EUROPEAN UNIVERSITY INSTITUTE

DEPARTMENT OF ECONOMICS

E U I W O R K I N G P A P E R No.85/162

OPTIMAL EMPLOYMENT AND INVESTMENT POLICIES IN SELF-FINANCED PRODUCER COOPERATIVES

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Printed in Italy in April 1985
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Acknowledgements

I am grateful to Pierre Dehez, Alexis Jacquemin and Mario Nuti for helpful comments at various stages in the preparation of this paper, although any errors are my own responsibility. Earlier drafts of the paper were presented at the Workshop on Labour-Managed Firms, European University Institute, April 1984; the conference of the Development Studies Association, Bradford, September 1984 and the International Conference on Economic Policies and Control Theory, Venice, February 1985. Financial assistance for the research was provided by the Project on Workers' Participation and Enterprise Performance in Western Europe at the European University Institute.

Abstract

That a producer cooperative sector may form part of an employment-creating programme of industrial restructuring and reform in Western Europe has been given increasing attention in recent years. However, existing firms of this type often find difficulty in raising outside finance for expansion. In this paper it is shown that the long-run prospects for employment creation within such firms, when they are entirely dependent upon internal sources of accumulation, are rather bleak, even though they may, upon start-up, provide a low cost-per-workplace and thus generate relatively much employment per unit of initial capital. The analysis is thus consistent with the view that an active policy of new-firm creation, and the development of specialized outside credit institutions would be important measures of policy to enhance the long-run job-creation effects of a cooperative sector.

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As unemployment in Western Europe follows its seemingly irresistible upward course, increasing attention is being given to the countercyclical growth in the numbers of producer cooperatives. Either in a defensive or innovative mode, such organizations are coming to be seen as at least a part of a possible solution to the withering base of productive employment opportunities in conventional capitalist enterprises. Skills and enthusiasms which would otherwise be dissipated in fruitless job-search on the dole may be preserved and enhanced in organizations which reverse the orthodox production relationship between capital and hired labour.

This paper addresses the issue of the employment and growth behaviour of producer cooperatives by analyzing a dynamic model of a "labour-managed firm". Analysis of such firms originated in the classic works of Ward (1958) and Vanek (1970). These and subsequent developments in the theory have been succinctly set out in texts by Ireland and Law (1982) and Stephen (1984). Most analyses have focused the discussion on the conditions of static equilibrium, either of a fixed membership cooperative with hours variable (Sen, 1966; Berman, 1977) or a variable membership cooperative with fixed hours as in Ward's original analysis.[1] Furubotn (1971) was the first to extend the static model of the labour-managed firm by requiring a fixed membership cooperative to maximize the discounted utility of intertemporal consumption. In a later article (Furubotn, 1976) the initial membership sets an exogenously determined upper limit to the labour force over the time horizon so as to retain decision-making control. The principal result is to show that some self-financed investment will be undertaken by the firm, but the actual path of accumulation is not analyzed. Atkinson (1973), Sapir (1980) and Bonin (1983) analyze labour-managed firms which finance expansion from external sources. Atkinson presents a model of 'managerial' labour-management[2] in which the firm can grow faster than the expansion of demand in the industry via expenditure on sales promotion. Sapir presents a model of a "tenured" labour-managed firm in which there is a central group of skilled workers who hire unskilled employees but may admit them to membership after costly training.[3] Bonin analyzes a model which depends upon costly adjustment of both membership and capital with the result that the sensitivity of optimal policies to parameter shifts depends upon the direction of adjustment, i.e. whether the firm is expanding or contracting.

However, the analysis of the labour-managed firm under external financing is not very appropriate in the case of most Western European producer cooperatives since these typically face extremely imperfect capital markets.[4] It is therefore more plausible to model such firms under a regime of self-financed expansion. Moreover where external financing is available, a matching amount of internal finance is often stipulated.[5] This is understandable, since, as Schlicht and von Weizsäcker (1977) have observed, the problem of moral hazard which exists when creditors have no control over the disposition of funds will drive lenders to seek to obtain some evidence of commitment from the borrowing cooperative. The assumption of self-financing, in addition, highlights the essence of the problem of growth for the labour-managed firm in that future gains in consumption are derived at the expense of reductions in current consumption, and also, that membership expansion is attractive to support any capital accumulation programme, but simultaneously unattractive since its benefits have to be shared over a wider workforce.

