CREDIT-PRODUCT INTERLINKAGE, CAPTIVE MARKETS AND TRADE LIBERALIZATION IN AGRICULTURE: A THEORETICAL ANALYSIS*

Sarbajit Chaudhuri

and

Asis Kumar Banerjee

Dept. of Economics, University of Calcutta

56A, B.T. Road, Kolkata 700 050, India.

Address for communication: Dr. Sarbajit Chaudhuri, 23 Dr. P.N. Guha Road, Belgharia, Kolkata 700083, India.

Tel: 0091-33-2541-0455 (R), 91-33-2557-5082 (C.U.) Fax: 0091-33-2844-1490 (P)

E-mail: sarbajitch@yahoo.com, sceco@caluniv.ac.in http://papers.ssrn.com/author=294419

ABSTRACT: This paper builds a model of fragmented duopsony in backward agriculture following Basu and Bell (1991) in which the purchasers (traders) have captive markets each but compete in a contested market. We focus on the formation of captive markets through trader-farmer interlinkage in the form of interlinked credit-product contracts (ICPCs). ICPC (or the formation of captive markets) is not an entry-preventive strategy in the model. Its motive is to push the farmers to their reservation income level. However, the captive and the contested markets are linked by the requirement that the reservation income of a captive farmer has to equal the income of a farmer in the contested market. In general, in our model strategic considerations determine the extent of use of ICPCs rather than explaining their existence. In this set-up we examine the effects of trade liberalization in agriculture on the village economy. We show that a reduction in the credit subsidy will raise the size of the captive market, leads to deterioration in the welfare of the farmers and may lower the agricultural productivity of the economy. On the contrary, an increase in the international price of the crop unambiguously improves the welfare of the farmers but the effect on the agricultural productivity is ambiguous. The paper argues that unless the developed countries liberalize trade in their agricultural sector, it would be premature for the developing countries to go in for agricultural trade liberalization and remove all farm subsidies, as this policy may in fact be counterproductive.

Keywords: Trader, Farmer, Captive segment, Contested segment, Interlinkage, Nash equilibrium, Trade liberalization in agriculture.

JEL classification: Q13; D43, C70.

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1. Introduction:

In a backward agricultural economy input as well as output markets are frequently observed to be fragmented.[1] A fragmented market comprises of two segments: a captive segment and a contested segment. In the captive segment of a fragmented market, a firm enjoys monopolistic (or monopsonistic) power while it competes with other firm(s) in the contested segment. The formation of the captive segment (of course by incurring some costs) is made in the strategic interest of the firm since it affects the outcome in the contested segment. One type of such fragmentation occurs when at least one of the grain merchants (traders) in the village economy has a captive market while all of them compete in contested markets[2]. The traders find it profitable to discriminate between these two types of markets. Price discrimination is an important feature of their behaviour. Since captive markets are taken to be a feature of underdevelopment, governments in such economies are likely to be interested in pursuing policies seeking to reduce the size of the captive segment of the market.

Fragmented oligopolies in backward agriculture have been analyzed before in the literature. Basu and Bell (1991) analyzed a model of fragmented duopoly where firms have a captive segment each. This line of research is pursued further in Mishra (1994) where it is shown that a firm, through suitable choice of its captive segment, can prevent the entry of competing firms in the contested segment. This line of analysis provides a rationale of the existence of the captive segment, which is based on strategic considerations and is different from other explanations, for instance Bardhan (1984), Basu (1983), Bell (1988), Braverman and Stiglitz (1982), Chaudhuri and Gupta (1995a,b), Chaudhuri (1996), Gangopadhyay and Sengupta (1987), Fabella (1992), Gupta (1987) and Mitra (1983).

In this paper we emphasize *the contractual process* by which the captive markets are formed in backward agriculture. We focus on the interlinked credit-product contract (ICPC). An ICPC refers to a contract where traders make advance payments to farmers against commitment of future delivery of crops at pre-determined prices. The terms of the contract, namely the interest rate on the loan and the price of the crops

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[1] See, for instance, Bardhan (1984), Basu (1983), Bhaduri (1983) and Rudra (1982).

[2] This form of trader fragmentation has indeed empirical foundation. See Mishra (1994) (footnote 2 in particular), Sarap (1991) and Rudra (1982) in this regard. A survey conducted by a Delhi School of Economics group at village Nawadih, India also reports similar features.

are determined by the interlockers. Farmers who receive advance payments from traders get lower prices[3] for their outputs than those who do not take such loans. The debtor-farmers of a trader constitute his or her captive market. The farmers who do not come into any such credit-product contracts with any grain trader form the contested segment of the fragmented product market. In this framework, ICPCs are offered to push the farmers to their reservation income (or utility) level (the conventional argument). However, this brings into picture the fact that income or utility has to be equal across the captive and the contested segments for those contracts to be acceptable to the farmers. This is how the captive and the contested segments become interdependent in the present model. In the earlier strategic models, the interdependence came simply from the assumption that the firms cannot discriminate between the customers in the two segments.

We here analyze the determination of the size of the captive market and the impact of the much discussed worldwide trade liberalization in agriculture in the context where traders purchase grains from farmers in both the captive and the contested markets and sell these in a competitive market. However, the formation of a captive segment is not designed for entry-prevention. In fact, since we are mainly concerned with interaction between *traders* we assume away entry costs and other fixed costs (which we take to be associated with production rather than trading activities.).[4] Entry here is essentially unpreventable.

We consider a game between a creditor-trader with a captive segment and a pure trader without one. We show that in the game equilibrium, the size of the captive segment (denoted by n) chosen by the creditor-trader lies strictly between the (discriminating) monopsony equilibrium value of n and its value when the pure trader is a monopsonist. The existence of an upper limit on n is explained by the presence of the pure trader, which prevents the creditor-trader from choosing too large a captive segment. In fact, in our model there is an element of strategic complementarities between n and the pure trader's profitability. Thus the strategic role of the captive segment here is different from that in the earlier strategic models. On the other hand, the fact that n strictly exceeds the (non-negative) lower limit shows that, as in the models emphasizing entry prevention, strategic considerations push n above the monopsony value. Thus in our model while strategic considerations do not explain ICPCs, they play a role in determining the *extent of usage* of such contracts.

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[3] However, in the personalized rural markets of the kind described in Bardhan (1984), the possibility of price discrimination may be precluded by social norms.

[4] The assumption that the traders do not have to incur any entry costs and other fixed costs is justified in the context of the present paper, because the emphasis here is not on entry prevention by the existing trader. Here entry is essentially unpreventable. In the overall game equilibrium, the contested segment of the market is duopsonistic. Strategic considerations do not explain the existence of ICPCs i.e. the captive segment of the existing trader, but play a crucial role in determining the *extent of usage* of such contracts.

In the special case where the lower limit is zero, however, strategic considerations do play a role in explaining the captive segment ($n > 0$).[5] Although the formation of the captive segment is not here an entry prevention strategy, the explanation is nevertheless strategic in nature in the sense that $n = 0$ in the absence of the game.

It is needless to say that the multilateral agreement and the formation of the World Trade Organization (WTO), resultant of the Uruguay round of discussions, have brought about revolutionary changes in liberalizing international trade across countries whether developed or developing. With the setting up the WTO in 1995, it was hoped that international trade would become freer and fairer. The developing countries would get the opportunities to reverse the long continuing adverse terms of trade for their exports. Although the developing countries have sufficiently opened up their markets to the developed countries the latter has so far failed to reciprocate. The developing countries are still unable to penetrate the markets of the developed countries. The two markets of most importance to the developing economies, agriculture and textiles are still among the most protected markets in the developed countries. In agriculture, exports from developing countries remain severely hampered by massive domestic support and export subsidy programs in developed countries, by peak tariffs and difficulties in the implementation of the tariff quota system (UNCTAD, 1999, p 41). The tariffs of many agriculture items of interest to the developing countries are prohibitively high (some are over 200 and 300 percent). Besides, agricultural subsidies to farmers in the US, Europe, and Japan have rises to almost \$ 1 billion a day, more than six times the amount these countries provide in development assistance. Even more damaging, agricultural exports from the rich countries drive small farmers out of business even in their home countries. This threatens domestic food security and undermines exports potentials of the poor nations. In the circumstances, the developing countries in the last few rounds of the WTO meetings vehemently fought together to wrest some benefits from their developed counterparts.

