WPSC5+1

Credit's Effect on Productivity in Chinese Agriculture

A Microeconomic Model of Disequilibrium

Gershon Feder
Lawrence J. Lau
Justin Y. Lin
and
Xiaopeng Luo

Not all farmers — sometimes only a minority — are constrained in their farming operations by inadequate credit. And part of formal credit is diverted to consumption so the effect on output of greater supplies of formal credit might not be as large as one would expect if one assumed that it would all be used productively.

This paper — a product of the Agricultural Policies Division, Agriculture and Rural Development Department — is part of a larger effort in PRE to evaluate agricultural credit policies and review institutional designs so as to formulate better guidelines for Bank activities in rural credit. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Cicely Spooner, room N8-035, extension 30464 (27 pages).

Many government programs want to provide more credit to the farm sector to increase agricultural productivity. If the marginal effect on productivity is small, those resources might be put to better use elsewhere.

Feder, Lau, Lin, and Luo conducted an econometric analysis of the effect of credit on output supply which recognizes that credit markets are not necessarily at equilibrium — so that credit rationing (with unsatisfied demand) and nonborrowing (when credit could be available) are both possible. Only about 37 percent of the farmers in the study area were constrained by inadequate formal credit. Informal credit sources provided funds for specific non-agricultural activities that were not fungible.

The results indicate that one additional yuan of liquidity (credit) yielded 0.235 yuan of additional gross value of output. These results suggest that for the area of China covered in the study, a good part of the short-term credit may actually be used for consumption and investment. Indeed, medium- and long-term formal credit is practically nil among the agricultural households in the study area. Rolled-over short-term credit is sometimes used for small-scale investments. The diversion of short-term credit for farm investment is about 40 percent for an average household in the study area. This implies that almost a third of the formal credit is used for consumption (of current goods or durables).

What conclusions does this suggest in evaluating the probable effect of expanding agricultural credit? First, not all farmers, and sometimes only a minority, are constrained in their farming operations by inadequate credit. And second, greater supplies of formal credit will be diverted in part to consumption, so the likely effect on output will be smaller than what one might expect if all funds are assumed to be used productively.

Credit's Effect on Productivity
in Chinese Agriculture: A Microeconomic Model of Disequilibrium

by
Gershon Feder, Lawrence J. Lau,
Justin Y. Lin, and Xiaopeng Luo

Table of Contents

I. INTRODUCTION

Credit is an important element in agricultural production systems. It allows producers to satisfy the cash needs induced by the production cycle which characterizes agriculture: preparation, planting, cultivation and harvesting of the crops are typically done over a period of several months in which very little cash revenue is earned, while expenditures on materials, purchased inputs and consumption need to be made in cash. Cash income is received a short time after the harvest. In the absence of credit markets, farmers would have to maintain cash reserves so as to facilitate production and consumption in the next cycle. The availability of credit allows both greater consumption and greater purchased input use, and thus increases welfare of the farmers.

If a producer faces an infinite supply of liquidity at a given price, the production decisions will be independent from consumption decisions, as has been shown in the household models of Singh et al. However, asymmetric information and adverse selection typically prevail in credit markets, giving rise to credit rationing as an optimal behavior (Stiglitz and Weiss). Furthermore, government intervention in the form of interest rate ceilings or subsidized interest rates is common in many countries' agricultural sectors, necessitating rationing. When credit is rationed, some borrowers cannot obtain the amount of credit they desire at the prevailing interest rate, nor can they secure more credit by offering to pay a higher interest rate. In such circumstances, liquidity can become a binding constraint on many farmers' operations.

When liquidity is a binding constraint, the amounts and combinations of inputs used by a farmer deviate from their notional optimal levels (the levels that would have been utilized if liquidity were not a binding constraint). The marginal contribution of credit is therefore to bring input levels closer to the optimal levels, thereby increasing output and, since the quantity of land

is fixed, yield. This potential gain in productivity is one motivation underlying many government programs seeking to provide more credit to the farm sector. An important issue in the context of agricultural credit policy is the magnitude of the expected productivity gain. If the marginal productivity effect of credit is small, then the resources may be more beneficially deployed elsewhere. Assessment of the expected productivity gain is not trivial because the effect of credit is likely to differ between liquidity-constrained and unconstrained farm households.

Some studies attempt to identify the effect of credit by estimating separate production functions or supply functions for borrowers and non-borrowers, and then proceeding to compare the estimates (see review in David and Meyer, 1980, pp. 206-215). One major weakness of this approach is the implicit assumption that all borrowers and all non-borrowers are respectively homogenous with respect to their credit demand/supply situations. This assumption is often not valid, as many non-borrowers do not borrow because they actually have sufficient liquidity from their own resources and not because they cannot obtain credit, while some cannot borrow because they are not credit-worthy. Similarly, the marginal effect of credit may actually be zero for borrowers for whom liquidity is not a binding constraint.

The same criticism applies to other studies in which all sampled observations are pooled to estimate production functions (or output supply functions) with credit as a production input or as a supply determinant. As will be argued in a subsequent section, the supply function is different (both in parameters and in variables) depending on whether liquidity is a binding constraint. Estimates which do not take account of these restrictions on the specification are therefore flawed.