In the next section, therefore, an analysis of an internally financed labour-managed firm is presented which follows from and develops the model of Furubotn (1971). The major difference is that the assumption of an exogenously fixed labour force is dropped. Rather, the level of optimal employment is derived endogenously as a solution to the optimization problem.[6]

Consider a labour-managed firm maximizing the discounted utility of consumption per head of the workforce. Thus the actual size of the workforce is not in itself a direct consideration in the utility function.[7] The cooperative is in a competitive market environment for its output, facing a product price $p = 1$. Output at time t, $Q(t)$, is produced by means of capital $K(t)$ and labour $L(t)$, according to the production function $Q(t) = F(K(t),L(t))$, which is characterized by increasing returns to scale at low levels of output and decreasing returns to scale at higher levels of output, so that the scale elasticity $\varepsilon(K,L)$, equal to the sum of the output elasticities,[8] varies smoothly from higher to lower values passing through the unit value at a unique locus in K-L space.[9]

It is of particular interest to consider the case where, for given L, the function is convex for low values of K and concave at higher values. Thus we assume $F_K, F_L \geq 0$; $F_{LK} = F_{KL} \geq 0$; $F_{LL} \leq 0$ and $F_{KK} \gtrless 0$. Somewhat similar versions of a convex-concave production function have received increasing attention recently in studies of dynamic optimization under central planning (Skiba, 1978) and under monopolistic capitalism (Dechert, 1983, 1984). In the present case we consider a labour-managed firm with its distinctive maximand, which saves and invests a proportion s(t) of its net revenue, y(t), where $y(t) = \frac{Q(t) - rK(t)}{L(t)}$ where in turn r is a fixed unit charge on capital, which may be taken to represent a capital tax, or a minimum return which the cooperative wished to make on its capital stock, **reflecting the interest rate on outside lending opportunities.** It is further assumed that physical capital depreciates at a constant proportional rate δ, and that the cooperative discounts future income at a rate of time preference ρ. Thus the maximization problem for an infinite horizon[10] is:

$$\max \int_0^\infty u\{(1 - s(t))y(t)\}e^{-\rho t}dt \qquad \text{i)}$$

subject to

$$\dot{K}(t) = s(t)\cdot y(t)\cdot L(t) - \delta K(t) \qquad \text{ii)}$$

$$K(o) = K_o \qquad \text{iii)}$$

$$0 \leq s(t) \leq 1 \;;\; L(t) \geq 0 \qquad \text{iv)}$$

(From this point on the time dependence notation "x(t)" will be replaced by the notation "x" where time dependence is treated implicitly.)

The utility function is assumed to have the following properties:

$$u'(c) > 0 \;;\quad u''(c) < 0 \;;\quad \lim_{c \to 0} u'(c) = \infty \qquad \text{v)}$$

In this problem K is the state variable and the control variables are s and L. The current value Hamiltonian is given by:

$$H = u\{(1 - s)\cdot y(K,L)\} + m\{s \cdot y(K,L)\cdot L - \delta \cdot K\} \qquad \text{vi)}$$

where $m = m(t)$ is the current value multiplier associated with ii), and is equal to $e^{-\rho t}\cdot\psi(t)$ where $\psi(t)$ is the ordinary multiplier.

The optimality conditions are as follows:

$$\frac{\partial H}{\partial s} = u'(c)\cdot(-y) + m\cdot y \cdot L \gtreqless 0 \quad \text{as} \quad \begin{matrix} s = 1 \\ 0 < s < 1 \\ s = 0 \end{matrix} \qquad \text{vii)}$$

The case where $s = 1$ is ruled out by assumption v). In the following analysis we consider the case where vii) holds with equality and $s > 0$ throughout.

$$\frac{\partial H}{\partial L} = u'(c)\cdot(1 - s)y_L + m\cdot s\cdot[y_L L + y] \lesseqgtr 0 \quad \text{as } L \geq 0 \qquad \text{viii)}$$

and again we consider only the case where $L > 0$ throughout, so viii) holds with equality.

$$\dot{m} = \rho m - H_K = (\rho + \delta)m - u'(c)\cdot(1 - s)\cdot y_K - m\cdot s\cdot y_K \cdot L \qquad \text{ix)}$$

and

$$\lim_{t \to \infty} e^{-\rho t}\cdot\psi(t)\cdot K(t) = 0 \qquad \text{x)}$$

is the transversality condition.[11]

From vii) it can be seen that, along the optimal path:

$$m = \frac{u'(c)}{L} \qquad \text{xi)}$$

Thus the shadow valuation of investment, m, is inversely related to consumption per head (for given L), as one might expect. However, for given levels of consumption per head, the more workers among whom the benefits of an additional unit of investment must be spread, the lower the shadow valuation of that unit.

