Predicting Creditworthiness With Publically Observable Characteristics: Evidence From ASCRAs and RoSCAs in the Gambia

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Summary

While informal finance flourishes in Africa, formal finance flounders. This is especially true for poorer households. This paper investigates whether publicly observable characteristics help predict which households get access to informal finance and which do not. It also examines whether Accumulating Savings and Credit Associations (ASCRAs) reach poorer borrowers than do Rotating Savings and Credit Associations (RoSCAs). Because informal lenders are astute judges of creditworthiness and because publicly observable characteristics are cheap for formal lenders to observe, formal lenders may be able to follow in the footsteps of informal lenders if publicly observable characteristics predict the decisions of informal lenders well.

It is found that, for some characteristics, this is indeed the case. In particular, being female and having borrowed from other informal sources are good predictors of whether an informal lender will judge a potential borrower to be creditworthy or not. Thus, knowledge of these characteristics may help a formal lender to make good loans. It is also found that both ASCRAs and RoSCAs reach borrowers of similar poverty levels. Lessons from informal finance may help reform formal finance in Africa.

Predicting Creditworthiness With Publically Observable Characteristics: Evidence From Informal Borrowing From Groups in The Gambia

1. Introduction

1.1. *Beyond descriptive analysis of informal finance*

People in Sub-Saharan Africa without access to formal financial institutions often use informal financial arrangements provided through groups. A huge literature describes the incarnations of these arrangements across the continent (Adams and Fitchett, 1992). Explorations of rotating savings and credit associations (RoSCAs), accumulating savings and credit associations (ASCRAs), moneylenders, moneykeepers, and trade finance have unearthed five basic virtues of informal finance: slashed transaction costs, supply of savings as well as loans, substitution of confidence for collateral, socially enforced and/or self-enforced contracts, and sequences of repeated interactions.

Econometric studies of informal arrangements have been rare. Quantitative analysis, however, promises to clarify the insights of descriptive analysis by sharpening characterizations of informal arrangements, testing empirical regularities suggested by case studies, and measuring the forces affecting informal arrangements.

Although descriptive studies are fascinating, they often praise informal arrangements without indicating how formal arrangements can imitate them. Research should go beyond extolling the virtues of informal arrangements to explore ways to graft those virtues onto formal arrangements. This study attempts to understand better the diversity and development of informal groups in order to inform the design of formal financial services (Hospes, 1992).

1.2. *Questions of This Study*

This study analyzes borrowing by individuals from informal groups in peri-urban Banjul, The Gambia. Its goal is to inform the incorporation of the virtues of the informal arrangements into formal arrangements. The paper characterizes borrowers and loans associated with two informal groups, RoSCAs (*osusus* in the Mandinka language), and ASCRAs (*kafos*). The econometric model focuses on the decision to borrow and on the matching of borrowers and lenders. Interest centers on two questions. First, do publicly observable characteristics help predict creditworthiness? Second, do ASCRAs or RoSCAs reach borrowers with different levels of poverty?

Five sections follow. Section 2 describes the informal groups and the data set. Section 3 characterizes the borrowers and the loan contracts associated with ASCRAs and with RoSCAs. Sections 4 and 5 use a bivariate probit model with sample selection to examine if publicly observable characteristics help predict the decision to borrow and/or the matching of borrowers with an ASCRA rather than with a RoSCA. Section 6 summarizes the results.

2. Description of the informal groups and the data set

2.1. *ASCRAs and RoSCAs*

The first type of informal group is the *kafo*, a cooperative community organization fitting Bouman's (1995) definition of an ASCRA. These ASCRAs have about 100 members who provide each other with basic social, financial, and insurance services. Most groups maintain a common fund built up by occasionally collecting dues and/or by selling produce from a plot farmed collectively by members of the group. The ASCRA draws on the common fund to make grants to members with emergencies or to make loans. Many groups also collect small deposits at regular intervals and periodically return the accumulated sum, often immediately before Ramadan.

ASCRAs in The Gambia are documented by Nagarajan *et. al.* (1993b and 1993c), and by Shipton (1992, 1993).

The second type of informal group is the *osusu*, a cooperative community organization fitting Ardener's (1964) and Bouman's (1979, 1977) definitions of a RoSCA. These RoSCAs are groups of 10 to 30 members who meet regularly to contribute a fixed amount of cash to a pot which is immediately distributed by some rule of rotation to a single member. More meetings follow until each member has received the pot once. Thus, RoSCAs collect deposits and immediately lend them out again. All pots except the first and the last have a loan component (the amount yet to be contributed by the recipient in future meetings) and a savings-withdrawal component (the amount already contributed by the recipient in previous meetings). RoSCAs in The Gambia are documented by Nagarajan *et. al.* (1993a, 1993b) and by Shipton (1992, 1993).

