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THE DEMAND AND SUPPLY OF FUNDS AMONG AGRICULTURAL HOUSEHOLDS

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PREFACE

This Note was prepared with support from The Rand Corporation's Family in Economic Development Center, which is funded through Grant No. AID/OTR-G-1822 from the Agency for International Development. The Center was created to provide effective policy research through the integration of technical research with the training of and collaboration with Third World scholars and government officials. The Center's research emphasizes the role of human resources in the process of economic development, and individual family responses to programs and policies for promoting growth and development.

The research presented in this Note is drawn from a larger study of borrowing and saving behavior among agricultural households in India. Technical and policy conclusions should be of interest to those concerned with the functioning of rural credit markets in developing countries and to those who manage credit operations in both international donor agencies and Third World governments.

At the time this Note was written, the author held a Family in Economic Development Center Postdoctoral Fellowship.

SUMMARY

This study investigates the borrowing behavior of farmers in less-developed countries (LDCs). Borrowing functions are estimated on a set of variables suggested by a life-cycle utility-maximizing model, using data from a national survey of approximately 3,000 cultivating households across rural India in 1970-71. The major findings of the study are related to the following special features of our approach: (1) an improved definition of what constitutes the demand for credit, (2) an examination of the interaction between technical change (in agriculture) and the rural finance market, and (3) an explicit formulation of the supply side of the market through an analysis of the determinants of farm-specific interest rates.

Our study departs from previous studies in that we define the demand for credit to include the lending and other financial-asset management activities of farmers. It is argued that neglecting these factors renders empirical estimates of the borrowing function subject to bias. This bias is shown to be quite important and may account for some anomalous results encountered in previous studies.

The interaction between technical change and the rural finance market is captured through two equations, one showing how technology characteristics of farmers and their environment are related to the demand for funds and the other showing how these characteristics are related to the rate of interest charged by lenders and thereby to the supply of funds. It is shown that such characteristics are important on both the demand and the supply side of the market. Specifically, farm-

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ers who are in a position to benefit from the technology and information generated by agricultural research tend to borrow more and also to face lower interest rates. This is consistent with an interpretation that stresses the income-augmenting and risk-reducing nature of this sort of technical change. An important policy implication of this finding is that the generation and diffusion of improved investment opportunities provides the government with an additional instrument for influencing developments in the rural finance market.

The third special feature of the present study consists essentially of modeling the interest rate as being jointly determined with the amount borrowed and of devising an imputation procedure for those cases in which no external borrowing, and therefore no interest rate, is reported. We define the interest-rate function over variables that reflect the opportunity, administrative, and risk costs of lending and by predicting potential interest rates for non-borrowers. This function is identified through information on the presence or absence of formal lending agencies (e.g., banks, cooperative credit societies) in a village, since such agencies shift supply but not demand. Structural estimates reveal that while the demand for funds is quite sensitive to changes in the interest rate faced, the interest rate itself is not responsive to variation in borrowing. This result suggests an unexpectedly strong role for monetary policy in rural India.

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I. INTRODUCTION

This Note presents a theoretical and empirical characterization of the demand for funds for investment and consumption among agricultural households in less-developed countries (LDCs). The importance of the role of credit in agriculture is widely recognized, and agricultural planning in LDCs could benefit significantly from both a better theoretical understanding of the workings of rural finance markets (RFMs) and an improved base of empirical results. This need is particularly great in countries where technological developments in agriculture over the past two decades have made well-grounded financial planning imperative; if the momentum of agricultural development in those countries is to be maintained, information is needed on the crucial link between the rate of agricultural innovation and the operations of RFMs.

Several related issues must also be addressed: First, the relationship between the ownership of land and the demand and supply of funds must be examined before the costs and benefits of a land reform policy can be fully assessed. Second, most LDC governments have elaborate programs for intervention in factor markets through, for example, minimum wage policies or maximum interest-rate policies. While something is known about the direct effects of such policies on their target markets, very little is known about their effects on other markets. There has been little theoretical or empirical analysis of the effects of labor-market interventions on the capital market, and vice versa. Yet these effects could be very important for agricultural

households who participate regularly in both markets. Finally, even the direct effects of policy intervention on the market for rural funds are not well known or understood. A systematic statistical investigation of the interest elasticity of borrowing, for example, would shed light on many policy debates that have hitherto been conducted largely on the basis of conjecture.

Much of the previous work in this area has been done in something of a theoretical vacuum, without benefit of appropriate empirical techniques and also without adequate data. Some of the major shortcomings of earlier work are examined in Sec. II, and a simple life-cycle model of borrowing is proposed which provides a suitable theoretical foundation for the present analysis. Section III presents an empirical analysis of the demand and supply of funds. The data are obtained from a comprehensive national (panel) survey of approximately 3,000 farm households in India for the years 1968-71, conducted by the National Council of Applied Economic Research (NCAER). The empirical analysis is guided both by theory and by special characteristics of the data at hand. Section IV summarizes the important findings of the study.

II. SOME PRELIMINARY CONSIDERATIONS

SHORTCOMINGS OF EARLIER STUDIES

The literature dealing with the demand for agricultural credit in LDCs (e.g., Long, 1968; Pani, 1966) suffers from a number of drawbacks. It is convenient to review these briefly because the importance of the present study derives largely from its differences from conventional approaches.[1]

Perhaps the most serious drawback of conventional studies is that they define the dependent variable to be simply the amount borrowed from external sources by an agricultural household. The present analysis, however, deals with the demand and supply of "funds" rather than "credit," because both external and internal sources of financing must be considered if we are to develop an accurate model of the financial behavior of farmers. On-farm investments, for example, can be financed in one or more of the following ways: borrowing from external sources such as agricultural development banks, cooperative societies, and moneylenders; borrowing from internal sources such as savings accounts and other financial assets; decumulating consumer durable stocks; and/or abstinence from current consumption. This range of options should be included in a model of the financial behavior of farmers; however, previous studies have limited their analyses to the demand for external borrowing. The term "borrowing" is used in this Note to mean borrowing

[1] The literature on the demand for credit is reviewed in David and Myer (1979). It is worth noting that none of the shortcomings emphasized here receive much attention in David and Myer's survey.

from both internal and external sources and is equivalent to the demand for funds. Lending is treated in like fashion, with the appropriate change in sign.

The problem with using only external borrowings as a measure of the true demand for funds is that it renders empirical estimates subject to what may be called truncation bias. This bias can arise for one or both of two reasons: Suppose we assume that separating the sample into borrowers and lenders is correct because there are essentially two distinct populations th different behaviors which should be estimated separately. It is important that the discrimination between the two populations be quite accurate. Otherwise, biases are likely to be produced. In the case of rural borrowing, it does not seem appropriate to use the level of current borrowing to distinguish between populations of borrowers and non-borrowers, because current borrowing behavior is likely to vary for reasons not related to the permanent status of a household. The second, more important, problem is that the assumption that two separate populations exist may not be tenable. There may, in fact, be only one population, containing some households who choose to borrow and others who choose to lend in the face of a common set of exogenous determinants. Consider the relationship between the interest rate and the amount borrowed. This relationship is a stochastic and not a deterministic one--i.e., some individuals will borrow more and others will borrow less, even when faced with the same interest rate. By focusing only on those who borrow, we increase the likelihood of observing a positive, rather than the expected negative, relationship between these two variables, partly because those who reduce their

borrowings by a large amount (in response to an increase in the interest rate) are more likely to switch from borrower to non-borrower status and therefore to be excluded from the sample; those who reduce their borrowings by a small amount are more likely to remain in the sample. Although the direction of the bias cannot be unambiguously determined in cases involving more than one independent variable, it appears likely that the exclusion of non-borrowers from the analysis will exaggerate all coefficients in a positive direction.[2]

The typical approach to analyzing the demand for credit suffers from other problems as well. The underlying model of the farm household in most studies ignores labor-leisure choices: The production function is assumed to be defined on only one input, capital, and the utility function is implicitly assumed to be defined over consumption of goods only. These models are inadequate to the extent that labor-leisure choices are important to agricultural households--and the evidence is that they are important. Most studies confirm the sensitivity of agricultural output and labor supply to economic variables, and ignoring the labor-leisure tradeoff in the borrowing decisions of households is likely to lead to a serious specification error.