Now, from viii) and xi) we obtain:

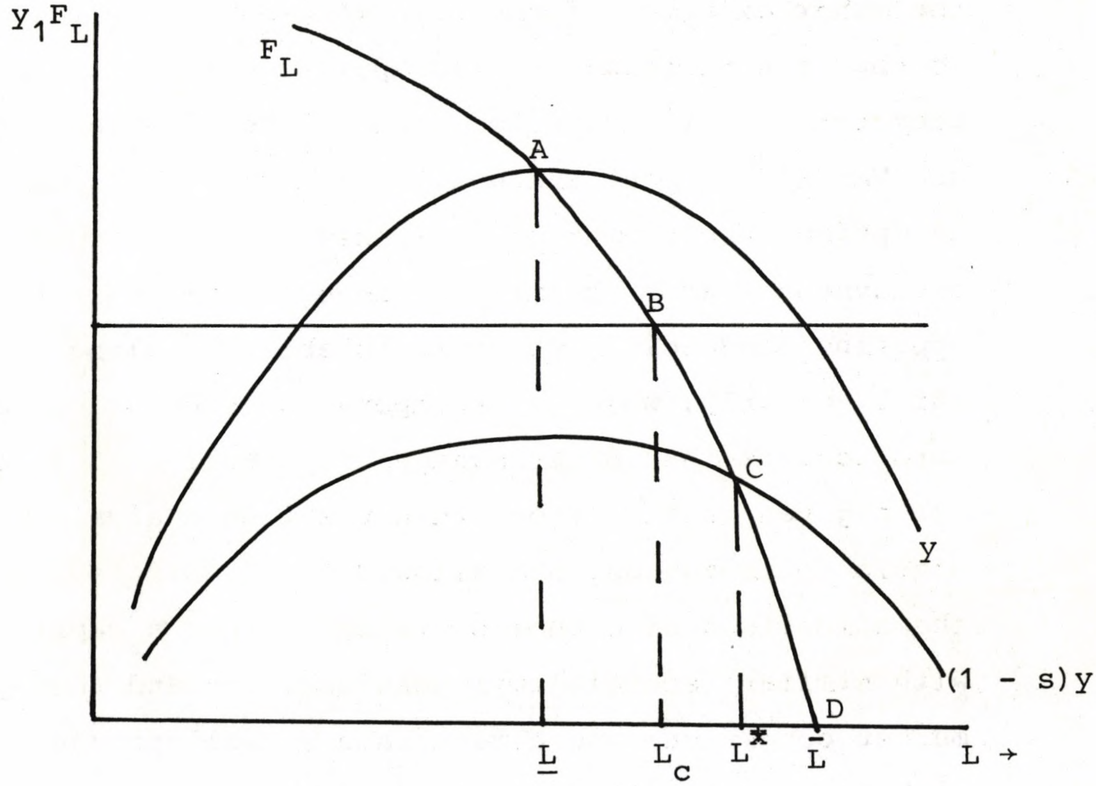
$$(1 - s)y_L + s(y_L + y/L) = 0 \qquad \text{xii)}$$

Thus:

$$F_L = (1 - s)y \qquad \text{xiii)}$$

Equation xiii) is quite striking. It shows that for any given momentary level of savings (which varies along the optimal path) the optimal employment level is found by equating the marginal product of labour with the level of consumption per head. This could be considered to be a sort of "golden rule" for cooperative investment in which, however, employment itself is an endogenous choice variable, rather than being exogenously determined by the "natural growth rate" as in the standard one-sector neoclassical growth model. The situation at any instant is shown in the following diagram.

Fig. 1



The intuitive explanation of the rule is that employment of an additional worker adds to the total saving of the firm by an amount $s \cdot F_L$. However it changes the utility of the average consumption level by $-u_L = -u' \cdot c_L = -u' \cdot (1 - s) \cdot y_L$. The value of the extra investment measured in units of consumption is $m \cdot s \cdot F_L = u' \cdot s \cdot F_L / L$. When these two effects are equated, the rule shown in xiii) emerges.

The optimal employment level is found at L^* where F_L and $(1 - s)y$ intersect at C. Should the level of savings fall to zero optimal employment would fall to $\underline{L}$. At this point the marginal product function intersects the average revenue per head at its maximum at A. This is precisely the static maximization solution originally presented by Ward (1958). Thus Ward's solution emerges as a special case of the present model, where the shadow valuation of investment, m, is zero. At the other extreme, if the firm were entirely "growth-minded" so that the maximization was applied only to the accumulation term in vi), then for such a "megalomaniac" firm (to use Vanek's phrase) the equilibrium would be found at D with an optimal employment of $\bar{L}$. These are limiting values of employment, and L^* represents an equilibrium of these two opposing tendencies, which is established along the optimal path. Clearly, when intertemporal considerations are taken into account the worker-managed firm will employ more labour for a given capital stock than previous analysis, based upon static optimization, has allowed for. This is important for the comparison of economic systems, since a capitalist firm with similar technological possibilities and facing similar market conditions and a wage rate $\bar{w}$, will produce at a point such as B (where it is earning positive profits). The standard comparison is then between points A and B showing the labour-managed firm to be employment restrictive relative to its capitalist counterpart (Stephen, 1984). However in an intertemporal model under self-financing, the comparison is between points B and C. An illustrative example is shown in Figure 1 where it is the capitalist firm which is relatively employment restrictive.[12] In general however, the comparison between points B and C may go either way, but the important point is that the supposed superiority of the capitalist firm in this respect no longer applies.

