Some Issues on Fixed Capital in Terms of Farm Operation

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I. Introduction

The relation of fixed capital to production efficiency, supply response and farm operation is an important subject in economic analysis. Some shifting arrangements for the analysis of fixed capital are often associated with the elements and concepts of fixed capital valuation. By relating the technique of linear programming, it has been also noted that a capital stock is at least potentially transient. Capital stock can be reduced by sale at salvage value and, if profitable, the same stock can generally be increased by purchase at acquisition price.

The purpose of this paper is to explore the conditions under which the quantities of resources are fixed capital, to relate some problems of capital fixity to farm operation and supply response, and to discuss the capital valuation problem in relation with the step-function properties in LP programming model.

II. Fixed Capital Theory

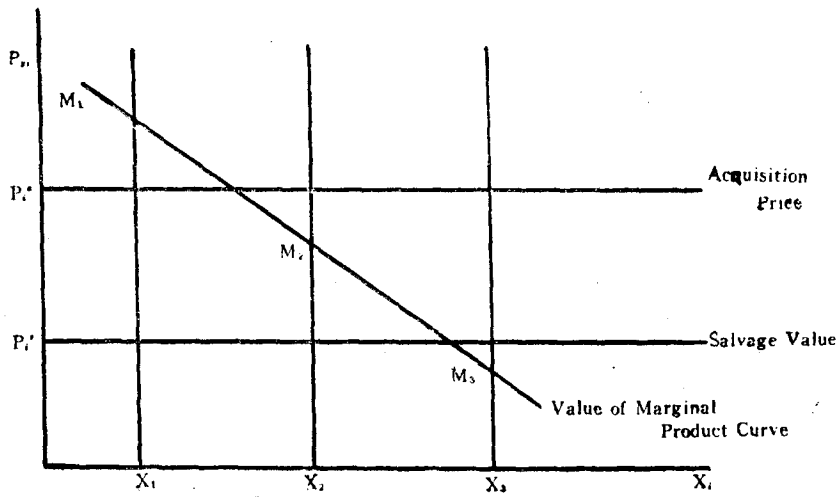
The theoretical framework for the study of capital fixity in production process depends on an operational definition of fixed capital and a theory of valuation. Adam Smith defined that capital employed without changing owners may be called fixed capital.[1] A. Marshall said that fixed capital exists in durable shape in contrast to capital which fulfils the whole of its process by a single use, and the return to which is spread over a period of corresponding duration.[2] G.F. Warren discussed the relation of price to capital fixity, but the definition of fixed capital was not explicitly presented.[3] S. Weintraub, with his study on income distribution, defined that, so long as a firm establishes that a further

1) A. Smith, *The Wealth of Nation*, New York, 1937, p. 263.
2) A. Marshall, *Principles of Economics*, Macmillan Co., N.Y. 1949, p. 75.
3) G.F. Warren, *Farm Management*, Macmillan Co., N.Y., 1913, p. 208.

unit of an agent would not be profitable, then the factor is fixed.[4] In fact, the divergence of acquisition cost from salvage value is related to capital fixity.

Neoclassical economic theory assumes that markets are such that a farm operator can purchase more of an asset if it is profitable and that he can dispose of unprofitable quantities at the same price. Such a situation is shown in the following graph.[5]

Figure 1. VMP Curve and the Different Levels of Acquisition Price and Salvage Value of the Capital



In general, beyond certain limits within a given farm, additional quantities of utilized capital tend to be used less efficiently, thus the shape of VMP shows the downward slope to the right. Acquisition price is here defined as the marginal factor cost when the capital is purchased.

If a farm has an input quantity of X_1, $VMPx_1$ is greater than acquisition price of P_i^a, therefore it would be profitable to purchase more of it. On the other hand, for an input quantity of X_3, $VMPx_3$ is less than salvage value of P_i^s, the farm is willing to dispose of X_3 at P_i^s. In these two cases, the X quantities are regarded as variable.

4) S. Weintraub, *An Approach to the Theory of Income Distribution*, Chilton Co., Philadelphia, 1958, p. 170.