The role of technological change in influencing the demand for LDC agricultural credit has often been discussed but has never been properly

[2] The bias produced by stratifying along the dependent variable has been most commonly observed and discussed in the literature on the human-capital earnings function. In particular, it has been shown that looking at a subsample of relatively poor households alone tends to underestimate the true effect of schooling on earning power. In general, the direction of bias cannot be unambiguously predicted if there is more than one independent variable involved (see Goldberger, 1975).

explored, either theoretically or empirically. While much rural borrowing is undertaken to compensate for temporary shortfalls in earnings, there is much evidence to suggest that borrowing for investment purposes is growing in importance. The purpose-wise distribution of loans in India, for example, indicates that loans for investment purposes have increased from 40 percent to 52 percent of total loans between 1950 and 1970.[3]

The specification of a borrowing function depends on the underlying theoretical framework. If borrowing is considered to be simply rental of capital for investment purposes, then its determinants will include a measure of current wealth or assets. This is the approach taken by Hesser and Schuh (1962) and Lins (1972) in their studies of the demand for credit among U.S. farm households, and by Long (1968) and Pani (1966) in their studies of Indian farmers. If, however, we take a life-cycle view of the borrowing process, the level of current wealth or assets becomes an inappropriate variable (for ordinary least-squares estimation) because both asset accumulation and borrowing are endogenously (and simultaneously) determined now. Since assets have been an important variable in previous studies, it will be useful to see how their role changes under alternative theoretical and empirical formulations.

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[3] This result is taken from Table 12 of Credit Requirements for Agriculture, a monograph published by NCAER, which also contains tabulations of average levels of borrowing by farm size and by technology-adoption status. Farmers who have adopted new technology (over 1968-70) tend to borrow more per acre and also tend to borrow more for investment purposes.

A MODEL OF BORROWING

We shall now describe a life-cycle model of a farm-household which yields a "correct" measure of the demand for funds, incorporates labor-leisure choices, and allows for technological change in production.

The basic assumptions of this model are standard ones: farm households are assumed to act as if they were maximizing a monotonic, twice continuously differentiable, strictly concave utility function as in

$$U = U(C_1, C_2, L_1, L_2), \tag{1}$$

subject to the budget constraints shown by

$$p_1 . f(K_1, D_1) + w_1 M_1 + B = C_1 + I \tag{2}$$

and

$$\alpha . p_2 . f(K_2, D_2) + w_2 M_2 + s.K_2 = C_2 + B(1+r), \tag{3}$$

and a time constraint shown by

$$M = T - L - D \tag{4}$$

where the subscripts refer to the two periods being considered, and

C = consumption expenditure

L = leisure or non-market time

M = net market labor supply

D = on-farm labor (family + hired)

K = initial endowment of productive capital

I = on-farm investment such that $K_2 = K_1 + I$

p = price of output

w = market wage rate

s = depreciation factor

r = interest rate or cost of funds

B = amount borrowed or lent

α = technical-improvement parameter

T = total available time

The model is cast and analyzed in terms of two periods only, current and future, although it is meant to be interpreted as a full life-cycle model. Part of the reason for this telescopic assumption lies in the considerable notational simplicity thereby achieved; however, no substantial differences arise if the model is extended to n periods.

Two special features of this model, which deserve attention because of their relevance to present-day LDC agriculture, are (1) the incorporation of a labor-leisure choice in the utility function and labor market participation in the budget constraint, and (2) the use of an index of technological change or investment opportunity on the production side. The first feature broadens the range of economic activities hitherto considered to be important in the borrowing and saving decisions of LDC farmers, and the second allows for explicit theoretical analysis of the link between these decisions and the opportunity to invest, a connection whose importance became dramatically obvious during the "Green Revolution" of the late 1960s.[4]

[4] The "Green Revolution" denotes essentially the introduction of chemical fertilizers and new high-yield varieties of seeds in several LDCs throughout the 1960s. It was widely thought that the diffusion of

The greater the value of expected future income, the greater will be the tendency to borrow in anticipation of it. Similarly the higher the rate of return to capital, the greater will be the tendency to borrow and thereby employ more capital. Both of these effects can be captured by the use of a measure of investment opportunity, a term defined by Fisher (1930) as the opportunity to shift from one "option" or possible income stream to another. In the case of farm households, an improvement in investment opportunities could be thought of as an outward shift of the production-possibility frontier. This effect is captured in our model by a parameter, α, which shifts the production function in a manner analogous to Hicks-neutral technical change. Empirically, α is meant to be interpreted as a vector containing all the factors that bring about differences in the investment opportunities open to farmers. As such, it should include managerial ability, together with soil quality and differences in the availability of government extension services, irrigation services, and the like.

The depreciation factor, s, is introduced to keep the accounting straight. Under the assumption that the household "dies" at the end of the second (future) period and leaves no bequests, it has to consume everything by that time, including its now-depreciated stock of assets. Since no reliable empirical information is available on rates of depreciation of farm equipment in India, we have not considered this factor further in the present study.

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this technology across farm-size groups and regions was critically affected by the differential availability of credit. A rigorous study, however, of the connection between credit availability and the adoption of new techonolgy has yet to be undertaken.

This sort of life-cycle model yields the following determinants of the demand for borrowing (or consumption, or savings, or investment, for that matter): initial endowment, current and expected output prices and wages, the marginal cost of funds, depreciation rates, and shifts in investment opportunities. Most of the empirical literature to date has used specifications that include only different versions of the initial endowment variable and the interest rate. We have improved upon past studies by redefining the dependent variable and by enriching the specification of the model in accordance with life-cycle theory and econometric requirements. These issues are dealt with in Sec. III.

The workings of the model are described in detail in the Appendix. Under the assumption of additive separability the following results can be shown to hold unambiguously:

$dB/dr < 0$ for $B>0$; $dB/dp_1 < 0$; $dB/dp_2 > 0$;

$dB/d\alpha > 0$ and $dB/ds > 0$.

The signs for dB/dw_1, dB/dw_2, and dB/dK_1 remain ambiguous unless certain further assumptions, also discussed in the Appendix, are made.

III. EMPIRICAL ANALYSIS

DEFINING THE DEPENDENT VARIABLE

As indicated earlier, our concept of borrowing and lending is sufficiently different from that used in most previous studies to require some discussion. Previous studies have used only external borrowing as the measure of the demand for credit and have ignored the lending activities of farm households. Such a measure involves stratification by the dependent variable, a procedure that yields biased estimates.

