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## Financial Structure and the Dynamics of Investment Decisions in Supply Cooperatives

by

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Jerome Hammond



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## **Financial Structure and the Dynamics of Investment Decisions in Supply Cooperatives**

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## **Introduction**

Cooperatively owned firms, like Investor Owned Firms, IOFs, require capital for business activities. Apart from external financing, capital in IOFs is raised largely by issuing new equity while cooperatives tend to rely heavily on retained earnings. For the most part, net earnings for IOFs are considered only as return to capital invested and ownership, which is realized immediately at market value. The situation is quite different for cooperatively owned enterprises. In cooperatives there is no market for ownership rights. Equity capital bears limited return and there is usually slow equity retirement programs. The combined effect of these characteristics have induced the horizon problem<sup>1</sup>, (Jensen and Meckling), which in turn led members to promote short term projects and higher cash refunds, (Condon, Vitaliano and Staatz 1987<sub>s</sub>). Thus, with benefits perceived as reductions (increase) in price for supply (marketing) cooperatives, allocation of net earnings and the dynamics of investment decisions appears to be more complicated for the cooperative firm than for the IOF.

Though these issues have occupied cooperative's practitioners as well as scholars' attention, with few exception (see Cotterill), cooperative theory has emphasized the linkage of pricing methods to goods and services provided while ignoring aspects of cooperative finance and, the dynamics of investment decisions. Confined mainly to the static economic theory of the firm, aspects of raising equity capital, redemption of equity and in general cooperative's growth could not be examined. This deficiency, accentuated by rapid changes in the agricultural sector, has led researchers to conclude that existing theory is inadequate to address issues facing cooperative firms, (Staatz 1987<sub>s</sub>).

This paper is directed to providing a theoretical framework for cooperative enterprise that can cope with the issues discussed above, hereafter, termed the allocation problem. As a

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<sup>1</sup> The horizon problem is the tendency to increase current cash benefits at the expense of future gains.

first step towards a dynamic unified theory of cooperative firm and finance, an effort was made to incorporate some of the key characteristics of the cooperative organization with recent development in the dynamic theory of the firm. We focus our attention on the supply cooperative organization while investigating the impact of the financial structure on its investments and policies regarding the returns to patronage and equity capital. The framework utilizes a dynamic optimization method to solve the cooperative's allocation problem. It examines the set of possible optimal trajectories which depend on the nature of capital market imperfections and the financial structure of the cooperative. Also it distinguishes among different capital accumulation regimes which correspond to different stages of development of the cooperative. The model provides the decision maker with vital information regarding the optimal financial structure at each time period, the cost and sources of capital and the amount of earnings that should be retained and or distributed to members. In the last section the framework is used to examine and compare cooperative and IOF optimal behavior. Here, we make use of the dynamic shadow prices to infer about the potential horizon problem in cooperatives.

### **Dynamic Theory of Supply Cooperative**

To model the allocation problem for an agricultural supply cooperative, the following assumptions are retained: (1) The cooperative and its members operate in a deterministic tax free environment. (2) Business is conducted with patrons only. (3) All production functions are continuous, twice differentiable, concave functions with respect to each and all of their arguments. (4) Variables are continuous functions of time<sup>2</sup>. (5) Initial investment in the

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<sup>2</sup> For notational purposes unless specified explicitly otherwise, variable  $Y$ ,  $X$ ,  $U$ ,  $E$ ,  $Z$ ,  $\lambda$  means  $Y=Y(t)$ ,  $X=X(t)$ ,  $U=U(t)$ ,  $E=E(t)$ ,  $Z=Z(t)$  and  $\lambda=\lambda(t)$ .

cooperative is financed by an interest bearing loan from an outside agency paid in fixed installments.

The above assumptions facilitate the construction and discussion of the model. Assumptions (2) to (5) can be dispensed without altering the main results which hold when taxes are taken into account, but they simplify the exposition of the model. As for uncertainty, at this stage, it is unclear what might be the impact once incorporated due to the unique risk sharing features that exist in cooperative enterprises.