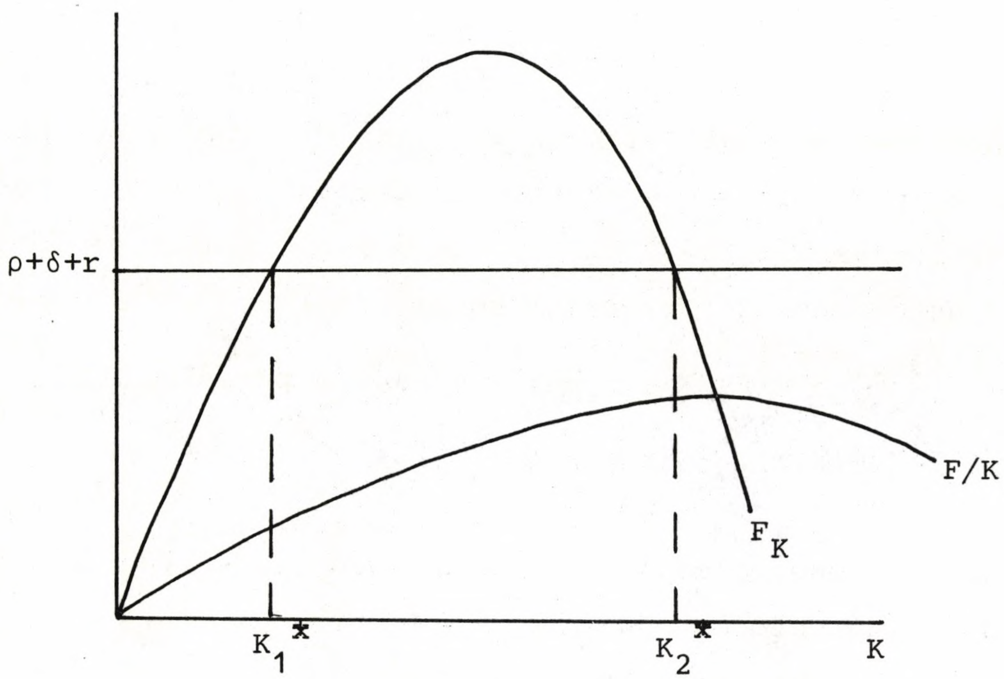
Continuing with the analysis, from ii) and ix) and using conditions xi) and xiii) we can obtain the equations of motion of the system as:

$$\dot{m} = -m[F_K(K,L) - (\rho + \delta + r)] \qquad \text{xiv)}$$

$$\dot{K} = F(K,L) - LF_L(K,L) - (\delta + r)K \qquad \text{xv)}$$

and the equilibrium of the system satisfies $\dot{m} = \dot{K} = 0$. Now xiv) has two roots by virtue of the convexity-concavity of the production function:

Fig. 2



The two solutions are $F_K(K_i^*, L_i^*) = \rho + \delta + r$, $i = 1,2$. Substitution into xv) gives the two solutions for $\dot{K} = 0$, namely:

$$\varepsilon(K_i^*, L_i^*) = 1 + \rho v_i(K_i^*, L_i^*) \qquad \text{xvi)}$$

where v is the capital-output ratio. Thus the two equilibria are in the increasing returns to scale region of the production function.[13]

Now, xi) and xiii) together imply that along an optimal path the following relation holds:

$$m \cdot L = u'[F_L(K,L)] \qquad \text{xvii)}$$

which implicitly gives L as a function of K and m. Therefore we may write

$$L = \phi(K,m) \qquad \text{xviii)}$$

(along an optimal path), and it can be easily shown (see Appendix) that

$$\phi_m < 0 \ , \quad \phi_K < 0 \qquad \text{xix)}$$

whenever the elasticity of marginal utility is not unreasonably high.[14] The equations of motion of the state and costate variables (K and m) can now be written as a system of autonomous differential equations:

$$\dot{m} = -m[F_K(K,\phi(K,m)) - (\rho + \delta + r)] = \psi_1(K,m) \qquad \text{xx)}$$