This problem is avoided in the present construction of the dependent variable, which is essentially based on the first-period budget constraint, where that constraint is viewed as an identity:

$$f(k_1, d_1) + w_1M_1 + B = C_1 + I.$$

This can be rewritten as

$$[f(k_1,d_1) + w_1M_1 - C_1] + B = I,$$

and by condensing the income terms on the left-hand side into an overall income term Y_1, as

$$(Y_1 - C_1) + B = I.$$

Overall borrowing from internal and external sources can now be calculated as the difference between on-farm investment and current savings:

$$B = I - (Y_1 - C_1) \text{ or } B = I - S.$$

One way to understand this method of construction is to examine the components of B. From the definition of savings, S, as change in net worth from one period to the next, we can write

$$S = (I + CD + FA + EL - EB),$$

where I is on-farm investment, CD is net change in consumer durable stocks, FA is net change in financial assets, and EL, EB are external lendings and borrowings. Substituting for S now in the identity

$$B = I - S,$$

we obtain a measure for B in terms of its components:

$$B = (EB - EL - FA - CD).$$

This indicates that the demand for funds is simply the algebraic sum of changes in liabilities (EB - EL), changes in internal borrowing (-FA), and changes in the stock of consumer durables (-CD).

The dependent variable used in the empirical analysis here is actually constructed as above from the components of B. Two measures were calculated, one including and the other excluding consumer durables as a source of funds. The results for the two are broadly similar, so only those for the latter definition are reported below.[1]

[1] We also attempted to calculate borrowing as the difference between investment and savings. However, reported savings are adjusted for repayments of loans such that if a loan was taken and completely repaid within the reference period, the calculation of B would not reflect the taking of the loan at all. Our breakdown of savings into its various components is, strictly speaking, relevant only for those cases where no repayments are made within the reference period.

SOME DATA RESTRICTIONS

The data used in our empirical analysis of the model come from the third round (1970-71) of the NCAER panel survey. The data set is described in detail in the Appendix, but some special features deserve mention here. First, questions on interest rates were asked only of those households that reported positive levels of borrowing; thus this information is available for only 1,083 observations of the sample of 2,695 households for which we can calculate B.[2] The resulting problem of missing interest rates for a large fraction of our sample is similar to the missing-wage (for housewives) problem in the labor supply literature, and the solution attempted here is one that has been widely used in that literature. For non-reporters, interest rates are imputed from an interest-rate function regressed over a set of personal characteristics and a set of locality-specific characteristics which denote differences in transaction costs of supply across districts and villages. Since this "conventional" regression is based only on information from the subsample that did report positive levels of external borrowing, our estimates could be subject to selection bias resulting from the confounding of the behavioral function relating the interest rate to its determinants with the sample-selection function relating the probability of borrowing to its determinants. This possibility is ignored in the present analysis.

[2] The size of the overall sample depends on assumptions made regarding the content of missing data. If we assume that external borrowings or lendings recorded as missing are really zero, we obtain a sample of 2,695 complete observations. If we delete all such observations, the sample size shrinks to 1,785 households. The empirical results reported here are based on the first assumption and do not change much even if the smaller sample size is used.

Table 1 indicates why the selection problem may not be critical in our sample. The last two columns describe the average characteristics of external and non-external borrowers. By and large, the characteristics are very similar. External and non-external borrowers are similar with respect to the wage they face, the land they own, and the investment opportunities they face (proxied by government research and soil quality); they differ only in levels of transitory income. To some extent, the evidence suggests that non-external borrowers are randomly excluded from the sample.

A second characteristic of the information on credit deserves mention also. External borrowings and interest rates are identified separately according to whether a loan was taken for operational or non-operational purposes. Operational-purpose loans include investment loans to finance the acquisition of tractors, seeds, fertilizers, and irrigation equipment; and non-operational-purpose loans include consumption loans taken to cover marriage and other ceremonial expenses, unexpected consumption needs, medical and litigation charges, and the like. Since the costs associated with each kind of loan may be different, this information is also incorporated in the imputation procedure by means of a dummy variable which takes the value of 1 for an investment loan and 0 for a consumption loan.

THE STRUCTURE OF THE EMPIRICAL MODEL

The empirical model consists of two equations, one representing the demand for funds and the other, in the form of a function relating the interest rate to its determinants, the supply of funds.

Table 1

SELECTED SAMPLE MEANS (μ) AND STANDARD DEVIATIONS (σ)

Variable	All Households		Large[a] Landholders Only		Small Landholders Only		External Borrowers Only		Non-External Borrowers	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Male agricultural wage rate (WAGE), rupees/day	3.2	1.2	3.2	1.2	3.1	1.0	3.1	1.2	3.2	1.2
Land owned (LAND), hectares/household	10.3	12.9	15.1	14.5	2.5	2.1	10.5	11.9	9.9	13.4
Investment opportunity index (RESEARCH), thousands of rupees/block	24.9	14.3	26.9	15.5	20.0	9.2	25.9	15.4	24.2	13.5
Transitory income (TY), rupees/household	260	1707	412	2074	17	775	300	1727	232	1666
Borrowings (BORW), rupees/household	204	1760	264	2055	105	1118	1260	2057	-603	1624
Interest rate (INTEREST), percent/year	15.5	2.4	14.8	2.5	16.4	2.0	14.4	3.0	...	...
Soil quality index: price of unirrigated land (SQINDEX), rupees/hectare	2574	2646	2326	2536	2980	2769	2561	2808	2643	2505
No. of observations	2695		1671		1024		1083		1612	

[a]Large landholders are defined as those cultivating more than 4 hectares of land; the rest are considered small landholders.

Consider the latter function first. In a competitive market, three basic costs enter the nominal interest rate (Rn): the opportunity cost (Re) of providing a loan, the administrative cost (Ra) of handling a loan, and the risk premium (Rp) to be assigned to different borrowers. Thus the nominal interest-rate function can be written as

$$Rn = Re + Ra + Rp, \tag{5}$$

or as

$$Rn = r_1.Z + r_2.B + r_3.X, \tag{6}$$

where the vectors Z and X contain variables that affect the opportunity and risk costs of lending, respectively, and the variable B denotes levels of borrowing and proxies for the administrative (as well as risk) cost of lending.

In the empirical analysis below, the opportunity cost of funds is assumed to vary across villages according to (1) the presence or absence of a formal lending agency (e.g., a bank or a cooperative credit society) in the village and (2) the proximity of the village to market centers and urban areas. The first factor is assumed to reduce the opportunity cost of funds because formal lending agencies in India obtain a large part of their funds from the government and are obliged to pass on a subsidy on each loan in the form of interest charges lower than the going rate. The operations of formal lending agencies are regulated by the government in India, and subsidized loans are offered for "development" purposes. The actual variable used here is BANK, a

dummy variable which takes a value of 1 if a commercial bank was present in the village, and 0 otherwise.[3]

Distance from market areas (DSMKT) is a parameter designed to capture lending costs incurred by village moneylenders (the source of 50 percent of the loans in our sample) who have to obtain their own funds from larger town moneylenders. If, as also happens, the borrower goes to the town moneylender directly, this lender still incurs the costs of traveling to the borrower's village to assess his creditworthiness and collateral. Furthermore, distance is also likely to affect the probability of having idle funds. A moneylender situated close to a town or with easy access to one is more likely to have his stock of loanable funds placed on loan throughout the year, while those in remote locations may have idle funds in the post-harvest season.