The present study reports an econometric analysis of the effect of credit on output supply which avoids some of the aforementioned pitfalls. The central feature is the recognition that credit transactions are not necessarily in equilibrium at the household level. That is, the amount of credit desired and the amount offered are not necessarily equal so that credit supply

rationing (with unsatisfied demand) and non-borrowing (while supply is potentially available) are both possible. The analysis utilizes cross-sectional household-level data from a study area in northeast China, obtained in a recent farm survey designed by the authors. The plan for the paper is as follows: Section II provides background on the farm sector and the rural credit market in China, and describes the specific study area and data utilized in the analysis. Section III discusses the formal model underlying the empirical analysis (the mathematical model is presented in an annex). It is followed by a discussion of the econometric procedure and the empirical results in Section IV. The last section discusses the implications of the results.

II. CHINA'S FARM SECTOR AND RURAL CREDIT MARKET

China introduced a smallholder agricultural production system in a series of reforms between the years 1979-1984. The "household responsibility system" made individual households, rather than the communes to which they belonged, the decision-makers and managers of their own farms. Individual families were allocated land by the communes on leases that run typically for 15 years. The improved incentives brought about a significant increase in agricultural output and in rural income (Lin). While prior to the reforms there was only limited interaction between households and financial institutions, the emergence of smallholder agriculture implies that many households now need liquidity for seasonal production and consumption, or longer-term credit to finance investment, construction and ceremonial social events.

Most of agricultural households' transactions with the formal financial sector are done with the rural credit cooperatives (RCCs).[1] The interest rates for agricultural loans (as well as other loans) made by formal credit institutions are fixed by the government, with some variations according to loan categories. In 1987, the rates of interest for agricultural loans ranged between 7 and 14 percent. The degree of interest subsidy is believed to have been small.

There is evidence that following the introduction of reforms the volume of liquidity obtained from informal sources is substantial in China. Jiang asserts that non-institutional

sources contribute roughly half of the credit volume in rural areas. Feder et al. (1989) report non-institutional credit shares of between one third and two thirds in several study areas. The most common sources of informal credit in China are relatives and friends. Most of such loans carry no interest charges. Possible reasons for the absence of a substantial profit-motivated informal credit market in China are discussed in Feder et al. (1990a). They include: unclear legal status, residual ideological resistance and absence of collateral assets.[2]

The present study relies on data collected in December 1987 in Gongzhuling. Gongzhuling is located in Jilin province, within the corn belt of northeastern China, where agro-climatic conditions dictate essentially one corn season a year. The original sample consists of 200 households selected at random from eight randomly selected townships. The information gathered covers inputs, outputs, financial assets, credit transactions, and household characteristics. Thirteen households are deleted after determining that their main activity was not agriculture or that their situation was unusual (e.g., a widow maintaining a home garden plot).

The data show that nearly three quarters of the sample borrowed from formal sources (essentially the RCCs) during the study season. The frequency of informal credit transactions is much lower than that of formal transactions (about one fifth of the sample), and three quarters of these loans were provided free of interest. Given the significant differential between the rates of interest on the two types of loans, this may be taken as evidence that informal credit is not a good substitute for formal credit due to limited fungibility (otherwise every borrower would exhaust his or her informal credit first before going to the RCC). The share of formal credit in the total volume of new credit is 66.5 percent.

Table 1 presents the distribution of loans by purpose and by type of lender. It is readily apparent that the predominant stated purpose of formal loans (all of which are short-term) is for the financing of current production. Most of the informal credit is reported to have been obtained for purposes other than production, with construction and social expenditures appearing

dominant. Informal loans contracted for these purposes, however, cannot be easily diverted to finance day-to-day consumption or production, because the lenders, mostly relatives and friends, can easily monitor compliance. The bulk of the fungible credit, defined as credit which is not granted for easily monitored purposes, in the study area thus comes from the formal sector (87 percent).

Given the dominance of formal credit, a key issue for the present study is the extent to which its supply is a constraint on households' desired activities. The survey data collected permit an answer to this question. Borrowing households were asked if at the going rates of interest they would have liked more institutional credit than the amount they were actually granted. Households which did not borrow were asked the reason for not borrowing. The most common reason for not borrowing was availability of sufficient own resources. The borrowers who indicated a desire for more credit, and the non-borrowers who responded that they could not obtain credit, are classified as credit-constrained. As reported in Table 2, about 37 percent of the farm households in Gongzhuling were constrained by credit according to this classification. The liquidity position of credit-constrained households as compared to non-constrained households is compatible with intuitive expectations: They have significantly lower deposits in financial institutions, and overall, their liquid resources per unit of land are 12 percent below those of unconstrained households.