Gambian ASCRAs and RoSCAs are similar in that they are both informal, cooperative community organizations that collect deposits and make loans. They differ in that the amount lent by ASCRAs need not equal the amount collected at a given meeting, whereas all the deposits mobilized by a RoSCA are immediately lent out. In addition, not every member of the ASCRA borrows, and the timing of ASCRA loans depends on borrower demands, whereas all members of a RoSCA must borrow and the timing of RoSCA loans is somewhat fixed. Bouman (1995) compares ASCRA and RoSCAs in detail.

2.2. *The sources of the data*

This study uses data from two random surveys in 1993 in peri-urban Banjul, The Gambia. Roth (1993) and Nagarajan *et al.* (1994) detail the methods used in the surveys. The data set was restricted to observations with non-missing data for age, sex, household size, and education. This

was partly the result of a desire to analyze only publicly observable characteristics and partly the result of the limited overlap between the two surveys. The 716 observations include 104 borrowers and 612 non-borrowers. Of the 104 borrowers, 69 used RoSCAs and 35 used ASCRAs.

3. Characteristics of borrowers and dimensions of loans

Table I summarizes the frequencies and medians for the terms and conditions of the loans and for household size, sex, age, borrowing from other informal sources, and education. The variables are classified for the overall sample, for non-borrowers and borrowers, and for borrowers from RoSCAs and from ASCRAs.

3.1. *Demographics of borrowers*

The integer variable **Number in family** has a median of 9 for the overall sample. Borrowers (8) have significantly smaller households than non-borrowers (9). Borrowers from RoSCAs (7) have significantly smaller households, and borrowers from ASCRAs (12) have significantly larger households.[1]

The dummy variable **female** equals one for females and zero for males. Of the 716 informants, 371 were female. Of these, 85 borrowed, and 286 did not. The proportion of females in the overall sample (0.52) is significantly smaller than the proportion of females in the sub-sample of borrowers (0.81).

The dummy variables **young**, **middle-aged** and **elderly** correspond to ages in years

[1] Unless otherwise noted, *significant* means that the appropriate non-parametric test (either Wilcoxon rank-sum or Fisher's exact test for 2-by-2 contingency tables) had a p-value of 0.1 or lower against the null hypothesis of no difference (Hollander and Wolfe, 1973).

between 18 and 25, 26 and 35, and 36 or more.[2] Age does not vary significantly between borrowers and non-borrowers nor between borrowers from RoSCAS and borrowers from ASCRAs.

The dummy variable **informal** indicates borrowing from an informal source that was not a RoSCA nor an ASCRA. These informal sources include moneylenders, friends, and relatives. The percentage of borrowers who had also borrowed informally from these lenders (6) was significantly larger than the percentage of the overall sample (2).

The dummy variables **illiterate**, **koranic**, and **literate** indicate education. A koranic education implies basic numeracy and the ability to recite part of the Koran. Education does not vary significantly across the various categories.

3.2. *Terms and conditions of loans*

The surveys collected three variables on the terms and conditions of loans. The first variable was loan size. From Table I, the median loan size for all borrowers was 160 dalasi, or about $18, given the exchange rate of 9 dalasi per dollar at the time of the survey. The median loan from RoSCAs[3] (106) is significantly smaller than the median loan from ASCRAs (240).

The second variable was the size of installments. The median size of installments for loans from RoSCAs (10) is significantly larger than that of loans from ASCRAs (5).

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[2] These classifications were imposed by the design of the surveys. Life expectancy in The Gambia is 44 years (World Bank, 1991).

[3] For RoSCAs, the loan size was taken as the number of members multiplied by the size of the contribution at each meeting. In fact, this exaggerates the loan size because only the first recipient of the pot receives a loan this large. As more members get their turn, the portion of the pot representing a loan shrinks and the portion of the pot representing the withdrawal of savings grows. Thus, the average participant in a RoSCA gets a loan of about half the size reported here.

The third variable is the number of installments. The median number of installments for ASCRAs (39) is significantly more than the median for RoSCAs (20).[4]

In summary, loans from informal groups are small (median $19) and are repaid in installments of about a dollar. Loans from ASCRAs are typically twice as large and repaid over a period twice as long as are loans from RoSCAs. Borrowers tend to be younger than non-borrowers, and borrowers from ASCRAs tend to be younger than borrowers from RoSCAs.