The administrative cost of funds is perhaps best captured through the size of loan negotiated, i.e., the larger the loan, the smaller the unit cost of administering it. However, the size of loan could also carry a risk cost, so that the risk would increase with the size of the loan. This possibility renders the expected sign ambiguous.

The risk cost of lending is proxied by all those variables that are likely to affect repayment probability. Thus the income-earning opportunities of the borrower are proxied by the wage rate he faces, the amount of land he owns, and the investment opportunities he faces. The general location-specific risk introduced by differences in soil quality

[3] A dummy variable indicating the presence or absence of a cooperative credit society was tried in place of the variable for banks, with approximately the same results. Since cooperatives are present in almost 90 percent of the cases in our sample, however, we chose to use the dummy variable that possessed greater discriminating power.

and weather must also be taken into account. Only soil quality is considered here, with the price of unirrigated land in the village taken to be a measure of the average soil quality.[4]

These personal and locational risk characteristics also affect the amount demanded. These characteristics will be discussed in the context of the borrowing function, which may be written as

$$B = b_1.Y + b_2.Rn + b_3.TY, \tag{7}$$

where Y is a vector of all those factors that theoretical analysis suggests ought to be determinants of the demand for funds, Rn is the nominal interest rate faced, and TY is a measure of transitory income.

The theoretical analysis calls for the following set of regressors: initial endowment, current and expected wage, current and expected output prices, investment opportunity measures, and the marginal cost of borrowing. Some of these require proxies, discussed below. Since prices for identical outputs are invariant in the cross-section, given a competitive market for the product, they will not be used in the present empirical analysis. It may appear that the same argument should be applied to remove wages and the interest rate from consideration in the cross-section, but there is considerable geographical immobility in the

[4] The NCAER data contain crude information on weather in the form of a dummy variable which indicates whether local weather was good or bad in the reference period. We used this variable in some empirical runs, and it was never significant. What we really need is information on whether or not the weather experienced was unexpectedly good or bad. We attempted to construct such a measure based on survey information covering three years. This was also insignificant in all runs. While this lack of significance may indicate something about the mobility of funds in rural India, it is probably not wise to speculate on the basis of a variable measured in so rough a fashion.

labor markets in India and regional differences in transactions costs in the credit market, so that variations in both wages and interest rates are observed, even in the cross-section.

WAGE. Because the NCAER data do not contain individual wage information, we have used the district average daily male agricultural wage (for 1970-71) as our measure of the opportunity cost of leisure. The theoretical analysis calls for an expected future wage in addition to the current wage; we have assumed that the future wage rate is simply a multiple of the current one. This eliminates the separate role of the unobservable variable, but the coefficient of w_1 now must be interpreted as the sum of the effects of both current and expected wages.

LAND. The proxy for initial endowment used here is a measure of the total area owned by the farm household (in hectares). Although a measure of gross or net cropped area, both owned and leased, might contain more information about the household's wealth, such a measure cannot be used here because the act of leasing involves a capital accumulation decision that is, in the context of our model, made jointly with the borrowing decision. It could be argued that land ownership itself is subject to variation and that current ownership may not reflect original endowment. However, the land-ownership market in rural India (as opposed to the land-lease market) is quite thin. Because of the status and security conferred by land, very few farmers are willing to part with it; hence very few transactions are typically observed in this market. In our data, only 112 of 2,939 households reported sales or purchases of land in the reference period. Given this infrequency of change of ownership, current land owned appears to be a reasonable

measure of initial endowment. Another variable used here, the village price of unirrigated land, could provide additional and exogenous information regarding the quality of a household's land endowment.[5]

RESEARCH. The RESEARCH variable is a proxy for those variables in the vector α that represent investment opportunity differences across regions and over time. A good investment opportunity index should be exogenous and should capture differences in the quality of soil and the availability of credit, extension services, fertilizers, and irrigation across regions. Bhalla (1980) uses the district adoption rate of high-yielding varieties of seeds as such an index. We have used an alternative index, which measures annual expenditures by each state and by the central government on major crop research, adjusted by the number of community development blocks, in each state. These blocks contain a roughly equal number of farms, and they form the basic extension and village development units in rural India; thus a measure of comparative research intensity is obtained which can be used as an index of investment opportunity. The advantage of this measure over the Bhalla index is its potential as a direct policy tool. It has been used to

[5] It is also possible that the use of a physical measure of initial endowment rather than a monetary one may introduce some error. The quality of land varies so much in India that a 10-hectare plot in, say, the Punjab area may reflect a different endowment position than a plot of the same size in, say, remote Madhya Pradesh. A monetary measure would capture differences in land quality, whereas a physical one does not. To the extent that the value of land is affected by choices regarding irrigation and fertilizer use among other such endogenous land improvement measures, however, a monetary measure might introduce simultaneity bias in the sort of life-cycle framework we are using here. For this reason, we have retained the physical measure in spite of its possible disadvantages. As mentioned above, the price of unirrigated land is introduced as an independent regressor proxying for soil quality. To some extent, this mitigates the shortcomings of using a physical rather than a monetary measure of initial endowment.

advantage by Evenson and Kislev (1975) in studies of productivity and agricultural research in India. The figures used in the present empirical work pertain to 1968 and are based on the assumption that research expenditures in a given year are reflected in enhanced investment opportunities in the region a few years later.[6]

TY. The variable TY is a measure of transitory income, calculated as the difference between current income and permanent income, where the latter is calculated as a weighted average of the incomes of the past three years. The technique used to calculate the weights comes from Friedman (1957) and is used by Bhalla (1980) on the NCAER data set. Bhalla carries out a sensitivity analysis using different weights and finds that the calculation of permanent income is not much affected by different discount rates. He also calculates Yp using a "fixed effects" earnings function approach, which makes it even more unlikely that the transitory income derived therefrom will be contaminated by permanent effects. He reports that this method yields a measure that has a mean not very different from that yielded by the weighting procedure. The straightforward weighted-average method is adopted here, and permanent income is calculated as

$$Yp = 0.43Y_3 + 0.32Y_2 + 0.25Y_1,$$

where Y_3 refers to current income, and the others to past incomes.

[6] It could be argued that agricultural research is a public good and hence is available in equal and undiminished quantities to all farmers in a region, regardless of their number. To the extent that the effects of research are typically transmitted through an extension system, it seemed appropriate to take into account the differences in research intensity that result. Lacking adequate information on extension services we use a proxy: gross research expenditure figures, adjusted by the number of community development blocks in a region.

The variables in the vector Y are identical to those in the vector X, since those "personal" factors that affect a household's demand for funds are also likely to reflect its creditworthiness and hence will enter into the lender's supply function. Putting the demand and supply equations together, we obtain the following structural model (constants and error terms added):

$$B = b_0 + b_1.X + b_2.Rn + b_3.TY + Ub, \tag{8}$$

$$Rn = r_0 + r_1.Z + r_2.B + r_3.X + Ur. \tag{9}$$

The model is identified by the presence of TY in the demand function and the opportunity-cost vector Z in the supply function. Note that the manner in which the interest rate enters the borrowing function implies that the lender is uncertain about repayment. If he were certain about repayment, the risk element would not be important, since both borrower and lender could anticipate the probability of repayment accurately and adjust for it; the appropriate interest rate in this case would be Re + Ra. Certainty about repayment would make sense in an agricultural environment which is technologically and climatically stable, allowing production to be successfully anticipated by both borrowers and lenders, and where the parties have dealt with each other over a prolonged period. The circumstances of Indian agriculture in 1970-71, however, suggest that the assumption of uncertainty is a more reasonable one. To begin with, lenders are not likely to be well-acquainted with their clients in cases where formal agencies are making the loans. Such institutions, unlike moneylenders, do not typically have close relationships with their clients and are known to use borrower

characteristics to determine the risk premium, or simply to determine access to their loans. Furthermore, because the late 1960s were characterized by rapid technological change in Indian agriculture, the assumption of technological stability is untenable, especially to the extent that debt is often incurred to finance the acquisition of new technology.