$$\dot{K} = F(K,\phi(K,m)) - (r + \delta)K - \phi(K,m) \cdot F_L(K,\phi(K,m)) = \psi_2(K,m) \qquad \text{xxi)}$$

and the associated phase diagram can be derived from the following information:

$$\left.\frac{dm}{dK}\right|_{\dot{m}=0} = -\frac{(F_{KK} + F_{KL}\,\phi_K)}{F_{KL}\,\phi_m} \gtrless 0 \quad \text{as} \quad F_{KK} + F_{KL}\,\phi_K \gtrless 0 \qquad \text{xxii)}$$

$$\left.\frac{dm}{dK}\right|_{\dot{K}=0} = -\frac{(F_K - (r + \delta) - LF_{LK} - LF_{LL}\,\phi_K)}{-LF_{LL}\,\phi_m} \gtrless 0 \quad \text{as}$$

$$F_K - (r + \delta) \gtrless LF_{LK} + LF_{LL}\,\phi_K \qquad \text{xxiii)}$$

Equation xxii) will be positive for small K when F_{KK} is large enough to be the dominant term. At larger values of K, the expression will have a negative sign. Expression xxiii) is sign indeterminate.

We can also calculate

$$\frac{\partial \dot{m}}{\partial m} = -mF_{KL}\ \phi_m - /\overline{F}_K - (\rho + \delta + r)\overline{/} \gtrless 0 \qquad \text{xxiv)}$$

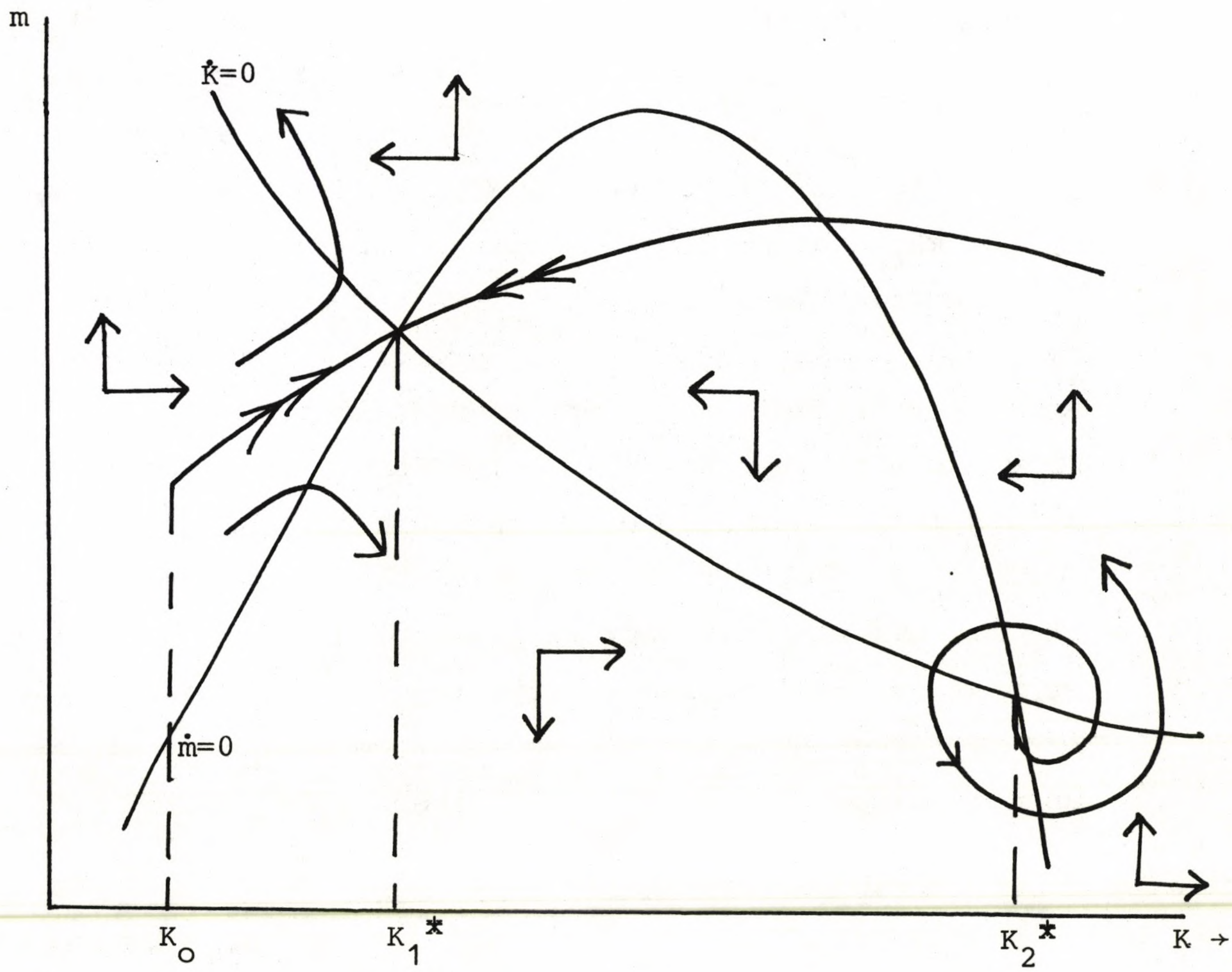
which is positive near K^*, L^* when $/\overline{\cdot}/ = 0$.

