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MICROECONOMIC BEHAVIOR OF AGENTS IN A CREDIT-OUTPUT MARKET IN AN AGRICULTURAL SETTING*

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Introduction

An interlinked deal is one in which two or more interdependent exchanges are agreed upon by the contracting parties. The price of a commodity in one market therefore, cannot be isolated from the price of the other commodity in another market.

Empirical evidence shows that many of the lenders in the informal rural credit market engage in interlinked deals (TBAC 1978 and 1981; Quiñones 1982; Floro 1986; Bardhan and Rudra 1978). This is specifically true among trader-lenders who comprise most of the lenders in the rural area (TBAC 1978; Quiñones 1982; Floro 1986). These studies also show that both lenders and borrowers engage in interlinked credit-output market deals.

Rural agents engage in interlocking market transactions to minimize costs due to underdevelopment of rural markets. This study assumes that agents will naturally involve themselves in interlinked deals due to the structure of the rural economy – its imperfect and incomplete markets, assymmetry of information, high risks and the nature of agricultural loans. This study aims to model the economic behavior of agents in a credit-output market. Specific behavior of borrowers and lenders will be looked into to determine how these agents interact with one another using a single-lender and a many lender case. The reasons for interlinkage found in the literature will be assumed and will not be studied. However, the monitoring process and the provision of finance capital to be used for production inputs in order to ensure adequate output will surface in the optimizing behavior of the economic agents. While there are several

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theoretical work on the behavior of agents in a credit-output market, not much have been done to model the economic behavior of trader-lenders and their farmer-borrowers. Most of the theoretical work are done in the context of a landlord-tenant relationship. So far, only Floro (1986) has looked into the behavior of trader-lenders and farmer-borrowers in a credit-output market.

Section 2 presents a discussion of the theoretical model. Section 3 verifies the hypothesis arising from the model and finally Section 4 gives the summary and conclusion of the paper.

The Model

The model makes the following initial assumptions. The farmer borrows from a trader-lender, since most rural banks or other formal financial institutions are reluctant to lend to small farmers. The trader-lender, on the other hand, is willing to extend loans to these farmer-borrowers. These trader-lenders normally have sufficient capital compared to other informal lenders, to meet the credit requirements of farmer-borrowers. Farmer-borrowers use loans either for production or consumption. Assuming that farmer-borrowers are heterogeneous, with varying production and input demand functions, then the purposes for which they use their loans determine the nature of their maximizing behavior. A farmer-borrower using his loan for production maximizes his income while a farmer-borrower who uses his loan for consumption maximizes utility. The trader-lender engaged in an interlinked credit-output activity maximizes his profits. He knows how a specific farmer-borrower behaves and therefore acts accordingly. If the farmer borrows for production purposes, he would ensure that sufficient inputs are used to generate the right output. On the other hand, if the farmer borrows for consumption purposes, he ensures that maximum effort is exerted by the farmer to generate desired output. The behavior of the farmer-borrower is thus incorporated in the trader lender's maximization problem. It may be argued that with imperfect information, the foregoing may be difficult to achieve. However, in a rural setting where trader-lenders reside in the areas where they operate and where relationships tend to be personal, it is not very difficult for the lender to know how his clients behave and classify them accordingly. In the following, this presumption will be made, allowing us to separately model the decisions made according to whether the purpose of borrowing is production or consumption.

Behavior with Production Loans

Because of relatively underdeveloped markets in rural economies, a farmer obtains a loan from a trader-lender typically by engaging in a tied sale of his output, i.e. he promises to pay his loan in kind and sell the remaining amount of his produce to the same trader-lender. Under this arrangement, the farmer-borrower is able to borrow from the trader-lender without the necessity of a land collateral (Floro 1986). At the same time, the trader lender, through the interlinked deal, is assured the output of the farmer months in advance before the actual purchase. Thus, he ensures that the farmer gets sufficient finance capital to purchase required production inputs so that output can be sufficiently supplied.

With the foregoing motive for interlinkage, the trader- lender is faced with an incentive problem which resembles that confronting a landlord-lender in the interlinkage literature. The problem of the trader-lender resembles the problem of the principal in a principal-agent relationship, although there are some important differences. There is no uncertainty in this model, hence there is no problem of confounding effort and adverse consequences. The contract arrived at is always "first best." The adverse selection problem is also assumed away since the trader-lender can distinguish between those who maximize income and those who maximize utility. Thus, this model is a more modest attempt to delineate the shape of the first-best contract under certainty, when markets are linked.

Behavior of a farmer-borrower with production loans

The farmer is assumed to be an income maximizer with respect to his farm activities.

Let p be the price offered by the trader-lender for the farmer-borrower's output and i the interest rate charged by the lender on the farmer's loan.

Assuming that the amount borrowed by the farmer borrower (L) is equal to his total outlay on inputs, I, then this implies that input expenses are entirely financed by borrowings. The farmer-borrower is assumed to sell all his output to the trader-lender. Hence his residual cash income is defined by the following:

$$(1) \qquad Y = pX(I,N) - I(1+i)$$

where X gives the farmer's total produce ($X_I > 0$, $X_N > 0$, $X_{II}, X_{NN} < 0$) and N the farmer's size of the land. Effort is not included in the borrower's production function since the amount of effort exerted by each borrower per unit of land (N) is assumed to be the same across borrowers. (Although the function X may differ across borrowers.) Moreover, it is assumed that the farmer-borrower maximizes his income from production. He sees to it that the amount he borrows generates maximum income for him. In this case, there is no need to "monitor" the effort of the farmer. If this assumption is not satisfied, then the farmer behaves as one who may use the loan for consumption purposes (as the farmer-borrower described in p.11) and who therefore requires monitoring of effort. Since payments are made in kind, a farmer-borrower will only borrow up to the amount I^o where:

(2) $pX \geq I^o(1 + i)$ or $I^o \leq pX/(1+i)$

where I^o is the ceiling for the farmer's borrowings.

The farmer-borrower then maximizes his residual cash income, Y by choosing the appropriate level of input demand, I given p and i. For an interior solution,

(3) $Y_I = pX_I - (1+i) = 0$

Equation (3) then results in the following:

(3a) $X_I = (1 + i)/p$

This equation implicitly defines I as a function of p, i, and N, i.e. $I = I(i,p,N)$. With the assumption of strict concavity of $X(I,N)$, we obtain $I_i < 0$, $I_p > 0$, and $I_n > 0$. (See Appendix 1 for a formal derivation.) That is, an increase in i (respectively p or N) has a negative (respectively positive) effect on the borrower's loan demand. More accurately, note that, $I = I((1+i)/p,N)$. This also shows that various combinations of i and p are consistent with unchanging loan demand I.