4. An econometric model of the decision to borrow

Informal lenders are generally acknowledged to be excellent judges of creditworthiness because they have cheap access to information concerning a borrower's character (willingness to repay) and financial condition (ability to repay). Many formal institutions, on the other hand, have a dismal record of picking good credit risks when trying to lend to the poor. Formal lenders assume that investigating a borrower's character is not cost-effective and thus base decisions only on financial condition as signaled by either collateral or on the analysis of business plans and accounting records. Because the poor usually cannot signal financial strength in these ways, they end up with few, if any, formal loans.

Some information about potential borrowers can be obtained cheaply by formal lenders. For example, a loan officer can easily note an applicant's household size, sex, age, and education during a short visit to a residence. Applicants cannot easily misrepresent these publicly observable characteristics.

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[4] As for loan size, the number of installments for RoSCAs is exaggerated by taking it as the number of members in the RoSCA. In fact, a given member pays only as many installments as there are turns remaining after that member gets the pot. Thus the average number of installments is about half the figure reported here.

If informal lenders are good judges of creditworthiness, they will not lend often to bad credit risks. If publicly observable characteristics help predict who borrows from informal lenders, then they may also help predict creditworthiness. This cheap information may help formal intermediaries screen applicants better.

Vigano (1993) investigated a similar hypothesis. Using data from the loan portfolio of a development bank in Burkina Faso, Vigano found that a credit-scoring model discriminated well between good and bad credit risks even when the lender had no measures of the applicant's financial condition and the prediction depended only on publicly observable characteristics such as sex, employment, and marital status.

4.1. *The econometric model*

It is assumed that a borrower decides whether to borrow or not and is simultaneously matched either with an ASCRA or with a RoSCA. A bivariate probit model is appropriate because both the dependent variable of borrowing and the dependent variable of being matched with an ASCRA or with a RoSCA are binary. A bivariate probit model with sample selection is appropriate because the ASCRA/RoSCA match is only observed for borrowers.[5]

It is hypothesized that the likelihood of deciding to borrow will depend on five characteristics: **household size**, **sex**, **age**, **other informal borrowing**, and **education**. Because certain characteristics may signal character and/or financial condition, it seems that higher creditworthiness and thus greater borrowing may be observed for those in large households,

[5] An appendix available from the authors gives details of the econometric specification of the bivariate probit model with sample selection. The appendix also describes the calculations necessary to find the estimated change (and the standard error of the estimated change) in the expectation of the dependent variable caused by a change in an independent variable.

females, the elderly, those who have borrowed informally elsewhere, and the more educated. For example, females with children cannot skip town as easily as single females, and older, more educated people should have relatively more wealth and income sources.

Table II presents the signs, magnitudes, and statistical significance of the estimated parameters and of the estimated changes in the probability of borrowing caused by a change in an independent variable. As explained in the appendix, interest centers on the estimated changes, not the estimated parameters themselves.

Although loans result from the simultaneous interaction of supply and demand, only their intersection is observed. The interpretations offered here recognize that a complete analysis would explicitly model both supply and demand. For example, an agent's failure to borrow could be attributed to supply, to demand, or both to supply and to demand (Schreiner *et al.*, 1996). Given the ubiquity of informal groups in The Gambia, however, it seems likely that most creditworthy borrowers could find informal groups willing to lend to them.

4.2. *Results*

Household size does not affect the decision to borrow from informal groups. Surprisingly, the estimated change in the probability of borrowing caused by a unit change in household size is not statistically different from zero. A larger household would be expected to increase borrowing through two channels (Besley and Levenson, 1993; Cuevas and Schrieder, 1991). First, large households invest more in productive opportunities and consume more than do smaller households. Second, large households are better credit risks because they have more interlinkages with the community, have more sources of income, and have more diversified sources of income.

Females are 16 percentage points more likely to borrow than are males. This can be

understood in at least three ways. First, people resort to informal loans only after exhausting cheaper sources of financing. If females are poorer than males are and thus have less access to formal finance, they may resort to informal finance more often. For example, government agricultural cooperatives make fertilizer loans only to males, who often relend or sell the fertilizer to their wives or others (Shipton, 1993). Second, females, whether because of cultural or religious custom, responsibilities to children, or reduced literacy, hold fewer of the salaried jobs whose predictable income streams both reduce the desirability of borrowing informally and increase the ability to borrow formally. Third, females dominate petty trade in the Gambia. Small, frequent loans are useful in petty trade for financing inventories and working capital. Traders also desire to make small, frequent deposits as they sell inventory. Informal arrangements, especially RoSCAs, are well-tailored to this pattern of cash flow.

Age does not affect the decision to borrow from informal groups. The change in the probability of borrowing caused by a change in age class is not statistically different from zero. It would seem that the chance to build a reputation with age is balanced by a greater demand for loans by the young caused by their fewer non-loan resources.