$$\frac{\partial \dot{K}}{\partial K} = F_K - (r + \delta) - LF_{LK} - LF_{LL}\ \phi_K \gtrless 0 \qquad \text{xxv)}$$

which has the same sign as xxiii). At (K^*, L^*) both xxv) and xxiii) have sign given by $\rho \gtrless LF_{LK} + LF_{LL}\ \phi_K$, and will therefore be negative for "small" ρ, positive for "large" ρ. These sign changes affect the dynamics symmetrically and so do not alter the quantitative nature of the solution paths. (We could say the system was "structurally stable").

The phase diagram, for the case ρ "small", then looks as follows.

Fig. 3



For any initial capital endowment K_o, the firm chooses an employment level and savings rate so as to place itself on the optimal path. If $K_o < K_1^*$, then a gradual process of capital accumulation takes place until the optimal capital stock is reached.[15] However, since $\phi_K < 0$, the labour force would be gradually reduced along such an optimal path. The intuitive reason is as follows. When the capital stock is low, in order to achieve desired savings, for any given savings rate relatively much labour must be employed (i.e. relative to the static case--see Fig. 1). However, as the capital stock rises relatively less labour is needed to produce output from which savings may be made. Moreover, as the equilibrium is approached, the savings rate diminishes, so a movement "up" the labour marginal product curve takes place, bringing about a further reduction in labour input. At equilibrium, the savings rate is just sufficient to cover depreciation and the firm produces at a level in y-L space formally equivalent to that described by the static model. Notice also that since $F_{KL} > 0$, the marginal product of capital curve shifts down with the reduction in labour input. Thus the target capital stock (K_1^*) recedes as it is approached. If this effect were very strong an equilibrium might not be attained. This explains the presence of the term F_{KL} in equations xxii-xxiv). (See also equation A8 in the Appendix.) Similarly if ρ were "very high" (so that $\rho + \delta + r$ were above the maximum marginal capital product) no equilibrium will be attained, reflecting the implied unwillingness of workers to forego present consumption. Notice also that along an optimal path, from $K_o < K_1^*$, the shadow valuation of investment is increasing (since L is decreasing). This is analogous to the "reverse flexible accelerator" effect described by Dechert (1983) for the case of a monopolistic capitalist firm facing increasing returns to scale.

It is precisely because of the presence of increasing returns to scale that cooperative workers (in this model) are willing to invest at all, in order to capture the gains of increasing returns, relative to the opportunity cost of capital ($r + \delta + \rho$). It seems paradoxical that an equilibrium should be found where the marginal productivity of capital is still rising, but the explanation is that in the labour-managed firm, there is no interest in maximizing the return to capital as such. As long as the marginal unit of capital is covering its opportunity cost, that is all that is required. This point may be made clearer by considering the case where $K_o > K_1^*$. In this case there is an incentive to make net disinvestment by not meeting the full depreciation cost of existing assets. Incomes may be maximized by moving at least close to the maximum of the average revenue function and augmenting current income by allowing capital to depreciate. However, as capital is run down, the average and marginal labour productivity is reduced shifting down the maximum of the average productivity curve. This forces an increase in employment to maintain income per worker as the capital stock diminishes. As long as capital marginal productivity is above its opportunity cost it pays to keep running down capital and consuming the "producer surplus". Eventually the process terminates at K_1^*, at which point the savings rate has risen sufficiently to just cover depreciation of the remaining assets.[16]

Conclusion

A model of a self-financed producer cooperative firm has been analyzed in a dynamic framework where the level of employment and the savings rate are freely chosen. It has been shown that, where the initial capital endowment is low relative to its equilibrium level, the initial level of employment will exceed that predicted by previous analyses of such firms conducted, as they have mostly been, in a static framework. Initial employment levels may also exceed those predicted for a similarly placed profit maximizing capitalist firm, especially in an environment where average labour productivity is low relative to the level of wages, e.g. in depressed or declining industries. However, along the subsequent expansion path as capital accumulates, employment within the firm is reduced.[17] This reinforces the commonly accepted notion that an active policy of new-firm creation would be necessary to maintain aggregate employment in a producer cooperative sector. It also provides an easily testable hypothesis against which to assess the validity of the income-per-worker maximizing model.