Since i and p have opposing effects on demanded I, which eventually has an effect on the farmer-borrower's income Y, there are therefore various combinations of p and i which result in a constant income for a farmer-borrower. We term this as an iso-income curve, with a slope given by slope Y which is

$$dp/di = X/I > 0$$

and which is concave to the origin in the p-i plane. (The slope and the shape of the curve are shown in Appendix 1). Figure 1 illustrates such an iso-income curve for a farmer borrowing for production purposes. This means that for a constant income for a farmer-borrower, an increase in i should be accompanied by increase in p.

FIGURE 1

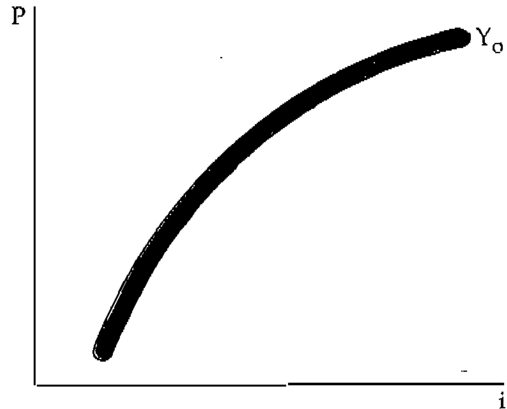


FIGURE 2

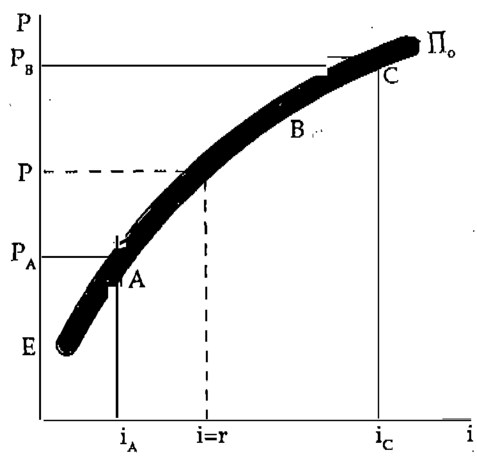
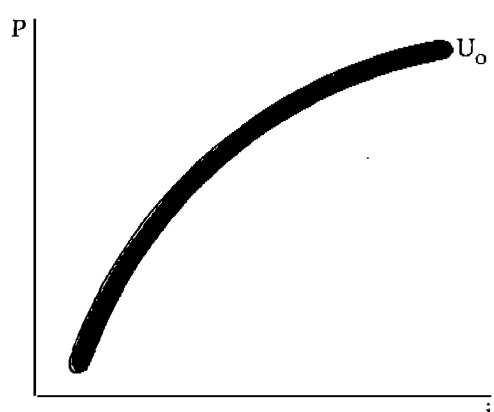


FIGURE 3



The trader-lender's behavior with production loans

Let us now look at the decision problem of the trader-lender who extends production loans to farmer-borrowers behaving in the manner described above.

Since the farmer-borrower sells his entire output to the trader-lender, we let X^j (the farmer's total production) be the total volume of produce bought by a trader-lender from an individual farmer-borrower j

$$(4) \qquad X^j = X^j(I^j, N^j) \qquad X^j_I > 0 \;\; X^j_N > 0$$

where I^j is determined from the farmer's optimizing problem as discussed previously, and where X^j is the production function of farmer j. We assume the trader-lender has access to the formal financial market, where he either has an opportunity cost r for his excess funds or where he seeks loan assistance, also at a rate r, to further finance his trading activity. He lends to the farmer with interest i. It is assumed he can sell the farm produce at some market price P. He offers to buy the farmer's produce at price p.

The trader-lender's objective function is then formulated as follows:

$$(5a) \qquad \underset{(p^j,i^j)}{\text{Max}}\, \Pi = \sum_{j=1}^{n} (P - p^j)X + (i^j\text{-}r)I^j$$

$$(5b) \qquad \text{s.t. } X^j = X^j(I^j,N^j), \text{ all j}$$

$$(5c) \qquad I^j = I^j(i^j,p^j,N^j), \text{ all j}$$

where it will be noted I^j is the solution to the farmer's optimizing problem in (1). This implies that in maximizing his profits, the trader-lender knows how a farmer-borrower behaves.

The solution to (5) may be thought of in two ways. First, either the lender has an absolute financial constraint B^o, which limits the loanable amount. Then (5) must be augmented by another constraint:

$$(5d) \qquad I^j < B^o$$

The other possibility is that the lender has access to unlimited funds at the market rate r, in which case (5a)-(5c) need only be supplemented by the condition that

$$(5e) \qquad \Pi^j > 0 \qquad \text{for all j}$$

Taking either interpretation, it can be seen that the lender is maximizing Π^j separately for each farmer j (since (5a) is separable in its arguments), computing optimal (p^j,i^j) pairs for each j, which in turn determine the loan demand I^j. In any event, the situation will allow a ranking of farmer-borrowers $\{1,2,...j,...\}$, where

$$\Pi^1 > \Pi^2 > ...\Pi^j > ...$$

Where (5d) is relevant, the lender may be viewed as simply moving down the list of borrowers until B^o is exhausted. Where (5e) is relevant, on the other hand, the lender simply moves down the list and chooses all borrowers j for which $\Pi^j > 0$. Without loss of generality and for simplicity therefore, the subscript j can be dropped and the lender's decisions can be examined with respect to a single borrower. Hence:

$$\text{(6)} \qquad \text{Max}\ \Pi = (P - p)X(I,N) + (i - r)I(i,p,N)$$

from which the following first order conditions can be derived:

$$\text{(6a)} \qquad \Pi_i = (P - p)X_I I_i + (i - r)I_i + I(i,p,N) = 0$$
$$\text{(6b)} \qquad \Pi_p = (P - p)X_I I_p - X(I,N) + (i - r)I_p = 0$$

A trader-lender therefore maximizes his profits at the point where the following hold true:

$$\text{(6a')} \qquad I_i\ (PX_I + i) + I = I_i(pX_I + r)$$
$$\text{(6b')} \qquad I_p\ (PX_I + i) = I_p(pX_I + r) + X$$

i.e. the marginal revenue from a change in p or i should be equal to the marginal cost due to the same change in p or i. The trader-lender could increase i or decrease p as long as the addition to his revenues,both from the credit and output market, is equal to the additional cost brought about by the increase in i and decrease in p. Note that changes in i and p affect both the revenue and costs of a trader-lender since they affect the amount of credit borrowed by a farmer-borrower which in turn affects the amount of output that can be bought by the trader-lender.

A trader-lender will charge a different i and necessarily p per farmer-borrower depending on the latter's characteristics, as represented by the size of land and the production function. This is so since the farmer-borrowers may be heterogeneous with respect to production and input demand functions resulting in varying volume of output available to the trader-lender per farmer-borrower. Considering the foregoing results, a trader-lender will charge a farmer-borrower an i and p which equates his marginal revenue to his marginal costs.