Consider now a representative member,  $i$ , who produces a single good,  $Y$ , according to  $Y_i = c_i f(U_i)$ , where  $U_i$  is the input purchased from the cooperative and  $c_i \in (0,1)$  is a normalized parameter that captures fixed factors such as land, managerial skill, and capital invested in the farm. Farmer  $i$ , purchases  $U_i$  at the current market price  $w$ , which is known at the time of the production decision. Output,  $Y_i$ , is sold at a competitive price,  $p$ . Apart from the direct profit from the farming operation, defined as  $p c_i f(U_i) - w U_i$ , each member/producer receives a return,  $R_i = R_i(U_i, E_i)$ , from the cooperative, which is a function of current patronage,  $U_i$ , and the member's share in the cooperative's equity capital,  $E_i$  and  $E$  respectively. In practice,  $R_i$  may lag the corresponding production activity which in turn can affect  $R_i$ . This feedback has led several analysts to argue that the receipt of patronage refunds with such a delay will induce patrons to overproduce so that cooperative output is maintained at the suboptimal level where economic rent is zero (Cotterill, pp. 190-92). Such a behavioral specification which may be consistent with individuals' long range planning is addressed in this study.

The supply cooperative produces a single homogenous output  $U$ , according to the production function:  $U = g(X)$ . The capital of the cooperative,  $X$ , evolves over time according to the equation:

$$\dot{X} = -\gamma X + I, \quad (1)$$

where  $\dot{X}$  is the rate of change in capital over time, and  $\gamma$  is the rate at which capital decays, a fixed rate. As for the investment  $I$ , it is assumed that the cooperative acquires capital either through retained earnings or borrowing and that investments are irreversible. The former enables us to address the horizon problem cited in Condon, LeVay and Staatz. Furthermore, as mentioned in Caves and Petersen, the use of retained earnings is by far the most popular in cooperatives due to the disincentive to invest in common stock induced by cooperatives' principles.

To analyze the impact of the financial structure, the cooperative is permitted to borrow capital which introduces the balance identity,  $X = E + Z$ , where  $Z$  is the borrowed capital. In addition, the organization must operate under restrictions:  $R \geq 0$ ,  $E > 0$ , and  $\bar{L}E \geq Z \geq \underline{L}E$ , and  $\bar{L}$  ( $\underline{L}$ ) is the maximum (minimum) leverage allowed. The revenue is defined as  $G(X) = wg(X)$ . If we assume that the cooperative's objective is to maximize members' cash flow,  $\pi_i = c_i pf(U_i) - wU_i + R_i(U_i, E_i)$ , and that  $R$  and  $R_i$  are linear with respect to their arguments<sup>3</sup>, the cooperative's allocation problem is then defined as:

$$\text{Max } \int_0^T \sum_{i=1}^n e^{-\delta t} \pi_i(U_i, E_i) dt + E(T)e^{-\delta T}, \quad (2)$$

$$\text{subject the constraints: } \dot{E} = G(X) - R(U, E) - \gamma X - rZ, E(0) = E_0 > 0, \quad (3)$$

$$\dot{X} = I - \gamma X, X(0) = X_0 > 0, \quad (4)$$

$$\underline{L}E \leq Z \leq \bar{L}E, 0 \leq \underline{L} \leq L \leq \bar{L}. \quad (5)$$

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<sup>3</sup> Linearity of  $R$  and  $R_i$  reflect the common practice in cooperatives where  $R_i$ , in general, takes the form of  $R_i = \alpha_i + \alpha U_i + (\beta_k + \beta)E_i$  where all parameters reflect the pricing policy of the cooperative and are determined for example by majority rule.

In (2),  $E(T)$  is the terminal stock of equity and  $\delta$  is the discount rate. Equation (3) specifies that revenue is used to pay the costs of capital, which includes depreciation  $\gamma$  and interest  $r$  paid on debt. The remainder is left to be reinvested and/or to pay dividends and patronage refunds.  $R(X,U)=\Theta(R_1,...R_n)$ ,  $\Theta$  is the sum of  $R_i$  and  $R$  is the total rent generated by the cooperative. Such formulation complies with the normative requirement that cooperatives distribute all gains. This, and the assumption that members' technology differs by a constant  $c_i$  substantially simplifies the analysis and facilitates a comparison of the present approach to previous models that assumed existence of a single objective pursued by a single agent (Helmberger and Hoos) or group of identical agents (Phillips).