5) For further discussion, see G.L. Johnson and L.S. Harding, "Economics of Forage Evaluation", *Statistical Bulletin* 623, Pindue University Agricultural Experiment Station, April 1955, and G.L. Johnson, "Supply Function Some Facts and Notions", *Agricultural Adjustment Problems in a Growing Economy*, Iowa State Univ. Press (1958).

When a farm has a quantity of X_2, where VMPx_2 is between P_i^a and P_i^s, there would be no reason to purchase more of input or to dispose of some of it. In this case, the input factor is fixed within this farm. Except when the asset is fixed at X_2 level, the farm operator is ready to reorganize the operation by varying the quantity of input quantities, and such reoganization would affect the level of VMP as well. This theoretical definition can be extended to the context of service flows, since the rate of flow of seovice is worth changing depending on the opportunity cost for using the resource in relation to the acquisition and salvage values.

III. Capital Fixity and the Theory of the Firm

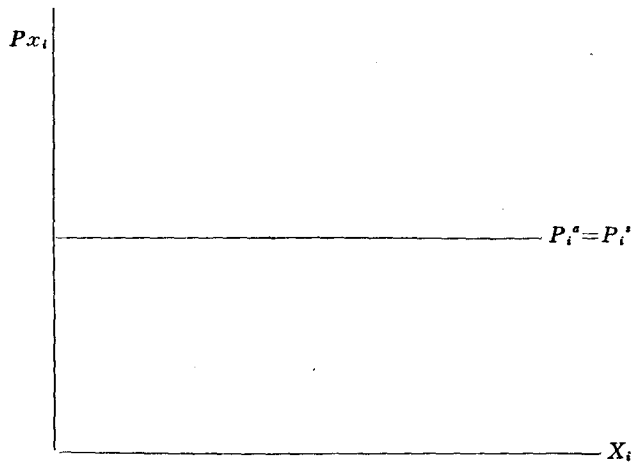
The theoretical definition of fixed capital and the procedure for valuation of fixed capital are integrated into the theory of the firm by means of propositions about the firm organization and the supply function of input factors.

Let Px_i=unit price of ith input for a firm
x_i=ith input factor
P_i^a=the acquisition cost of an additional ith input, and
P_i^s=the salvage value of existing ith input (i=1,...,n)

then $P_i^s < P_i^a$

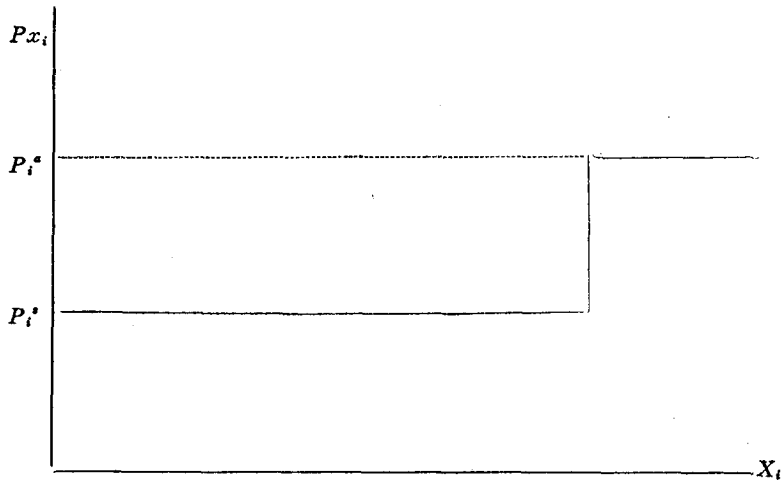
That is, when $P_i^a = P_i^s$, the supply function for input would be as in Figure 2 and the input factors are not subject to fixity. However when $P_i^a \neq P_i^s$(in general $P_i^s < P_i^a$) as in Figure 3, the input factor is subject to fixity.