Informal borrowing from other sources increases the probability of borrowing from informal groups by 14 percentage points. Having borrowed from a moneylender, a friend, or a relative probably signals an above-average demand for loans.

Education does not affect the decision to borrow from informal groups. The changes in the probability of borrowing caused by a change in the dummies representing education are not statistically different from zero. This is mildly surprising because literacy is often required for the salaried government jobs whose smooth income streams reduce the desire to borrow and while

simultaneously increasing the ability to borrow. Also, a koranic education may signal a person as a relatively serious Muslim. Such people would be more likely to borrow from informal groups both because of their trustworthiness and because of the lack of explicit interest charges.

4.3. *What can cheap information reveal about creditworthiness?*

The significance of the effects of being female and of having borrowed from other informal sources on the decision to borrow from an informal group suggests that knowledge of these characteristics may indeed help a formal lender predict a potential borrower's creditworthiness.

The results should be interpreted with care. Just because informal lenders consider females to be creditworthy does not imply that formal lenders should begin giving preference to females. Rather, it illustrates that even the relatively poor desire financial services and can fulfill their obligations under adequate incentive structures.

The fact that borrowers from ASCRAs and RoSCAs often borrow from other informal sources also suggests that a single informal lender often cannot satisfy all of the demand of some borrowers. Because one of the hallmarks of formal finance is the provision of relatively large loans, this would suggest that informal finance is at best an imperfect substitute for formal finance. Those using informal finance heavily are those without better options.

5. An econometric model of matching borrowers with ASCRAs or RoSCAs

Governments and donors often wish that formal financial institutions would lend to the poor. It is unlikely, however, that formal lenders can do this profitably if informal lenders themselves avoid this group in spite of their better information, more appropriate guarantees, and lower transaction costs.

5.1. *Why borrowers would prefer ASCRAs to RoSCAs*

Both ASCRAs and RoSCAs lend. Each entrusts the borrower with resources in the present in exchange for a promise to return resources in the future. A borrower from a RoSCA, however, is more constrained than a borrower from an ASCRA for at least five reasons. First, all RoSCA borrowers, except the first, must save before borrowing. Second, potential borrowers must find a RoSCA matching their cash flows. Third, RoSCA loans are small and short, especially for those for those late in the rotation. Fourth, it is not the borrower but the RoSCA that fixes the number and the size of installments. Fifth, if the pot is allocated by lottery at each meeting, then the borrowers in a RoSCA do not know when they will get their loans.

Relative to loans from RoSCAs, loans from ASCRAs are less constrained. Deposits are more flexible, loans are larger and longer, and the borrower chooses whether and when to ask for a loan. Perhaps most importantly, the Gambian ASCRA offers flexible repayment. In fact, as long as a borrower makes good progress in good faith, the Gambian ASCRA leaves the size and spacing of installments up to the borrower. This allows the borrower to make choices unfettered by rigid repayment schedules.

Gambian ASCRAs can offer this flexibility because their members have many non-financial interlinkages which eliminate most information asymmetries. When a family illness interrupts repayments, the reason is known, understood, and uncontested. The ASCRA can always punish deliberate delinquency by shunting more and tougher work on the group's common plot to the borrower or by excluding the defaulter from the group’s non-financial activities.

5.2. *Why borrowers use RoSCAs if they prefer ASCRAs*

There are two reasons why a borrower would prefer an ASCRA but use a RoSCA. The first reason is choice; saving is more important to some people at some times than is borrowing,

and RoSCAs are better for saving than ASCRAs for at least three reasons. First, the mandatory contributions to a RoSCA provide a socially acceptable excuse for refusing to give cash to family and friends. Second, RoSCAs are well-suited to the cash flows of traders, providing a haven for cash and returning it in a usefully large sum. Third, contributions to RoSCAs are more liquid than deposits in an ASCRA because ASCRAs generally return deposits annually whereas RoSCAs rotate more frequently.

The second reason is constraint; loans from ASCRAs may not be available in all amounts at all times to all people because the common funds used to make loans may be so small that the ASCRA must ration loans (Nagarajan *et.al.*, 1993b). In addition, it costs more to participate in an ASCRA than in a RoSCA, and these costs may outweigh the benefits of access to better loans.

The product of choice and constraint is a matching of those who have decided to borrow either with an ASCRA or with a RoSCA.

5.3. *Results of an econometric model of the ASCRA/RoSCA match*

The equation for the selected sample in the bivariate probit model assumes that the matching of a borrower with an ASCRA rather than with a RoSCA depends on **household size**, **sex**, **age**, and **education**. If characteristics that signal wealth (such as age or education) increase the likelihood of being matched with an ASCRA, it would suggest that the poorest are restricted to RoSCAs, given that borrowers probably prefer ASCRAS to RoSCAs. On the other hand, if characteristics which signal wealth are not associated with matching with ASCRAs, then both types of informal groups reach borrowers of similar levels of poverty.