As a consequence of developing countries' vehement demand for opening the markets of the developed countries the WTO is now embarking upon a new round of negotiations on agricultural trade. Multilateral liberalization in the context of the WTO negotiations will primarily imply reduced protection of agriculture where the rates of protection are highest, i.e. in developed countries. It will imply reduced protection against imports and reduced subsidies for domestic production, including reduced export subsidies. A new agreement may impose limitations on these policies and on the introduction of new protectionist policies in other developing countries. As multilateral liberalization in agriculture following the Uruguay round has been limited in scope and is still being phased in, there is not yet much direct evidence available to judge empirically the consequences of such liberalization (see Haug and Øygard 1999). However, if the result of reduced trade barriers and increased international competition are uniform in both developed or developing

[5] See footnote 19 in this context.

countries, the prices of the primary agricultural exports of the developing countries are most likely to rise because of the probable reduction of the multilateral tariffs by the large trading countries and increase in their import demands. Model simulations of multilateral trade liberalization, e.g. (Hoekman and Anderson, 1999) are quite unanimous in predicting that such a liberalization would result in higher world market prices than otherwise for those goods currently being protected and subsidised.[6]

The paper is purported to analyze the consequence of possible trade liberalization in agriculture on the product market in a village economy of a developing country. The impacts of such liberalization on the agricultural productivity and on the welfare of the farmers are also studied. Trade liberalization in agriculture in this paper is captured by a reduction in credit subsidy and an increase in the price of the crop. We show that while a reduction in credit subsidy unambiguously increases the size of the captive segment in the game equilibrium, worsens the welfare of the farmers and is likely to decrease the agricultural productivity, an increase in the product price has an ambiguous effect on the size of the captive market and on the agricultural productivity. But the latter policy definitely improves the welfare of the farmers.

2. The Model

We consider a fragmented duopsonistic market for grains in a backward agricultural economy. There are two buyers (traders). For simplicity, we assume that only trader 1 is in a position to offer ICPCs to the farmers[7]. Therefore, only trader 1 can have a captive segment. Trader 2 can compete in the contested segment, which we call the *village retail market*. There are a given number (normalized to unity) of

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[6] The paper deals with the case of a village economy of a developing country. In the literature on trade and development, a typical developing country is depicted as a small open economy, which is a price taker in the commodity markets. Now if the agricultural sector of the developed countries is liberalized, the consequence would be increases in the prices of the agricultural commodities in the international markets (Haug and Øygard 1999, Hoekman and Anderson, 1999). The grain traders and large farmers in the developing countries who have means of access to the wholesale markets for agricultural commodities get higher prices for their products. However, the small and marginal farmers who do not have that accessibility may derive the benefits trade liberalization only if the traders to whom they sell their products pass on some benefits of price increases in the international markets to these hapless class of farmers. On the other hand, if the government of a developing country liberalizes its agricultural sector by removing/lowering different subsidies hitherto provided to its farmers, it hurts the farmers directly by increasing their production costs.

[7] The assumption that of the two village traders only one is assumed to have a captive segment while both of them are allowed to operate in the contested segment may be justified in a closed village economy where there is lack of complete information. In Basu and Bell (1991) and Mishra (1994) we come across the same type of assumption. From the theoretical point of view there will not be a major difference in the results if both of the players are allowed to have their own captive segments. But the algebra of the paper will be much more complicated. This aspect has also been taken up in footnote 25 of this paper.

identical sellers (farmers) in the village. We shall follow some recent contributions in assuming that each farmer's output is a function of credit (C). The production function[8] is:

$Q = Q(C); Q'(C) > 0, Q''(C) < 0.$

The farmers in the captive segment get subsidized credit from trader 1 at the interest rate i per period and sell their output to this trader at the pre-determined price P_1.[9] The values of i and P_1 are set by trader 1 □[10].

The farmers who are in the contested segment borrow funds from the formal credit agency at an interest rate r per period determined administratively and sell their output in the village retail market at the duopsony price P.

The inverse supply function of each farmer in the village retail market is:

$P = f(Q, r); f_1, f_2 > 0; f_{11} = 0.$

The supply function is derived from the profit maximizing behaviour of each farmer. The restrictions on f(.) imply that the output price is a linearly increasing function of the quantity supplied and the price increases with an increase in the interest rate. In order to derive simple results we shall, in some parts of the paper, specialize the inverse supply function to $P = 2.(1+r).Q$, which follows from the production function $Q = \sqrt{C}$ and from the following optimization exercise:[11]

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[8] This is a derived production function. Any production function that is well behaved may be written as a function of the total expenditure provided input markets are perfectly competitive. Consequently, Q(.) can be interpreted as a general production relationship with many inputs under competitive conditions. See Gangopadhyay and Sengupta (1987), Chaudhuri and Gupta (1995a,b), Chaudhuri (1996) and Chaudhuri (2004) in this context.

[9] This type of contract goes by the name of 'dadan' in the villages of the states– West Bengal and Bihar in India.

[10] The existing trader (trader 1) maximizes his aggregate income (trade profit plus net interest income) with respect to his instrumental variables, i and P_1, and subject to the reservation income constraint of the farmer. The reservation income constraint implies that the income of the farmers in the captive segment cannot be less than that of their counterparts in the contested segment. Trader 1 keeps the farmers on their reservation income level by adjusting his control variables, i and P_1 and appropriates the maximum amount of surplus from the ICPCs. In this paper these results have not been proved explicitly, as these are well established in the existing literature on interlinkage (see for example, Gangopadhyay and Sengupta (1987), Chaudhuri and Gupta (1995a,b), Chaudhuri (1996) and Chaudhuri (2004)).

[11] This is line of the literature on the industrial organization (I-O). Basu and Bell (1991) and Mishra (1994) have also considered specific algebraic forms of different functions. As evident from proposition 1 and its proof presented in the appendix, the existence and uniqueness of a sub-game perfect equilibrium in this model does not require any algebraic specificity of the production function. However, the subsequent policy analysis is based on this specific algebraic form of the production function. Unless a specific form of the production function of such type is assumed, the algebra of the subsequent analysis becomes much complicated.

$\text{Max } \Pi = P.Q - (1+r).C$

subject to $Q = \sqrt{C}$.

The traders purchase grains from the farmers and sell in the wholesale market at the internationally given price P*. We assume that the wholesale market is inaccessible to the farmers[12]. The traders are price-takers in the wholesale market. We assume that P* always exceeds f(.) i.e. the traders always find (wholesale) trading profitable.

The size of the captive segment (denoted by n) is measured by the proportion of farmers entering into ICPC with trader 1. Each farmer in the captive segment has a reservation level of income, Y*, which is equal to the level of income earned by each farmer in the contested segment.

Following the existing literature on the analysis of ICPCs in the principal-agent framework[13], we assume that in the captive segment trader 1 is concerned with the sum (Y_1) of his own income and the excess of the income of the farmers in this segment over Y*.

$$Y_1 = n.[P^*.Q(C) - (1+g).C - Y^*] \qquad (1)$$

where g is the opportunity interest rate of trader 1. Each farmer behaves efficiently but manages only to get an income of Y* out of the maximized value of Y_1 since trader 1 has sufficient instruments (i and P_1) to push the farmers to Y* and to appropriate the remaining surplus from the contract. (The values of P_1 and i can be determined by solving simultaneously the farmer's first-order condition of income maximization and the income-equivalence condition of the farmer.)

It is easily seen that if g is a constant, an ICPC is always preferred by trader 1 to a non-interlinked contract. n will take the corner value 1 in this case. The contested market does not exist unless g is an increasing function[14] of the volume of loans. We, therefore, assume that

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[12] See Rudra (1982,Ch 3) for a discussion of the reasons for such an assumption.

[13] See, for instance, Gangopadhyay and Sengupta (1987), Gangopadhyay (1994) and Chaudhuri (1996).

[14] The lenders in the rural credit market generally borrow funds from the urban sector and re-lend it to the borrowers in the rural credit market. In this situation this assumption that $g'(.) > 0$ can readily be explained by the 'Lender's Risk Hypothesis'. On the other hand, if the lender uses his own funds for lending, he may alternatively invest his money in any profitable production activity with diminishing returns to credit. If he now withdraws larger and larger sums from production, the marginal product of credit in the alternative use increases and, therefore the opportunity cost of the lender's funds also rises.
Actually there must be some cost associated with the formation of the captive segment e.g. cost relating to collection of information about the clients and enforcement of contracts that are quite high in a backward rural economy. g(.) captures all such costs. The larger the size of the captive segment the higher will be the above associated costs. Thus the assumption $g'(.) > 0$ is fully justified. Mishra (1994) also considered such costs, C, which is increasing in the size of the captive segment, n. See Assumption 2 of his paper on page 274.

$g = g(n.C);\ g'(.) > 0;\ g''(.) \geq 0.$

With this assumption the first-order condition for the maximization of Y_1 with respect to C is given by

$$P^*.Q'(C) = (1+ g(n.C)) + g'(n.C).n.C \qquad (2)$$

The value of the marginal product of credit equals the marginal cost of credit in equilibrium. The optimal use of credit[15] obtained as a solution of this condition is denoted by C*. Thus,

$$C^* = \underset{(-)\ (+)}{C^*(n, P^*)}$$

The game between the two traders is a two-stage game. In the first stage, trader 1 chooses the size of the captive segment, n. In the second stage, both the traders play a Cournot duopsony game and determine their levels of purchase of the crop, q_1 and q_2, in the contested segment simultaneously. However, the second stage sub-game is solved first and q_1 and q_2 are expressed as functions of n. Trader 1 then determines the value of n that gives him the maximum profit.