Figure 2 $P_i^a = P_i^s$ case



It is therefore argued that the firm's condition of profit maximization can be defined with the condition of capital fixity and the supply function of input factors as:

Figure 3 $P_i^e > P_i'$ case



$$\pi = P_y Y - \sum_{i=1}^{n} P_i X_i \tag{1}$$

where

π=profit of a firm

Y=product of a firm

P_y=price of Y product, with the previous definition of P_i and X_i.

If we also define a continuous implicit production function as

$$Y = f(X_i) \text{ for } i = 1, \ldots, n \tag{2}$$

and

$$X_i = X_i' - A_i + B_i \tag{3}$$

where X_i'=existing quantities of input for a specified output

A_i=decreased amount of input factors at the P_i' on the factor market, and

B_i=increased amount of input factors at the P_i^e.

By using Lagrangian function with the above (1), (2) and (3),

$$L = P_y Y - \sum_{i=1}^{n} P_i X_i + \sum_{i=1}^{n} \alpha_i (X_i' - A_i + B_i - X_i)$$

where α_i=Lagrangian multiplier.

By substituting Y by (2) and X_i by (3) again

$$L = P_y f(X_i) - \sum_{i=1}^{n} P_i (X_i' - A_i + B_i) + \sum_{i=1}^{n} \alpha_i (X_i' - A_i + B_i - X_i)$$

For a solution of maximizing with respect to X_i, A_i and B_i,

$$\frac{\partial L}{\partial X_i}=P_y\frac{\partial f(X_i)}{\partial X_i}-\alpha_i=0$$

$$\therefore\ P_y\frac{\partial f(X_i)}{\partial X_i}=\alpha_i \tag{4}$$

$$\frac{\partial L}{\partial A_i}=P_i'-\alpha_i=0$$

$$\therefore\ P_i'=\alpha_i \tag{5}$$

$$\frac{\partial L}{\partial B_i}=\alpha_i-P_i^a=0$$

$$\therefore\ P_i^a=\alpha_i \tag{6}$$

for $i=1,\ldots,n$

From (4), α_i can be interpreted as the measure of the on-firm opportunity cost of using the ith input. That is, if $P_y\frac{\partial f(X_i)}{\partial X_i}<\alpha_i$ this implies that $\mathrm{VMP}x_i$ is less than opportunity cost for ith input, and thus the ith input is not used.

Furthermore, if the ith input is used in the optimal firm operation, the relation of $P_i'=\alpha_i$ in (5) implies $P_i'\leqq\alpha_i$ and the relation of $P_i^a=\alpha_i$ in (6) implies $P_i^a\geqq\alpha_i$, such that

$P_i^a\geqq\alpha_i\geqq P_i'$, where

α_i=on-firm opportunity cost for ith input

P_i^a=acquisition cost for ith input

P_i'=salvage value for ith input.

It is therefore said that, if the optimal farm operation (on the firm operation in the theory of firm) uses more than X_i^* this means that according to (6) on-firm opportunity cost equals acquisition cost for ith input. If less than X_i^* is used, then it implies by (5) that on-firm opportunity cost equals salvage value of ith input.

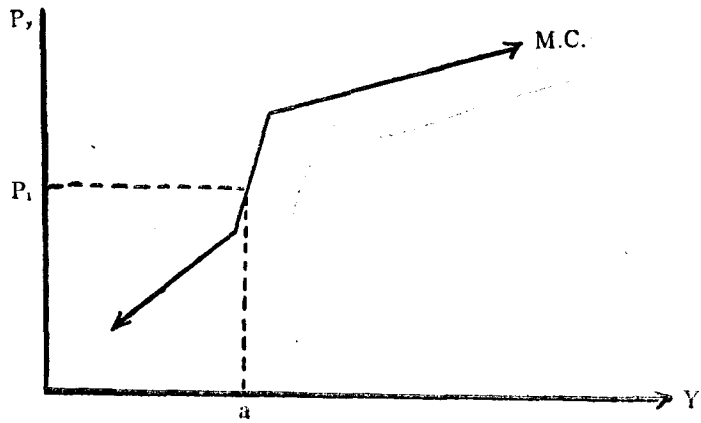
IV. Capital Fixity and Supply Response

The acquisition costs and salvage values for input factors therefore are some of conditions which determine the input capital fixity of a farm operation. Changes in the fixed assets due to changes in the conditions such as P_y, P_i^a, P_i' and other economic and noneconomic factors impose a non-reversible character on firm's marginal cost function. This non-reversibility is associated with kinks resulted by the several factors in the function.