III. A MODEL OF FARM HOUSEHOLD CONSUMPTION, PRODUCTION AND INVESTMENT

Suppose the household considers the allocation of resources at its disposal at the beginning of the production period between the following uses: (i) current consumption; (ii) investment; (iii) the purchase of variable inputs for current production (including labor and fertilizers). Variable inputs, in combination with land and existing capital, will produce this period's output. Investment will not mature by the time this period's output is produced, but its contribution to the household's welfare may be accounted for through a valuation function which

TABLE 1: Distribution of Loan Purposes by
Type of Lender (Percent)

		Purpose					
Source of Loans	Sample Size (Number of Loans)	Prod-uction	Farm Equip-ment	Constr-uction	Consump-tion	Social (Wedding Funeral, etc.)	Other
Formal	209	92.3	4.3	1.9	0	1.0	0.5
Informal	44	9.1	4.6	20.5	15.9	27.3	22.7

TABLE 2: Extent of Formal Credit Constraint

Category	Sample Size (Number of Households)	% Constrained
Borrowers	145	41.3
Non-borrowers	42	28.3
All	187	37.4

summarizes the contribution of capital to the future consumption stream. The household's initial endowments of liquid resources, family labor, capital, and land (the latter two assumed not convertible to liquidity during the period) can be augmented by borrowing at the beginning of the period. Whether the household can borrow the entire desired amount or is constrained by a binding upper limit on the availability of credit is of considerable consequence, as it determines whether production decisions are separable from the consumption decisions. The household is assumed to maximize a utility function defined over consumption per family member in the current and next period, plus the utility of future streams of consumption summarized by the valuation function of next period's capital, per family member. The optimization can be carried out under two scenarios: (i) The supply of credit is greater than or equal to the demand (i.e., credit constraint not binding); and (ii) The supply of credit is less than the notional demand for credit (credit constraint binding).

The essence of the results of such a model [3] is that under case (i) above, the supply of output is not affected by the level of liquidity (including credit), the size of the household's own family labor force or the total size of the household. The parameters of the output supply function in this case are determined by the production function alone. Under case (ii), however, output supply is positively affected by increases in liquidity (e.g. increased credit supply) and in the household's labor endowment, while the effect of total household size is indeterminate. Increases in the initial endowments of land and capital would have a positive effect on output supply in both cases (i) and (ii), while they would have an indeterminate impact on input demands, depending on substitutability. The parameters of the output supply function under case (ii) are determined by both the production function and the utility function.

IV. ECONOMETRIC SPECIFICATION AND EMPIRICAL RESULTS

The econometric model most suitable for estimating the output supply function with the data available to us is the switching regression model with an endogenous criterion function described in Maddala (pp. 223-228). The model postulates for any observation I

$$(1) \quad Y_{1I} = \beta_1 X_{1I} + U_{1I} \qquad \text{iff} \qquad \gamma Z_I + U_I \leq 0$$

$$(2) \quad Y_{2I} = \beta_2 X_{2I} + U_{2I} \qquad \text{iff} \qquad \gamma Z_I + U_I > 0$$

where X_{1I}, X_{2I} and Z_I are vectors of exogenous or predetermined variables, β_1, β_2, and γ are the corresponding vectors of parameters, and U_{1I}, U_{2I} and U_I are random disturbances. Y_{1I} and Y_{2I} are two possible values of the dependent variable, only one of which is actually observed for any given household, depending on the value of the (unknown) criterion function $\gamma Z_I + U_I$. The random disturbances are assumed to have a trivariate normal distribution, identically and independently distributed across households. Applied to the particular issue at hand, equations (1) and (2) may be viewed as the output supply equations under a non-binding and binding liquidity constraint respectively. The criterion for whether liquidity is binding or not is whether the demand for credit exceeds credit supply, and the criterion function $\gamma Z + U$, in our case, is the excess credit demand function (i.e., demand minus supply). Excess credit demand is not directly observable. However, from the survey responses, we know whether a given household is constrained or unconstrained by liquidity. Using data on the dichotomous responses, the vector of parameters γ can be estimated up to a proportionality constant by a probit procedure. The estimated parameters are then used to generate Mills ratios which are incorporated in the second stage estimates, where the equations (1) and (2), with their Mills ratio corrections, are estimated by a linear regression. Under model assumptions, the estimated coefficients are consistent and asymptotically normal, and with appropriate corrections to their estimated variance-covariance matrix (due to the heteroscedasticity of the stochastic disturbance terms in the second stage estimates) can be subjected to statistical tests based on normality.

The empirical specification of the variables which constitute the vector Z involves both determinants of credit demand and credit supply. Thus, in the case of variables which affect both demand and supply in the same direction, one cannot predict a priori the expected sign. These variables are (with the expected effect on the probability of being credit constrained indicated in parentheses for those with an unambiguous effect): (1) Land; (2) Capital; (3) Number of adults (-); (4) Number of dependents;[4] (5) Education; (6) Farm experience; (7) Savings in financial institutions (-); (8) Total initial liquid assets (-); (9) Outstanding debt to financial institutions (+); (10) Total outstanding debt (+); (11) Last season's income (-); (12) Previous loan default dummy (+). In addition, eight dummy variables for townships were introduced. The results of the probit estimates are presented in Table 3.[5] Two estimated coefficients are statistically significantly different from zero at the 5 percent level of significance and have the theoretically predicted sign: Savings in financial institutions and last season's income. Eighty-two percent of the observations are properly classified as being credit constrained or unconstrained, implying a fairly good fit.