So far as the second stage sub-game is concerned, there are three logically possible outcomes: (I) trader 2 does not compete (i.e. trader 1 is a monopsonist) in the retail market, (II) trader 1 does not compete (i.e. trader 2 is a monopsonist), and (III) both the traders decide to compete in the retail market. We shall show below that in the (unique) sub-game perfect equilibrium of the overall (two stage) game the traders compete in the contested segment. However, some of the properties of this equilibrium will refer to outcomes I and II of the second stage game. For later reference, therefore, we analyze the outcomes of the two stage game for all the three possibilities regarding the second stage game.

<u>Outcome I</u>:

Consider first the case, where $q_2 = 0$ i.e. trader 1 is a monopsonist in the retail market for grains. In this case, the total income of trader 1is given by

$$Z_1^{m1} = n.[P^*.Q(C^*) - (1+g).C^* - \{f((q_1^{m1}/(1-n)), r).Q(C^{m1}) - (1+r).\ C^{m1}\}] + [P^* - f((q_1^{m1}/(1-n)), r)].q_1^{m1} \quad \ldots\ldots\ldots\ldots.(3)$$

where q_1^{m1} denotes the volume of crop purchased by trader 1 in the retail market and C^{m1} is the volume of credit used by each farmer in the retail market. The first of the two square bracketed terms on the right-hand side of (3) is the trader 1's income from the captive segment while the second one denotes income from trading in the contested segment. $\{f((q_1^{m1}/(1-n)), r).Q(C^{m1}) - (1+r).C^{m1}\}$ is the reservation level of income of a farmer in the captive segment (Y_1* of equation 1), because this is the net income of a farmer in the contested segment in the case under consideration.

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[15] C* increases as n decreases or P* increases since $Q''(.) < 0$.

Z_1^{m1} is first maximized through a choice of q_1^{m1}, given n. The first-order condition, after using the demand-supply equality condition, $((q_1^{m1}/(1-n)) = Q(C^{m1})$, becomes

$$[P^* - f(.)] = f_1.(q_1^{m1}/(1-n)^2) \tag{4}$$

From (4) we get $(\partial q_1^{m1}/\partial n) = -\{q_1^{m1}.(3-n)/(1-n).(2-n)\} < 0$ and $(\partial((q_1^{m1}/(1-n))/\partial n) = -(q_1^{m1}/(1-n)^2.(2-n)) < 0$.

It is easy to check that the optimal q_1^{m1} increases as r decreases or P* increases. Let $Z_1^{m1}(n)$ denote the value of Z_1^{m1} maximized with respect to q_1^{m1}, given n.

$Z_1^{m1}(n)$ is then maximized with respect to n. Putting the values of $(\partial((q_1^{m1}/(1-n))/\partial n)$ and $(\partial q_1^{m1}/\partial n)$ in the first-order condition the maximization condition can be shown to take the following form.

$$[P^*.Q(C^*) - (1+g).C^* - \{f((q_1^{m1}/(1-n)), r).Q(C^{m1}) - (1+r).\ C^{m1}\}] - g'.n.C^{*2} - [P^* - f(.)].(q_1^{m1}/(1-n)) = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (5)$$

As expected, trader 1 in this case chooses n so that the marginal gain (loss) with respect to n from the captive segment equals the marginal loss (gain) from the contested segment. Since $q_1^{m1}/(1-n) = Q(C^{m1})$, (5) can be rewritten as

$$P^*.Q(C^*) - (1+g).C^* - g'.n.(C^*)^2 = P^*.\ Q(C^{m1}) - (1+r).C^{m1}$$

Since P* > f(.), it follows that $Q(C^*) > Q(C^{m1})$. Thus, in the case where trader 1 is a monopsonist in the village retail market, the output of each farmer in the captive segment is greater than that in the contested segment.

If the g function rises sufficiently fast, Z_1^{m1} can be taken to be a strictly concave function with a unique maximizing n < 1. $Z_1^{m1}(n)$ is shown in figure 1a.[16] n^{m1} is the value of n maximizing $Z_1^{m1}(n)$. It may be noted that $n^{m1} = 0$ if Z_1^{m1} is a falling function of n throughout.

<u>Outcome II</u>:

We next analyze the case where trader 1 does not participate in the contested segment. The income of trader 2 who is now the monopsonist in the retail market is

$$Z_2 = [P^* - f((q_2^{m2}/(1-n)), r)].q_2^{m2}$$

where q_2^{m2} is the quantity purchased by trader 2 in the retail market. Trader 2 takes (1–n) as datum and maximizes Z_2 with respect to q_2^{m2}. The first-order condition of maximization is

$$P^* - f(.) = f_1.q_2^{m2} / (1-n) \tag{6}$$

[16] This assumption is necessary for Z_1^{m1} to be a strictly concave function of n. The assumption is also required to prove that the overall game (two-stage) has the unique sub-game perfect equilibrium. The theoretical model and the policy analysis are meaningful only when there exists a unique overall game equilibrium. It may be pointed out that the same assumption has also been made in Mishra (1994) for the sake of mathematical analysis.

From (6) one can easily show that the optimal q_2^{m2} is a decreasing function of both n and r and that trader 2's monopsony price $f((q_2^{m2}/(1-n)), r)$ is independent of n.

Trader 1's income in this case is:

$$Z_1^{m2} = n.[P^*.Q(C^*) - (1 + g(nC^*)).C^* - \{f((q_2^{m2}/(1-n)), r).Q(C^{m2}) - (1+r).C^{m2}\}] = Z_1^{m2}(n) \quad (7)$$

where C^{m2} is the amount of credit use of each farmer in the contested segment when trader 2 is the monopsonist. Trader 1 maximizes his income through a choice of n. The first-order condition is:

$$P^*.Q(C^*) - (1+g(.)).C^* - f((q_2^{m2}/(1-n)), r).Q(C^{m2}) + (1+r).C^{m2} - n.g'(.).(C^*)^2 = 0 \quad (8)$$

The optimal value of n, denoted by n^{m2}, is obtained from (8). $Z_1^{m2}(n)$ is shown in figure 1a. It can be shown to be a strictly concave function of n with $Z_1^{m2} = 0$ when $n = 0$.

Using equations (2) and (8) as well as the first-order condition of income maximization of each farmer in the contested segment, $(f(.).Q'(C^{m2}) = (1+r)$, we get

$$P^*.[Q(C^*) - Q'(C^*).C^*] = f(.).[Q(C^{m2}) - C^{m2}.Q'(C^{m2})]$$

since $P^* > f(.)$ and since $Q''(.) < 0$, $Q(C^*) < Q(C^{m2})$. Thus, it follows that when there is monopsony of trader 2 in the contested segment, the productivity of each farmer in the contested segment is greater than that in the captive segment.

<u>Outcome III:</u>

When both the traders operate in the retail market, their incomes can be written as

$$Z_1^d = n.[P^*.Q(C^*) - (1+g).C^* - \{f((q_1^d + q_2^d)/(1-n), r).Q(C^d) - (1+r).C^d\}] + [P^* - f((q_1^d + q_2^d)/(1-n), r)].q_1^d \quad (9)$$

and

$$Z_2^d = [P^* - f((q_1^d + q_2^d)/(1-n), r)].q_2^d \quad (10)$$

where $f((q_1^d + q_2^d)/(1-n), r)$ is the duopsony price, q_1^d and q_2^d are the volumes of trading of the two traders, and C^d and $Q(C^d)$ are , respectively the amount of credit use and the output of each farmer in the contested segment. The second stage subgame is now assumed to be played in the Cournot fashion. Thus, Z_1^d and Z_2^d are maximized with respect to q_1^d and q_2^d respectively. The first-order conditions[17] are:

$$[P^* - f(.)] = [f_1.[q_1^d + n\, Q(C^d)] / (1-n)] \quad (11)$$

$$\text{and } [P^* - f(.)] = f_1.(q_2^d / (1-n)) \quad (12)$$

Each trader equates the wholesale price to the marginal expense in equilibrium. Using equations (11) and (12) and the equality $(Q(C^d) = (q_1^d + q_2^d)/(1-n))$ we get,

$$q_1^d = (1-2n).q_2^d \quad (13)$$

Hence $q_1^d > 0$ if and only if $n < 0.5$.

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[17] In each case the second-order condition is satisfied by virtue of the assumption $f_{11} = 0$.