Flexible interest-price determination

A lender involved in interlocking transactions is able to maximize profits by employing flexible lending terms. From the first order condition in (6a) and (6b), the following can be derived:

(7a) $P\text{-}p = [-(i-r)I_i - I(i,p,N)] / X_I I_i$
(7b) $P\text{-}p = [X(I,N) - (i-r)I_p] / X_I I_p$

This indicates the possibility that a trader-lender may charge a low or even zero interest rate as long as he can buy the farmer's output at a price which is much below the prevailing market price. Note that for $i=0$, the RHS of both (7a) and (7b) are positive. The first order conditions need not be violated for some $p < P$. Note that a trader-lender can charge various combinations of i and p as long as this will result in some minimum income representing some reservation income, for the farmer-borrower. This is illustrated in Fig. 2. Π_o is the curve which gives (i, p_X) coordinates that will yield a constant profit Π_o. This is the iso-profit curve.

Equation (3a) and equation (6) show that p and i are positively related. For a constant positive profit, an increase in i should be accompanied by an increase in p since i and p have opposite effects on I which influence X and ultimately the trader-lender's profit.

Suppose P is the prevailing market price of output and r is the prevailing cost of capital. The diagram shows that points A, B, and C, yield the same level of profit to the trader-lender. At point A, $P > p$ but $i < r$. At point C, $P < p$ but $i > r$. Note that he may even charge a zero interest rate, as in E, as long as he buys the output at OE, a price which is well below the market price P. Losses in the credit market may be offset by gains in the output market.

Suppose further that Π_o is the maximum profit for the trader-lender, an interior maximum solution for the trader's problem requires the profit function to be more concave than the income function.

Evidence on the existence of zero rural interest rates in fact validate this possibility. Results concur with Basu's (1983) argument that a zero interest rate should not necessarily be taken as an indicator of peasants being better off. This is because in an interlinked credit-output market, i and p cannot be separated from each other. i cannot be strictly defined as the cost of credit in credit market nor p the cost of product in the output market.

In interlinked markets, peasants who pay no interest may get a lower price for their produce, one which is way below the prevailing market price. Thus, charging an $i < r$ may not necessarily improve a peasant's well-being.

Loan elasticities and price and interest differentials

From (6a)and (6b), the following expressions are obtained for the interest and price elasticities of loan demand, we get the following:

(8a) $E_i/i = -1/(P-p)X_I + (i-r)$

(8b) $E_pI/P = X(I,N)/(P-p)X_I + (i-r)$

where

E_i is the interest elasticity of the farmer-borrower's loan demand

E_p is the elasticity of the farmer-borrower's loan demand with respect to buying price

Equation 8a and 8b show that as the farmer's demand for loan becomes more elastic (as farmers' loan demand becomes more sensitive to interest rates and buying price of output, i.e. E_i becomes a larger negative number and E_p becomes a larger positive number), output price and interest rate differentials $(P-p)$ and $(i-r)$, respectively) become smaller implying inability of the trader-lender to exact higher i or lower p and therefore less profit for the trader-lender. This is further explained by the following: as loan demand becomes more interest and price elastic, an increase in i or a decrease in p will reduce I which in turn reduces X and may ultimately reduce the trader-lender's profit.

Since interest inelasticity is more prevalent among poor farmers having no other sources of financing , large differentials between P and p and betweeen i and r are more likely to be found among these borrowers. Among farmers with relatively greater resources, loan demand may be more elastic since these farmers have a wide array of lenders including formal sources to choose from. This theoretical result conveys that competition among lenders (which make E_i and E_p more elastic) make interest rate and price differentials smaller. Furthermore, if loan elasticities are assumed across borrowers, a situation arises where lenders may not necessarily prefer richer farmers if bigger price and interest differentials can be charged due to smaller loan elasticities of poorer farmer-borrowers. This breaks the results derived by Floro (1986) wherein trader-lenders are thought to lend more to larger- sized farmers.

Including operation costs

If $P > p$ and $i > r$, this could lead to a quick conclusion that a trader-lender garners extra profits. However, note that aside form the direct cost incurred by the trader-lender in both the output and credit market (i.e. r and p), he still incurs an amount of operation cost to cover the costs of his fixed investments (e.g. warehouses, trucks, mills, etc.) and other costs (transportation, information costs, etc.). This is clearly shown by including these costs (C) in the profit function of the trader-lender. Therefore, let C $= g_j(X_j)$ since the amount of a trader's costs depend on the volume of his purchases. Thus the trader-lender's profit function for a single borrower becomes:

$$(9) \qquad \Pi = (P-p)X(I,N) + (i-r)L(i,p,N) - g(X)$$

Maximizing the foregoing expression results in the following first order conditions.

$$(9a) \qquad \Pi_i = (P-p)X_I I_i + (i-r)I_i + I(i,p,N) - g'X_I I_i = 0$$
$$(9b) \qquad \Pi_p = (P-p)X_I I_p - X(I,N) + (i-r)I_p - g'X_I I_p = 0$$

These conditions simply state that for a single trader-lender in an area, maximum profits are realized when the sum of the marginal revenue from each individual borrower is equal to the total marginal costs.

Since a higher volume of trade with an individual borrower results in lower cost per unit of quantity on the part of the trader (lower MC) and since profit maximization requires MC=MR, a trader-lender maximizing profits may reduce his MR from that borrower through an increase in buying price or a lowering of interest rate.

Hence, part of the difference between the prevailing market price for output and that which a trader-lender pays his borrowers and the difference between the interest charges and the oppurtunity cost of money to the trader-lender may be accounted for as payment for his other operation costs (transport cost, delivery cost,etc.) and his ownership of specific assets such as warehouses, trucks, mills, etc. and as payment for other costs.

Similarly, g(X) could also be interpreted as the cost incurred by the trader-lender in delivering services to the farmer-borrowers. These services include delivery of loan to farmer-borrowers and pick-up of output loan payment. Hence, for a trader-lender who has fixed investments and who delivers varied services to his farmer-borrower client, g(X) increases and consequently also his marginal costs. Thus, to attain optimum profits, he increases his marginal revenue per individual borrower. This therefore implies that the differentials P-p and i-r increase with improvements (which entail an additional cost to the trader-lender) in the services extended by the trader-lender to his borrowers.

