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A REVIEW OF EMPIRICAL STUDIES OF DEMAND FOR AGRICULTURAL LOANS

By

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INTRODUCTION

Rural financial markets in most low income countries are highly regulated. Usury laws set interest rates that often do not equate loan supply with demand. With the generally high inflation rates in recent years, usury laws have frequently resulted in negative real interest rates and, therefore, non-price credit rationing. Several policy instruments are also aimed at influencing the allocation of scarce loanable funds to priority sectors or activities through lending quotas, rediscount arrangements, special credit programs, and so forth. To determine budget requirements, planning agencies estimate the amount of funds the sector and/or activity "needs" or will "demand" under alternative policy scenarios. With concessionary interest rates and excess loan demand, it is not surprising that government expectations regarding sectoral, functional, and personal loan allocation as well as viability of special credit programs frequently are not realized [1].

In this paper, we review some of the recent literature on loan demand. The emphasis is on low income countries. The studies reviewed are classified into 1) those dealing mainly with projections of loan demand, and 2) those which quantify loan demand relationships. The latter group is important, not only as they relate to credit planning, but also in facilitating analysis of policy issues concerning rural finance such as the on-going debate regarding th appropriateness of concessionary interest rates. The emphasis throughout the paper is on metho-odological issues rather than on empirical results per se. Likewise, the approach is illustrative rather than comprehensive in the literature review.1/

The first section of the paper presents a conceptual model of factors affecting demand for loans. This model is useful in evaluating the methodologies used in the studies reviewed. Next, studies are reviewed covering projections of agricultural loan demand. The following section reviews econometric and mathematical programming studies which estimate loan demand relationships. The final section contains a few comments about directions for future research.

A MODEL OF FARM HOUSEHOLD LOAN DEMAND

The integrated nature of consumption and production decisions of farm households in low income countries has been increasingly recognized in the literature [21, 27]. The supply of savings, labor, and other resources of most rural households are applied to farm production and a significant part of production is consumed

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1/ We recently prepared another paper reviewing methodological issues associated with measuring the impact of borrowing on farmers [11]. An annotated bibliography of the studies reviewed for these two papers is available [10].

by the farm-household. Decisions with respect to consumption and savings, leisure and work, farm input allocation, borrowing and lending are expected to be interdependent. A conceptual model is presented in this section to identify factors affecting demand for credit by a farm-household.2/ The model follows Hirschleifer's model of optimal investment decisions. The conditions under which the demand for production credit are inseparable from consumption credit are also discussed.

For simplicity, assume a farm-household (FH) facing a two-period time horizon, perfect capital markets, and certain production and price relationships. The FH decision framework is portrayed in Figure 1 where the horizontal axis denotes present consumption (C_o) and the vertical axis future consumption (C_1). The income possibilities curve (PP_1) depicts the various attainable combinations of present and future consumption, given factor endowments, output and input prices, and available production technology for both farm and nonfarm enterprises. The slope at any point on PP_1 is $-(1+r)$ where r measures the marginal rate of return on investment. A curve lower than PP_1, say PP_2, represents a more rapidly declining rate of return on investment.

The FH time preference for present and future consumption is indicated by the family of indifference curves, U_o, U_1,...,.

2/ A more detailed explanation of this conceptual framework in understanding farm-household financial behavior is given in another paper [9].