(11) and (12) can be used to solve for the optimal values of q_1^d and q_2^d as functions of n. It can be checked that

$(\partial q_1^d/\partial n) = -(q_2^d.(4n^2 - 12n + 7)/(1-n).(3-2n)) < 0,$

$(\partial q_2^d/\partial n) = -(q_2^d/(1-n)(3-2n)) < 0$, and,

$(\partial((q_1^d + q_2^d)/(1-n))/\partial n) = -(2q_2^d/(1-n)(3-2n)) < 0$

Let $q_1^d(n)$ and $q_2^d(n)$ denote the values of q_1^d and q_2^d obtained from equations (11) and (12) for a given value of n. Let $Z_1^d(n)$ denote the value of Z_1^d obtained from (9) with $q_1^d = q_1^d(n)$ and $q_2^d = q_2^d(n)$.

In the first stage of the over-all game Z_1^d is maximized with respect to n. Using the partial derivatives evaluated above the first-order condition for this maximization can be shown to imply

$$[P^*.Q(C^*) - (1+g).C^* - f((q_1^d + q_2^d)/(1-n), r).Q(C^d) - g'(.).n(C^*)^2] - f_1(q_2^d(n))^2.((4n^2 - 10n + 5)/(1-n)^2.(3-2n)) = 0 \qquad (14)$$

If the g(.) function is rising sufficiently fast, it can be assumed that Z_1^d is a strictly concave function of n so that there is a unique maximum at $n = n^d$ (say). (See figure 1a.). Since $q_1^d = 0$ for $n \geq 0.5$, Z_1^d coincides with Z_1^{m2} over this range.

From equations (2) and (14) we can show that

$Q(C^*) > (<) Q(C^d)$ according as $n < (>) 0.5$ (15)

We now state the following proposition, the mathematical proof of which has been relegated to the appendix.

PROPOSITION 1: The over-all (two-stage) game between the traders has the unique sub-game perfect equilibrium $[n^d, q_1^d(n^d), q_2^d(n^d)]$. If $Q(C) = \sqrt{C}$, then $n^{m1} < n^d < n^{m2} < 0.5$ and $q_i^d(n^d) > 0$, i = 1,2.

Proposition 1 establishes that in the unique sub-game perfect equilibrium of the two-stage game, the village economy is non-trivially fragmented (since $n^{m1} \geq 0$, n^d is strictly positive) and the village retail market is non-trivially contested. Strategic considerations impose a strictly narrower range on the equilibrium value of n^d (i.e. on the extent of use of ICPCs). The more stringent upper limit 0.5 (for the production function considered), rather than 1, follows from the existence of trader 2. In fact, it can be shown that in our model there is a strategic complementarities between n and the profitability of trader 2 over the relevant range.[18] (See Figure 1b). The following proposition can now be established.

PROPOSITION 2: $Z_2^d(n)$ is a concave function increasing over the range [0, 0.5].

[18] See the appendix for its mathematical proof.

However, strategic considerations tend to rule out very small values of n. In the absence of trader 2, n^d would coincide with n^{m1} in equilibrium while in the case of non-trivial duopsony it exceeds that value.

Thus, in general, the role of strategic considerations in this model is different from that in Basu and Bell (1991) and Mishra (1994). Here, they do not explain the existence of ICPCs. But they play a role in determining the extent of their usage.

However, it should be noted that there is a case where strategic considerations would play an explanatory role regarding ICPCs in the present model. Note that an increasing g function only guarantees that $n^{m1} < 1$. Positivity of n^{m1} is not a necessary consequence of this assumption. In fact, if g is rising sufficiently fast, $n^{m1} = 0$ (the Z_1^{m1} function in figure 1a would be decreasing throughout). In this case duopsony explains the existence of the captive segment: $n^d > 0$ because $n^d > n^{m1}$. Here formation of the captive segment is not an entry-preventing strategy. (In fact entry is not prevented). Nonetheless, it is strategic in character in the sense that in the absence of trader 2, a captive segment would not exist.[19]

In the game equilibrium, the reservation income of each farmer in the captive segment (which is equal to that in the contested segment) is given by the following.

$$Y_f^d = f(((q_1^d+q_2^d)/(1-n^d)), r).Q(C^d) - (1+r).C^d \qquad (16)$$

If $Q(C) = \sqrt{C}$, then the first-order condition of maximization of farmer's income is $P_d = 2(1+r).Q(C^d)$; or, $f(((q_1^d+q_2^d)/(1-n^d)), r) = 2(1+r).Q(C^d)$; $(\partial P^d/\partial Q^d) = 2(1+r) = f_1$. From (13) and (12) we respectively get $Q(C^d) = ((q_1^d+q_2^d)/(1-n^d)) = 2q_2^d$; and, $q_2^d = [P^*.(1-n^d)/f_1.(1-2n^d)]$. Now from (16) it can be easily shown that

$$Y_f^d = 2f_1.(q_2^d)^2 = (2/f_1).[P^*.(1-n^d)/(3-n^d)]^2 \qquad (16.1)$$

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[19] In this case strategic considerations do explain the existence of the ICPCs. Note that if g(.)is rising sufficiently fast, the Z_1^{m1} curve would be a monotonically decreasing function of n. Therefore, the value of n that maximizes Z_1^{m1} is zero. In other words, it is optimal for the trader 1 not to keep a captive segment and get involved with ICPCs with some farmers. So, in this case outcome I where trader 1 is a monopsonist cannot be the equilibrium outcome of the overall (two-stage) game. Naturally, the only equilibrium outcome is the case where the contested segment is duopsonistic, as entry is unpreventable in this model. But we should note that when the contested segment of the market is duopsonistic, n^d is positive, as Z_1^d is maximum for a positive value of n. Thus, trader 1 finds it strategically optimal to have a captive segment when trader 2 participates in the contested market. But in the absence of trader 2, the optimal size of the captive segment is zero as the value of n that maximizes Z_1^{m1} is zero.

3. Policy Analysis

The captive segment of the village market for grains is more productive[20] than the contested segment from the viewpoint of agricultural productivity although the farmers belonging to either of two segments earn the same income. We are now all set to study the effects of trade liberalization in agriculture on the village economy of a developing country. Here trade liberalization is captured by a reduction in credit subsidy and an increase in the price of the crop in the wholesale market. More specifically, we are interested to study the impacts of trade liberalization on the size of the captive segment of the market, agricultural productivity and on the welfare of the farmers.

3.1 A Reduction of Credit Subsidy

A reduction of credit subsidy policy raises the interest rate r on formal credit. As r increases, the income of each farmer in the contested segment (and, hence, the reservation income of each farmer in the captive segment) decreases. So in the case where trader 1 does not participate in the contested market, his income Z_1^{m2} increases as r increases. Also we can show[21] that $(\partial^2 Z_1^{m2}/\partial n\partial r) > 0$. So as r increases, the Z_1^{m2} curve shifts upward with a higher slope. The latter means that the maximum point of the Z_1^{m2} curve shifts to the right (see the Z_1^{m2*} curve in figure 2a).

In the case where trader 1 enjoys monopsonistic power in the contested segment, an increase in r raises the cost of credit of each farmer in the contested segment which lowers the level of production at the same value of P*. The income of each farmer decreases in the contested segment given n, which in turn lowers the reservation income of each farmer in the captive segment. But the volume of trade of trader 1 in the contested segment q_1^{m1} decreases as r increases which in turn raises the trade margin per unit $(P^* - f(.))$, given n, through a decrease in f(.). However, an increase in r also leads to an increase in f(.) directly. So the net effect of an increase in r on Z_1^{m1} depends upon the relative strengths of the two opposite effects. However, if we consider the specific algebraic form of the production function, $Q = \sqrt{C}$, it can be shown[22] that the net marginal gain (with respect to n) of trader 1 from the captive segment vis-à-vis the contested segment rises as r rises. As a consequence, the size of the captive segment at which Z_1^{m1} attains its maximum value rises. So the Z_1^{m1} curve shifts downward with a higher slope (i.e. the maximum point of Z_1^{m1} shifts to the right) as r increases (see the Z_1^{m1*} curve in figure 2a).

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[20] This is because n^d (< 0.5) is the equilibrium size of the captive segment and $Q(C^*) > Q(C^d)$ for n < 0.5. The formal proof is available from the authors on request.

[21, 22, 23] Interested readers may check these results or details can be obtained from the authors on request.