The reduced form output supply equation for liquidity-constrained households, estimated with the double-log specification, involves the following variables (with the direction of the expected effect noted in parentheses): (1) Total liquidity [6] (+); (2) Number of adults (+); (3) Number of dependents (?); (4) Land (+); (5) Capital (+); (6) Education (+); (7) Farm experience (+). The specification for the households not constrained by liquidity is similar except for the first three variables, which do not theoretically belong in the reduced form for output supply.[7] The estimated coefficients are reported in Table 4.

In the output supply equation for constrained households, (column 1) the estimated coefficient of the total liquidity variable is positive and statistically significantly different from zero at the 5 percent level of significance, but the number of adults and the number of

TABLE 3: Estimated Coefficients of Probit Model
(probability of being credit-constrained)

Variable [a]	Estimated Coefficient (t-value)
Land	-.212 (.505)
Capital	-.029 (.265)
Number of adults	.282 (1.950)
Number of dependents	.093 (.509)
Education	-.101 (1.502)
Farm experience	-.025 (1.666)
Savings in financial institutions	-.121 (2.223)
Total initial liquid assets	.376 (1.552)
Outstanding debt to financial institutions	-.053 (.977)
Total outstanding debt	.057 (1.182)
Last season's income	-.974 (2.973)
Previous loan default	.587 (1.260)
Percent correctly predicted	.820
No. of observations	156

a/ The equation also included also eight township dummy variables. These are not reported.

TABLE 4: Estimated Coefficients of Second Stage Switching
Regression Model for Output Supply
(Reduced Form)

Variable [a] Regression	(1) Credit Constrained (N=48)	(2) Credit Unconstrained (N=108)	(3) Credit Unconstrained Counter factual (N=108)
Total liquidity	.183 (2.951) [b]	−	.042 (1.261)
Number of adults	.015 (.641)	−	.001 (.004)
Number of dependents	−.020 (.538)	−	−.005 (.247)
Land	.863 (8.166)	.875 (18.120)	.846 (15.202)
Capital	.027 (1.193)	.051 (3.287)	.052 (3.306)
Education	−.004 (.261)	.018 (2.216)	.018 (2.206)
Farm experience	−.028 (.533)	.063 (2.324)	.062 (2.250)
R^2	.863	.867	.869

[a] Regressions included also eight dummy variables for townships and the Mills ratios computed from the first stage probit. These are not reported.

[b] Numbers in parentheses denote t-values

dependents do not have statistically significant estimated coefficients. The hypothesis that all three variables do not affect the supply of output for constrained households has a F-statistic of 2.96 and is rejected at the 5 percent level of significance, confirming the theoretical predictions of the model. The quantity of land is an important and statistically significant determinant of output supply for constrained and unconstrained households (the estimated coefficients of the output supply function for the latter group are reported in column 2). It is also worth noting that capital, education and farm experience have statistically significant positive effects on output for the credit-unconstrained households but have statistically insignificant effects for the credit-constrained households. This finding suggests that capital, education and experience are less likely to contribute to output if the farmer's choices are constrained by liquidity.

While under the assumptions of our model it is not appropriate to estimate the output supply equation for the unconstrained households with the inclusion of liquidity and household composition variables (liquidity is theoretically endogenous for such households and the estimated coefficients would be subject to simultaneity bias), we experimented with the estimation of such a hypothetical counter-factual case on the assumption that the classification was wrong and therefore these households were liquidity-constrained. The results (column 3 in Table 4) indicate that none of the estimated coefficients of the first three variables are statistically significantly different from zero (the hypothesis that all three are not significant has a F-statistic of 0.55 and cannot be rejected at any level of significance) implying that the counter-factual case is not borne out empirically. Another experiment was the estimation of the model using the whole sample without separation, that is, as if all households were liquidity-constrained. The results show that the estimated coefficient of total liquidity in the output supply equation would have been about two-thirds of that in column 1. Predictions based on the wrong estimated

coefficients would thus lead to significantly inaccurate assessments of the effect of credit on output supply. ¯

V. IMPLICATIONS

Based on the estimated coefficients, if every credit-constrained household in the sample is given an additional credit of 17.82 yuan (equal to 1 percent of the average level of liquidity of the credit-constrained households), the total output of these households may be projected to increase by 201.08 yuan, or approximately 0.04 percent of the total output. Thus, on average, one additional yuan of liquidity (credit) would yield $201.08/(17.82 \times 48) = 0.235$ yuan of additional gross value of output. These results suggest that for the area of China covered in the present study, a significant proportion of the short term credit provided by the rural credit cooperatives as "production credit" may actually be utilized for consumption and investment. Indeed, medium and long term formal credit is practically nil amongst the agricultural households in our study areas, and a similar picture is given by aggregate statistics. Rolled-over short term credit is sometimes utilized to finance small scale investments. A recent study by Feder et al. (1990b) finds that the diversion of short-term credit for farm investment is about 40 percent for an average household in the study area. This, in turn, implies that almost a third of the formal credit is utilized for consumption (whether of current goods or durables).