Given the uncertainty assumption, the borrowing function can be estimated consistently from our structural system in standard two-stage fashion: An estimate of Rn is formed by regressing it on all the exogenous variables in the system (X, Z, and TY), and this estimate can then be used in Eq. (4) to obtain the parameters of the borrowing function.

PARAMETER ESTIMATES

The Interest-Rate Function

Table 2 presents estimates for the determinants of the nominal interest rate. The dependent variable is the maximum interest rate reported by a farm household for current loans, and the dummy variable is triggered by the taking of any loan for investment purposes. Both reduced-form and structural estimates are reported, and since the differences between them are minor, the discussion below applies to both sets of estimates.[7]

[7] A specification issue should be clarified before the results are examined. We also ran interest-rate functions on a specification which included a set of interaction terms relating the dummy variable to the variables proxying for risk premiums. This was done to capture differences in the relationship of consumption and investment loans to risk considerations, given that different agencies tend to specialize in

Table 2

INTEREST-RATE FUNCTIONS
(t-statistics in parentheses)

Independent Variable	Reduced-Form Estimates		Structural Estimates	
WAGE	10.92	(3.03)	9.53	(2.29)
LAND	-0.64	(2.42)	-0.71	(1.92)
RESEARCH	-0.66	(2.55)	-0.75	(2.22)
SQINDEX	-0.002	(1.78)	-0.002	(1.49)
Dummy	-34.8	(5.70)	-28.3	(3.03)
BANK	-19.04	(3.11)	-22.6	(3.41)
DSMKT	0.39	(2.36)	0.40	(2.24)
TY	-0.0004	(0.23)	...	
BORWHAT[a]	...		0.003	(0.26)
Intercept	160		168	
R^2	0.08		0.07	
F	10.9		8.5	
No. of observations	1083		1083	

[a]BORWHAT is estimated from all the exogenous variables in the system of structural equations relating the interest rate and the amount borrowed.

these different types of loans (formal agencies account for 80 percent of investment loans, and moneylenders account for 83 percent of consumption loans). This specification was marred by a high degree of collinearity between the interaction terms and the original risk proxies. The reason for this is not difficult to fathom: Because formal agencies cannot tailor interest rates to match the risk characteristics of their clients, they tend to use these characteristics to determine access to their loans instead; consequently, clients with low-risk characteristics tend to be the ones who qualify for low-interest investment loans from formal agencies. Because of the imprecision of the estimates provided by the interaction-term model, we abandoned that model in favor of the one reported in Table 2.

The results indicate that LAND, RESEARCH, and SQINDEX act as risk-reducers, whereas WAGE and the amount borrowed act as risk-increasing elements in the lenders' assessment. BANK reduces and DSMKT increases the opportunity cost of lending, and the taking of an investment loan is associated with a lower interest rate. It is difficult to make a comparative assessment of these results, since they appear to be unique in the literature. Long (1968) contains a reference to an attempt to estimate the determinants of rural interest rates using cross-section data, but no results are reported. And Hesser and Schuh (1962) estimate but also do not report an interest-rate equation. So the present results must be discussed in terms of some general views found in the literature.

The results for LAND and SQINDEX sit well with casual impressions regarding the repayment behavior of well-to-do and small farmers, viz., the better-off a farmer is, the better the collateral he can put up and the better his chances of repayment. To the extent that formal agencies also give consumption loans, however, this result could simply be a reflection of the fact that wealthier farmers have superior access to subsidized loans.

RESEARCH, our investment-opportunity proxy, also appears to reduce the nominal interest rate. This result could be interpreted as supporting the assertion that the spread of agricultural research and information helps to reduce the risks inherent in farming and thereby encourages lenders to reduce their risk premiums. Indeed, this result is obtained even while controlling for the existence of banks and distance from market areas and is therefore less likely to be a spurious

correlation reflecting the influence of unobserved supply-of-credit variables. While state governments probably provide more low-interest loans in special areas where they are also pushing new research and technology, this effect should be picked up by BANK and DSMKT. The partial correlation coefficients relating BANK and DSMKT to RESEARCH turn out to be on the order of 0.14 and -0.06, further strengthening the interpretation presented here.[8]

The wage-rate effect is a bit puzzling. On the one hand, it can be interpreted as reflecting the increase in risk associated with the increase in operating costs that a wage increase entails, especially for households that are net labor-importers. On the other hand, it should reflect the enhanced income-earning ability of smaller farmers, who are more likely to be net labor-exporters and demanders of consumption loans. Since we have used the district-level wage as our measure, however, our result may simply reflect the fact that labor and capital markets can experience situations of excess demand and excess supply simultaneously. Thus, Green Revolution districts are likely to have experienced an excess demand for all inputs during the late 1960s when they were growing rapidly, a disequilibrium situation that would have resulted in an increase in the price of all inputs in the short run,

[8] It is possible, of course, that the relevant correlation is between the amount of loanable funds available through banks and cooperatives and the provision of agricultural research and extension activities. This is not picked up by our dummy variable, which records only the existence or absence of formal lending agencies. However, preliminary results from a related study of the determinants of moneylender interest rates (Iqbal, 1981; also Iqbal, unpublished work at The Rand Corporation on dualism, technological change, and rural finance markets) indicate that even these are strongly and negatively affected by the technological characteristics of districts: The higher the level of research, or the higher the number of progressive farmers, the lower the level of the interest rate charged by moneylenders to residents of the district.

i.e., wages and interest rates would be likely to move together. Whatever the reason, our results suggest that labor and capital markets are interlinked. However, policy implications will depend on the exact linkage mechanism that is at work.

The sign of the loan-size coefficient indicates that the greater the amount borrowed, the higher the nominal interest rate. This effect, however, is not significant in either the version of the model described here or another version in which the amount borrowed is entered directly. This result may be a consequence of the fact that loan size carries both a positive risk-increasing effect and a negative administrative-cost-decreasing effect which may cancel each other. It is also possible that amount borrowed is an exogenous and insignificant determinant of the interest rate as far as formal agencies are concerned. Again, to the extent that formal agencies provide consumption loans, our results should be expected to reflect not only economic forces but also institutional forces.

The dummy variable is highly significant and negative, indicating that loans taken for investment purposes are less expensive. Whether such loans are intrinsically less risky or less costly to administer or whether this finding simply reflects the fact that official institutions supply most operational-purpose loans at subsidized rates cannot be ascertained from these results alone.