Proceeding with the same algebraic form of the production function it can be shown[23] that in the duopsonistic case (in the contested segment) the Z_1^d curve shifts downward for n < 0.293; for n > 0.293, the Z_1^d curve shifts upward as r increases. However, the slope increases and the maximum point shifts to the right. But irrespective of the value of r, trader 1 drops out of the contested segment for n > (=) 0.5 (see the Z_1^{d*} curve in figure 2a). One can check that the maximum value of Z_1^d decreases as r increases. Also an increase in r, besides raising the cost of credit to the farmers in the contested segment of the market, lowers the duopsony price received by the farmers for their output. These two factors push down the reservation level of income (and hence welfare) of the farmers. Differentiating (16.1) and using the envelope theorem, it can be checked that $(\partial Y_f^d/\partial r) = -\,[\{2f_{12}/(f_1)^2\}.\{P^*.(1-n^d) / (3-2n^d\}^2] < 0$. The effect of a reduction in the credit subsidy on the total agricultural production is, however, not so straightforward. This is because of the following reasons. The total agricultural production in this model's equilibrium is, $Q_T = n^d.Q(C^*) + (1-n^d).Q(C^d)$, where the first and the second terms in the right-hand side of this expression denote the total production levels in the captive segment and contested segment, respectively. Differentiating Q_T with respect to r one obtains the following expression.[24]

$$(dQ_T/dr) = Q(C^*).\{1 + E_{Q,C}\,.\,\xi_{C^*,n}\} + [(1-n^d).Q'(C^d).(\partial C^d/\partial r) - Q(C^d).(dn^d/dr)$$

$$+ (1-n^d).Q'(C^d).(\partial C^d/\partial P^d).(dP^d/dr)] \qquad (17)$$

where, $E_{Q,C} = \{(dQ(C^*)/dC^*).(C^*/Q(C^*))\}$= the input elasticity of credit; and, $\xi_{C^*,n} = \{(n^d/C^*).(\partial C^*/\partial n^d)\}$ = partial elasticity of demand for credit of each farmer with respect to the size of the captive segment, n^d. We should note that $\xi_{C^*,n} < 0$ as $(\partial C^*/\partial n^d) < 0$. Thus from (17) it follows that

$$(dQ_T/dr) \;<\; 0 \;\text{ if }\; \{1 + E_{Q,C}\,.\,\xi_{C^*,n}\} \leq 0 \qquad (18)$$

Condition (18) can be explained as follows. As r increases following a reduction in credit subsidy, n^d increases but C*, $(1-n^d)$ and $Q(C^d)$ decrease. So the total level of production in the contested segment of the market decreases. On the other hand, as the optimum size of the captive segment, n^d, increases following an increase in r, the marginal cost of having a captive segment of the trader increases, which in turn implies a worse borrowing terms for the farmers. As a consequence, the credit demand of each constituent (farmer) in this segment decreases. This leads to a lower agricultural productivity per farmer. However, as the number of constituents has increased total production both of this segment and of the economy as a whole may decrease. But the total production of the economy falls if $\{1 + E_{Q,C}\,.\,\xi_{C^*,n}\} \leq 0$, i.e. if the production level of the captive segment does not rise. However, we should note that this is only a sufficient condition to make (dQ_T/dr) negative. Thus we have the following proposition.

PROPOSITION 3: A reduction in credit subsidy leads to (i) an increase in the equilibrium size of the captive segment (n^d) along with the lower and upper limits (n^{m1} and n^{m2}, respectively) and, (ii) an unambiguous deterioration in the welfare of the farmers. The total agricultural production of the economy decreases as a consequence if $\{1 + E_{Q,C} \cdot \xi_{C^*,n}\} \leq 0$.

3.2 *An increase in P**

If all countries whether developed or developing liberalize trade in their agricultural sector, the international price of the crop, P*, will rise. From (7) and (8) it follows that Z_1^{m2} curve shifts upward (see the Z_1^{m2**} curve in figure 3a) with a higher slope as P* increases.
Also from equation (3), applying the envelope theorem we have
$(\partial Z_1^{m1}/\partial P^*) = [n.Q(C^*) + q_1^{m1}] > 0.$
Again from equation (5), it is easy to check that when $Q = \sqrt{C}$
$(\partial^2 Z_1^{m1}/\partial n \partial P^*) = [Q(C^*) - Q(C^{m1})] + 2(1+r).P^*.[(1-n)/f_1.(2-n)]^2 > 0$ (since $Q(C^*) > Q(C^{m1})$).
So the Z_1^{m1} curve also shifts upward with a higher slope as P* increases.

An increase in P* raises the profits of the trader 1 both in the captive and contested segments. So Z_1^{m1} increases as P* increases. But since the productivity of each farmer in the captive segment is greater than that in the contested segment, the net marginal gain (with respect to n) from the captive segment vis-à-vis the contested segment increases as P* increases. This means that the maximum point of the new Z_1^{m1} curve lies to the right of the maximum point of the previous one (see figure 3a). It can be checked that as a result of an increase in P*, the Z_2^d curve shifts upward with a higher slope (when n < 0.5). The new Z_2^d curve also has its maximum point at n = 0.5. The Z_2^d curve shifts to Z_2^{d*} in figure 3b.

From equations (9) and (14) one can respectively derive
$(\partial Z_1^d/\partial P^*) = [(q_1^d + n.Q(C^*) - ((q_1^d + n.Q(C^d)/(3-2n))] > 0$ (since for n < 0.5, $Q(C^*) > Q(C^d)$ and $(3 - 2n) > 1$);
and,
$(\partial^2 Z_1^d/\partial n \partial P^*) = Q(C^*) - Q(C^d).[\{2(1-n)^2.(3-2n) + (4n^2 - 10n + 5)\}/\{(1-n).(3-2n)^2\}].$
The sign of the last expression is uncertain. So due to a price subsidy policy the Z_1^d curve shifts upward. But the maximum point may shift in either direction. Hence the effect of an increase in P* on the equilibrium size of the captive segment, n^d, is uncertain. But, using the envelope theorem from (16.1) it can be checked that $(\partial Y_f^d/\partial P^*) = (4P^*/f_1).[(1-n^d)/(3-2n^d)]^2 > 0$. An increase in P* raises both the duopsony price, P^d, and the output of each farmer in the contested segment, $Q(C^d)$. So the reservation income of the

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[24] See the appendix for its derivation.

farmers and hence their welfare improves due to an increase in P*. The following proposition can now be established.

PROPOSITION 4: An increase in the international price of the agricultural commodity resulting from worldwide trade liberalization in agriculture has ambiguous effects on the equilibrium size of the captive segment, and on the agricultural productivity. But, the welfare of the farmers definitely improves.

4. Concluding Remarks:

In this paper we have analyzed the extent of use of interlinked credit product contracts in a village economy with two traders of whom one is a creditor-trader using such contracts to maintain a captive market of debtor-farmers from where the crop can be purchased at a discriminatory price and the other a pure trader who can only compete in the contested segment of the village economy.[25] Since we have assumed away entry cost and other fixed costs, entry by the pure trader in the contested market cannot be prevented. A two-stage game is played between the two traders where in the first stage the creditor-trader fixes the size of the captive-segment and in the second stage the two traders play a Cournot duopsony game to determine their levels of purchase from the contested segment of the market. In offering ICPCs to farmers the motive of the creditor-trader is to push them to their reservation income level (rather than to prevent the entry of the pure trader). A farmer's income is the same across the two segments of the market. It is this that makes the ICPCs acceptable to the farmers. The absence of fixed costs enabled us to prove the existence of a unique sub-game perfect equilibrium of the two-stage game. In general, in our model the role of the strategic interaction between the players is to determine the exact extent of usage of ICPCs rather than their existence. In some particular cases, however, they do explain existence. In this set-up we have analyzed the effects of possible worldwide trade liberalization in agriculture on the village economy.

The central message of this paper is that the government of a developing country should think it twice before going in for trade liberalization in agriculture. If it reduces subsidies on agricultural credit and other essential inputs like fertilizers and pesticides, not only the welfare of the farmers deteriorates but also the aggregate level of production of the crop may fall. On the contrary, an increase in the international price of the crop improves the farmers' welfare but the effect on the agricultural productivity is ambiguous. But it should be noted that price-increases of the agricultural commodities are not within the control of the

[25] The assumption that of the two traders only one is in a position to offer ICPCs to farmers is a simplifying one. Notionally it is not difficult to extend the model to the case where both the traders have their (non-overlapping) captive markets while competing with each other in the contested segment. However, the proofs of the propositions will then be considerably longer but will not provide any additional insight because all the propositions of the paper (suitably reworded) will continue to hold. This exercise, therefore, is not undertaken here.

government of a developing country. Only when the developed countries liberalize their agricultural sector sufficiently by reducing different subsidies and removing tariff and non-tariff barriers, their import demands and consequently the international prices of the agricultural products are likely to increase. But empirical evidence so far has revealed that the developed countries are yet to liberalize their agricultural sector, which is still heavily protected from foreign competition. In some cases, the degree of protection instead of falling has increased in recent times. The vehement demand of the developing countries in the recent rounds of the WTO meetings for granting accessibility to the agricultural markets of the developed countries so far has been in vain. Therefore, unless the developed countries liberalize their agricultural sector, it would be premature for the developing countries to go in for trade liberalization in agriculture and remove all farm subsidies, as this policy may in fact be counterproductive.

References:

Bardhan, P.K. (1984): *Land, Labour and Rural Poverty*, Columbia Press, New York.

Basu, K. (1983): "The emergence of isolation and interlinkage in rural markets", *Oxford Economic Papers* 35, 262-80.

Basu, K. and Bell, C. (1991): "Fragmented duopoly: Theory and applications to backward agriculture", *Journal of Development Economics* 36, 259-81.