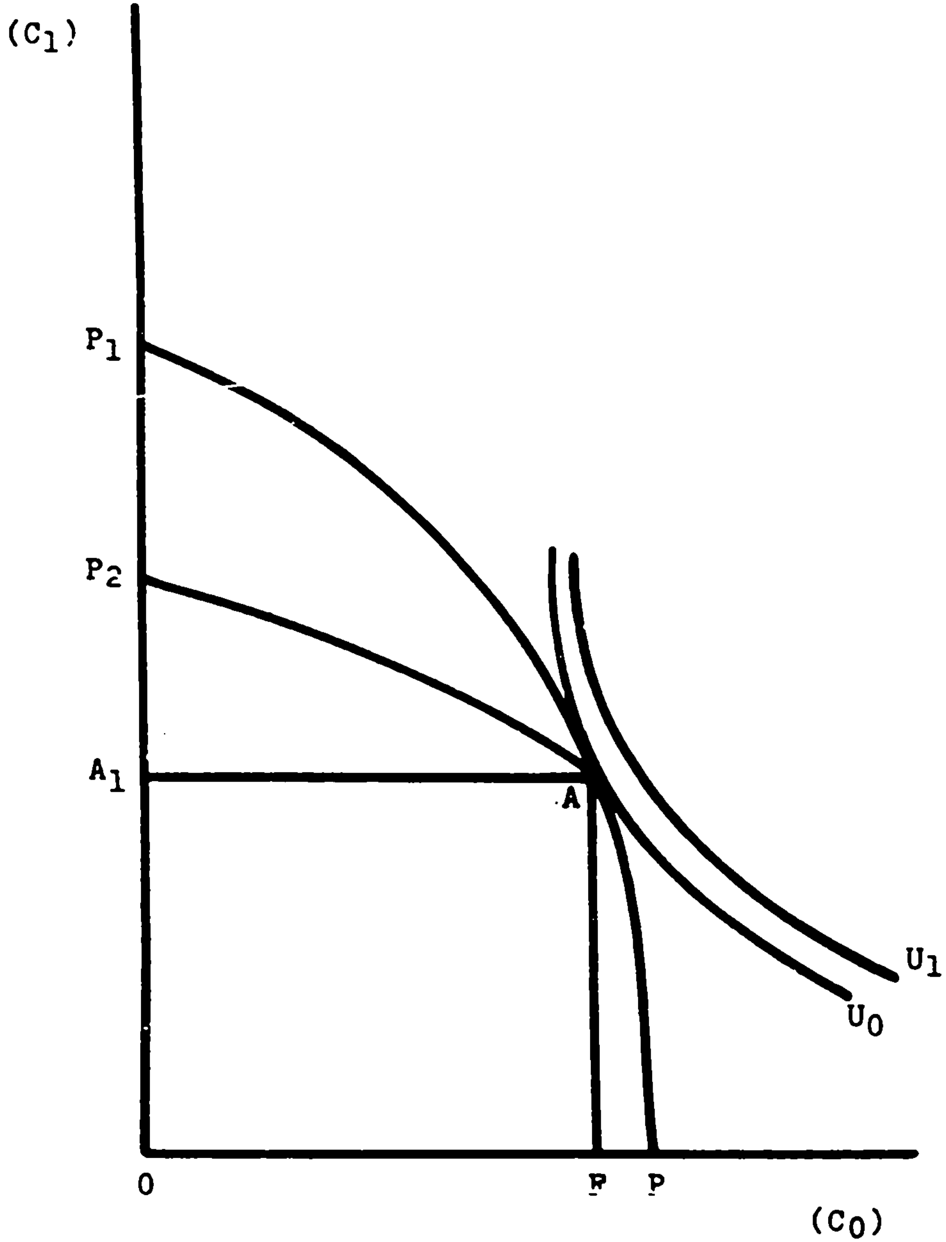

Figure 1a. Farm-Household Resource Allocation Without a Financial Market

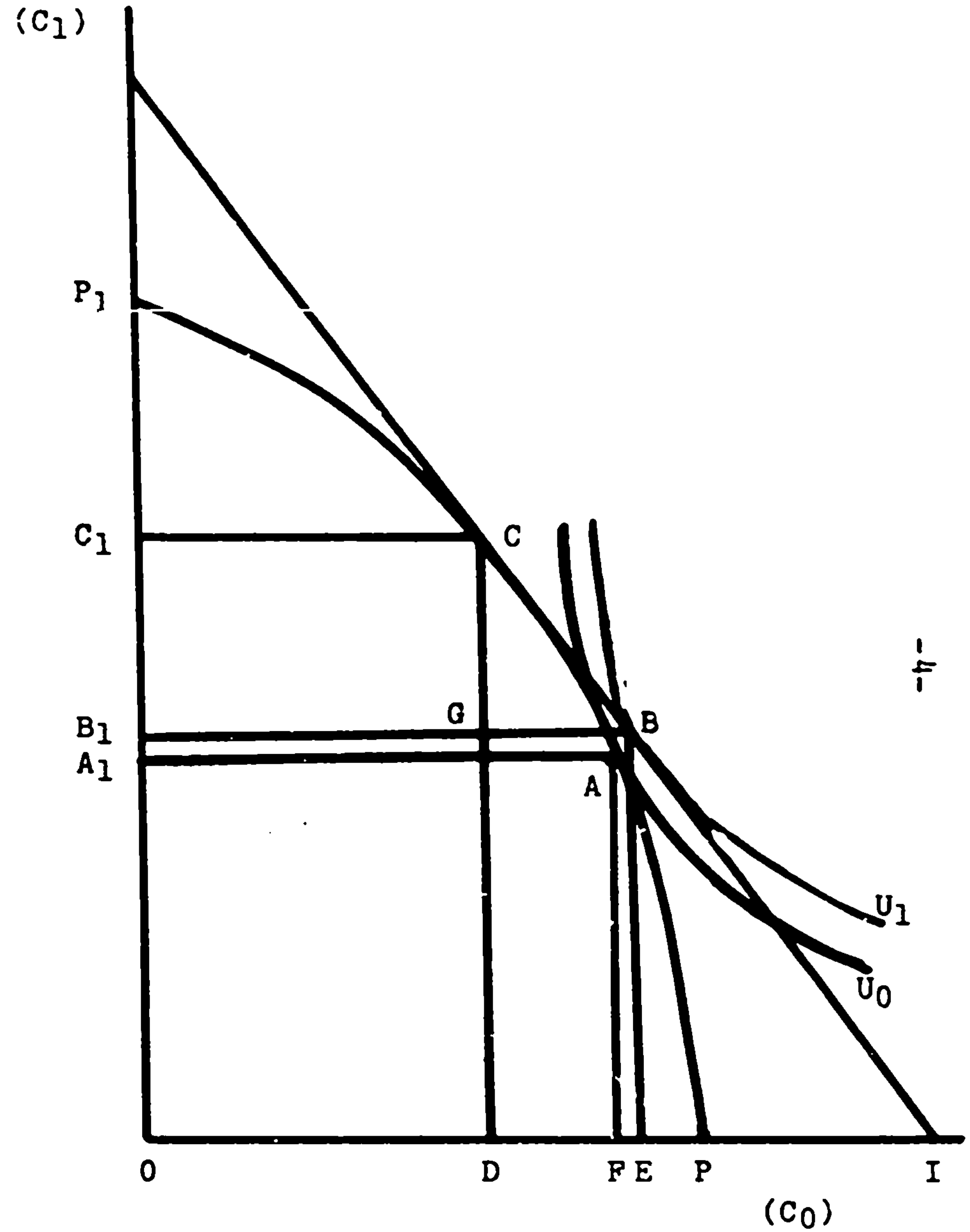

Figure 1b. Farm-Household Allocation With a Financial Market

Time preference depends on a variety of factors such as level of real income, expected time pattern of income flows, and personal characteristics of the household like frugality, foresight, habit, value systems, etc. The curves for both income possibilities and preferences have the usual neo-classical properties of diminishing marginal rate of return on investment and diminishing marginal rate of substitution between present and future consumption.