Behavior with Consumption Loans

Behavior of a farmer-borrower with consumption loans

Aside from production loans, farmers also borrow to augment if not totally finance, their consumption needs. Stylized facts suggest that a sizeable number of borrowers in the rural areas, particularly in some crop areas like coconut, borrow not to finance their production needs but rather their subsistence. This practice is common among farmer-borrowers cultivating crops which do not require large production inputs. Farmers engaged in copra production provide one example. The following model is adopted from Braverman and Srinivasan (1982), with the following assumptions: The farmer-borrower at the beginning of each season borrows his entire consumption needs for the coming season and repays his loan with interest at the end of the harvest season. No stocks are held from one season to the next, nor are there any investment oppurtunities. Thus, in any season a farmer borrows an amount c for consumption equal to the amount of his income (pX) at the end of the season discounted by (1 + i), where p, X, and i have the same meanings as in the previous sections.

$$(13) \qquad c = pX/(1 + i)$$

Equation (13) simply says that the higher the discounted value (using i as interest rate) of the gross output of the farmer, the larger the consumption loan he can obtain. The farmer's output X is given by

$$(14) \qquad X = X(e,N)$$

where e is the production effort exerted by the farmer-borrower and N the size of land being cultivated. The assumption of having standardized effort across borrowers is now dropped. The rationale for this will be explained when the trader-lender's behavior is addressed. Input demand is assumed to depend only on N, hence I is fixed per borrower. X is a concave function with continuous first and second-order derivatives, $X_e > 0$, and $X_{ee} < 0$.

Unlike a production loan, which is seen by a farmer-borrower as an investment with expected returns, a consumption loan is treated by the farmer-borrower as a commodity that enters his utility function. A farmer's choices are limited to the amount of consumption he consumes in the next period and the amount of effort he exerts to be able to attain the desired level of consumption. However, since c becomes a function of e (from equation (13) and (14)), in effect the farmer's control variable is e alone. The farmer-borrower's maximization problem becomes

$$(15) \quad \underset{e}{\text{Max}}\ U(c, e) \quad \text{s.t. } X = X(e, N), \quad C = pX/(1 + i)$$

The farmer's utility function is assumed to be quasi-concave with $U_i > 0$, $U_p < 0$ and U_{ii}, $U_{pp} < 0$. Maximizing (15) with respect to e yields the following first-order condition:

$$(16) \quad U_e = \{U_e\, pX_e / (1 + i) + U_e\} = 0$$

From which the following can be derived:

$$(17) \quad X_e = -U_e(1 + i) / U_1 p$$

Since $U_e < o$, this implies that i is positively and p is negatively related to X_e (the marginal product of effort). Assuming diminishing returns to e, the foregoing implies a negative relationship between e and i and a positive one between e and p. Hence,

$$(18) \quad e = e\,(i,p) \quad e_i < 0 \quad e_p > 0$$

This means that if i is higher, less effort is exerted, and if p is higher, more effort is exerted. Formal derivation of the foregoing relationship is given in Appendix 2.

Similar to the behavior of a farmer-borrower borrowing for production purposes, i and p also have opposing effects on e which eventually has an effect on a farmer-borrower utility. There is also,therefore,a combination of i and p which gives a farmer-borrower constant utility (iso-utility curve). The slope of this curve is shown by the following:

$$dp/di = -e_i/e_p > 0$$

The derivation of the slope and shape of U_o is shown in Appendix 2. Figure 3 shows the iso-utility curve of a farmer-borrower borrowing for consumption purposes. Note that U_o is also concave with a positive slope in the (i – p) plane.

The trader-lender's behavior with consumption loans

The foregoing shows that a farmer-borrower's behavior differs, depending on the purpose for which he makes a loan. A farmer-borrower who borrows production loans borrows to produce hence maximizes income, while a farmer-borrower who borrows for consumption purposes borrows to consume (hence maximizes utility). Since a trader-lender's main motive is higher profits through an expansion in trading activity, his lending behavior will differ depending on the type of farmer-borrower he deals with. A trader-lender who extends a production loan is interested in having his loan repaid and in being able to buy the maximum amount of output from the farmer-borrower. He is primarily interested in the productivity of the loan (l) he extends. Because a farmer-borrower with production loan is an income maximizer, he will exert maximum effort to be able to produce more. Thus, the trader-lender can already influence the output through the very tangible production inputs.

A trader-lender who extends consumption loans, on the other hand, becomes interested in e, that is assuming that e can be observed. Like the trader-lender extending production loans, the main objective is still to maximize profits and to expand trading activity. He is still interested in having his loan repaid and in being able to buy the maximum output from the farmer-borrower. However, he becomes interested in e, since the borrower now maximizes utility with consumption and leisure as main arguments. The amount he borrows and eventually repays depends on the utility he attaches to both consumption and leisure.

Moreover, a trader-lender becomes interested in e, since it is the only way by which he can affect the total produce of a farmer-borrower which is his primary interest. He cannot influence production through l, since the loan he extends is used for consumption purposes, nor can he influence N for it is assumed fixed per borrower. The amount of produce a farmer-borrower has determines the amount of output to which the trader-lender can have access.

When confronted by any farmer-borrower j, the trader-lender's maximization problem is

$$(19) \qquad \underset{i,p}{\mathrm{Max}\,U} = \sum_{j=i}^{n}(P-p)X^j + (i^j-r)C^j \quad i$$

$$\text{s.t. } X^j = X^j(e^j,N^j)$$

$$C^j = p^jX^j/(1+i^j)$$

Without loss of generality, the subscript j can again be dropped and consider only the decision with respect to a single borrower. The constraints in the maximization problem are substituted to obtain the following:

$$(20) \qquad \mathrm{Max}\Pi = (P- \ p)X(e(i,p),N) + (i-r)pX(e(i,p),N)/(1+i)$$

Maximizing (20) with respect to i and p yields the following first-order conditions:

$$(20a) \quad \Pi_i = Xp(1+r)/(1+i)^2 + [(P-p) + (i-r)p/1+i]X_1e_i = 0$$

$$(20b) \quad \Pi_p = -X(1+r)/(1+i) + [(P-p) + (i-r)p/1+i]X_1e_p = 0$$

Dividing the first equation by the second results in the following:

$$(21) \quad -e_i/e_p = p/(1+i)$$

which implies that at an optimum, the rate at which an increase in i can be replaced by a decrease in p without any decrease in the effort level of a farmer-borrower (hence maintaining the level of X to be sold to the trader-lender) should be equal to the discounted output price given to the farmer-borrower.

Thus, a trader-lender extending consumption loans to his borrowers expands traded volume by influencing the farmer-borrower's level of effort, while a trader-lender extending production loans does so by influencing the farmer-borrower's level of input demand. Again, as in the case of production loans, one cannot distinguish between p and i as payment for output and payment for credit respectively.

It must be noted that the results described in p.6 where trader-lenders rank the farmers according to profits derived, p.8 (flexible interest-price determination) and p. 9 (relationship between loan elasticity and interest and price differentials) and p. 10 (including operation costs), all apply to consumption loans as well.

Behavior of Agents: Verification of Hypotheses

Several propositions have been raised in the theoretical framework. These propositions may now be verified.

Does a lender involved in a credit-output market interlinkage system prefer to lend to farmer-borrowers with bigger resource status?