Bell, C. (1988): "Credit markets and interlinked transactions". In H.B. Chenery and T.N. Srinivasan (eds.), *Handbook of Development Economics*, North-Holland, Amsterdam.

Bhaduri, A. (1983): *The Economic Structure of Backward Agriculture*, Academic Press, London.

Braverman, A. and Stiglitz, J.E. (1982): "Sharecropping and the interlinking of agrarian markets", *American Economic Review* 72, 695-715.

Chaudhuri, S. (1996): "Credit-product interlinkage: Different explanations", *The Indian Journal of Economics* 70(305), 173-90.

Chaudhuri, S. (2004): *Some Aspects of Agricultural Credit in a Developing Economy*, Serials Publications, New Delhi.

Chaudhuri, S. and Gupta, M.R. (1995a): "An analysis of delayed formal and interlinked informal credit in agriculture", *Journal of International Trade and Economic Development* 4(1), 45-62.

Chaudhuri, S. and Gupta, M.R. (1995b): "Price uncertainty and credit-product interlinkage: An extension of the analysis of Gangopadhyay and Sengupta", *Journal of International Trade and Economic Development* 4(1), 93-113.

Fabella, R. V.(1992): "Price uncertainty and trader-farmer linkage", *Journal of Public Economics* 47.

Gangopadhyay, S. and Sengupta, K. (1987): "Small farmers, moneylenders, and trading activity", *Oxford Economic Papers* 39, 333-42.

Mishra, A. (1994): “Clientelization and fragmentation in backward agriculture: Forward induction and entry deterrence”, *Journal of Development Economics* 45, 271-85.

Mitra, P. (1983): “A theory of interlinked rural transactions”, *Journal of Public Economics* 20, 169-91.

Rudra, A. (1982): *Indian Agricultural Economics: Myths and Realities*. Allied Publishers Private Limited. New Delhi.

APPENDIX:

Proof of proposition 1:

Since[$q_1^d(n^d)$, $q_2^d(n^d)$] is the Cournot solution of the second-stage sub-game, it is , by definition, a Nash equilibrium of this subgame. In the two-stage game it is trivially true that if trader 1 adopts the strategy [$n^d, q_1^d(n^d)$] it is optimal for trader 2 to choose $q_2 = q_2^d(n^d)$. Hence, to establish sub-game perfection it only remains to check that [$n^d, q_1^d(n^d)$] is an optimal strategy of trader 1 if trader 2 chooses $q_2^d(n^d)$.

For this, we consider the expression

$$Z_1 = n.[P^*.Q(C^*) - (1+g).C^* - \{f((q_1^d(n) + q_2^d(n^d).)/(1-n), r).Q(C) - (1+r).C]$$
$$+ [P^* - f((q_1 + q_2^d(n^d).)/(1-n), r)].q_1$$

where C is defined implicitly by $Q(C) = (q_1 + q_2^d(n^d))/(1-n)$.

We denote by $Z_1^*(n)$ the function obtained by considering, at each n, the maximum value of Z_1 with respect to q_1.

Under our assumption regarding the g function $Z_1^*(n)$ is a strictly concave function of n. It is easily seen that $Z_1^*(n) = Z_1(n)$ at $n = n^d$. Moreover, by using the fact that, at any given n, the first derivative of Z^*_1 with respect to q_1 equals zero and that n^d, by definition, maximizes $Z_1(n)$, it can be shown[26] that the first derivative of $Z_1^*(n)$ vanishes when evaluated at $n = n^d$. It then follows that $q_1 = q_1^d(n^d)$. This completes the proof that [n^d, $q_1^d(n^d)$, $q_2^d(n^d)$] is a sub-game perfect equilibrium of the (two stage) game between the traders. Uniqueness follows from the strict concavity assumption regarding the function $Z_1^d(n)$.

Suppose now that each farmer's production function is: $Q(C) = \sqrt{C}$. Then the inverse supply function of each farmer is: $f(Q, r) = 2Q.(1+r)$. Hence, $f_1(.) = 2(1+r) > 0$.

Since equation (8) implies that

$$P^*Q(C^*) - (1+g)C^* - n\,g'(.).(C^*)^2 = f(q_2^{m2}/(1-n), r)Q(C^{m2}) - (1+r).C^{m2} \qquad \text{(A.1)}$$

from (14) we can write the value of $(d\,Z_1^d(n)/dn)$ at $n = n^{m2}$ as :

$$[f(q_2^{m2}/(1-n), r)Q(C^{m2}) - (1+r).C^{m2}] - [f((q_1^d(n) + q_1^d(n))/(1-n), r).Q(C^d) - (1+r).C^d]$$
$$- [f_1.(q_2^d(n))^2.(4n^2 - 10n + 5)/(1-n)^2.(3-2n)] \qquad \text{(A.2)}$$

evaluated at $n = n^{m2}$.

Denote the first and the second square-bracketed expressions in (A.2) by B_1 and B_2 respectively.

If $Q(C) = \sqrt{C}$, equation (6) can be used to establish that $P^* = 2.f_1.(q_2^{m2}/(1-n))$ or, $q_2^{m2} = P^*.(1-n)/2.f_1$.

Also $Q(C^{m2}) = ((q_1^{m2}/(1-n)) = (P^*/2.f_1)$. Thus $C^{m2} = (Q(C^{m2}))^2 = (P^*/2.f_1)^2$ and $Q'(C^{m2}) = (1/2.Q(C^{m2}))$.

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[26] Interested readers may check this result or details can be obtained from the authors on request.

Hence B_1 becomes (after simplification) $(f_1/2). (P^*/2.f_1)^2$. Similarly, from (12) and (13) we can show that for the above specific algebraic form of the production function B_2 reduces to $(2(P^*)^2.(1-n)^2 / f_1.(3-2n)^2)$.
Hence after simplification (A.2) becomes

$-[(P^*)^2.(7 - 20n - 12n^2) / f_1.8.(3-2n)^2] - f_1.(q_2^d(n))^2.[(4n^2 - 10n + 5) / (1-n)^2.(3-2n)]$

evaluated at $n = n^{m2}$.

For $n \leq 0.5$, this expression is negative in sign. Hence, the $Z_1^d(n)$ function is falling at $n = n^{m2}$.

Also using (6), (12) and (13), we can show[27] from (7) and (9) that for $n < 0.5$, $Z_1^d(n) > Z_1^{m2}(n)$ and for $n \geq 0.5$, $Z_1^d(n) = Z_1^{m2}(n)$. Recalling that both $Z_1^d(n)$ and $Z_1^{m2}(n)$ are strictly concave in n we therefore reach the conclusions that $n^d < n^{m2}$ and that $n^{m2} \leq 0.5$.

On the other hand, from (4) and (10) it follows that $f((q_1^d(n) + q_2^d(n^d).)/(1-n), r) > f((q_1^{m1}/(1-n)), r)$ for all $n < 1$ and, hence, $Q(C^d) > Q(C^{m1})$. From (3) and (9) it will, therefore, follow that $Z_1^{m1}(n) > Z_1^d(n)$ for all $n < 1$. Using (5) and (14) and the proposed special production function it can now be shown[28] that $(d Z_1^d(n)/dn) > 0$ at $n = n^{m1}$. This implies that the maximum point of $Z_1^d(n)$ must lie to the right of that of Z_1^{m1}. Thus $n^{m1} < n^d$. Thus, we get: $n^{m1} < n^d < n^{m2} \leq 0.5$.

Finally, since $n^d < 0.5$, $q_1^d(n^d) > 0$. To establish the positivism of $q_2^d(n^d)$, note that if $Q(C) = \sqrt{C}$, the reaction functions of the two traders (equations (11) and (12)) for $n = n^d$ take the following forms:

$q_1^d = (D/2) - ((2.n^d + 1)/2).q_2^d$,

and, $q_2^d = (D/2) - (q_1^d/2)$

where, $D = (P^*.(1 - n^d)/2.(1+r))$.

It can now be checked that $q_2^d(n^d)$ cannot be zero in the Nash equilibrium of the second-stage sub-game. Q.E.D.

Proof of proposition 2:

From (10) and (12) we get

$Z_2^d(n) = f_1.(q_2^d)^2/(1-n)$.

Hence, $(d Z_2^d(n)/dn) = [[f_1.(q_2^d)^2.(1-2n)] / [(1-n)^2.(3-2n)]] > (=) < 0$ according as $n < (=) > 0.5$, and

$(d^2 Z_2^d(n) / dn^2) = -8n.f_1.(q_2^d)^2 / [(1-n)^2.(3-2n)^2] < 0$. Q.E.D.

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[27] The proof of this result is left to the readers.

[28] Interested readers may check this result or details can be obtained from the authors on request.