The FH is assumed to maximize utility or preference level subject to the income possibility curve. Without financial markets, the optimal level of production and consumption is A where the marginal rate of transformation in production is equal to the marginal rate of substitution in consumption. In terms of Figure 1a, OF will be consumed and FP invested for future consumption of OA_1.

Figure 1b illustrates FH behavior with a perfect financial market. With a constant interest rate, i, shown by the slope $-(1+i)$ of the market opportunity line I_1I, the FH will produce at C equating the marginal rate of return on investment to the interest rate. Optimum consumption is at B where the market opportunity line is tangent to the highest possible utility level. Demand for loans will be DE to be repaid with C_1B_1 from future income. Thus, the financial market raises investment from FP to DP, present consumption from OF to OE, future consumption from OA_1 to OB_1 and utility from U_0 to U_1.

The FH model in Figure 1b suggests that various factors affect demand for loans. Cost of borrowing is expected to be negatively related with demand. The elasticity of demand with respect to cost of borrowing will depend on the shapes of the income possibilities and time preference curves.3/ The nature of farm household investment opportunities also affects demand. Technological change, higher farm prices, greater factor endowments and better nonfarm investment opportunities raise demand. Changes in relative prices and technology, which increase optimal level of divisible inputs (e.g. fertilizer) or employ under-utilized resources (e.g. family labor), will have a lesser impact on loan demand because the additional cash requirements are more easily financed by increased savings. Conversely, changes in loan demand will be greater with technological and price changes requiring lumpy inputs such as irrigation pumps or agricultural machinery.

Loan demand is also influenced by the farm-household's time preference between present and future consumption. Low income farm-households or households with rising or fluctuating income are likely to have stronger preferences for present

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3/ It should be noted that the relevant variable is the effective cost of borrowing including interest rate, other charges, and borrower's transactions costs. The smaller the proportion of interest cost (which is typically the variable specified) to the effective cost of borrowing, the more understated is the estimated interest elasticity of demand.

consumption. Thus, demand for loans will be higher to finance present consumption, ceteris paribus.

Other explanatory factors of loan demand have not been considered in this highly simplified model. Perhaps the most important are the substantial yield and price risks facing farm-households in low income countries. Risk and uncertainty affect demand through their impact on resource allocation and through adjustments made for unusually high expenditures or low income [17]. The adoption of new cash intensive technological innovations may be impeded by yield and price uncertainty. Borrowing, rather than selling assets, may be a cheaper source of funds to cope with short-run cash-flow problems.

Institutional arragements, such as land tenancy systems, which affect FH cash flow patterns may also affect loan demand. With crop sharing or fixed rental tenancy, farm income is often received only at the end of the crop season. Thus, the household borrows for subsistence during lean months. When the FH provides hired labor employed by landlords, there is less problem in reconciling uneven income and expenditure flows. Likewise, labor income from off-farm activities may facilitate FH cash management.

Most studies of loan demand focus on production factors, especially those studies primarily concerned with projecting farm-level and aggregate levels of borrowing. This emphasis may be explained in part by the policymakers' concern with increasing agricultural production. However, it is clear in Figure 1b that the separation of production from consumption decisions is limited to certain conditions. The assumption of perfect financial markets permits such separation, i.e., household preferences are not required to predict optimal production allocation and, conversely, the income possibilities curve is not necessary to predict household consumption decisions. With the commonly held assumption of fixed savings rate, the optimal level of borrowing is likewise separately determined. On the farm production side, demand for borrowing is the difference between desired investment and savings. On the household consumption side, demand for borrowing is the difference between present income and desired present consumption.

In most low income countries, however, the assumption that savings respond to changes in investment opportunities as well as income appears more plausible because of the dynamic economic and technological environment facing farm-households in many countries.[4/] Financial markets are also highly imperfect. Interest rates for formal institutions are frequently set at concessionary levels, while rates in informal markets seek market levels. Hirschleifer showed that with financial market imperfections, such as when interest rates increase with scale of

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4/ This issue is a subject of much controversy because of the few empirical tests available [38].

borrowing; optimal levels of production, consumption, and borrowing are simultaneously determined.[5/]

The need for an interdependent FH model is also evident when the fungible nature of credit or money is understood. A unit increase in household liquidity becomes indistinguishable from a unit from another source. It will be allocated to the activity producing the greatest utility. If future consumption is preferred to present consumption, additionality may occur in farm or nonfarm activities, whichever is more profitable. If present consumption is preferred, the additional liquidity will be spent on present consumption. Observed expenditures of loans may not adequately reflect where the additionality occurred.[6/] Thus, distinguishing a demand function for production loans while ignoring consumption will likely lead to specification errors.

PROJECTIONS OF DEMAND FOR LOANS

Loan demand projection studies have been recently reviewed by Tinnermeier. They may be classified by the type of data and methodology employed into farm budgeting and time series aggregate approaches.

5/ This situation may be represented by a concave market opportunity line in Figure 1b.

6/ Even if loans were used to buy inputs like fertilizer, they may merely substitute for own resources or the fertilizer may be resold for money.