Table 1 shows that lenders do not lend to those with bigger land sizes. Among palay farmer-borrowers only six percent of those who borrowed from trader-lenders have land sizes greater than three hectares while among coconut farmer-borrowers, around 17 percent of the total loans extended went to these type of farmer-borrowers. Most of the loans

Table 1
DISTRIBUTION OF SAMPLE FARMER-BORROWERS' LOANS BY SOURCE OF CREDIT AND BY SIZE OF LAND

	0 to 1.00 ha.				1.01—3.00 ha.				3.01—5.00				greater than 5 ha.				Total		
	Amount	%1/	%2/	No.	Amount	%1/	%2/	No.	Amount	%1/	%2/	No.	Amount	%/	%2/	No.	Amount	%	No.
SOURCES OF CREDIT																			
Palay Borrowers																			
traders-lenders	68646	23.49	26.91	46	199120	68.15	38.93	53	24420	8.36	24.89	5	0	0.00	0.00	0	292186	33.54	104
friends	61940	22.00	24.28	62	169250	60.13	33.09	31	45700	16.24	46.58	4	4600	1.63	69.70	0	281490	32.31	100
relatives	118159	43.56	46.33	62	123110	45.38	24.07	31	28000	10.32	28.54	5	2000	0.74	30.30	1	271269	31.14	99
farmer	6320	24.01	2.48	3	20000	75.99	3 .91	3	0	0.00	0.00	—	0	0.00	0.00	0	26320	3.02	6
Total	255065	29.28	100.00	173	511480	58.71	100.00	118	98120	11.26	100.00	14	6600	0.76	100.00	1	871265	100.00	309
Proportion of farmers in each land size category				55.9				38.2					4.5				1.5		
Average loan size				1474				4334					7000				1320		
Coconut Borrowers																			
trader-lenders	17712	31.96	52.00	22	13666	24.66	52.59	31	13278	23.96	79.00	20	10700	19.31	58.15	6	55426	58.14	86
friends	4800	19.55	14.09	9	12020	48.96	46.26	22	2030	8.27	12.08	9	5700	23.22	30.98	5	24550	25.75	50
relatives	11550	86.52	33.91	7	300	2.25	1.15	2	1500	11.24	8.92	2	0	0.00	0.00	0	13350	14.00	11
farmer	0	0.00	0.00	—	0	0.00	0.00		0	0.00	0.00	—	2000	****	10.87	0	2000	2.10	1
Total	34062	35.73	100.00	38	25986	27.26	100.00	55	16808	17.63	100.00	31	18400	19.30	100.00	11	95326	100.00	142
Proportion of farmers in each land size category				26.7				38.7				21.8				16.9			
Average loan size				896				471				542				375			

1/Proportionof loans extended to each group by specific lenders to total loans extended by the same lenders
2/ Proportion of each lender's loans extended to each group

for both crops went to those cultivating three hectares or less. Apparently, land sizes do not seem to make a big difference among farmer-borrowers. Majority of those who borrowed from trader-lenders were cultivating only around one to three hectares of land.

Among palay farmer-borrowers, average loan size increases as size of land increases as opposed to that of coconut farmer- borrowers where loan per farmer was higher among those with smaller land sizes. This is because palay loans, which are mostly used for production purposes increase with increases in land sizes. On the other hand, coconut loans which are mostly for consumption purposes do not increase with land size. It should be noted that this goes against the theoretical assumption that a farmer-borrower borrows an amount c for consumption equal to the amount of his discounted income (pX (e, N) / (1 + i) at harvest time. The assumption implies that consumption loan increases as the farmer's size of land increases. The seeming contradiction may be explained by the fact that those with bigger land size may have other sources of income to tide them over until the next harvest season and thus borrow smaller amounts only.

The foregoing shows that most lenders do not lend to those with bigger land sizes. This could be explained by the fact that first, bigger land sized farmers get more formal loans so interlinked market and informal sources of credit are more prevalent among farmers with smaller land size. Second, trader-lenders do not necessarily get larger profits with big land-sized farmers. Theoretical results show that if smaller land-sized farmers have loan demand inelastic to both interest rate and buying price, (because smaller farmers do not have any other sources of credit), then interest rate and price differentials may allow the trader-lenders to have high profits. This result differs from Floro (1986) who claimed that trader-lenders prefer to lend to farmer-borrowers with bigger resource status.

A positive relationship is hypothesized to exist between i (interest rate) and p (output price) for a constant profit, a constant utility or constant income, all other things being constant.

It was shown that in an interlinked market, lenders are able to employ flexible lending arrangements. Because deals are interlinked, the price of credit (i) in the credit market and the price of the farmer's produce (p) in the output market cannot be isolated from one another. As shown in Figure 2, there is a locus of points A which shows the combination of i and p that yields the same amount of utility or income for the farmer- borrower.

Admittedly, the relationship between i and p can best be validated

using information from the lenders' side. However, most of the lenders were apprehensive to divulge the needed information.
Thus, farmer-data was used to test the hypothesized relationship between i and p.

Table 2 shows that as expected, most of the farmer-borrowers in both developed and less-developed areas received output prices which were below the average market price. These farmer-borrowers, however, paid annual interest rates ranging from 0 to 120 percent.

The table shows little variation in prices for both palay and coconut. However, the interest rate seems to fluctuate widely. As explained earlier, the buying price and the interest rate are determined by many factors (P_m, r, elasticity of loans with respect to price and interest, land size, etc.).

The specific relationship between i and p for a certain level of income or utility for a farmer-borrower or for a particular level of profit for the trader-lender cannot be deduced from the table due to identification problems (since income, utility and profits and other variables vary from farmer to farmer). Another method however of showing the relationship between i and p is to use regression analysis . This is shown in Table 3.

Regression results show that among palay farmer-borrowers, output price differential (P-p) is positively related with interest rates implying that buying price (p) and interest rates (i) are negatively related. This goes against the hypothesized positive relationship between i and p. This may be a case of omitted variable. Operation costs (which include cost of services rendered) incurred by palay trader-lenders should be considered as another variable affecting i. This is so because operation costs significantly affect the prices paid by the trader-lenders. An increase in the operation costs, due to better and improved services rendered, incurred by the trader-lender may result in higher interest rates charged and low buying price paid by the lender to the borrower. Omission of this variable may lead to a biased estimate of the coefficient of (P-p) resulting in reversive sign. Operations cost cannot be incorporated in the equation because data on this variable are from the lender data-set while the data on the rest of the variables are from farmer-data.

The foregoing is supported when the other factors affecting the variability of interest rates are considered. Results show that among palay farmer-borrowers, another significant variable affecting interest rates is the level of development of the area (Table 3). The variable has a negative coefficient implying that interest rates are higher in more developed areas. This is consistent with the results in Table 4 wherein higher interest rates were observed in more developed palay areas compared to the less developed ones.