That the model may not stand up to such a test is suggested by the historical experience of the labour-managed industrial sector in Yugoslavia, where employment and the capital stock have increased simultaneously, despite the absence of much new-firm creation, and have not moved in an inverse fashion as the current model predicts. Should the current model be refuted by evidence from Western European producer cooperatives, future theoretical research could be oriented in a number of directions. The most promising would seem to be the incorporation of adjustment costs along the lines of Bonin (1983) and Feichtinger (1984), and the modification of the objective function of the firm to incorporate a less individualistic maximand. A number of possibilities have been suggested in the literature, and they are reviewed in Stephen (1984). However, the present model, by pushing a simple structure to its logical conclusions, has yielded insights that may be robust in the face of anything other than a quite radical reformulation of the theory.

Finally it should be noted that the provision of external credit facilities, by providing the possibility of external financing, would alter the results of this paper significantly. The advantages of external as against internal means of financing have been argued at length in the literature from Vanek (1970, 1977) onwards. Although a formal dynamic model of the external financing case is beyond the scope of this paper, the analysis contained here should be viewed as giving support to Vanek's contention. To overcome the problem of the "low level equilibrium trap" described above (i.e. the equilibrium at K_1^*), it may be necessary to establish specialized credit institutions to finance the producer cooperative sector.[18]

Appendix

Putting $L = \phi(K,m)$ we can write xvii) as:

$$m\phi(K,m) = u'[F_L(K,\phi(K,m))] \qquad \text{A1.}$$

a) Differentiating implicitly w.r.t. m gives:

$$L + m\phi_m = u'' \cdot F_{LL}\ \phi_m \qquad \text{A2.}$$

So $$\phi_m = -\frac{L^2}{(1 - \alpha\beta)u'} < 0 \quad \text{for } \alpha\beta < 1 \qquad \text{A3.}$$

where $\alpha = \dfrac{u'' \cdot F_L}{u'} = \dfrac{u'' \cdot c}{u'}$ = elasticity of marginal utility evaluated along an optimal path

$\beta = \dfrac{F_{LL} \cdot L}{F_L}$ = marginal output elasticity of labour

$\alpha < 0$, $\beta < 0$.

b) Differentiating A1 implicitly w.r.t. K gives:

$$m\phi_K = u''[F_{LK} + F_{LL}\ \phi_K] \qquad \text{A4.}$$

So $$\phi_K = \frac{u''\ F_{LK}}{m - F_{LL}\ u''}$$

Using xi), this becomes:

$$\phi_K = \frac{\alpha\gamma(L/K)}{1 - \alpha\beta} < 0 \quad \text{for } \alpha\beta < 1 \qquad \text{A5.}$$

where $\gamma = \dfrac{F_{LK}\ K}{F_L}$ = marginal output elasticity of capital

$\gamma > 0$.

Stability Analysis

Linearize xx) and xxi) around K^*, m^* by Taylor expansion:

$$\begin{bmatrix} \dot{m} \\ \dot{K} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} m - m^* \\ K - K^* \end{bmatrix} \qquad \text{A6.}$$

$a_{11} = -m[F_{KL} \ \phi_m]$

$a_{12} = -m[F_{KK} + F_{KL} \ \phi_K]$

$a_{21} = F_L \ \phi_m - \phi_m \ F_L - \phi[F_{LL} \ \phi_m] = -LF_{LL} \ \phi_m$

$a_{22} = \rho - LF_{LK} - LF_{LL} \ \phi_K$

This gives: $$a_{11} + a_{22} = \rho \qquad \text{A7.}$$

And:

$$a_{11}a_{22} - a_{12}a_{21} = \frac{L}{(1 - \alpha\beta)} \cdot [\rho F_{KL} + L(F_{LL}F_{KK} - F_{KL}^2)] \qquad \text{A8.}$$

The characteristic equation of the system is:

$$\lambda^2 - (a_{11} + a_{22})\lambda + (a_{11}a_{22} - a_{12}a_{21}) = 0 \qquad \text{A9.}$$

This has two roots. If $(a_{11}a_{22} - a_{12}a_{21})$ is negative, the roots will be real and of opposite sign. This will clearly be the solution associated with K_1^* where $F_{KK} > 0$. This gives the saddle point solution at K_1^*, m_1^*. If, however, $(a_{11}a_{22} - a_{12}a_{21})$ is positive the roots will be imaginary with positive real parts. This is the solution associated with K_2^*, where $F_{KK} < 0$. In this case there is an unstable focus at K_2^*, m_2^*. (See Derrick and Grossman, 1981.)