The results of the study highlight two important factors which should be considered when evaluating the likely impact of agricultural credit expansion: (i) Not all farmers, and sometimes only a minority, are constrained in their farming operations by inadequate credit; (ii) Expanded supplies of formal credit will be diverted in part to consumption, thus the likely output effect will be smaller than that which is expected when all funds are assumed to be used productively. These ideas have been propounded by the Ohio State school critics of credit supply-led development schemes. The present paper thus provides empirical verification of these views.

References

David, Cristina and Richard Meyer, "Measuring the Farm Level Impact of Agriculture Loans," in John Howell (ed.), Borrowers and Lenders: Rural Financial Markets and Institutions in Developing Countries, London: Overseas Development Institute, 1980.

Feder, Gershon, Lawrence J. Lau, Justin Y. Lin and Xiaopeng Luo, "Agricultural Credit and Farm Performance in China," Journal of Comparative Economics, 13: 508-525, December 1989.

Feder, Gershon, Lawrence J. Lau, Justin Y. Lin and Xiaopeng Luo, "The Nascent Credit Market in Rural China," Working Paper, Department of Economics, Stanford University, 1990a.

Feder, Gershon, Lawrence J. Lau, Justin Y. Lin and Xiaopeng Luo, "The Determinants of Farm Investment and Residential Construction in Post-Reform China", World Bank, Department of Agriculture and Rural Development, Working Paper, March 1990b.

Jiang, Shiji, "How Are the Various Types of Non-Bank Credits in Rural Areas at Present to be Treated?", Rural Finance Research Institute, Guangxi Zhuang Autonomous Region, July 1984.

Lin, Justin Y., "The Household Responsibility System in China's Agricultural Reform: A Theoretical and Empirical Study," Economic Development and Cultural Change, Supplement 36: 199-224, April 1988.

Maddala, G.S., Limited - Dependent and Qualitative Variables in Econometrics, Cambridge: Cambridge University Press, 1983.

Singh, Inderjit, Lyn Squire and John Strauss (eds.), Agricultural Household Models, Baltimore: Johns Hopkins University Press, 1986.

Stiglitz, Joseph E., and Andrew Weiss, "Credit Rationing and Markets with Imperfect Information," American Economic Review 71:393-410, June 1981.

Footnotes

The authors are respectively a Principal Economist at the World Bank, Professor of Economics at Stanford University, Professor of Economics at Beijing University, and Visiting Scholar, Cambridge University. We are indebted to Angus Deaton for useful comments and to Shu-Cheng Liu for research assistance.

1/ Greater detail on the credit market in rural China and in the study area is provided in Feder et al. 1989, 1990a.

2/ Land is on a fifteen-year lease and until recently use rights could not be transferred.

3/ A rigorous derivation of model implications is provided in an annex.

4/ The number of dependents plus number of adults constitute household size. While the number of adults has an unambiguous effect, household size (and consequently the number of dependents) does not.

5/ The households with special large scale ceremonial expenditures were not included in the econometric analysis, as their liquidity requirements and borrowing patterns could be quite different. This reduces the sample size for the econometric analysis to 156. However, including these households, with appropriate dummy variables and interaction terms, does not alter the nature of the results qualitatively.

6/ This consists of cash value of product inventory, deposits in financial institutions, and fungible formal loans. Informal credit was assumed non-fungible as observed in Section II. Total liquidity differs from the total initial liquid assets in the probit equation, which do not include current fungible credit.

7/ The equations should have included output and input prices. However, because the data are derived from a cross-section within a confined geographical area, there is no price variation and price variables are omitted.

A MODEL OF HOUSEHOLD CONSUMPTION AND INVESTMENT

Suppose the household considers the allocation of resources at its disposal at the beginning of the production period between the following uses: (i) current consumption (ii) investment (iii) the purchase of variable inputs. Variable inputs, in combination with land and existing capital, will produce next period's output. Investment will not mature by the time next period's output is produced, but its contribution to the household's welfare is accounted for through a valuation function which summarizes the contribution of capital to the optimal consumption stream. The household's initial endowments of liquid resources, family labor, capital, and land (the latter two assumed not convertible to liquidity) can be augmented by borrowing at the beginning of the period. Whether the household can borrow the desired amount or is constrained by a binding upper limit on the availability of credit is of great consequence, as it determines whether production decisions are separable from the consumption decisions. Below we describe the various components of the model, and then set up the optimization problem.

a. Initial endowments

The household possesses initial liquid wealth (W_0), physical capital (K_0), land (A) and household labor (X_0). Household labor can be approximated by the number of adults.

b. Production

Output is produced through a standard neo-classical production function which combines initial capital, labor and land.

