2	0.841	0.849

Source: IFPRI household survey data 1994-95.
[a] Asymptotic t-ratios in parenthesis.
* Coefficients are significant at less than 10% level of significance
** Coefficients are significant at less than 5% level of significance

access to credit might have caused the coefficient of *amount-borrowed* from lending institutions to be insignificant.

On the other hand, the significance of informal credit under both specifications implies that the adopter-cum-member households have borrowed close to their credit limit, which is, of course, a special case in which *credit limit* and *amount-borrowed* are close to each other. One might ask is: why did households borrow from expensive informal sources when they had access to micro-lending? The answer lies in the fact that most of these loans are from friends and relatives and not as expensive as loans taken from the moneylenders. It is, however, not clear whether the same households would have obtained such informal credit if they had not joined one of the lending programs. As Bell (1993) argues, costs of informal credit may significantly depend on whether or not a household has access to formal credit. Therefore, significance of informal credit in this analysis should be partly attributed to households' access to lending programs.

Although the primary focus of the analysis has been on the relationship between land allocation and credit, the estimated parameters associated with the other explanatory variables also bear important implications. Two sets of estimates are of particular interest. First, *mills ratios* $(\lambda's)$ related to program participation equation are significant in three out of four models considered. This implies that failure to control of *selection bias* would have led to inconsistent parameter estimates.[17] Second, three household specific variables—irrigated land, household size, and gender of the household head—are found significant under all four specifications of

[17] Other econometric implications of selection problems are well described in Green (1993), pp. 706-714.

the model. Since irrigation is a prerequisite for HYV cultivation, it is expected that the coefficient associated with it would be significant.

The significant negative relationship of family size and gender of the household head, however, may seem counter-intuitive at first sight. As cultivation of HYV requires more supervision, it is usually hypothesized that male-headed households would allocate more land to HYV i.e., the coefficient of gender dummy should be positive. In our analysis, the negative sign of the gender dummy simply implies that more female-headed households join the micro-lending programs; and that although some member households are male-headed, they do not allocate as much land to HYV, as do the female-headed households[18].

6. CONCLUSIONS AND POLICY IMPLICATIONS

Despite high profitability of HYVs, farm households in the developing countries continue to allocate a portion of their land to traditional crop varieties. One of the micro-theoretic explanations of this observed behavior is that, if traditional varieties outperform HYVs at low levels of input use, it is optimal for a credit-constrained farmer to cultivate the traditional varieties. This paper has attempted to examine the issue in the context of a specially designed micro-lending program for small farmers in Bangladesh.

The concept of a *credit limit,* defined as the highest amount of credit a household is able to borrow if needed, has been used as an indicator of access to credit. The underlying idea is that, the investment decision of a farm household is

[18] In fact, 90 percent of the participating households in the sample are female-headed.

influenced more by how much the household is able to borrow than how much it has already borrowed. Results indicate that the impacts of credit on farm households' land allocation decisions significantly depend on how access to credit is defined. In particular, while the *credit limit* is found to have a significant positive impact on the amount of land allocated to HYV, the relationship becomes insignificant when the *amount-borrowed* is considered as a measure of access to credit. This result has a simple explanation. In our sample there are member households, who either did not borrow or borrowed less than their credit limit at the time of interview. Therefore, while *credit limit* always received a positive value, *amount-borrowed* was reported as either zero or an amount less than the *credit limit,* which might have caused the coefficient of *amount-borrowed* to be insignificant.

Both measures of access to credit, credit limit and amount-borrowed, from informal sources are found to be significant determinant of HYV cultivation under all model specifications. The relationship, however, becomes weaker when *amount-borrowed* is considered to be an indicator of access to credit. Given our empirical methodology, this results imply that the adopter-cum-member households have borrowed close to their maximum credit limit from the informal sources—a special situation where credit limit and amount-borrowed are not significantly different.

The findings of this study hold clear policy implications for Bangladesh. Although the country has gained international reputation for its success in micro-lending programs, the focus of these programs has almost exclusively been on income generation through non-farm activities. The majority of small farm households continue to rely on the informal sector for their credit needs. They neither have access to formal financial sector nor to the micro-lending programs administered by the NGOs. This study has presented empirical evidence that there is room to increase

agricultural productivity by providing the small farmers with financial services through micro-lending institutions. While our focus has been on land allocation to HYV, access to micro-lending can also increase the use of other inputs such fertilizer and pesticides. As the *Small and Marginal Farm Crop Intensification Project* of RDRS has demonstrated, small farmers can be brought closer to formal banking by establishing successful partnerships between NGOs and commercial banks. Such initiative will not only increase productivity but also improve the performance of the formal banking system that has long been struggling to reach the poor farmers.

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