Farm Budgeting Approach

A farm budgeting approach is typically based on farm-level data and has been frequently used in low income countries. Examples include Columbia [42], India [34], and the Philippines [39]. Basically, a two-step procedure is involved. First, loan requirements are estimated for a representative farm. The average cash costs of production are calculated. Then a proportion of these costs is assumed to be self-financed and the balance funded from external sources. These proportions are judgemental, based on some notions of farm savings. The representative farm may be defined for different farm sizes, regions, crops, type of inputs, levels of technology, etc. Second, aggregate demand is established by multiplying the average loan required per hectare on the representative farm by the expected number of hectares to be financed by a credit program.

Normally the budgeting method refers only to short-term credit. A similar procedure could also be used for medium and long term loans if a proportion of expected capital investments was also assumed to be financed by external funds.

While the farm budgeting technique is simple, quick and gives the illusion of careful bottom-up planning, it is likely to produce estimates inconsistent with actual borrowing. For example, Vogel and Larson found virtually no relation between programmed and actual credit use for ten agricultural commodity groups in Columbia where elaborate budgeting methods were employed. The ratios between programmed and actual credit use ranged widely from .09 to 5.45 for the period 1971 to 1977 and the correlations between the two variables ranged from -.42 to .82.

Deviations between projected and actual borrowing should not be surprising since agricultural loans are influenced by a variety of supply and demand factors. The farm budgeting approach covers only potential farm demand for loans and ignores other household uses of loans. Furthermore, it is difficult to capture the great heterogeneity among farms in profitability of input use and household liquidity requirements. The budgeting approach also assumes that farmers are indifferent to borrowing costs and that lenders actually follow the lending targets set by policymakers. But, because of concessionary interest rates, lenders tend to minimize risk and transactions costs by rationing credit in favor of relatively progressive farmers with good previous borrowing histories. A large share of loans going to such farmers may not be consistent with government's objectives and targets.

Time Series Aggregate Projections

Estimates of aggregate loan demand for the agricultural sector have been made with trend analysis, ratio analysis, and a flow of funds approach. These models can be expressed, respectively, as:

1) $C = f(t)$

2) $C = f(Q)$

3) $C = f(K, Q)$

where C = aggregate loan demand

t = time

Q = gross or net agricultural domestic product

K = value of capital flows

In trend analysis a lending growth rate is estimated for past periods and projected into the future assuming that past determinants of supply and demand will continue unchanged. Ratio analysis assumes a stable relationship between loans and agricultural output [20]. An average relationship can be estimated based on historical data, or the marginal increase in loan demand per unit increase in agricultural output can be determined. Future loan demand is then estimated based on projections of future agricultural output.

With the flow of funds approach, it is argued that loan demand depends on savings potential as well as historical flows of capital and investment. Given a well established relationship between savings and income, loan demand is related to capital outlays and agricultural output. Melichar used this approach to estimate flow of funds in the U.S. Future capital outlays (fixed capital, inventories and land transfers) and future farm cash flows are carefully estimated based on historical data. Projected savings available for agricultural investments are computed as a proportion of future cash flows. This proportion is based on historical experience.[7/] Future loan

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7/ Data on past savings pertain to those allocated to farm investments and are computed as the difference between farm capital investment and borrowing.

demand is then estimated as the residual between projected farm investments and projected savings.

It might be expected that these more aggregate methods of projecting loan demand would be superior to the farm budgeting approach. Tinnermeier noted these methods provide better opportunity for capturing the effect of the various supply and demand factors associated with time, production and investment that historically determined lending. Many low income countries do not have the necessary data to estimate historical relationships. Furthermore, these approaches are less appropriate for those countries experiencing rapid technological change or for those countries attempting to rapidly expand the number of farmers served by formal credit sources. On the other hand, a country such as Brazil has expanded agricultural loans so rapidly that the subsidies involved are becoming very burdensome [6]. Thus, the growth rate of lending is likely to slow down.

EMPIRICAL ANALYSIS OF LOAN DEMAND RELATIONSHIPS

Quantitative estimates of the structural demand and supply relationships in rural financial markets would provide the basis for more meaningful projections of loans. Few studies have been conducted on these relationships in the U.S. and even fewer in low income countries, particularly concerning the supply function. This section reviews the econometric and mathematical programming studies conducted to estimate loan demand relationships.

Econometric Studies

Loan demand relationships have been quantified directly by specifying a loan demand function and indirectly by deriving demand elasticities from estimated profit functions.

Loan Demand Functions

Single equation loan demand models based on cross-section data have been typically used in low income countries. Table 1 summarizes four studies conducted for Brazil, India and Korea.[8/] The models included variables to represent cost of borrowing, farm and household expenditures, internal funds, and other socio-economic variables.

The measures for goodness of fit for these models were reasonably high given the cross-section nature of the data. Most coefficients were statistically significant and the signs of the coefficients met a priori expectations. Interest rate had the expected negative sign and was significant for India, but not for Brazil. This discrepency may be explained by the wider use of informal credit in India which may have introduced greater variation in the interest rate variable. Alternatively,

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8/ The two Indian studies by Long and Pani were based on the same 1951-52 data. The number of observations in the Long study was higher because district level data were divided into subclasses.