(1) $Q = F(K_0, X, A)$

Partial derivatives are denoted by a letter subscript

(e.g., $\dfrac{\partial F}{\partial X} = F_x$).

c. The utility function

The utility function is defined over consumption per family member in the present period, plus the utility of future streams of consumption summarized by the valuation function of next period's capital, per family member. The notation is

(2) $U = U_0(C_0/N) + U_1(C_1/N) + V(K_1)/N$

where C_0 and C_1 are respectively total consumption in the present period and in the next period, K_1 is capital in the next period, N is family size, U_0 and U_1 are current and next period utilities of consumption, and V is the capital valuation function. The time discount factor is omitted from the notation as it is implicit in the definition of U_1 and V. The marginal utility of consumption and of capital value is assumed decreasing, i.e., $U'' < 0$, $V'' < 0$.

d. Second period consumption and capital

The capital stock in the next period is simply the present stock K_0 augmented by present investment I, i.e.,

(3) $K_1 = K_0 + I$

Consumption in period 1 is given by the value of output minus debt repayment, i.e.,

(4) $C_1 = F(K_0, X, A) - (1+r) \cdot L$

where r is the interest rate and L is the amount of credit used. The price of output is normalized to 1, without loss of generality.

e. The budget constraint

The total amount of liquid resources (i.e., initial liquid wealth, plus borrowing) have to equal the cash expenditures on current consumption, labor costs for hired labor, and investment, i.e.,

(5) $W_0 + L = C_0 + \theta \cdot (X - X_0) + I$

where θ is the wage rate.

The optimization problem is

(6) $\underset{C_0, C_1, K_1, I, L, X}{\text{Max}}$ $U_0(C_0/N) + U_1(C_1/N) + V(K_1)/N$

subject to equations (1), (3), (4), (5)

By proper substitutions, the optimization problem can be simplified to

(7) $\underset{I,X,L}{\text{Max}}$ $U_0[(W_0 + L - I - \theta X + \theta \cdot X_0)/N] + U_1 \left([F(K_0,X,A) - (1+r)\cdot L]/N \right)$

$$+ V(K_0 + I)/N$$

Consider first the case where there is no binding constraint on the amount which the household borrows.

Credit not a binding constraint

The first order conditions for optimum under this scenario are (assume internal solutions)

(8) $(-U_0' + V')/N = 0$

(9) $(-\theta \cdot U_0' + U_0' \cdot F_x)/N = 0$

(10) $[U_0' - (1+r)\cdot U_1'], = 0$

Substituting for U_0' in equation (9) using equation (10) and rearranging yields

(11) $F_x = \theta \cdot (1+r)$

The optimal amount of labor (labor demand), say X^*, can be derived from equation (11) as a function of θ, r, K_0 and A

(12) $X^* = X^* (\theta, r, K_0, A)$

Note that total labor demand does not depend on any of the parameters of the utility functions, neither does it depend on family size, the number

of adults or initial liquidity. This is the well known separation property of household production and consumption models as developed in Singh et al. (1986). Using equation (12), the supply function of output (when credit is not a binding constraint) can be written as

(13) $Q^* = Q^* (\theta, r, K_0, A)$

Note that the econometric estimation of equations (12) and (13) should not include the amount of credit as an explanatory variable, because it is endogenously determined.

We turn now to discuss the case where the household cannot obtain as much credit as is needed to satisfy the first order conditions (8) - (10). One characteristic of such a situation is that equality (11) cannot hold, and instead

(14) $F_x > \theta \cdot (1+r)$

Credit a binding constraint

The derivation of first order conditions for this scenario is based on the same objective function (7), except that L (the amount of credit) is treated as a parameter (it is determined by the supplier of credit and not by the household). The control variables are therefore only I and X. The first order conditions are:

(15) $(-U_0' + V')/N = 0$

(16) $(-\theta \cdot U_0' + U_1' - F_x)/N = 0$

The Hessian of equations (15) - (16) is

$$
H = \begin{bmatrix}
U_0''/N^2 + V''/N & \theta \cdot U_0''/N^2 \\
\\
\theta \cdot U_0''/N^2 & (\theta^2 U_0'' + U_1'' \cdot F_x^2 \ D + U_1' \cdot F_{xx})/N^2
\end{bmatrix}
$$

The determinant of H is

$$
(17) \quad \Delta = (\theta \cdot U_0'' \cdot V''/N^3) + [(U_0''/N) + V''] \cdot (U_1'' \cdot F_x^2 + U_1' \cdot F_{xx})/N^3 > 0
$$

The sign of (17) is established given the concavity of U_0, U_1, V and F.

The derivation of comparative statics results is discussed below. A general observation, however, is that the input demand function (and consequently the output supply function) depends on parameters of the utility functions and on household size the household's labor endowment and liquidity (including the exogenously determined amount of credit).

A differentiation of equations (15), (16) yields the following comparative static results, summarized in Table 1 (a fuller treatment is provided in the appendix).

An increase in the availability of credit will increase investment, variable input use, and output of credit-constrained households, because it allows both increased consumption and production. The analysis can demonstrate that an additional unit of credit will typically not be fully used for productive purposes (i.e. investment or inputs), but rather, a portion will be used for increased current consumption (the so called

"leakage" problem), due to the fungibility of credit

Table 6: Comparative Static Results for Credit-Constrained Households

Effect On Change In	Investment I	Variable Input X	Output Q
Credit (L)	+	+	+
Household size (N)	-	?	?
Household labor (X_0)	+	+	+
Initial capital (K_0)	?	?	+
Land (A)	?	?	+

An increase in the household size while holding the household labor force constant (i.e., an increase in the number of dependents) will have a negative impact on investment, while the impact on current input use and output is undetermined. This is because the marginal utility of both present and next period consumption is increased, while the marginal valuation of capital is unchanged. This result would not obtain if the capital valuation function were defined in terms of capital per household member.