The above specification maintains the conflicts relating to the allocation of revenue  $G(x)$  to investment and returns to members which are implied by (2) and (3). Also, it allows one to examine the dependency of dividends (patronage refunds) on the business volume (equity). This aspect could be captured by properties that  $R$  is assumed to possess. For example,  $\partial^2 R / \partial E \partial U < 0$ , implies that the marginal rate of return to capital is strictly decreasing as the business volume increases. However, with the assumed linearity, only the indirect effect is deduced from (3). Yet, the linear return to patronage and equity still involves sub-allocations within  $R(U,E)$ , (see footnote 3) which may be very controversial. This controversy is detailed in Staatz, Sexton, Cobia, Cotterill and others who investigated how the 'windfall' of net margin should be rebated to patrons as a single unit price or a linear combination of two price regimes.

We now consider the situations under which it would be beneficial for the cooperative to borrow money. For these situations we exclude the possibility of lending and assume that capital markets are not perfect i.e.,  $\delta \neq r$ . The assumption reduces the number of feasible trajectories while eliminating the case where the cooperative is indifferent between equity and debt. More importantly,  $\delta \neq r$  as we show below is the driving force for investment decisions. The direction of the inequality indicates the weight placed by members on non-

market benefits that are provided by the cooperative organization.

Following the standard approach in optimal control theory, we form the Hamiltonian for the cooperative allocation problem in (2) to (4) (suppressing individuals' subscripts) as:

$$H = e^{-\delta t} \pi(.) + \varphi_1 [G(X) - (r+\gamma)X + rE - R(.)] + \varphi_2 [I - \gamma X] . \quad (6)$$

Without loss of generality let  $\underline{L} = 0$  and append (5) to (6) to account for non-negativity of X, E, Z and R. This introduces the Lagrangian:

$$\underset{u, I}{MAX} \quad \mathcal{L} = H + \lambda_1 [X - E] + \lambda_2 [(1+L)E - X] + \lambda_3 R(.) . \quad (7)$$

Note that by the above specification I and R are bounded from above whereas lower bounds for I and R are given by the assumptions; non-negativity of R and irreversibility of investment. In additions the model suggests that some positive earnings must exist prior to any sub-allocation.

For the problem defined in (7), with the maximum principle of (Pontryagin et. al), the necessary conditions are:

$$\mathcal{L}_u = e^{-\delta t} \pi_U - \varphi_1 R_U + \lambda_3 R_U = 0 \quad (8)$$

$$\mathcal{L}_I = \varphi_2 = 0 \quad (9)$$

$$\dot{\phi}_1 = -e^{-\delta t} R_E - \varphi_1 (r - R_E) + \lambda_1 - \lambda_2 (1+L) - \lambda_3 R_E \quad (10)$$

$$\dot{\phi}_2 = -\varphi_1 [G_X - \gamma - r] + \varphi_2 \gamma - \lambda_1 + \lambda_2 \quad (11)$$

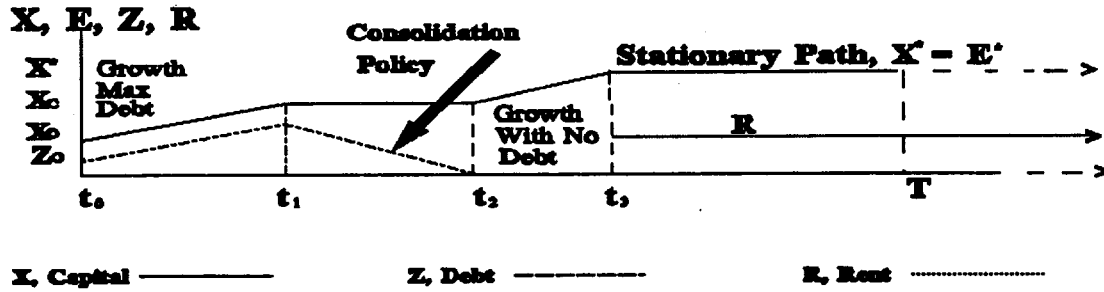
$$\lambda_1 \geq 0, \lambda_1 [X - E] = 0, \lambda_2 \geq 0, \lambda_2 [(1+L)E - X] = 0, \lambda_3 \geq 0, \lambda_3 R = 0 . \quad (12)$$