NOTES

1. A number of recent analyses have tried to combine aspects of both these approaches by supposing short-run employment variability within a fixed membership group. See Miyazaki and Neary (1983) and Bonin (1983).

2. The "managerial" theory of the firm is based on the notion of the separation of ownership from control and holds that managers are able to influence the objectives of the firm in their own interest.

3. This model has been criticised by de Meza (1983) on the grounds that it possesses no interior steady state solution. However, the addition of the reasonable assumption of imperfect substitutability between members and non-members, is, as de Meza shows, sufficient to rescue the model from this criticism.

4. In a study of Western European producer cooperatives Younge and Rigge (1984) found that: "Loan capital is frequently hard to raise because of ignorance about worker cooperatives in financial institutions. Banks are frequently reluctant to lend to cooperatives and even when they do interest rates may be higher than those charged to more conventionally run enterprises" (p. 3). In U.K. cooperatives, Jones and Backus (1977) found that "most investment is financed by retained earnings", and Stephen (1984) reports a similar situation in French producer cooperatives and the Spanish Mondragon group where "much capital is internally financed" (p. 191). In the latter case however, the

group has developed its own bank, a credit cooperative, the resources of which are a major source of working capital for the group. The same argument follows through for cooperatives in developing countries such as those discussed by Espinosa and Zimbalist (1978) in Chile and by Uca (1983) in Turkey.

5. The Cooperative Bank in the U.K. will advance credit to cooperatives only on condition of a matching amount of internal finance. A similar situation exists for Yugoslav self-managed firms.

6. Recently a dynamic model of a labour-managed firm with endogenous employment has been presented by Feichtinger (1984), but the analysis is limited to short-run adjustments through the assumption of a fixed capital stock. The present paper does not impose this restriction.

7. See Stephen (1984, p. 43-44) for an analysis of the case where the cooperative's objective includes employment, in and for itself. This additional objective seems to be important in the Mondragon case, according to reports of interviews made there. See Thomas and Logan (1982).

8. Thus $\varepsilon(K,L) = (\frac{\partial F}{\partial L}\cdot\frac{L}{F}) + (\frac{\partial F}{\partial K}\cdot\frac{K}{F}) = \frac{LF_L + KF_K}{F}$, where $F_x = \frac{\partial F}{\partial x}$.

9. Along this locus therefore, there are locally constant returns to scale. Vanek dubs this the locus of maximum physical efficiency.

10. There is a large literature on the impact on investment decisions of a short, finite, horizon (Furubotn, 1978).

An infinite horizon, however, represents the general case, and is therefore adopted in this paper. A finite time horizon, $[0,T]$, can be treated as a special case of the present model.

11. In common with Dechert (1984) we may use a result proved by Michel (1982) which demonstrates that the transversality condition is necessary for optimality in a general class of models in which the Hamiltonian is concave in the control variables though not necessarily concave in the state variable.

12. Of course, the comparison is only valid for a given capital stock, and hence at the beginning of a programme of capital accumulation when $K(0) = K_o$, since the accumulation paths of the two types of firm will differ over time.

13. In the static model where the labour-managed firm maximizes average revenue per head net of a capital charge per head $(\frac{pQ - rK}{L})$, production is shown to take place where $\varepsilon = 1$. If the static self-financed firm were modelled by setting $r = 0$, as in Vanek (1977), the same result would emerge since $pF_L = y$, $pF_K = 0$ would be the optimal input rules. These results can be seen to follow from the assumption of myopic decision making, which implies $\rho = 0$, and that there is only one period of production.

14. Specifically, the condition for xiv) to hold is $\alpha\beta < 1$, where α is the elasticity of marginal utility, β is the marginal output elasticity of employment. Typically α will be small enough to ensure this inequality.

15. So long as K_o is not too small. There may be a critical value, K_o^c, below which the cooperative would not produce at all, since incomes would be too low to attract any workers.

16. A self-financed labour-managed economy in which neither borrowing nor lending took place would therefore not yield the same "equivalence" property which Vanek (1970) and Drèze (1976) have claimed between a labour-managed economy under external financing and a profit-maximizing capitalist economy.

17. It should be noted however that the inverse association between employment and accumulation will be weak if α, and hence ϕ_K, is close to zero. In the limit, however, employment will be at best insensitive to accumulation.

18. For example the Banca Nazionale del Lavoro in Italy has a special fund of 100 billion Lira to finance cooperative enterprise (Younge and Rigge, Prospects for workers' cooperatives in Europe, Vol. 1 - Overview, Commission of the European Communities, Luxembourg, 1984).

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