An increase in the household's labor force while holding household size constant will lead to an increase in investment, variable input use and output. The reason is that under a binding liquidity constraint, an increase in the number of employees who do not need to be paid in cash has

an affect similar to that of increased credit supply.

Changes in the complementary inputs (capital and land) will increase output, as one would expect intuitively. However, the impact on input use and investment depends on the substitutability of inputs and on the nature of the utility function.

APPENDIX

Derivation of Comparative Static Results

The results below are derived for the case of a household with a binding credit constraint. We rewrite the first order conditions (15), (16), omitting unnecessary terms

(1A) $-U_0' + V' = 0$

(2A) $-\theta \cdot U_0' + U_1' \cdot F_x = 0$

and the corresponding Hessian

(3A) $H = \begin{bmatrix} U_0'' + N \cdot V'' & \theta \cdot U_0'' \\ \\ \theta \cdot U_0'' & \theta^2 \cdot U_0'' + U_1'' \cdot F_x^2 & U_1' \cdot F_{xx} \end{bmatrix}$

The determinant of H is given by Δ.

$\Delta = \theta^2 \cdot N \cdot V'' \cdot U'' + (U_0'' + N \cdot V'')(U_1'' \cdot F_x^2 + U_1' \cdot F_{xx})$

Results of a change in each parameter of the system (1A), (2A) are obtained by differentiation and a solution using Cramer's rule.

(i) Change in credit availability (L)

(4A) $[H] \begin{bmatrix} \dfrac{dI}{dL} \\ \\ \dfrac{dX}{dL} \end{bmatrix} = \begin{bmatrix} U_0'' \\ \\ \theta \cdot U_0'' + U_1'' \cdot F_x \cdot (1+r) \end{bmatrix}$

$$(5A) \quad \frac{dI}{dL} = \frac{U_0'' \cdot U_1'' \cdot (F_{xx} + F_x \cdot [F_x - \theta \cdot (1+r)])}{\Delta} > 0$$

The sign is established using the concavity of U and F, and the fact that in the case of a binding credit constraint it must hold $F_x > \theta \cdot (1+r)$ (see (14) in the text).

$$(6A) \quad \frac{dX}{dL} = \frac{N \cdot U_0'' \cdot V'' + (U_0'' + N \cdot V'') \cdot U_1'' \cdot F_x \cdot (1+r)}{\Delta} > 0$$

where the sign is established by the concavity of U and V. The sign of $\dfrac{\partial Q}{\partial L}$ follows trivially, as

$$(7A) \quad \frac{\partial Q}{\partial L} = \frac{F_x \cdot dx}{dL} > 0$$

(ii) Change in household size N

$$(8A) \quad N^2 \cdot [H] \begin{bmatrix} \dfrac{dI}{dN} \\ \dfrac{dX}{dN} \end{bmatrix} = \begin{bmatrix} - U_0'' \cdot C_0 \\ - \theta \cdot U_0'' \cdot C_0 + U_1'' \cdot C_1 \cdot F_x \end{bmatrix}$$

$$(9A) \quad \frac{1}{N^2} \cdot \frac{dI}{dN} = \frac{-U_0'' \cdot C_0 \cdot (U_1'' \cdot F_x^2 + U_1' \cdot F_{xx}) - \theta \cdot U_0'' \cdot U_1'' \cdot C_1 \cdot F_x}{\Delta} < 0$$

$$(10A) \qquad \frac{1}{N^2} \cdot \frac{dX}{dN} = \frac{U_0'' \cdot U_1'' \cdot C_1 \cdot F_x + N \cdot V'' \cdot (U_1'' \cdot C_1 \cdot F_x - \theta \cdot U_0'' \cdot C_0)}{\Delta}$$

The sign of $\dfrac{dX}{\partial N}$ cannot be established because the term $U'' C_1 \cdot F_x - \theta \cdot U_0'' \cdot C_0$ can be positive or negative. Consequently, the impact on output is also undetermined.

(iii) Change in household labor (X_0)

$$(11A) \qquad [H] \begin{bmatrix} \dfrac{dI}{dX_0} \\ \dfrac{dX}{dX_0} \end{bmatrix} = \begin{bmatrix} \theta \cdot U_0'' \\ \\ \theta^2 \cdot U_0'' \end{bmatrix}$$

$$(12A) \qquad \frac{dI}{dX_0} = \frac{\theta \cdot U_0'' \cdot (U_1'' \cdot F_x^2 + U_1' \cdot F_{xx})}{\Delta}$$

$$(13A) \qquad \frac{dX}{dX_0} = \frac{\theta^2 \cdot N \cdot V'' \cdot U_0''}{\Delta} > 0$$