Subscripts U, I, E, and X denote partial derivatives. With the assumption that the Hamiltonian is concave in X, E, and Z and that  $E(T)e^{-T}$  is concave in X and E and because the constraints are linear in X, E and I, it can be verified that the costate variables are continuous for

$t \in (0, T)$ . Thus, the above necessary conditions are sufficient, (see Kort, 1989).

Given the preceding formulation, consider first the case where  $r > \delta$  (the interest rate exceeds members' rate of time preference), and that the initial capital stock is below the optimal level. Further assume that the cooperative invests at any point in time ( $t$ ), up to the level where net present value of marginal dollar invested is zero. In such a case, the organization would utilize external capital and/or its earnings to raise the capital stock to the level at which marginal revenue equals the marginal cost ( $\gamma + \delta$ ). Solving backward from the stationary level of capital stock to the initial level, the trajectories of capital growth, equity, debt and  $R$  can be determined according to the relevant constraints at each period. The resulting analytical solution is illustrated in Figure 1 below.

**Figure 1: Cooperative Growth & Finance**



Thus for the case  $X = E$ ,  $Z = 0$ , and the cooperative distributes net earnings as a patronage refunds and/or dividends on equity. The description implies that  $\lambda_2 = \lambda_3 = 0$  and  $\lambda_1 > 0$ . From the necessary conditions, after making necessary substitutions and accounting for transversality condition,  $\varphi_1(T) = e^{-\delta T}$ , the solution for (10) is:

$$\varphi_1 = e^{(\gamma + R_E - G)t} \int_0^T R_E e^{-(\delta + \gamma + R_E - G)s} ds + e^{(\gamma + R_E - G)t} e^{-(\delta + \gamma + R_E - G)T} \quad (13)$$

On this path the marginal contribution of a dollar invested is  $wG_x$ , while its marginal cost is  $\gamma + \delta$ . Because of this, Equation (13) reduces to:

$$\phi_1 = e^{R_x - \delta} \int_t^T e^{-R_x s} R_E ds + e^{(R_x - \delta)x} e^{-R_x T} \quad (14)$$

When  $\delta < r$ , internal financing is cheaper than external financing,  $X^* = E^*$ ,  $Z^* = L = 0$ , and  $X^*$  is stationary at the point where  $G_x(*) = \gamma + \delta$ ,  $I = \gamma X^*$  and  $U^*$  is given by (8).

An interesting feature of this solution suggest that when the members' objective coincides with management's objective,  $R_E$  should equals  $\delta$ . Using this framework, we may investigate situations where those interests depart from each other. For example, the case in which  $\delta < R_E$ , which signifies a more conservative management.

The above discussion together with Figure 1 suggest that the optimal path, where  $E^* = X^*$ , is connected with the trajectory of growth without debt where,  $\lambda_1$  and  $\lambda_2 = 0$ . As for  $\lambda_3$ , it is zero along the stationary trajectory but positive for the period preceding  $t_3$ . Thus, without loss of generality we can rewrite (10) as:

$$\dot{\phi}_1 = -R_E[e^{-\delta t} + \lambda_3] - \phi_1[G_x - R_E - \gamma]. \quad (15)$$

For  $X < X^*$  we conclude that the first costate variable, from the consolidation level and onward,  $X_c$ , follows the path without debt that satisfies the necessary conditions:

$$\dot{\phi}_1 = -R_E[e^{-\delta t} + \lambda_3] - \phi_1[r - R_E] + \lambda_1; \quad (16)$$

$$\dot{\phi}_2 = -\phi_1[G_x - r - \gamma] - \lambda_1. \quad (17)$$

Solving for  $\lambda_1$  and substituting into (16) yields (15) as before.