Table III presents the signs, magnitudes, and statistical significance of the estimated parameters and of the estimated changes in the likelihood of borrowing caused by a change in an

independent variable. It turns out that no single characteristic helps predict the matching of a borrower with an ASCRA rather than with a RoSCA.[6] Thus, both groups reach borrowers of similar levels of poverty.

6. Summary of implications for formal financial intermediaries

This study has two main conclusions. First, some publicly observable characteristics help predict creditworthiness. Formal lenders may be able to profit from the fact that informal lenders consider females to be creditworthy. This is inferred because informal lenders are good judges of creditworthiness and because females borrow informally more than males do.

In addition, having borrowed from other informal lenders increases the probability of borrowing from an ASCRA or from a RoSCA. This suggests that borrowers cannot satisfy their demand for loans from a single informal lender and thus that informal finance is an imperfect substitute for formal finance.

The feasibility of using publicly observable characteristics when screening potential borrowers depends on the decreased costs of default and on the increased costs of collecting and using the extra information. The net benefit could very well be positive because obtaining and handling this information should be cheap. Some formal lenders already consider this information when screening potential borrowers.

Of course, knowledge of characteristics cannot completely substitute for knowledge of character. For example, females are significantly more likely to borrow informally than are males,

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[6] Although the parameter associated with **female** is statistically significant, the estimated change in the probability of being matched with an ASCRA rather than with a RoSCA caused by for a male as compared to a female is not statistically significant.

but this probably does not mean that females are especially good credit risks. Rather, it probably means either that males borrow from other sources or that males do not desire to borrow as much as females.

The second main conclusion is that ASCRAs and RoSCAs reach borrowers of similar levels of poverty. Publicly observable characteristics do not help predict the matching of borrowers with an ASCRA rather than with a RoSCA.

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Table I

Frequencies and Medians of Independent Variables By Overall Sample, by Non-borrowers and Borrowers, and By Borrowers From ASCRAS and From RoSCAs

Category	Variable	Measure	Overall	Non-borrower	Borrower	ASCRA	RoSCA
Sample Size	**N**	Frequency	716	612	104	35	69
Household Size	**Number In Family**	Median	9	9	9	12	7
Sex	**Female**	Frequency	371	286	85	23	62
Age	**Young**	Frequency	214	195	19	2	17
	Middle-Aged	Frequency	207	166	41	17	24
	Elderly	Frequency	295	251	44	16	28
Borrowing	**Informal borrowing**	Frequency	17	11	6	N/A	4
Education	**Illiterate**	Frequency	184	153	31	1	30
	Koranic	Frequency	409	342	67	33	34
	Literate	Frequency	123	117	6	1	5
Loan Dimensions	**Loan Size**	Median	0	N/A	160	240	106
	Size of installments	Median	0	N/A	10	10	10
	Num. of installments	Median	0	N/A	29	39	20

Source: Surveys by the Ohio State University and the University of Wisconsin-Madison, 1993.

Table II

Estimated Coefficients For Bivariate Probit Model For Overall Sample for the Decision to Borrow or Not to Borrow

Dependent variable **Borrower** is 1 if informant borrowed, 0 otherwise.

Variable	Estimated Parameters			Estimated Changes In Probability of Borrowing		
	Est. Parameter	Standard Error	Significance	Est. Change	Standard Error	Significance
Constant	-1.25	0.26	**	N/A	N/A	
Household Size	-0.01	0.01		0.00	0.10	
Female	0.82	0.15	**	0.16	0.06	**
Middle-aged	0.45	0.19	*	0.09	0.13	
Elderly	0.27	0.20		0.05	0.12	
Informal	0.71	0.33	*	0.14	0.07	*
Illiterate	0.24	0.27		0.05	0.12	
Koranic	0.41	0.26		0.08	0.13	
Rho	-0.72	0.72		N/A	N/A	
Log-likelihood	-307.41	N/A		N/A	N/A	

Sample includes 104 borrowers and 612 non-borrowers.

Table III

Estimated Coefficients For Bivariate Probit Model For Selected Sample for the Matching With an ASCRA or With a RoSCA

Dependent variable **Lender** is 1 if borrowed from an ASCRA, 0 if borrowed from a RoSCA.