TABLE 1. Empirical Results of Selected Estimates of Linear Demand Functions for Loans Based on Single Equation Models

Variables	Brazil (1965)	India Long (1951/52)	India Pani (1951/52)	India Pani (1956/60)	Korea (1970)
Interest Rate	-22.320 (-0.244)[a]	-5.9 (-2.6)	-4.43 (-2.41)	4.04 (-1.44)	
Value of Investment	0.218 (4.281)	0.53 (11.1)	0.74 (5.26)	0.63 (2.86)	0.928 (77.325)
Transitory Income		-0.11 (-1.2)			
Net Cash Farm Income	-0.184 (-4.153)				
Assets		0.02 (5.4)	0.004 (1.00)	0.001 (0.20)	
Family Expenditures		0.20 (3.7)	0.16 (1.78)	0.22 (1.47)	
Cash at Beginning of Year					-0.823 (-31.780)
Debt Outstanding	0.860 (3.168)				0.577 (7.540)
Debt Outstanding/Value of Assets	-268.260 (-2.695)				
Years of Schooling	604.600 (1.777)				
R^2	0.74	0.39	0.77	0.84	0.22
Interest Elasticity			-.43	-.25	
Number of Farms (Districts)	132	(672)	(75)	(36)	438

Sources: Brazil [5], India [25, [illegible]], [illegible].

a/ Values in parentheses are t-values.

the specification problem may be greater in Brazil where interest rates have been set so low relative to market clearing rates.

Value of investment was the most significant variable in all studies. Family expenditures were important in India. Demand for loans declines as the value of internal funds rises. Value of assets can represent several factors. On the demand side, they may denote availability of internal funds, investment opportunities, and ability to cope with risks. On the supply side, assets may reflect value of collateral. The positive coefficient indicates investment opportunities and value of collateral are important in explaining borrowing. The possibility of supply constraints is also shown by the negative coefficient for debt outstanding/value of assets found in Brazil.

A unique feature of Long's study was the specification of transitory income as a measure of farmer risk. Transitory income, measured as the ratio of actual to anticipated income, was found to be negatively correlated with loans implying that farmers tend to borrow more when incomes are unexpectedly low. As noted earlier, Jodha also found a significant role of credit as a means to adjust to unexpected changes in income or expenditures based on a different set of data and methodology.

Pani further examined whether the loan demand relationship differs between low and high income farmers. Table 2 presents the demand elasticities by income group. Differences in interest rate elasticity of demand are important in determining the potential distributional effect of changing interest rates.

TABLE 2. Loan Demand Elasticities for Different Income Groups, India.

Period, Subgroup of Cultivators (1)	Elasticity with Respect to Changes in				
	Interest Rate (2)	Capital Expenditure (3)	Family Expenditure (4)	Assets (5)	Total Expenditure (3)+(4)
1951-52					
Top 50%	-0.51*	0.71*	0.28	0.09	0.99
Bottom 50%	-0.10	0.62*	0.34*	0.11	0.96
1956-60					
Top 10%	-0.15	0.82*	0.12	-0.04	0.94
Top 30%	-0.10	0.88*	0.02	-0.01	0.90
Middle 40%	-0.39*	0.08	0.91	0.11	0.99
Bottom 30%	-0.25*	0.05	0.88*	-0.02	0.93

*Based on statistically significant coefficients.

Source: [31].

Unfortunately, the results did not show a consistent pattern. Demand appears to be more interest elastic among high income farmers in 1951-52, but the converse was true for the later period. A consistently higher elasticity of demand with respect to family expenditures was found for lower income farmers.

Simultaneous equation models avoid the inherent identification problem with estimating loan demand relationship. Studies based on this approach have been limited to the U.S. based on aggregate time series data. Results of the studies of the demand for real estate mortgage loans in the U.S. by Hesser and Schuh and Lins, covering slightly different time periods, are summarized in Table 3.[9/] The empirical models were estimated either by the limited information technique or by two-stage least squares. The analysis was limited to farm loans which may be justified given the relatively small share of demand for consumption loans and the nearly perfect U.S. financial markets. Hesser and Schuh defined credit in aggregate gross flows including refinancing of past debts, while Lins defined credit in net flow terms. The independent variables differed but can be classified into three categories: variables representing cost of borrowing, internal funds and investment opportunities. Hesser and Schuh included a lagged credit

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9/ The supply equations included interest rate, rate of return on alternative investments, national savings, rate of change of money stock, collateral, expectation variables, and time deposits.

TABLE 3. Empirical Results of Selected Estimates of Linear Demand Functions for Loans Based on Simultaneous Equation Models

Variables	Hesser & Schuh (1921-59)	Lins (1947-69) Land Bank	Commercial Bank	Insurance	Others
Interest Rate	-0. 90 (-1. 80)[a]	-3. 53 (-0. 06)	3. 35 (0. 05)	-337. 23 (-4. 68)	-17. 37 (-0. 12)
Internal Funds:					
Farm Income	-1. 99 (-2. 62)				
Money Balance/Gross Farm Expenses		-17. 01 (-2. 54)	-4. 75 (-0. 73)	-36. 93 (-5. 20)	-20. 00 (-1. 61)
Investment Opportunities:					
Technology	-3. 36 (-2. 90)				
Wage Rate	0. 91 (3. 07)				
Net Capital Appreciation		5. 05 (0. 72)	7. 14 (1. 32)	3. 99 (0.68)	20. 45 (2. 11)
Net Farm & Nonfarm Income		19. 84 (2. 00)	11. 29 (1. 34)	22. 28 (2. 45)	16. 90 (2. 39)
Others:					
Lagged Credit	0. 86 (3. 66)				
R^2	0. 66	0. 83	0. 64	0. 71	0. 82
Interest Elasticity	-2. 29	* [b]	*	-8. 37	*

Source: [15, 24].

a/ Values in parentheses are t-values.

b/ Elasticities were not computed because the coefficients were not significantly different from zero.

variable to distinguish short and long run response to interest rate.