The above result in palay areas could be explained by the following: Higher interest rates in palay developed areas are due to better and im-

Table 2
DISTRIBUTION OF SAMPLE FARMER-BORROWERS' LOANS
BY INTEREST RATE AND OUTPUT PRICE RECEIVED

PRICES RECEIVED (in Pesos)	INTEREST RATE RECEIVED: Zero		.1 to 60		60.1 to 120		> 120			
	No.	%	No.	%	No.	%	No.	%	Total	%
PALAY										
1 to 3 hectares	11	100.00	20	100.00	7	100.00	3	100.00	41	100.00
less than 2.50	8	72.73	6	30.00	4	57.14	3	100.00	21	51.22
2.51 to 3.00	3	27.27	13	65.00	3	42.86		0.00	19	46.34
3.01 to 3.50		0.00		0.00		0.00		0.00	0	0.00
3.51 to 4.00		0.00	1	5.00		0.00		0.00	1	2.44
3.1 to 5.0 hectares	9	100.00	20	100.00	9	100.00	1.00	100.00	39	100.00
less than 2.50	5	55.56	10	50.00	4	44.44	1.00	100.00	20	51.28
2.51 to 3.00	2	22.22	9	45.00	5	55.56		0.00	16	41.03
3.01 to 3.50	1	11.11	1	5.00		0.00		0.00	2	5.13
3.51 to 4.00	1	11.11		0.00		0.00		0.00	1	2.56
greater than 5.0 has	1	100.00	4	100.00	0	0.00	0	0.00	5	100.00
less than 2.50		0.00	1	25.00		0.00		0.00	1	20.00
2.51 to 3.00	1	100.00	2	50.00		0.00		0.00	3	60.00
3.01 to 3.50		0.00		0.00		0.00		0.00	0	0.00
3.51 to 4.00		0.00	1	25.00		0.00		0.00	1	20.00

Table 2, continuation. . .

PRICES RECEIVED (in Pesos)	Zero No.	Zero %	.1 to 60 No.	.1 to 60 %	60.1 to 120 No.	60.1 to 120 %	> 120 No.	> 120 %	Total	%
COCONUT										
1 to 3. 0 hectares	2	0.00	7	100.00	1	100.00	0	0.00	10	100.00
less than 3.00		0.00		0.00		0.00		0.00	0	0.00
3.01 to 3.50		0.00		0.00		0.00		0.00	0	0.00
3.51 to 4.00	1	0.00	6	85.71	1	100.00		0.00	8	80.00
4.01 to 4.50	1	0.00	1	14.29		0.00		0.00	2	20.00
3.01 to 5.0 hectares	3	100.00	8	100.00	0	0.00	0	0.00	11	100.00
less tha 3.00		0.00		0.00		0.00		0.00	0	0.00
3.51 to 4.00	1	0.00	6	85.71	1	100.00		0.00	8	80.00
4.01 to 4.50	2	66/67	8	100.00		0.00		0.00	10	90.91
greater than 5.0 has.	3	100.00	13	100.00	0	0.00	1	100.00	17	100.00
less than 3.00	1	33.33		0.00		0.00		0.00	1	5.88
3.01 to 3.50		0.00		0.00		0.00		0.00	0	0.00
3.51 to 4.00	1	33.33	11	84.62		0.00	1	100.00	13	76.47
4.01 to 4.50	1	33.33	2	15.38		0.00		0.00	3	17.65

Table 3
FACTORS AFFECTING THE LEVEL OF INTEREST RATES

Independent Variable	Dependent Variable: Effective Interest Rate LOGPBRC		
	Beta Coefficient	B	T–Value
Palay Farmer-Borrowers			
P - p	0.186	0.289	2.32
TOTAMTAV	2.74 x 10	0.052	0.378
RBL	0.11	0.052	0.416
AREA (size)	0.265	0.114	0.846
TYPEAREA	−0.998	−0.182	−1.34
FINCOME	3.24 X 10	0.02	0.136
Constant	1.89		1.46
R^2	0.194		
$\overline{R}^2$	0.112		
n	66		
F	2.37		
Coconut Farmer-Borrowers			
P - p	−0.028	−0.975	−4.619
TOTAMTAV	−7.56 X 10	−0.107	−0.695
RBL	0.723	0.324	2.501
AREA (size)	−0.158	−0.281	−1.45
FINCOME	−8.16 x 10	−0.196	−0.868
Constant	−3.26		−1.817
R^2	0.64		
$\overline{R}^2$	0.56		
n	32		
F	9.16		

Table 4
DISTRIBUTION OF SAMPLE FARMER-BORROWERS' LOANS BY INTEREST RATE LEVELS

	Developed Areas		Less Developed Areas		TOTAL	
	No.	%	No.	%	No.	%
Effective Interest Rates						
equal to 0	119	37.7	172	66.9	291	50.8
.01 - 10.00	50	15.8	60	23.3	110	19.2
10.01 - 20.00	12	3.8	4	1.6	16	2.8
20.01 - 50.00	40	12.7	9	3.5	49	8.6
50.01 - 100.00	86	27.2	6	2.3	92	16.1
100.01 - 150.00	4	1.3	1	0.4	5	0.9
greater than 150.00	5	1.6	5	1.9	10	1.7
TOTAL	316		257		573	
Average	75.3		32.95		56.3	
Average for Palay	114.72		16.71		87.18	
Average for Coconut	2.27		60		53.86	

proved services extended by lenders in the areas. The services which are prevalent in developed areas compared to less developed areas include timely releases of loan, release of loan at the form needed by the client (i.e. either in cash or in kind), pick-up of output payments and door-to-door delivery of loan. In less developed areas, borrowers bring their output to the trader from whom they owe a loan while in developed areas payment for loans in output terms are picked up by the trader-lender themselves.

Likewise, it may also be due to the higher opportunity cost of capital in more developed areas. This is so because there are more investment opportunities in more developed areas compared to the less developed areas.

The above observation validates our hypothesis that an increase in the operation costs (g'(X)) of a trader-lender results in an increase in the differentials (i-r) and (P-p). Thus, the higher effective interest rates prevailing in developed areas are due to better and improved services extended by lenders to his borrowers and not due to competition among lenders.

Also, among palay farmer-borrowers, the ratio of borrowers to lenders does not significantly affect the level of interest rate. This may be explained by the fact that lenders lending to palay farmer-borrowers do not necessarily compete in terms of interest rates and palay prices but rather in terms of the quantity and quality of services they offer their clientele.

On the other hand, Table 3 also shows that among coconut farmer-borrowers, i and p are positively related. Note that even if operations cost is not included in the regression equation, a positive relationship between i and p was observed. This is so because among copra trader-lenders, operations cost is not a significant variable affecting the output prices.

It should be noted that the váriable for level of development of an area is not included in the regression equation for coconut farmer-borrowers inasmuch as most of the farmer- borrowers with relevant data are from the less-developed areas.

The ratio of borrowers to lenders (RBL) affects i significantly only among coconut farmer-borrowers. This implies that in coconut areas, an increase in the number of lenders in an area results in lower interest rates. Thus in coconut areas both the positive relationship between i and p and the competition among lenders are validated by the data.