<u>Derivation of equation (17):</u>

Differentiating Q_T with respect to r one obtains the following expression.

$$(dQ_T/dr) = n^d.Q'(C^*).(\partial C^*/\partial n^d).(dn^d/dr) + Q(C^*).(dn^d/dr) + [(1-n^d).Q'(C^d).(\partial C^d/\partial r) - Q(C^d).(dn^d/dr)$$

$$(-) \qquad (+) \qquad (+) \qquad (-) \qquad (+)$$

$$+ (1-n^d).Q'(C^d).(\partial C^d/\partial P^d).(dP^d/dr)]$$

$$(+) \qquad (-)$$

$$= Q(C^*) + \{(dQ(C^*)/dC^*).(C^*/Q(C^*))\}.Q(C^*).\{(n^d/C^*).(\partial C^*/\partial n^d)\}$$

$$+ [(1-n^d).Q'(C^d).(\partial C^d/\partial r) - Q(C^d).(dn^d/dr) + (1-n^d).Q'(C^d).(\partial C^d/\partial P^d).(dP^d/dr)]$$

Thus

$$(dQ_T/dr) = Q(C^*).\{1 + E_{Q,C} \cdot \xi_{C^*,n}\} + [(1-n^d).Q'(C^d).(\partial C^d/\partial r) - Q(C^d).(dn^d/dr)$$

$$+ (1-n^d).Q'(C^d).(\partial C^d/\partial P^d).(dP^d/dr)] \qquad (17)$$

where, $E_{Q,C}$ = $\{(dQ(C^*)/dC^*).(C^*/Q(C^*))\}$= the input elasticity of credit; and, $\xi_{C^*,n}$ = $\{(n^d/C^*).(\partial C^*/\partial n^d)\}$ = partial elasticity of demand for credit of each farmer with respect to the size of the captive segment, n^d. We should note that $\xi_{C^*,n}$ < 0 as $(\partial C^*/\partial n^d) < 0$.

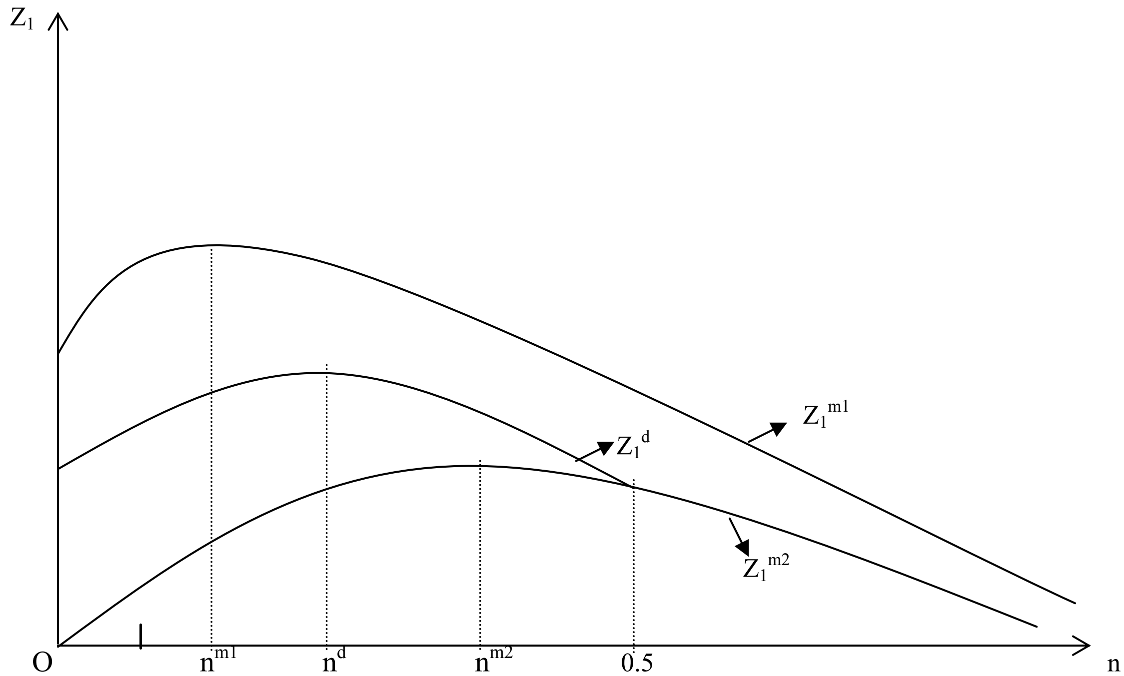

Figure 1a.

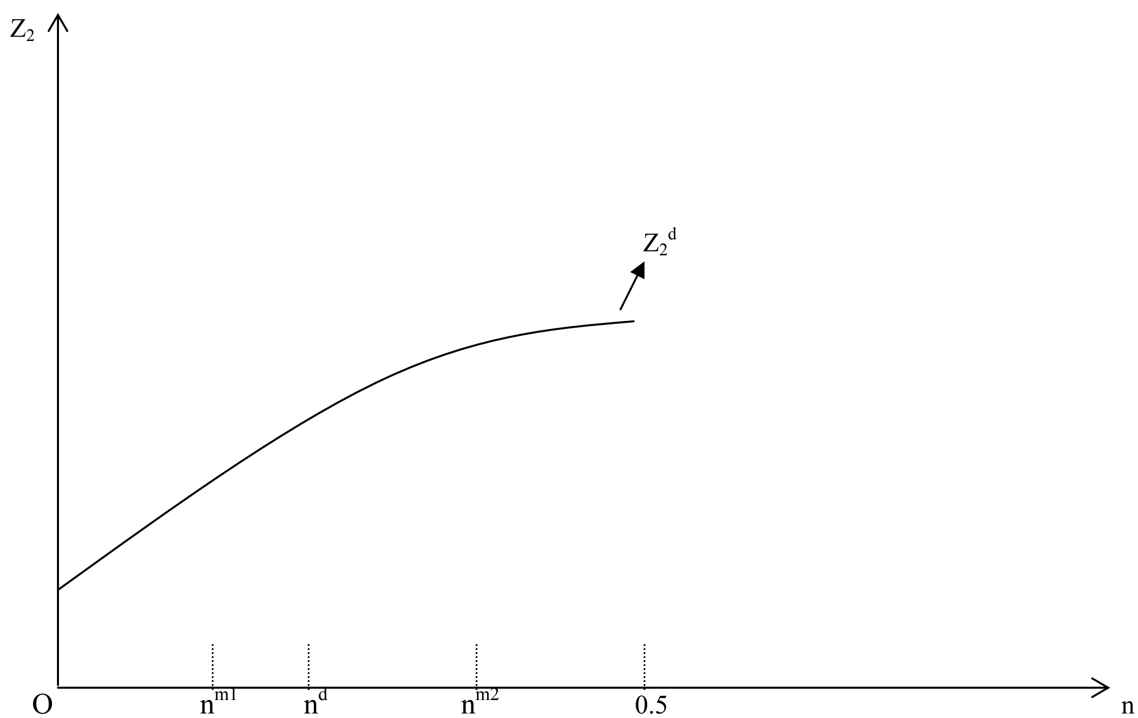

Figure 1b.

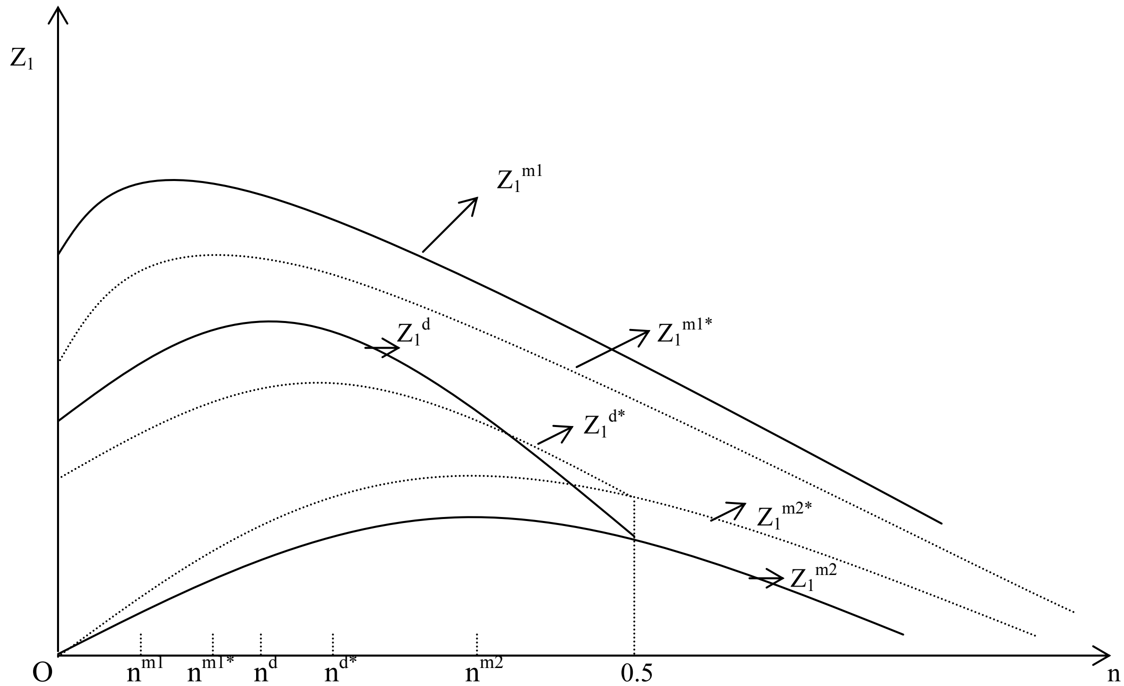

Figure 2a.