The results reported in Table 3 are generally statistically significant and the signs of the coefficients tend to meet prior expectations. Relatively more highly significant coefficients appeared in the Hesser and Schuh model in spite of a lower goodness of fit compared to most of Lins' models. Demand for loans appears less interest elastic in the Hesser and Schuh results contrary to expectations that a gross flow concept of credit would imply a higher elasticity than a net flow definition. The negative effect for technology suggests an increase in income and supply of internal funds, thus reducing demand for external funds. Demand increases with farm wages suggesting a substitution of capital for labor. Lins found that internal funds and investment opportunities were significant variables but interest rate did not seem to affect demand except for loans from insurance companies.

Profit Functions

Although the profit function model of farm resource allocation has been increasingly used in recent years, only two of these studies are related to farm-household financial behavior. Lerttamrab showed that liquidity and credit constraints affected economic behavior of farm-households in Northern Thailand. The other study by Kumar, et al., discussed below, is more directly concerned with estimating a demand function for loans based on a sample of farmers in Uttar Pradesh, India.

First, a profit function is estimated with the following independent variables: price of variable inputs (P_i), price of output (P), and fixed inputs-land (L), family labor (N_f), and bullock labor (N_b). Amount borrowed (C) is defined as the difference between the demand for variable input and supply of own capital. The latter in turn is assumed to be a function of previous crop season's profits (Π^*). The coefficients of the demand function for credit are then computed from the estimated coefficients of the profit and supply of own capital functions.[10/] Since the price of variable inputs is measured as the market price plus interest rate, the elasticity of loan demand with respect to interest rate can also be derived.

The computed coefficients of the loan demand function based on generally significant estimates of the profit and own capital supply functions for one crop season is reproduced below:

$$C = .01\ P_i^{-2.66}\ L^{0.62}\ N_f^{0.27}\ N_b^{0.17}\ P^{2.66} - 57\Pi^{*0.32}$$

These results indicate that demand for loans is highly responsive to changes in input and output prices. On the other hand, computed interest rate elasticities ranged from -.13 to -.57 for levels of interest rate from 10 to 70 percent. Thus, this study suggests that demand for credit by farmers in this area appears to be inelastic with respect to the rate of

10/ Coefficients of input demand function are derivable from Shephard's Lemma [22].

interest, but highly elastic with respect to prices of both inputs and output.

Despite the apparently good statistical results and consistency in these econometric studies, there are a number of problems which suggest caution in interpretation. For example, the estimated inelasticity of loan demand with respect to interest should not yet be taken as conclusive in these studies. First, the potential identification problem in single equation models has not been thoroughly evaluated. Given the concessionary interest rate observed in many countries, how valid is the implicit assumption typically made with single equation and profit function approaches that the supply function is perfectly elastic or inelastic? The inclusion of both supply and demand variables in the Brazilian and Indian studies suggest that a reduced form of the supply and demand model is being estimated, but the structural specification has not been presented. Simultaneous equation models which may resolve this problem have not been applied in low income countries primarily because of data limitations. There has been little attempt to collect micro-level data to study lending behavior and adequate time series aggregate data are usually not available.

As noted earlier, most empirical specifications of demand for loans have not included factors affecting demand for consumption loans. The possible interdependence of production and consumption decisions and fungibility of loan proceeds seems to have been ignored. An explicit conceptual model of loan demand would have clarified these issues and avoided some econometric problems. For example, from Figure 1b it is apparent that investment and family expenditures are simultaneously determined with demand for loans. Variables representing investment opportunities or profitability and time preference between present and future consumption potentially influence loan demand. Direct measures of these variables, however, such as output-input price ratio, adoption of new technology and level of income are more appropriate than ex post levels of investment or consumption which depend in part on loan use.

Finally, interest rates do not necessarily reflect borrowing costs. It has been shown that borrowing costs, especially for small farmers, may be much higher due to transaction costs of obtaining a loan [2]. If interest rates represent only a small share of effective borrowing cost, a small change in interest rate will have little effect on borrowing cost, and thus, loan demand.

Mathematical Programming Studies

Mathematical programming has been used in a wide variety of studies of agricultural credit. Table 4 highlights the main characteristics and results of a sample of these studies reviewed for this paper. These studies represent a combination of positive and normative approaches to research. On the one hand, the researchers try to replicate farmer behavior as much as

TABLE 4. Characteristics and Selected Results of Mathematical Programming Studies of Demand for Agricultural Loans