The opportunity cost proxies have expected signs. The nominal interest rate is decreased by the presence of banks and increased by distance from market areas. The effect of bank presence may support the view that official lending institutions in India have made significant

advances; the effect of distance certainly underscores the importance of regional development and financial integration in improving access to credit. The effect of BANK should not necessarily be interpreted as supporting the claim that moneylenders are monopolists and are forced to drop their interest rates in order to compete with official agencies. A proper test of that contention would have to examine the effect on moneylender interest rates rather than on average interest rate, which we are examining here. The present results primarily reflect the arithmetic consequence of introducing low-interest loans into the rural credit market.[9]

The Borrowing Function

Table 3 shows estimated borrowing functions for two definitions of the dependent variable. In the "All Households" column, the dependent variable is defined as B = EB - EL - FA, so that the sample is not stratified by the dependent variable. In the "External Borrowers Only" column, the dependent variable is defined conventionally as B = EB. The two sets of estimates differ sharply: The signs of WAGE, LAND, INTEREST, and SQINDEX are reversed, and significance of TY is sharply lower in the conventional estimate. The regression based on the truncated sample causes all coefficient estimates to be exaggerated in a

[9] The issue of monopoly power in the informal credit market is dealt with elsewhere (Iqbal, 1981; also unpublished work by the author at The Rand Corporation on dualism, technological change, and rural finance markets). Preliminary results confirm the presence of monopoly profit in that moneylenders are observed to reduce their interest rates in the presence of competition from formal lending agencies. We estimate that the "monopoly surcharge" adds roughly 4 percent to the "free-market" rate.

Table 3

BORROWING FUNCTIONS
(asymptotic t-statistics in parentheses)

Independent Variable	All Households		External Borrowers Only	
WAGE	+61.45	(1.50)	102.28	(1.28)
LAND	-5.97	(2.07)	60.06	(10.55)
RESEARCH	14.49	(4.69)	15.93	(2.85)
TY	-0.18	(8.87)	-0.07	(2.00)
SQINDEX	-0.01	(0.73)	0.03	(1.47)
INTEREST[a]	-11.26	(6.40)	6.21	(2.26)
Intercept	1914		-1055	
R^2	0.06		0.13	
F	29.7		27.2	
No. of observations	2695		1083	

[a]INTEREST is estimated from the regression function shown in column 1 of Table 2. An x% interest rate is recorded in the data as 10x.

positive direction, and the exaggerations are large and often significant. The wrong sign on the interest-rate coefficient is especially damaging to the conventional version, since theory leads us to expect an unambiguously negative result. Clearly, the definition of the dependent variable strongly affects the results.

In the all-households case, the wage rate is negatively related to the amount borrowed. The complexity of the theoretical model disallowed an unambiguous prediction in this case. We have made no attempt to disentangle the various effects of changes in current and expected wage

rates, net labor importing or exporting status, or the relationship between leisure and on-farm work, so we cannot offer a definitive interpretation for this result.

The initial endowment proxy, LAND, appears to have a negative effect on borrowing. Although there was also no unambiguous theoretical prediction for this effect, the expectation, based on previous theoretical analyses, was that the relationship should be negative. It is worth noting that none of the earlier studies concerning India (e.g., Long (1968), Pani (1966), and Ghatak (1976)) obtain this result. Rather, they obtain a positive relationship between their measures of land or assets and the demand for credit. They ascribe this generally to multicollinearity and to scale effects. Our result indicates that the choice of an inappropriate proxy for initial endowment or, as argued above, improper definition of the dependent variable, might be the real source of the problem.

The one variable for which an unambiguously positive effect was expected, RESEARCH (investment opportunity), turns out to have the expected sign and to be quite significant. While the fact remains that we are making do with a rather crude proxy, the strength of the result is encouraging. It is also possible that the true effect of RESEARCH operates not directly but indirectly through interaction with characteristics such as land and education. Our other investment opportunity proxy, SQINDEX, appears to be associated with a reduced demand for funds. This may be due to some collinearity of this index with RESEARCH or to its additional role as a proxy for initial endowment. At any rate, the coefficient is insignificant.

Transitory income (TY) turns out to be, as expected, negatively and significantly related to the demand for funds. This result may be compared with that obtained by Long (1968). His measure of transitory income, the ratio of gross produce to value of land, turned out to be statistically insignificant. As Long noted also, this result depends on measuring the relevant variable appropriately. The elasticity of borrowing with respect to TY is 0.23, indicating an important role for transitory income.

INTEREST is significantly and negatively related to the demand for funds, as expected from theory. This high level of significance stands in contrast to the generally inconclusive results obtained by other studies: Neither Long (1968) nor Pani (1966), for example, find uniformly significant relationships between their measures of borrowing and interest rates. The borrowing response derived here is quite elastic--an increase in the nominal interest rate of 1 percent reduces the amount borrowed by 8.5 percent.

Borrowing Functions by Farm Size

Since land is widely believed to be the most crucial factor in the rural economy, stratification by land size promises to yield further insights into the borrowing process. We have arbitrarily selected a limit of 4 hectares to separate "small" farmers from "large" ones. Sample means for the two groups are presented in Table 1, and borrowing (lending) functions are reported in Table 4. Some interesting patterns emerge.

Table 4

BORROWING FUNCTIONS BY FARM SIZE
(asymptotic t-statistics in parentheses)

Independent Variable	Large Landholders[a]		Small Landholders	
WAGE	+109.36	(1.90)	-54.69	(1.33)
LAND	-9.59	(2.54)	12.02	(0.74)
RESEARCH	17.57	(3.51)	16.97	(4.38)
TY	-0.17	(7.10)	-0.19	(4.28)
SQINDEX	-0.005	(0.28)	-0.008	(0.52)
INTEREST[b]	-14.02	(5.78)	-2.96	(1.39)
Intercept	2456		407	
R^2	0.07		0.06	
F	19.6		11.1	
No. of observations	1671		1024	

[a]Large landholders are defined as those cultivating more than 4 hectares of land. The remainder are considered small landholders.

[b]INTEREST is estimated from the regression function shown in column 1 of Table 2. An x% interest rate is recorded in the data as 10x.

Apparently, initial endowments play different roles for large and small farmers. LAND is related to borrowing positively (but not significantly) for the small farmer, but negatively for the large. While this result may suggest a non-linear relationship between initial endowment and borrowing, it might also be due to the stratification procedure which reduces the variation in LAND for small farmers.

RESEARCH turns out to have a larger elasticity impact (3.2 versus 1.8) on the borrowings of small farmers. This suggests that the technology provided by crop research is not biased in favor of large farmers, an impression corroborated by the lack of significance of interaction terms relating RESEARCH to LAND (not reported here).

The fact that the interest rate is not significant in the case of small farmers may indicate that the estimated interest rate is not an adequate measure of the true cost of funds for small households.

IV. SUMMARY AND POLICY IMPLICATIONS

This study has investigated the determinants of rural interest rates and the borrowing and lending decisions of farmers. A life-cycle utility-maximizing framework has been used to establish certain theoretical predictions and to guide empirical analysis. The results support the modeling strategy and yield a systematic picture of farming and finance in LDCs. The implications of the results of each empirical part have been discussed separately, and we shall now examine the implications of the overall results.

In many ways, our results confirm--in a more precise manner than earlier studies have done--some conventional beliefs. For example, the role of land is seen to be important to the demand and supply of funds, and the amount of land a household possesses reduces both the interest rate that the household faces and the amount it desires to borrow. The borrowing effect, however, varies by farm size: Large farmers reduce their borrowings and small farmers seem to increase theirs. These results have some implications for land reform policies. It has been show elsewhere that a redistribution of rural income (through land reform, for example) could result in a drop in aggregate rural savings (Bhalla, 1980). Our study suggests that the drop in rural savings need not have disastrous consequences for rural investment, however, since aggregate rural borrowing is likely to increase as a consequence of the transfer of land from larger to smaller farmers.