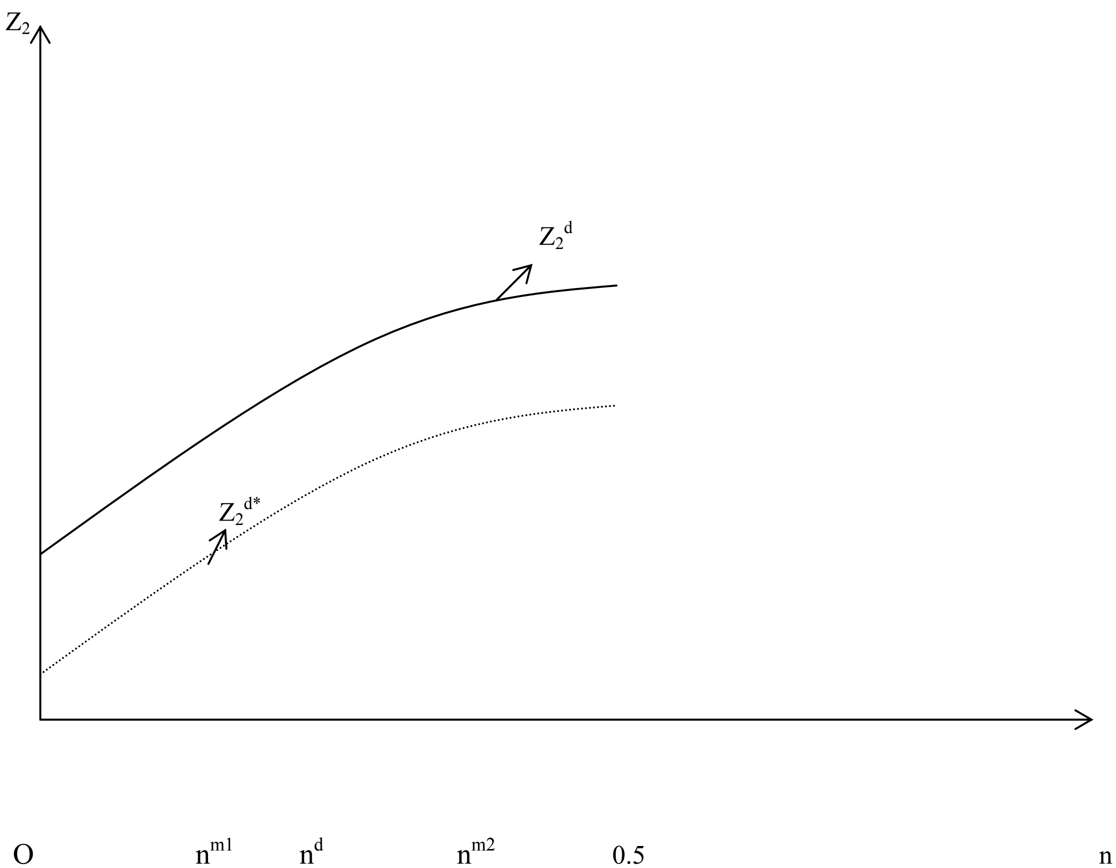

Figure 2b.

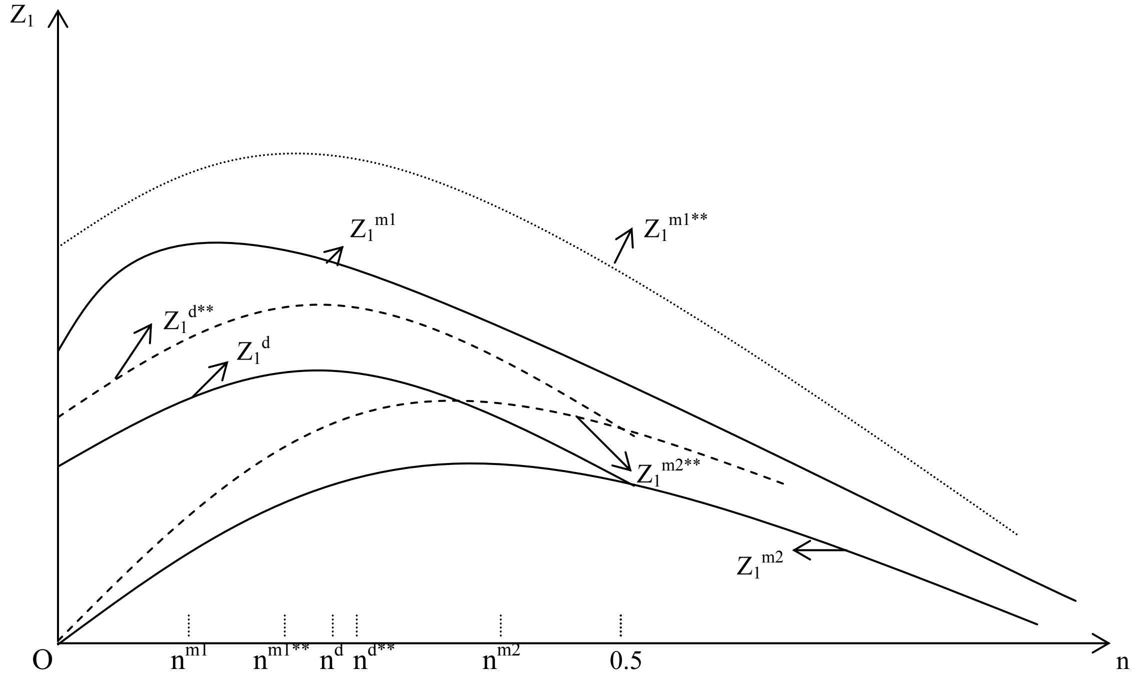

Figure 3a.

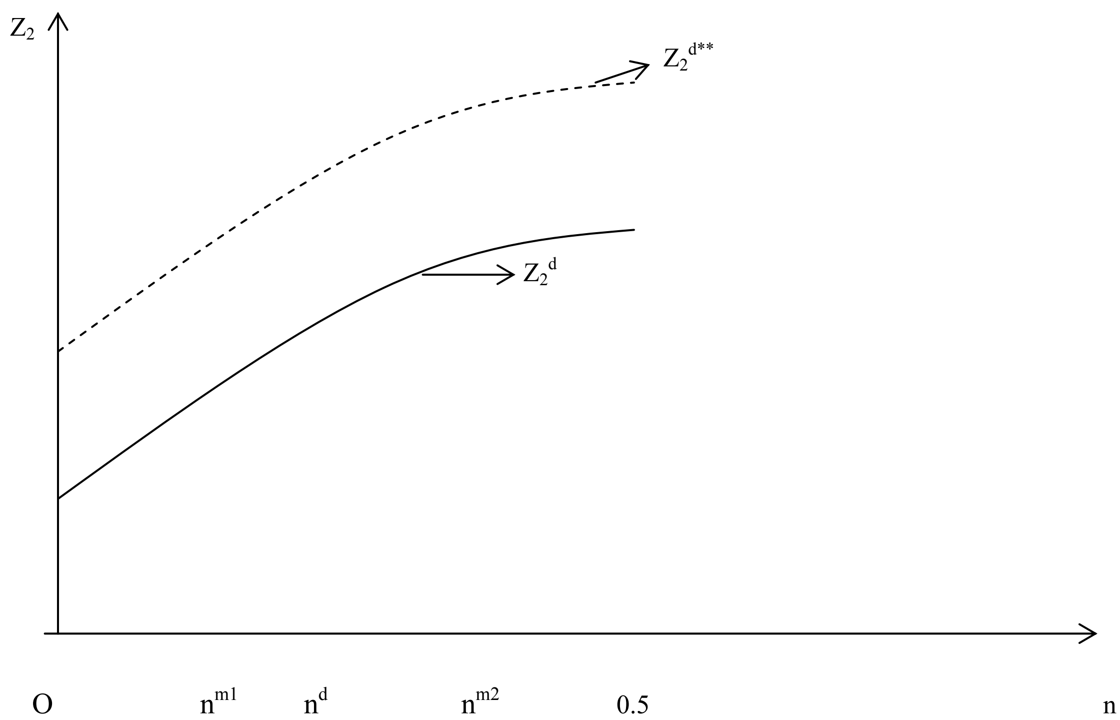

Figure 3b.