Summary and Conclusion

The farmer-borrower engaged in interlinked deals behaves according to the purpose for which he makes his loan. If he uses his loan for production purposes, he maximizes his income while if he uses his loan for consumption purposes, he maximizes his utility. The farmer who borrows for production purposes uses input demand (I) as control variable while the farmer who borrows for consumption purposes uses the amount of effort per unit of land (e). The trader-lender knows how a farmer-borrower behaves and thus incorporates the farmer-borrower's behavior in his maximization problem. He plays with the interest rate (i) and the price at which he buys the farmer's output (p) in maximizing his profit. Since deals are interlinked, any changes in i or p affect both his revenue and costs. An increase in i or a decrease in p, resulting in increased revenues, affects the amount of credit borrowed by a farmer-borrower and eventually the amount of output to which a trader lender can have access. This also results in increased costs if the output is reduced due to effect of i and p on I and e). He then employs flexible lending arrangements which vary per farmer-borrower.

The empirical results show that in more developed areas, where it is presumed for many lenders to exist, higher interest rates were observed. This is due to improved and better services employed by lenders in these areas. This is consistent with the theoretical result that operation costs incurred by trader- lenders affect the i and p they charge. Higher interest rates may also be due to the higher opportunity costs of money in more developed areas.

The foregoing assumes that the existence of interlinked deals in the informal rural credit market addresses efficiency problems. The high transaction and risk costs associated with rural lending are addressed by interlocking market transactions. Costs associated with one market are absorbed by the other market. Flexible lending arrangements enable agents to operate at efficiency.

Hence, in an economy where income is low, where market is segmented and where high transaction and risk costs exist, the presence of informal lenders is useful on efficiency grounds. Their usefulness however, may not necessarily be true when equity considerations are made.

Given this, the first-best solution is still to increase rural incomes. By increasing the incomes of farmer-borrowers and by making those fixed investments normally owned by trader- lenders available and accessible to the farmer, problems of market segmentation and high transaction and risk cost may be addressed.

This can be achieved by overall agricultural policies to increase farmer's income (i.e. policies that address both growth and equity objectives): agrarian reform, provision of stronger support services by the government such as marketing services, timely credit information, storage facilities (warehousing facilities e.g. Quedan financing scheme), and strong support for locally initiated cooperatives that will provide farmers direct access to finance capital (e.g. credit coops) and enable them to market their produce at reasonable prices (e.g. marketing coops).

Provision of the necessary services will make both the input and output markets competitive resulting in lower prices.

Meanwhile at the intermediate stage, the concept of cooperative system or self-help groups could be advocated to foster competition with individual private moneylenders. With the cooperative or self-help group system, both the efficiency and equity issues confronting informal rural credit markets may be taken into account. The rural market imperfection issue may be addressed since these systems can operate under the market interlinkage structure. The equity issue on the other hand, is taken care of since these groups are basically owned by the farmers themselves. The profits generated from the interlinked deal will therefore accrue to them.

APPENDIX 1
Formal Derivation of the Behavior of Agents with Production Loans

A. Derivation of the Input Demand Function of a Farmer-borrower

(A1.1) $\quad \text{Max } Y = pX(I,N) - I(1+i)$

F.O.C.

(A1.2) $\quad Y_I = pX_1 - (1+i) = 0$

The second order condition requires

$$\delta^2 Y/\delta 1^2 = pX'' < 0$$

which is fulfilled by the assumption on the concavity of X . (A1.2) defines I implicitly as a function of i, p, and N, i.e. $I = I(i,p,N)$.

To solve for I_i, I_p, I_N we let

$$F = pX' - (1+i)$$

(A1.3) $\quad I_i = -F_i/F_I = 1/pX'' < 0$

(A1.4) $\quad I_p = -F_p/F_I = X'/pX'' > 0$

(A1.5) $\quad I_N = -F_N/F_I = X'/pX'' > 0$

We know that X_I, $X_N > 0$ and by strict concavity of X, X_{II}, $X_{NN} < 0$. If in addition we assume that $X''' < 0$, we obtain:

(A1.6) $\quad I_i<0 \qquad I_{ii}<0$

$I_p>0 \qquad I_{pp}<0$

$I_N>0 \qquad I_{pi}>0$

B. The Trader-Lender's Behavior

(A1.7) $\quad \text{Max } \Pi = (P-p)X + (i-r)I$

$$\text{s.t. } X = X(I,N)$$

$$I = I(i,p,N)$$

The first-order conditions are:

(A1.8) $\Pi_i = I_i[(P-p)X_I + (i-r)] + I = 0$

(A1.9) $\Pi_p = I_p[(P-p)X_I + (i-r)] - X = 0$

The second order conditions for a local maximum requires that

$$\Pi_{ii} < 0 \text{ and } \Pi_{ii}\ \Pi_{pp} - \Pi_{ip}^2 > 0$$

By carrying out the derivation, we find that the following signs are implied:

(A1.10) $\Pi_{ii} = I_i[(P-p)X_{II}I_i + 1] +$

$[(P-p)X_I + (i-r)]I_{ii} + I_i<0$

(A1.11) $\Pi_{pp} = I_p[(P-p)X_{II}I_i - X_I] +$

$[(P-p)X_I + (i-r)]I_{pp} - X_I I_p<0$

(A1.12) $\Pi_{ip} = I_i[(P-p)X_{II}I_p - X_I] +$

$I_{ip}[(P-p)X_I + (i-r)] + I_p>0$

(A1.13) $\Pi_{pi} = I_p[(P-p)X_{II}I_i + 1) +$

$I_{pi}[(P-p)X_I + (i-r)] - X_I I_i>0$

These conditions are satisfied, given the derivative signs for I_i, I_p, I_{ii}, I_{pp}, I_{pi} in (A1.6).

C. Deriving the slope and concavity of Y_o

Let $Y_o = pX(I,N) - I(1+i)$

Getting the total derivative of Y_o

(A1.14) $dY_o = p[X_1(I_i di + I_p dp + I_n dn) + X_N dn]$

$$+ Xdp - Idi - (1+i)(I_i + I_p dp + I_n dN)$$

Grouping the terms and letting $dY = 0$, $dN = 0$

$$di[I_i(pX_1 - (1+i)) - I] + dp[I_p(pX_1 - (1+i)) + X] = 0$$

the slope is

$$dp/di = -I_i(pX_1 - (1+i)) - I / I_p(pX_1 - (1+i)) + X$$

In this case $pX_1 - (1+i) = 0$ since we are always assuming the borrower optimizes. Hence

(A1.15) $$dp/di_{Y=Y_0} = I/X$$

To determine the shape of the curve, we get the second derivative of equation (10)