Variable	Estimated Parameters			Estimated Changes		
	Est. Coefficient	Standard Error	Significance	Est. Change	Standard Error	Significance
Constant	-0.96	2.66		N/A	N/A	
Household Size	0.07	0.05		0.00	0.00	
Female	-1.20	0.38	**	-0.02	0.14	
Middle-aged	0.43	0.90		0.00	0.05	
Elderly	0.14	0.63		0.00	0.02	
Illiterate	-0.49	1.16		0.00	0.01	
Koranic	0.75	1.11		0.01	0.06	
Rho	-0.72	0.72		N/A	N/A	
Log-likelihood	-307.41			N/A		

Sample includes 35 borrowers from ASCRAs and 69 borrowers from RoSCAs.

Appendix

This appendix describes the bivariate Probit model with sample selection. It also describes the calculations necessary to find the estimated change (and the standard error of the estimated change) in the expectation of the dependent variable caused by a change in an independent variable. The exposition of the basic model is adapted from Greene (1993, pp. 660-664). The derivation and calculation of the estimated changes in the dependent variables and the standard error of the estimated changes for the bivariate Probit model with sample selection have not appeared elsewhere in the literature.

A general specification for a bivariate Probit model with sample selection is:

$$
\begin{aligned}
& y_i^* = \hat{a}_{i*}' X_* + \hat{a}_i' X_i + \varepsilon_i \ \textit{for} \ i = 1, 2, \\
& y_1 = \begin{cases} 1 \ \textit{if} \ y_2^* > 0, \ \textit{and} \\ 0 \ \textit{otherwise}, \end{cases} \\
& 0 = E[\varepsilon_1] = E[\varepsilon_2], \\
& 1 = Var[\varepsilon_1] = Var[\varepsilon_2], \ \textit{and} \\
& \tilde{n} = Cov[\varepsilon_1, \varepsilon_2].
\end{aligned}
\qquad \textbf{(1)}
$$

The indicator variable y_i is observed, but the latent variable y_i^* is not observed. Sample selection occurs because matching with an ASCRA rather than with a RoSCA (y_1=1) is observed only if the agent decides to borrow (y_2=1).

The bivariate Probit model with sample selection first appeared in Van de Ven and Van Praag (1981). Boyles *et al*. (1989) use it to model the fact that the decision to default is observed only for those households who also borrow. The conclusions in both models are suspect because neither calculated the estimated marginal effects of changes in the independent variables nor their standard errors.

For the model here, the dependent variables, the independent variables, and the parameters are defined as:

y_1=the matching with an ASCRA or with a RoSCA given that the household borrowed, with y_1=1 for ASCRAs and y_1=0 for RoSCAs;

y_2=the choice to borrow, with y_2=1 if the agent borrowed and y_2=0 otherwise;

$\boldsymbol{X}_1$=(k_1 x 1) vector of independent variables (including any constant) affecting the matching with an ASCRA rather than with a RoSCA but not affecting the decision to borrow or not to borrow;

$\boldsymbol{X}_2$=(k_2 x 1) vector of independent variables (including any constant) affecting the decision to borrow or not to borrow but not affecting the matching with an ASCRA rather than with a RoSCA;

$\boldsymbol{X}_*$=(k_* x 1) vector of independent variables (not including a constant) affecting both the decision to borrow and the matching with an ASCRA rather than with a RoSCA;

$\hat{\boldsymbol{a}}_1$=(k_1 x 1) vector of parameters associated with $\boldsymbol{X}_1$;

$\hat{\boldsymbol{a}}_2$=(k_2 x 1) vector of parameters associated with $\boldsymbol{X}_2$;

$\hat{\boldsymbol{a}}_{1*}$=($k_*$ x 1) vector of parameters associated with $\boldsymbol{X}_*$ in the equation for the entire sample; and

$\hat{\boldsymbol{a}}_{2*}$=($k_*$ x 1) vector of parameters associated with $\boldsymbol{X}_*$ in the equation for the selected sample.

In the application here, $\boldsymbol{X}_1$ includes a constant, $\boldsymbol{X}_2$ includes a constant and a dummy for having borrowed from other informal lenders, and $\boldsymbol{X}_*$ includes a variable for household size and dummies for age, sex, and education.

The econometrics package LIMDEP will estimate the parameters by full-information maximum likelihood. Given the following notation,