Under the assumption that  $X_0 < X^*$ , the trajectory of growth without debt is preceding by a trajectory with debt redemption where  $\lambda_3 > 0$ ,  $\lambda_1 = \lambda_2 = 0$ ,  $X = E + Z$ ,  $\dot{X} = 0$ ,  $\dot{E} > 0$  and  $\dot{Z} < 0$ . Here, net income is used to retire borrowed capital and increase capital.

No patronage refunds or dividends on equity are paid. On this trajectory, the necessary conditions are (8) and (9) and:

$$\dot{\phi}_1 = -R_E[e^{-\delta t} + \lambda_3] - \phi_1[r - R_E] ; \quad (18)$$

$$\dot{\phi}_2 = -\phi_1[G_X - r - \gamma] . \quad (19)$$

Expression (15) holds also in this case. Finally, the path of growth with maximum debt must satisfy necessary conditions (8) and (9), and:

$$\dot{\phi}_1 = -R_E[e^{-\delta t} + \lambda_3] - \phi_1[r - R_E] - \lambda_2[1 + L] ; \quad (20)$$

$$\dot{\phi}_2 = -\phi_1[G_X - \gamma - r] + \lambda_2 . \quad (21)$$

At the margin, the cost of one dollar borrowed is  $r$  and optimality requires  $G_X = \gamma + r$ .

Solving for  $\lambda_2$  in (21) and substituting for  $\lambda_2$  in (20) yields (15).

Similarly, for the case where  $\delta > r$ , we may connect the growth path with the stationary trajectory. The stationary trajectory of this solution satisfies  $\lambda_1 = \lambda_3 = 0$  and,  $\lambda_2 > 0$ , hence, necessary conditions (10) and (11), are revised for this case to:

$$\dot{\phi}_1 = -R_E[e^{-\delta t} + \lambda_3] - \phi_1[r - R_E] - \lambda_2[1 + L] \quad (22)$$

and

$$\dot{\phi}_2 = -\phi_1[G_X - \gamma - r] + \lambda_2 . \quad (23)$$

Combining (22) and (23), the solution for  $\phi_1$  is:

$$\phi_1(t) = e^{[(G_X - \gamma - R_E)(1+L) - L(r - R_E)]t} \int_0^t e^{-[R_E(e^{-\delta s} + \lambda_3)]s} ds + e^{[R_E(e^{-\delta t} + \lambda_3)]t} . \quad (24)$$

The trajectory of growth with maximum debt can be obtained in the same manner discussed for the case where the rate of time preferences is lower than the interest rate  $r$ . For this case the impact of the financial structure on cooperative's investments, and its policies

regarding the distribution of net earnings as dividends and or patronage refunds are similar to those for growth with maximum debt path and the stationary path. Finally, the analysis can be extended with further restrictions on  $R$  which may reflect more realistic cases (for example  $R_E$  is fixed throughout the planning horizon and or,  $R_E > 0$ ). Yet none of these would alter the nature of the solution discussed above.

### Net Present Value, Dynamic Shadow Prices, Supply, Cooperative vs IOF

Considerable attention has been given to the question whether or not cooperative performance differs from that of the IOF (see for example: C. Parliament, Z. Lerman and J. Fulton, 1989, Babb, E.M. and M.F. Lang, 1985, and Schrader et. al 1985). Many of these studies and others have focused on static comparisons of the firms according to standard financial ratios. The approach has obvious limitations since it applies to IOF firms that do not engage in production of non-market goods. Furthermore, some of these ratios, for example the rate of return to equity, while appropriate for firms that maximize net present value, completely ignore the horizon problem of cooperatives and its implications for a cooperative's conduct. In the following, we briefly examine the issue by comparisons of dynamic shadow prices.