(A1.16) $$d^2p/di^2 = d(I/X)$$

$$= [XI_i - IX'I_i]/X^2 = I_i/X^2[X - IX_1]$$

We know from equation (A1.2) that $X_1 = (1+i)/p$

Substituting this into the second term of equation (A1.16)

$$X - IX_1 = X - I(1+i)/p$$

But our constraint says

$$pX \geq (1+i)I$$

and for a strictly concave function X, this is a strict inequality

Hence: $pX \geq (1+i)I$ which implies that

$$X\ (1+i)I/p \text{ or } X - I(1+i)/p > 0$$

therefore

$$d^2p/di^2 = Ii[X - IX_1]/X^2 < 0$$

or Y_0 is concave in the (i-p) plane

APPENDIX 2
Formal Derivation of Behavior of Agents with Consumption Loans

A. Derivation of the effort function of a Farmer-borrower

(A2.1) $\quad \text{Max } U(C,e)$

$$\text{s.t. } X = X(e,N)$$

$$C = pX(e,N)/(1+i)$$

$$\text{where } U_c > 0 \qquad U_e < 0$$

$$U_{cc},\ U_{ee},\ U_{ce},\ U_{ec} < 0$$

$$X_l,\ X_N > 0$$

$$X_{ll},\ X_{NN} < 0$$

Through substitution, (A2.1) may be reduced to maximizing a function in e, namely

$$\text{Max } U[pX(e,N)/1+i,\ e]$$

The first-order condition then requires

(A2.2) $\quad U_e = U_c(pX_e/1+i) + U_e = 0$

The second-order condition requires

(A2.3) $\quad U_{ee} = U_{ce}(pX_e/(1+i)) + U_c(pX_{ee}/(1+i)) + U_{ee} < 0$

which is fulfilled by the assumption on the concavity of U and X.

To solve for e_i and e_p, we let

(A2.4) $\quad F = U_c[pX_e/(1+i)] + U_e$. Then

$$e_i = -F_i/F_e$$

(A2.5) $\quad F_i = p/(1+i)[X_e(U_{cc}pX/(1+i) + U_c) + U_{ec}X]$

The expression in bracket may be rewritten as $U_{cc}C + U_c$, since $C = pX/1 + i$. If we assume that the elasticity of the marginal utility of consumption is greater than or equal to unity, i.e. $-U_{cc}C/U_c > 1$, then the said expression is negative, and F_i is negative.

$$\text{(A2.6)} \quad F_e = p/(1+i)[X_e(U_{cc}pX_e/(1+i) + U_{ce}) + U_cX_{ee} + U_{ec}X_e] + U_{ee} < 0$$

Using the assumptions on U and X, $F_e < 0$, therefore

$$e_i = -F_i/F_e < 0$$

Again, using the implicit function theorem,

$$e_p = -F_p/F_e$$

$$\text{(A2.7)} \qquad F_p = -1/(1+i)[X_e(U_{cc}pX/(1+i) + U_c) + U_{ec}X]$$

using the same argument in equation (A2.5), we know that equation (A2.7) is positive.

Using equation (A2.6) and (A2.7), we know that

$$e_p = -F_p/F_e > 0$$

Therefore

$$e = e(i,p) \qquad \text{where } e_i < 0, \quad e_{ii} < 0$$

$$e_p > 0, \quad e_{pp} < 0$$

$$e_{ip} > 0$$

The second derivatives are sufficient to fulfill the second-order condition for a local maximum for the trader-lender's maximization problem.

B. The Trader-Lender's Behavior

$$\text{(A2.8)} \qquad \text{Max } \Pi = (P\text{-}p)X(e(i,p),N) + (i\text{-}r)pX(e(i,p),N)/(1+i)$$

The first-order conditions are:

(A2.9) $$\Pi_i = pX[p(1+r)/(1+i)^2] + [(P-p) + (i-r)p/(1+i)]X_e e_i = 0$$

(A2.10) $$\Pi_p = -X[(i-r)/(1+i)] + [(P-p) + (i-r)p/(1+i)]X_e e_p = 0$$

The second-order conditions for a local maximum requires that $\Pi_{ii} < 0$ and $\Pi_{ii}\ \Pi_{pp} - \Pi_{ip2} > 0$.

By carrying out the derivation, we find that the following signs are implied:

(A2.11) $$\Pi_{ii} = -2pX[(1+r)/(1+i)^3] + 2p(1+r)/(1+i)^2 X_e e_i + [(P-p)+(i-r)p/1+i][X_e e_{ii} + X_{ee} e_i{}^2] < 0$$

(A2.12) $$\Pi_{pp} = -2[(1+r)X_e e_p/1+i] + [(P-p)+(i-r)p/1+i][X_e e_{pp} + e_p X_{ee} e_p] < 0$$

(A2.13) $$\Pi_{pi} = (1+r)/(1+i)[X/1+i-X_e e_i] + [(P-p)+(i-r)p/1+i][X_e e_{pi} + e_p X_{ee} e_i] + X_e e_p[(1+r)/(1+i)^2] > 0$$

(A2.14) $$\Pi_{ip} = e_1 X_1[-(1+r)/(1+i)] + (1+r)/(1+i)^2[pX_1 e_2 + X] + [(P-p)+(i-r)p/1+i][X_e e_{ip} + X_{ee} e_i e_p] > 0$$

These conditions are satisfied, given the derivative signs for e_i, e_p, e_{ii}, e_{pp}, e_{ip}, e_{pi}.

B. Deriving the slope and shape of U_o

Let $U = U(C,e)$

$$= U[pX(e,N)/(1+i),\ e(i,p)]$$

Getting the total derivative of U

$$\text{(A2.15)} \qquad dU = U_c dC + U_e de$$

$$= U_c[p/(1+i)(X_e(e_i di + e_p dp) + X_n dn]$$

$$+ U_e(e_i di + e_p dp)$$

Let dU = 0 and dN = 0 and grouping the terms:

$$di[e_i(U_c pX_e/(1+i) + U_e)] + dp[e_p(U_c pX_e/(1+i) + U_e)] = 0$$

The slope of U_o is therefore

$$\text{(A2.16)} \qquad dp/di_{U=Uo} = -e_i/e_p$$

To determine the shape of the curve, we get the second derivative of equation (A2.9)

$$d^2p/di^2 = d(e_i/e_p)/di$$

$$= -1/e_p{}^2[e_i de_p/di - e_p de_i/di]$$

which is also equal to

$$d^2p/di^2 = -1/e_p{}^2[e_i(e_{pi} - e_{pp}e_i/e_p) - e_p(e_{ii} - e_{ip}e_i/e_p)]$$

$$= -1/e_p{}^2[e_ie_{pi} - e_{pp}e_i{}^2/e_p - e_pe_{ii} + e_{ip}e_i]$$

$$= -1/e_p{}^3[2e_ie_{pi}e_p - e_{pp}e_i{}^2 - e_p{}^2e_{ii}$$

Thus,

$$d^2p/di^2 < 0$$

or U_o is concave in the (i – p) plane.

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