$$
\begin{aligned}
w_i &= \hat{a}_{i*}^{/} X_* + \hat{a}_i^{/} X_i, \;\; i = 1, 2, \\
\ddot{a} &= \frac{1}{\sqrt{1 - \tilde{n}^2}}, \\
v_i &= \ddot{a}(w_j - \tilde{n} w_i), \;\; i = 1, 2, \;\; j = 1, 2, \;\; j \neq i, \\
\ddot{O}(w_i) &= \int_{-\infty}^{w_i^{/}} \ddot{o}(z) \; dz, \\
\ddot{o}(z) &= \frac{1}{\sqrt{2\delta}} e^{\frac{-z^2}{2}} \\
a &= \frac{1}{2\delta\check{\delta}\sqrt{1 - \tilde{n}^2}}, \\
b &= \frac{-(z_1^2 + z_2^2 - 2\tilde{n} z_1 z_2)}{2(1 - \tilde{n}^2)}, \\
\ddot{O}_2(w_1, w_2, \tilde{n}) &= \int_{-\infty}^{w_2} \int_{-\infty}^{w_1} \ddot{o}_2(z_1, z_2, \tilde{n}) \; dz_1 \; dz_2, \; and \\
\ddot{o}_2(z_1, z_2, \tilde{n}) &= a e^b,
\end{aligned}
\tag{2}
$$

then the estimated probability of observing y_2=1 is:

$$Prob(y_2 = 1) = \ddot{O}(w_2). \tag{3}$$

Given that y_2=1, the estimated probability of observing y_1=1 is:

$$Prob(y_1 = 1 \mid y_2 = 1) = \ddot{O}_2(w_1, w_2, \tilde{n}). \tag{4}$$

In empirical econometric work, interest usually centers on the signs, magnitudes, and statistical significance of the changes in the expectation of the dependent variable caused by changes in an

independent variable. For example, it may be of interest to know the probability of borrowing for females relative to males, all other characteristics unchanged.

In models which are linear in parameters (such as ordinary least squares), it turns out that the change in the expectation of the dependent variable caused by a change in an independent variable is simply the parameter associated with the given independent variable. In such models, the estimated parameter and the estimated change are equivalent.

This equivalence does not hold in models which are not linear in parameters (such as the bivariate probit model with sample selection). In these cases, the estimated change in the expectation of the dependent variable (the probability of observing a given decision) caused by a change in an independent variable is a non-linear function of several parameters and also of several independent variables. In Table II, for example, the estimated parameter associated with **female** is 0.82, whereas the average difference in the probability of having borrowed for males as compared to females is 0.16 percentage points.

In general, the estimated change in the probability of observing y_2=1, given a change in an independent variable in the equation for the entire sample, is:

$$\frac{\partial Prob(y_2 = 1)}{\partial x_*} = \hat{a}'_{2*}\ddot{o}(w_2), \text{ and}$$
$$\frac{\partial Prob(y_2 = 1)}{\partial x_2} = \hat{a}'_2\ddot{o}(w2). \quad \textbf{(5)}$$

Likewise, the estimated change in the probability of observing y_1=1, given that y_2=1 and given a change in an independent variable in the equation for the selected sample, is:

$$\frac{\partial Prob(y_1 = 1 \mid y_2 = 1)}{\partial x_*} = \hat{a}'_{1*}\hat{a}'_{2*}\ddot{o}_2(w_1, w_2, \tilde{n}),$$
$$\frac{\partial Prob(y_1 = 1 \mid y_2 = 1)}{\partial x_i} = \hat{a}'_i\ddot{o}(w_i)\ddot{O}(v_i), \; i = 1, 2. \quad \textbf{(6)}$$

There are two methodological implications of the non-equivalence of the parameter associated with an independent variable and the estimated change to the expectation of the dependent variable caused by a change in the independent variable. First, the estimated change varies over observations. This is because the estimated change depends on several independent variables and the values of these independent variables vary over observations.

Second, the change in the expectation of the dependent variable is a function of the estimated parameters which are themselves random variables. The change is thus itself a random variable with a distribution.

In this study, the first consideration is handled by calculating the estimated changes caused by each independent variable for each observation in the sample and then reporting the average. This method is

better than calculating the estimated change in the probability only at the mean values of the independent variables (McDonald and Moffitt, 1980).

The second consideration is handled by using the delta method to calculate the asymptotic standard errors of the estimated changes and then reporting the average (Greene, 1993). The ratio of the estimated changes and the standard errors of the estimated changes is unknown, but it roughly suggests the statistical significance of the estimated change. Nearly all authors report only the standard errors of the estimated parameters, even though it is the standard errors of the estimated changes that matter.