Authors & Study Area	Study Objectives	Objective Function	Selected Model Characteristics	Financial Component	Illustrative Results
SINGLE PERIOD LINEAR MODELS:					
Engler & Meyer; Rio Grande do Sul, Brazil	Analyze impact of wheat program	Maximize net farm profits	Typical wheat farm; simulated product prices and interest rate changes	Initial cash balance; loans for modern inputs and operating expenses	Increased interest rates had little impact on resource use and income
Patrick; N.E. Brazil	Analyze possible effect of government prices	Maximize net farm income	Various sizes; three counties; crops and livestock; simulation of alternative technologies, fertilizer and crop prices, land purchase and interest rates	Operating and investment loans from formal sources	Reduction in fertilizer prices and interest rates had little impact except on income distribution
White; Minas Gerais, Brazil	Analyze regional development potential	Maximize net farm income	Twelve typical farm situations; crop and livestock; simulated technology, borrowing limits, interest rates and specialized loan programs	Operating and investment credit from formal sources	Borrowing capacity limited adoption of technology; results insensitive to interest rates
MULTIPLE PERIOD LINEAR MODELS:					
Ahmed; Gezira, Sudan	Analyze supply and demand for credit	Maximize profits	Six farm types; 24 semi-monthly periods; minimum consumption constraints; production and marketing; parameterized interest rates and borrowing limits	Initial cash constraint; formal and informal loans	Borrowing required to reach optimum income; increased interest rates had little effect on income
Alexander; West Java, Indonesia	Analyze policy alternatives for Bimas program	Maximize net farm income	Six farm types by liquidity and size; consumption constraints; off-farm business specified; three crop seasons; parameterized interest rates, credit allocation rules, payback period and credit in-kind	Borrowing and savings activities; borrowing limits for each type of loan	Interest rates could be raised to 5% per month with little effect on borrowing; increasing loan costs altered marketing practices
Baker & Bhargava; Uttar Pradesh	Analyze liquidity management	Maximize farm returns plus values of cash and credit	Small farm; wet and dry seasons; minimum crop and cash requirements; reserve values for cash and credit	Borrowing from moneylenders and small farmer credit program; parameterized cash and liquidity requirements	Models with reserves concept approximate farmer plans; reliable sources of small farmer credit increase output and income
Hadiwigeno; East Java, Indonesia	Analyze effect of changes in credit policy	Maximize farm net income plus value of cash and credit reserves	Small farms in four villages; one year planning horizon; six seasons; padi and other annual crops; minimum household pati; simulated changes in Bimas credit	Borrowing from moneylender, bank and Bimas program	Changed terms for Bimas loans affected marketing; little effect on production; little effect of increased interest rate
Ladman; Ejido farm, Mexico	Analyze impact of short-term credit on farms	Maximize net farm income	Small crop farm; alternate fertilizer levels, insecticides and power sources; tests for internal and external credit rationing; parameterized borrowing limits	Monthly borrowing constraints; no savings	Limited credit explains unused land; fixed interest rates misallocates credit

Boehlje and White	Analyze investment and production decisions in firm growth	Maximize farm net worth or discounted future disposal income	160 acre hypothetical farm; ten-year planning horizon; investment, credit, debt servicing, land renting and income transfer activities; minimum consumption requirement	Long and intermediate term formal credit tied to net worth	Increased specialization in hogs; substitution of capital for labor; net worth maximization results in higher credit use and lower disposable income
Naseem; Punhab, Pakistan	Analyze effect of government policies on growth	Maximize discounted future net farm income	Small farm; four-year planning model; winter and summer seasons; simulated borrowing limits, savings rates, product prices and farm size	Borrowing and savings activities	Credit constrains full use of resources; farmers would borrow triple initial loan availability at prevailing interest rates; shift to higher-value crops and improved technology with loan
Oliveria; Goias, Brazil	Analyze demand for loan	Maximize present value of inflated farm net revenue	Three farm sizes; 12 year planning horizon; crops and livestock; minimum consumption constraints, future inflation; investment in land and machinery; parameterized interest rates, inflation rates and discount rates	Borrowing tied to net worth; initial cash balance; short, intermediate and long term formal loans	Loan demand inelastic with respect to interest rate; discount rate and rate of inflation affect farm income
MULTIPLE PERIOD RECURSIVE LINEAR MODELS:					
Day and Singh; Punjab, India	Analyze agricultural transformation	Maximize regional net farm profits each year	Regional model; regional cash and consumption constraints; feedback constraints; historic behavior 1952-65; projections to 1980	Borrowing and savings activities; loans tied to gross sales; operating and investment loans	Increasing internal finance overtime; elasticity of demand for loanable funds increases over time
Singh and Ahn; Rio Grande do Sul, Brazil	Analyze regional development process	Maximize regional net farm income each year	Three farm size models; crops and livestock; ten year period; feedback constraints; simulated alternative credit and price policies	Operating and investment credit from formal sources	Derived demand for loans showed increasing elasticity over time; small farms were relatively insensitive to interest rates
SINGLE PERIOD QUADRATIC MODELS:					
Peres; Sao Paulo, Brazil	Estimate derived demand for credit under risk and inflation	Minimize variance of farm income	Small and large farm models; crops and livestock; price expectation model; parameterized interest rates and labor supply	Initial savings; borrowing limits for loans for modern inputs and general expenses	Actual borrowings exceeded predicted for small farms, while large farms borrowed less than predicted
Schluter; Surat District, India	Analyze cropping pattern	Minimize mean absolute deviation of cash income (MOTAD)	Typical farms; irrigated and non-irrigated farms; annual crops; minimum consumption constraints; parameterized family size, farm size, wage rates and interest rates	Savings and borrowings from moneylender and cooperative; borrowing limits for formal and informal loans	Loans were required for production of high-income crops; interest rate has little effect
Soares; Northeast Brazil	Determine optimum resource use under risk	Minimize variance of farm income	Large farms; one cropping season; simple and inter-planted crops; sharecropping; parameterized technology, cotton prices, wages, labor supply, borrowing limits	Cash constraints; formal loans	Fifty percent reduction in formal borrowing limit reduced sharecropping and farm income, while increasing income variance

possible and frequently validate their models by comparing model results with observed behavior. On the other hand, these models often have their greatest usefulness in identifying what farmers should do to achieve the objective function when change is introduced in some paremeter, activity, or constraint of the model.

Several mathematical programming studies test the farm level impact of borrowing.11/ Demand for loans is assessed by analyzing optimum enterprise mix, resource use, and farm income under simulated conditions which may include one or more interest rates on formal and/or informal loans. Thus, the optimum amount of borrowing is determined for one or more interest rates. Other researchers deal more directly with loan demand by parameterizing the interest rate over a wide range so a derived demand curve is obtained.