(iv) Change in initial capital K_0

$$(14A) \qquad [H] \begin{bmatrix} \dfrac{dI}{dK_0} \\ \dfrac{dX}{dK_0} \end{bmatrix} = \begin{bmatrix} -N \cdot V'' \\ \\ - U_1' \cdot F_{xk} - U_1'' \cdot F_x \cdot F_k \end{bmatrix}$$

Typically inputs are complementary in the sense $F_{xk} > 0$, and the

signs of $\dfrac{dI}{dK_0}$, $\dfrac{dX}{dK_0}$ cannot be determined because the sign of $-U_1' \cdot F_{xk}$

$- U_1'' \cdot F_x \cdot F_k$ is not known. However, $\dfrac{dQ}{dK_0} = F_x \cdot \dfrac{dX}{dK_0} + F_k$ and it can be

shown that

$$(15A) \qquad \frac{dQ}{dK_0} = \frac{-(U_0'' + NV'') \cdot (U_1' \cdot F_x \cdot F_{xk} - U_1' \cdot F_{xx} \cdot F_k) + \theta \cdot N \cdot U_0'' \cdot V''(F_k + F_x)}{\Delta} > 0$$

(v) Changes in land endowment (A)

$$(16A) \qquad [H] \begin{bmatrix} \dfrac{dI}{dA} \\[2mm] \dfrac{dX}{dA} \end{bmatrix} = \begin{bmatrix} 0 \\[2mm] -U_1' \cdot F_{xa} - U_1'' \cdot F_x \cdot F_a \end{bmatrix}$$

As in the case of K_0, the sign of $\dfrac{dI}{dA}$ and $\dfrac{dX}{dA}$ cannot be determined

because the sign of $-U_1' \cdot F_{xa} - U_1'' \cdot F_x \cdot F_a$ is not known. However

$$(17A) \qquad \frac{dQ}{dA} = F_x \cdot \frac{dX}{dA} + F_a = \frac{N \cdot F_a \cdot U_1'' \cdot V'' - (U_1'' + N \cdot V'') \cdot (U_1' \cdot F_x \cdot F_{xa} - U_1' \cdot F_a F_{xx})}{\Delta} > 0$$

	Title	Author	Date	Contact for paper
WPS554	Korea's Labor Markets Under Structural Adjustment	Dipak Mazumdar	December 1990	M. Schreier 36432
WPS555	The Macroeconomics of Price Reform in Socialist Countries: A Dynamic Framework	Simon Commander Fabrizio Coricelli	December 1990	O. del Cid 39050
WPS556	Taxing Choices in Deficit Reduction	John Baffes Anwar Shah	December 1990	A. Bhalla 37699
WPS557	The New Fiscal Federalism in Brazil	Anwar Shah	December 1990	A. Bhalla 37699
WPS558	Alternative Instruments for Smoothing the Consumption of Primary Commodity Exporters	Kenneth M. Kletzer David M. Newbery Brian D. Wright	December 1990	J. Carroll 33715
WPS559	Fiscal Policy and Private Investment in Developing Countries: Recent Evidence on Key Selected Issues	Ajay Chhibber Mansoor Dailami	December 1990	D. Bilkiss 33768
WPS560	The Persistence of Job Security in Reforming Socialist Economies	Milan Vodopivec	December 1990	CECSE 37188
WPS561	The Labor Market and the Transition of Socialist Economies	Milan Vodopivec	December 1990	CECSE 37188
WPS562	Anticipated Real Exchange-Rate Changes and the Dynamics of Investment	Luis Serven	December 1990	S. Jonnakuty 39076
WPS563	Empirical Investment Equations in Developing Countries	Martin Rama	December 1990	E. Khine 39361
WPS564	Costs and Benefits of Agricultural Price Stabilization in Brazil	Avishay Braverman Ravi Kanbur Antonio Salazar P. Brandao Jeffrey Hammer Mauro de Rezende Lopes Alexandra Tan	December 1990	C. Spooner 30464
WPS565	Issues in Socialist Economy Reform	Stanley Fischer Alan Gelb	December 1990	CECSE 37188
WPS566	Measuring Outward Orientation in Developing Countries: Can It Be Done?	Lant Pritchett	January 1991	K. Cabana 37947
WPS567	Macroeconomic Management and the Division of Powers in Brazil: Perspectives for the Nineties	Antulio N. Bomfim Anwar Shah	January 1991	A. Bhalla 37699

	Title	Author	Date	Contact for paper
WPS568	Higher Wages for Relief Work Can Make Many of the Poor Worse Off: Recent Evidence from Maharashtra's "Employment Guarantee Scheme"	Martin Ravallion Gaurav Datt Shubham Chaudhuri	January 1991	C. Spooner 30464
WPS569	Domestic Purchase Requirements for Import License Allocations in Mali	Wendy E. Takacs	January 1991	S. Fallon 37947
WPS570	Debt Concentration and Secondary Market Prices	Raquel Fernandez Sule Ozler	January 1991	S. King-Watson 31047
WPS571	Credit's Effect on Producti y in Chinese Agriculture: A Microeconomic Model of Disequilibrium	Gershon Feder Lawrence J. Lau Justin Y. Lin Xiaopeng Luo	January 1991	C. Spooner 30464