The delta method finds the estimated standard errors by taking the square root of the diagonal of the quadratic form of $\boldsymbol{\Ø}$, the estimated variance-covariance matrix of the estimated parameters, and $\boldsymbol{J}$, the Jacobian matrix of the estimated changes in the expectation of the dependent variable caused by changes in the independent variables with respect to the estimated parameters:

$$\acute{O} = \sqrt{diag(J' \Ø J)}. \qquad \textbf{(7)}$$

For the equation for the entire sample, the elements of the Jacobian for changes in $\boldsymbol{X}_*$ are:

$$\frac{\partial\left\{\frac{\partial Prob(y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_{2*}'} = \ddot{o}(w_2)(1 - w_2 \hat{a}_{2*}' X_*), \ \textit{and}$$
$$\frac{\partial\left\{\frac{\partial Prob(y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_2'} = -\hat{a}_{2*}' X_2 w_2 \ddot{o}(w_2). \qquad \textbf{(8)}$$

The elements for changes in $\boldsymbol{X}_2$ are:

$$\frac{\partial\left\{\dfrac{\partial Prob(y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_{2*}'} = -\hat{a}_2' X_* w_2 \ddot{o}(w_2), \text{ and}$$

$$\frac{\partial\left\{\dfrac{\partial Prob(y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_2'} = \ddot{o}(w_2)(1 - w_2 \hat{a}_2' X_2). \qquad \textbf{(9)}$$

For the equation for the selected sample, the elements of the Jacobian for changes to $\boldsymbol{X}_*$ are:

$$\frac{\partial\left\{\dfrac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_{1*}'} = \hat{a}_{2*}' \ddot{o}_2(w_1, w_2, \tilde{n})[1 + \hat{a}_{1*}' X_* 2(\tilde{n} w_2 - w_1)],$$

$$\frac{\partial\left\{\dfrac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_1'} = \hat{a}_{1*}' \hat{a}_{2*}' X_1 2\ddot{o}_2(w_1, w_2, \tilde{n})(\tilde{n} w_2 - w_1),$$

$$\frac{\partial\left\{\dfrac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_{2*}'} = \hat{a}_{1*}' \ddot{o}_2(w_1, w_2, \tilde{n})[1 + \hat{a}_{2*}' X_* 2(\tilde{n} w_1 - w_2)], \qquad \textbf{(10)}$$

$$\frac{\partial\left\{\dfrac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_*}\right\}}{\partial \hat{a}_2'} = \hat{a}_{1*}' \hat{a}_{2*}' X_2 2\ddot{o}_2(w_1, w_1, \tilde{n})(\tilde{n} w_1 - w_2), \text{ and}$$

$$\frac{\partial\left\{\dfrac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_*}\right\}}{\partial \tilde{n}} = \hat{a}_{1*}' \hat{a}_{2*}' \ddot{o}_2(w_1, w_2, \tilde{n}) \ddot{a}^2 (\tilde{n} + w_1 w_2 + 2\ddot{a}^2 \tilde{n} b).$$

The elements for changes to $\boldsymbol{X}_1$ are:

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_1}\right\}}{\partial \hat{a}_{1*}'} = \hat{a}_1' X_* \ddot{o}(w_1)[\ddot{o}(v_1) - w_1 \ddot{O}(v_1)],$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_1}\right\}}{\partial \hat{a}_1'} = \ddot{o}(w_1)[\ddot{O}(v_1)(1 - \hat{a}_1' x_1 w_1) + \hat{a}_1' X_1 \ddot{o}(v_1)],$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_1}\right\}}{\partial \hat{a}_{2*}'} = \hat{a}_1' X_* \ddot{o}(w_1)\ddot{o}(v_1), \qquad \textbf{(11)}$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_1}\right\}}{\partial \hat{a}_2'} = \hat{a}_1' X_2 \ddot{o}(w_1)\ddot{o}(v_1), \ \textit{and}$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_1}\right\}}{\partial \tilde{n}} = \hat{a}_1' \ddot{o}(w_1)\ddot{o}(v_1)\ddot{a}(\ddot{a}\tilde{n}v_1 - w_1).$$

The elements for changes to $\boldsymbol{X}_2$ are:

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_{1*}'} = \hat{a}_2' X_* \ddot{o}(w_2)\ddot{o}(v_2),$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_1'} = \hat{a}_2' X_1 \ddot{o}(w_2)\ddot{o}(v_2),$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_{2*}'} = \hat{a}_2' X_* \ddot{o}(w_2)[\ddot{o}(v_2) - w_2 \ddot{O}(v_2)], \qquad \textbf{(12)}$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_2}\right\}}{\partial \hat{a}_2'} = \ddot{o}(w_2)[\ddot{O}(v_2)(1 - \hat{a}_2' X_2 w_2) + \hat{a}_2' X_2 \ddot{o}(v_2)], \textit{and}$$

$$\frac{\partial\left\{\frac{\partial Prob(y_1=1\,|\,y_2=1)}{\partial X_2}\right\}}{\partial \tilde{n}} = \hat{a}_2' \ddot{o}(w_2)\ddot{o}(v_2)\ddot{a}(\ddot{a}\tilde{n}v_2 - w_2).$$

A Gauss program, available from the authors, was used to compute the estimated changes and their standard errors.

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