Our results also show a link between the labor and capital markets. The district wage rate, which may be interpreted as a rough index of

labor-market developments, appears to be linked to household-specific interest rates and also appears to affect levels of rural borrowing, at least for larger farmers. The nature of this interaction is complex, and since its separate components could not be empirically isolated, a more complete analysis cannot be offered here.

In a slightly different context Bardhan (1980) and Braverman and Srinivasan (1979) have shown that government attempts to intervene in the landlord-tenant relationship are unlikely to be successful unless they are comprehensive, because a landlord can, for instance, raise the interest rate on his loans to his tenants to compensate for whatever loss of income he might suffer as a result of government legislation regarding wages or crop-shares. Our study shows that such factor-market interactions are empirically significant and need not be predicated on the existence of narrowly defined landlord-tenant relationships.

The link between the capital market and the rate of technical change in agriculture presumably goes both ways. On the one hand, the availability of funds could determine the rate of innovation; on the other hand, the pace of technical change itself might influence the demand and supply of funds. The first link has been the focus of much discussion in the past decade, and while a definitive study has yet to appear, the consensus seems to be that insufficient credit has hampered the spread of the Green Revolution. The present study sheds no light on the first link but examines the reverse link quite closely. Our results indicate that the capital market is affected by the rate of technical improvement on both the demand and the supply side: A higher rate of technical change (proxied here by RESEARCH) increases the demand for

funds and reduces the nominal interest rate. Apparently, such technical development offers the prospect of higher future earnings to farmers and thereby encourages them to borrow. The interest-rate effect can be interpreted as arising from the risk-reducing nature of technical change generated by agricultural research. Districts that are the beneficiaries of government sponsored research appear to lenders to be less risky, ceteris paribus, and hence residents of such districts face lower nominal interest rates. This risk-reducing effect of agricultural research stands in sharp contrast to some other interpretations of the Green Revolution which stress the potentially greater risk associated with new technology in explanations of farmer resistance to such change. While our results do not assess the direct risk associated with new technology, they do offer an indirect assessment: Lenders seem to consider beneficiaries of agricultural research (and, by extension, adopters of new seeds, fertilizers, and agricultural techniques) to be less risky, while borrowers appear to consider the income-enhancing aspects of such technical change to be more important than any possible downside risk.

A further set of issues regarding the interaction of the interest rate and the funds market can be only partially addressed here, since the provision of loans by the formal sector need not be in accordance with the same profit-maximizing principles expected in the case of moneylenders. Given this caveat, our interest-rate regressions indicate that the nominal interest rate does indeed respond to variables that proxy for the risk and opportunity cost of lending. On the demand side, the results indicate that the cost of funds is a significant factor in

determining how much is borrowed. For all households taken together, as well for those with large landholdings alone, the borrowing response to changes in the interest rate faced is quite elastic. This suggests that the interest rate remains an empirically important variable in the rural funds market, one that could be used to alter the leve' of credit use in the rural economy.

Appendix A

DATA AND DEFINITIONS

DATA

In 1968-69, NCAER undertook a national survey, known as the Additional Rural Incomes Survey, of approximately 5,000 agricultural households in India. This survey was repeated in 1969-70 and 1970-71 on the same households, but in the final year a core group of approximately 3,000 cultivating households were asked additional questions regarding borrowing, lending, interest rates, and interaction with formal lending agencies. The sampling design of the survey resulted in oversampling of rich households.

The present analysis is based on the core sample of households who were cultivators in 1970-71. Some exclusionary restrictions were applied to this group: Households with savings rates greater than 75 percent were excluded to eliminate some cases of logical inconsistency (savings greater than income, which implies negative consumption) and also to eliminate some cases where transcription errors appeared to be highly probable. These restrictions reduced the working sample to 2,912 observations. Not all these observations could be used in the regressions, because some of them were not complete, i.e., they contained missing values for some variables. In particular, values for the variable RESEARCH were not available for the states of Himachal Pradesh and Kashmir.

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DEFINITIONS

Savings (S). The savings of a household are defined as the change in net worth and computed as the difference between the change in the value of assets and the change in liabilities from year to year. They are adjusted for capital transfers through gifts, inheritances, and the like. A separate estimate of the vaue of consumer durables is also reported. Savings in the form of gold and silver and currency are not included, nor is any adjustment made for capital gains or losses and depreciation.

Income (Y). The income of a household is defined as the sum of the earnings of all members of the household during the reference period. This includes farm income, wages, rents, interest and dividends on financial investments, pensions, and non-farm business income.

Appendix B

THE WORKINGS OF THE MODEL

The optimal amount of borrowing (or lending) and the variation of it with respect to changes in the exogenous variables can be derived from the model described in the text by first setting up the Lagrangean equation and deriving the first-order conditions for a maximum and then totally differentiating these conditions and solving for the relevant expressions via Cramer's rule.

Our maximizing problem is:

Maximize

$$U = U(C_1, C_2, L_1, L_2) \tag{B.1}$$

subject to

$$p_1 \cdot f(K_1, D_1) + w_1 M_1 + B = C_1 + I, \tag{B.2}$$

$$\alpha . p_2 \cdot f(K_2, D_2) + w_2 M_2 + sK_2 = C_2 + B(1 + r), \tag{B.3}$$

$$M = T - L - D, \tag{B.4}$$

where all terms are as defined in the text.

The appropriate Lagrangean equation is thus

$$V = U(C_1, C_2, L_1, L_2) + \lambda_1\{p_1 f(D_1, K_1) + w_1(T - D_1 - L_1) + B - C_1 - I\}$$
$$+ \lambda_2\{\alpha p_2 f(D_2, K_2) + w_2(T - D_2 - L_2) + sK_2 - C_2 - B(1 + r)\}$$

where λ_1 and λ_2 are the period-specific Lagrangean multipliers. If only interior solutions are considered, first-order conditions for a utility

maximum are

$$U_{C1} - \lambda_1 = 0 \tag{B.5}$$

$$U_{C2} - \lambda_2 = 0 \tag{B.6}$$

$$U_{L1} - \lambda_1 w_1 = 0 \tag{B.7}$$

$$U_{L2} - \lambda_2 w_2 = 0 \tag{B.8}$$

$$p_1 f_{D1} - w_1 = 0 \tag{B.9}$$

$$\alpha p_2 f_{D2} - w_2 = 0 \tag{B.10}$$

$$\lambda_1 - \lambda_2(1 + r) = 0 \tag{B.11}$$

$$-\lambda_1 + \lambda_2(\alpha p_2 f_{D2} + s) = 0 \tag{B.12}$$

$$p_1 f(D_1, K_1) + w_1 M_1 + B - C_1 - I = 0 \tag{B.13}$$

$$\alpha p_2 f(D_2, K_2) + w_2 M_2 + sK_2 - C_2 - B(1 + r) = 0 \tag{B.14}$$

Totally differentiating the first-order conditions and rearranging the endogenous and exogenous factors yields the following matrix of second-order derivatives:

$$
\begin{bmatrix}
U_{C1C1} & U_{C1C2} & U_{C1L1} & U_{C1L2} & 0 & 0 & 0 & 0 & -1 & 0 \\
U_{C2C1} & U_{C2C2} & C_{C2L1} & U_{C2L2} & 0 & 0 & 0 & 0 & 0 & -1 \\
U_{L1C1} & U_{L1C2} & U_{L1L1} & U_{L1L2} & 0 & 0 & 0 & 0 & -w_1 & 0 \\
U_{L2C1} & U_{L2C2} & U_{L2L1} & U_{L2L2} & 0 & 0 & 0 & 0 & 0 & -w_2 \\
0 & 0 & 0 & 0 & T & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & V & 0 & Y & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -P \\
0 & 0 & 0 & 0 & 0 & R & 0 & Q & -1 & J \\
-1 & 0 & -w_1 & 0 & w_1 & 0 & -1 & -1 & 0 & 0 \\
0 & -1 & 0 & -w_2 & 0 & w_2 & -P & J & 0 & 0
\end{bmatrix}
\begin{bmatrix}
dC_1 \\ dC_2 \\ dL_1 \\ dL_2 \\ dD_1 \\ dD_2 \\ dB \\ dI \\ d\lambda_1 \\ d\lambda_2
\end{bmatrix}
\tag{B.15}
$$

$$
= \begin{bmatrix}
0 \\
0 \\
\lambda_1 dw_1 \\
\lambda_2 dw_2 \\
-p_1 f_{D1K1}\, dK_1 - f_{D1} dp_1 + dw_1 \\
-\alpha p_2 f_{D2K2} - \alpha f_{D2} dp_2 + dw_2 - p_2 f_{D2} d\alpha \\
\lambda_2 dr \\
\lambda_2 \alpha p_2 f_{K2K2} dK_1 - \lambda_2 \alpha f_{K2} dp_2 - \lambda_2 ds - \lambda_2 p_2 f_{K2} d\alpha \\
-p_1 f_{K1} dK_1 - f(K_1, D_1) dp_1 - M_1 dw_1 \\
-(\alpha p_2 f_{K2} + s) dK_1 - \alpha f(K_2, D_2) dp_2 - p_2 f(K_2, D_2) d\alpha - M_2 dw_2 - K_2 ds + B dr
\end{bmatrix}
$$

where $P = 1 + r$

$J = \alpha p_2 f_{K2} + s$

$Q = \lambda_2 \alpha p_2 f_{K2K2}$

$R = \lambda_2 \alpha p_2 f_{K2D2}$

$T = p_1 f_{D1D1}$

$V = \alpha p_2 f_{D2D2}$

$Y = \alpha p_2 f_{D2K2}$

Applying Cramer's Rule and rearranging, we get

$$\frac{dB}{dw_1} = \lambda_1 \frac{D_{37}}{D} + \frac{D_{57}}{D} - M_1 \frac{D_{97}}{D} , \tag{B.16}$$

$$\frac{dB}{dw_2} = \lambda_2 \frac{D_{47}}{D} + \frac{D_{67}}{D} - M_2 \frac{D_{10\cdot 7}}{D} , \tag{B.17}$$

$$\frac{dB}{dr} = \lambda_2 \frac{D_{77}}{D} + B \frac{D_{10\cdot 7}}{D} , \tag{B.18}$$

$$\frac{dB}{dp_1} = -f_{D1} \frac{D_{57}}{D} - f(D_1,K_1) \frac{D_{97}}{D} , \tag{B.19}$$

$$\frac{dB}{dp_2} = -\alpha f_{D2} \frac{D_{67}}{D} - \lambda_2 \alpha f_{K2} \frac{D_{87}}{D} - \alpha f(K_2,D_2) \frac{D_{10\cdot 7}}{D} , \tag{B.20}$$

$$\frac{dB}{ds} = -\lambda_2 \frac{D_{87}}{D} - K_2 \frac{D_{10\cdot 7}}{D} , \tag{B.21}$$

$$\frac{dB}{d\alpha} = -p_2 f_{D2} \frac{D_{67}}{D} - \lambda_2 p_2 f_{K2} \frac{D_{87}}{D} - p_2 f(K_2,D_2) \frac{D_{10\cdot 7}}{D} \tag{B.22}$$

$$\frac{dB}{dk_1} = -p_1 f_{D1K1} \frac{D_{57}}{D} - \alpha p_2 f_{D2K2} \frac{D_{67}}{D} - \lambda_2 \alpha p_2 f_{K2K2} \frac{D_{87}}{D}$$

$$-p_1 f_{K1} \frac{D_{97}}{D} - (\alpha p_2 f_{K2} + s) \frac{D_{10\cdot 7}}{D} , \tag{B.23}$$

where D is the determinant of the bordered Hessian matrix and Dij is the cofactor of row i and column j of that matrix. By assuming additive separability in the utility function, we can solve these terms algebraically to get

$$D > 0; \quad D_{37} < 0; \quad D_{77} < 0;$$

$$D_{47} < 0; \quad D_{87} > 0;$$

$$D_{57} > 0; \quad D_{97} > 0;$$

$$D_{67} > 0; \quad D_{107} > 0.$$

Using these results in Eqs. (B.16) - (B.23) yields the coefficient signs reported in the text. Details of the interpretation of the various terms involved in Eqs. (B.16) - (B.23) may be found in Iqbal (1981). Only a brief discussion of some of the important aspects of these results is presented here.

The theoretical results depend essentially on what may be called period-specific income effects. Thus, when variations in an exogenous factor cause income to rise in period 1, the household transfers some of this increase to consumption in period 2 by reducing its borrowings; increases in period 2 income similarly lead to an increase in borrowing as the household attempts to raise period 1 consumption. Thus $dB/d\alpha$, dB/dp_2, and dB/dS are all positive in sign because increases in α, p_2, and S all amount to increases in second-period income, whereas dB/dp_1 is negative because an increase in p_1 amounts to an increase in current-period income.

The results for dB/dW_1 and dB/dW_2 involve, in addition, what could be called "leisure substitution" effects. An increase in W_1, for example, increases the cost of L_1, and since L_1 and L_2 are substitutes (by the additive separability assumption), the consequence is a decrease in L and an increase in L_2. This intertemporal transfer of leisure is accomplished by a decrease in borrowing, which reduces repayment claims in period 2 and thereby permits greater consumption of goods and leisure. The case of an increase in W_2, which leads to an increase in borrowing ceteris paribus, is similar. It should be noted that the signs of db/dW_1 amd dB/dw_2 also depend on whether the household is a net labor importer or exporter and also on the relationship of on-farm labor (D_1, D_2) to leisure. Thus, in the case of an employed but landless household, where M_1 and M_2 are always positive and $D_1 = D_2 = 0$, it can be shown that $dB/dW_1 < 0$ and $dB/dW_2 > 0$.

The expression for dB/K_1 contains both income effects and is therefore ambiguous. An increase in K_1 causes first-period income to rise (through the production-function relationship) and thereby induces a decrease in borrowings. It also causes second-period income to rise (since K_1 is included in K_2) and thereby induces an increase in borrowings. The two effects oppose each other. Alternative models, by failing to take into account future-period effects, conclude that an increase in assets must have a negative effect on borrowing. Also, the expression dB/dK_1 contains terms pertaining to the cross-partial relationship of the arguments of the production function, and hence the sign will depend on the specifics of these relationships as well.

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