By relating the nature of this M.C. curve with the capital fixity problem, the following argument can be developed.

1. For small change in P_y, most assets subject to fixity would remain fixed at existing levels. Therefore an inelastic price response would be expected.
2. For larger change in P_y, additional resources would become worth changing and the response becomes more elastic.

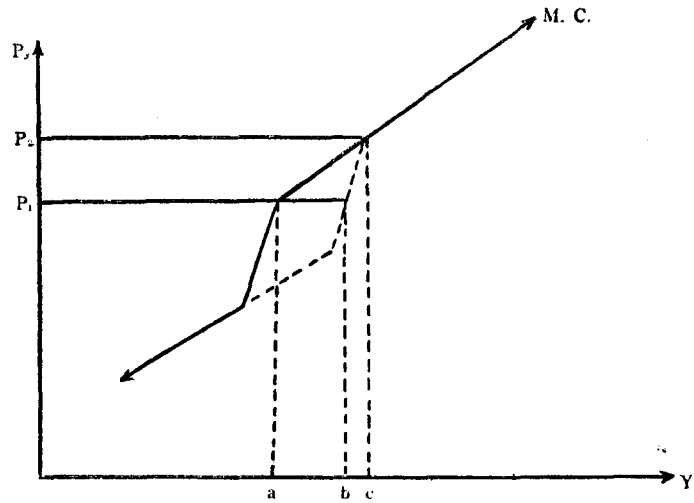
Figure 4 The Kinked M.C. Curve



The inelastic segment of the M.C. curve reflects price response by varying input factors not subject to fixity. The more elastic segment of the supply response curve reflects changes in fixed capital structure as well as changes in variable input factors.

Non-reversibility of supply response develops as such resources become fixed at new levels. This shifts the inelastic segment of the curve to the left or right relative to the elastic segments as a result of changes in fixed capital structure.

Figure 5 Non-reversibility of M.C. Curve



For example, from the following graph suppose P_y increases from P_1 to P_2 and the farm operator acquires more input factors to produce up to c from a of Y.

If P_y reverts to P_1 again from P_2, Y will be reduced along the inelastic segment of M.C. curve to b, which results a greater output of Y at the original P_1 level and this is because of capital fixity.

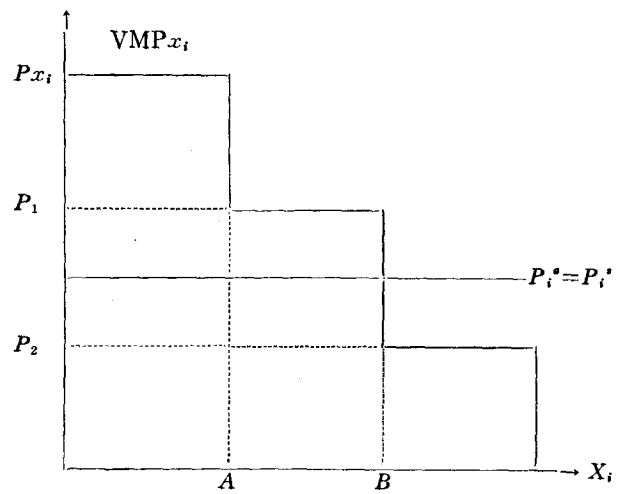
The non-reversibility of M.C. curve is in this study associated with the changes in capital fixity within a given technology. When a given technology is changed, the new level of M.C. curves would appear with the similar non-reversibility of Y response.[6]

One of the potential sources of kinks in M.C. curve originates from the divergence of P^a from P^r. There are other sources for this such as institutional rigidities, resource immobilities and other imperfections in the factor markets.[7]

V. Capital Valuation and Step Function Properties in Linear Programming Model

On linear programming assumptions, VMP curve of the input factor is a step function. By using the character of this function in L.P., and the process of degeneracy,[8] the VMPx_i in this paper is described as a sloping downward step function as X_i increases, shown in the following graph.