Consider, again, necessary conditions (8)-(12). Recall that the dynamic Lagrangian multiplier,  $\lambda_3$ , associated with non-negativity of benefits from cooperative is greater or equal to zero. By (24), a general expression for the first costate variable for the case where  $r > \delta$  is:

$$\varphi_1 = e^{(\gamma + R_E - G_E)t} \left\{ \int_t^T e^{-(\delta + D)s} R_E ds + \int_t^T e^{-Ds} \lambda_3 R_E ds + e^{-(\delta + D)(T-t)} \right\} . \quad (25)$$

Substituting (25) for  $\varphi$  in (8) and rearranging yields:

$$\lambda_3 e^{\delta t} = \int_t^T e^{-(\delta + D(s-t))} R_E ds + \int_t^T e^{-D(s-t)} \lambda_3 e^{\delta s} R_E ds + e^{-(\delta + D)(T-t)} - \left\{ \frac{P_f^u - w}{R_u} + 1 \right\} . \quad (26)$$

For an IOF, an appropriate objective is, the maximization of the value of the firm. The later is the discounted sum of the dividend stream over the entire horizon plus the discounted value of terminal equity capital stock, (see Lesourne, 1983, Van Loon, 1983 and Kort 1989).

Denoting dividends by  $D$  and making the necessary substitutions,  $R_E$  is now defined as:  
 $R_E = G_x - \gamma + (G_x - \gamma - r)(Z/E)$ . The IOF equivalent for (26) is:

$$\lambda_3 e^{\delta t} = \int_t^T (R_E + \gamma) e^{-(\delta + \gamma)(s-t)} ds + \int_t^T (R_E + \gamma) e^{-\gamma(s-t)} \lambda_3 e^{\delta s} ds + e^{-(\delta + \gamma)(T-t)} - 1 ; \quad (27)$$

see Kort, 1989 for detailed derivation.

For the IOF that maximizes net present value,  $\lambda_3$  is the discounted value of a retained dividend of one dollar for each  $t$  which is added to the Hamiltonian. Clearly, when  $r > \delta$ ,  $\lambda_3 = 0$  whenever  $X = X_B$ . Elsewhere, the first term of the RHS of (27), is the marginal yield of the increase in capital stock generated by one dollar of retained dividend that is either invested or used to pay-off debt. The second term on the RHS, is the implicit marginal yield of the increase in the capital stock that is generated by one dollar of retained earnings. The third term, is simply the imputed value of terminal capital stock associated with one extra dollar of investment.

In examining (27) for the IOF and (26) for the cooperative, we are led to similar interpretations, given the cooperative's objective and its financial structure. However, such is not the general case regarding the fourth term on the RHS of (26) which is lacking from (27). For the two firm types, opportunity costs/dynamic shadows prices of equity along the stationary paths differ by  $(pf_u - w)/R_u$ . This reflects the condition that cooperatives members, unlike IOF shareholders, must patronize the organization in order to realize some benefits. This ratio, which holds for each  $t$  on the stationary path, is the marginal rate of substitution of members' direct profit from farming for their benefits from patronage of the cooperative. Under these circumstances, a simple criteria could be constructed to test whether this ratio over time, is

significantly different from zero. If rejected, the test would indicate that the cooperative organization performs as IOF which maximizes its net present value.

### **Conclusions**

In this paper we developed a dynamic model of cooperative production and finance which was applied to a simple supply cooperative. The analysis that focuses on the financial structure enabled us to identify possible growth trajectories which depend on the level of capital stock and members' rate of time preference. The potential for the horizon problem induced in cooperatives by their operating principles and objective was identified from the dynamic shadow price associated with the restriction on  $R$ .

Limitations on the scope of this work led us to exclude the impact taxes, methods of equity redemption, deferred payments and diversified cooperative. Yet the framework can cope with these issues and it can be applied to other types of cooperatives, marketing and labor managed firm. In light of existing limitations in cooperative theory, the proposed methodology seems to be a promising development. From practical point of view the model provides simple decision rules to be used together with information available to cooperative's decision makers.

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