The studies summarized in Table 4 show the evolution that has occurred in programming studies of agricultural loan demand. Single period linear models are most common, partly because cross-sectional surveys provide the basic data for much research. Multi-period models have been used to advantage when the objective is to analyze borrowing for investment as well as working capital. For long-term planning horizons, researchers have discounted future cash flows in multi-period models to account for time preferences in consumption. Recursive

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11/ See our paper on impact of borrowing for a review of these studies [11].

models also analyze multi-period behavior but assume the objective function is maximized (or minimized) in each model period rather than for the entire planning horizon. Recursive models are also used to introduce flexibility constraints which link model periods and constrain each solution to more adequately reflect farm level adjustments in the face of uncertainty or physical constraints. Quadratic models to minimize variance of income have also been used to incorporate aspects of uncertainty into farm planning.

Two general results regarding loan demand emerge from these studies. The first is that the supply of formal credit influences model outcomes; that is the optimum solution in many models is constrained by the formal credit borrowing limit. When the constraint is relaxed, the optimum solution changes. Thus, researchers argue that adoption of new enterprises and technologies requires an abundant supply of formal loans.

Second, the optimum solution is fairly insensitive to the interest rate set for formal loans. Thus, demand for loans is fairly interest rate inelastic over the range of interest rates considered. The activities in the model are so profitable with respect to use of capital and the costs of borrowing are so small relative to other costs that an increase in interest rate makes little impact. If there is any response to interest rate changes, it usually occurs in models of larger farms. Models for small farms have produced results more insensitive to interest rates than large farm models [12, 33, 36].

Despite the similarity of results of these studies, caution in interpretation is required. It is our contention that the underlying limitations of these models produce the results obtained, and if the models could be improved the results might be quite different.

Consider the following problems. Although complex regarding farm activities, most models are quite simple compared to the wide range of activities of a typical farm-household. For example, family consumption is either left out entirely, or a fixed amount is subtracted from initial cash balances, or a fixed consumption function is specified in multi-period models. Few researchers have provided for portfolio diversification and income generation through financial savings and nonfarm activities. Working capital models usually ignore potential leakage of short-term loans into investment activities. Models of small farms frequently include few technological alternatives for capital/labor substitution. Furthermore, they are usually so constrained by land, labor, subsistence and other constraints that few feasible solutions are possible. If these shortcomings could be overcome, we suspect that in many cases demand for loans would be much greater and demand more elastic.

On the other hand, it is not clear that farmer attitudes towards borrowing and alternative sources of loans are understood and adequately modelled. For example, it is not clear that farmers have a fixed amount of savings to apply toward new technology. The promise of a high future return may cause farmers to reallocate current expenditures and self-finance large increases in working capital. It is assumed that farmers will borrow the maximum amount that is profitable and that interest rate alone will dictate source. Yet Baker and Bhargava, Hadiwegeno, and Tewari and Sharma have shown that the reservation price of unused credit may increase as borrowings increase, so farmers may exercise internal credit rationing. The ease and reliability of obtaining loans from informal sources and the need to protect valued sources suggests that farmers may use and repay informal sources more readily than formal ones. Current efforts to model risk have focused on the level and variability of income. But additional work is needed to link variability of income with leverage under various repayment schedules to more adequately capture financial risk. If these issues were more adequately treated in these models, it is quite likely that demand for loans would be less than currently predicted.

Finally, there is the problem of borrowings costs. Interest rates underestimate total borrowing costs and the degree of underestimation is probably greatest with small loans. With large loans to established customers, interest rates probably more closely reflect farmer borrowing costs. The problem of inflation complicates the interest rate issue. Single-period models tend to ignore the fact that real interest rates are frequently low and sometimes negative. Multi-period models attempt to deal with the problem of inflating the prices of production inputs, fixed assets and consumption goods. If the price of assets is inflating at a rate greater than the nominal interest rate, the solution will always exhaust the borrowing constraint subject to debt repayment capacity and other constraints. Thus in many models the so-called "demand" for loans is determined by the specification of the supply of loans; i.e., the borrowing limit. In such cases, the aggregate demand can be easily determined by equating it with expected supply and the only planning problem is one of deciding who should get it.

CONCLUSIONS

In this paper, we first presented a conceptual model which identified the cost of borrowing, investment opportunities and time preference for consumption as the principal factors affecting farm-household demand for loans. It was further argued that since capital markets are imperfect, savings rate may be related to investment opportunities, and credit is fungible, studies of loan demand in low income countries should be based on an interdependent production and consumption farm-household analytic framework.

The review of projections of loan demand and estimates of loan demand functions revealed that most studies have implicitly assumed the separability of borrowing for production and for consumption and focused mainly on the apparent demand for production loans particularly from institutional sources. Several limitations were discussed regarding these studies and the results must be interpreted with caution.

One disturbing observation from this review is the lack of relation between the studies projecting loan demand and studies quantifying loan demand functions. Loan projections can be improved by a clearer understanding of the underlying structural relationships among the variables to be projected. Yet, there are very few empirical estimates of loan demand relationships and even fewer of loan supply functions particularly for low income countries. Furthermore, there appears to be little recognition of the need to begin the systematic collection of data required to study such relationships.

Our analysis suggests that a priority for research in rural finance is to test hypotheses and estimate parameters related to borrower and lender behavior. We have emphasized the methodological limitations of many existing studies of loan demand with the hope of encouraging creative effort for improvements. However, the major challenge appears to be in reorienting research efforts in this area towards asking more relevant policy questions. For example, the important policy question is not what should be the level of loan demand, but what should be the price of loans and what would be the impact of raising interest rates. These issues can only be resolved through more precise information about the parameters of the supply and demand relationships found in formal and informal financial markets.

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