Figure 6 VMPx_i with a case of $P_i^a = P_i^r$



6) W.W. Cochrane, "Conceptualizing the Supply Relation in Agriculture", *Journal of Farm Economics*, Vol. 37 (Dec., 1955), p. 1172.

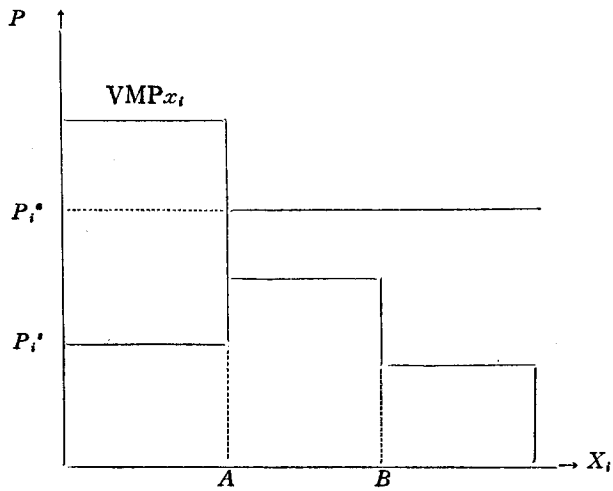
7) C.B. Haver, "Institutional Rigidities and Other Imperfections in the Factor Markets", in *Agricultural Adjustment Problems in a Growing Economy*, (edited by) Heady, Diesslin, Jensen and Johnson, Iowa State College Press (1958), p. 130.

8) Dorfman, Samuelson and Solow, *Linear Programming and Economic Analysis*, The Rand Series (1958), pp. 92–93.

The height of each step of VMPx_i depends on the prices in the competitive markets for products and for those factors which are not fixed capital. The position of A or B in X_i level is also determined by the amounts of fixed capital. If the case is $P_i^a = P_i'$, then in general M.C. curve cuts the VMPx_i in the vertical segment.

If $P_i^a > P_i'$, as in Figure 3, the two curves would meet generally as follows:

Figure 7 VMPx_i with a case of $P_i^a > P_i'$



If other economic factors are assumed to be constant, and if P_i^a is gradually reduced, then there will be no incentive for a farm operator to change the amounts of his capital. When $P_i^a < P_i'$, the capital stock of X_i would be increased from A to B for the maximum level of profit.

For the above two cases, $P_i^a = P_i'$ and $P_i^a \neq P_i'$, the effects on farm operators' responses in the market would be generally the same, and their reactions are in general corresponding to the effects on farm organization and M.C. response.

This adjustment process will be, however, tempered in the case of the aggregated demand curve because of differences in fixed capital structure by individual farm.

VI. Conclusion

One of the farm management problems associated with time factor is the capital management. An operational definition of capital fixity was reviewed in this paper from the theoretical concepts of acquisition cost, salvage value and the theory of the firm. Furthermore this study discussed the consequences for the M.C. curve as an individual supply function. Finally, the problem of capital fixity and the adjustment process of farm organization's capital structure was

analyzed with the L.P. model.

Farm policies with respect to the capital structure and production process must be reviewed based on the conditions of input factor markets. It is therefore necessary to analyze the consequences of price changes in factor market as well as product market. If, for example, the price of farm products were drastically reduced, the salvage value would fall faster than the declines in use values. Therefore, more capital would remain in production process than on the salvage market, and the decline in fixed capital value would reduce farm operator's income.

Although this paper presented the properties of capital fixity in a transient concept, no explicit analysis on dynamic factors was made. Further study in decision model and the dynamic program by relating to farm operation should be extended from the partial approach of this paper.

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