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LEARNING BY DOING: FORMAL TESTS FOR INTERVENTION IN AN OPEN ECONOMY*

M. C. KEMP

I. INTRODUCTION

Some ten years ago I offered a brief examination of the Mill-Bastable infant-industry dogma [2].[1] Drawing a sharp distinction between learning the benefits of which are confined to the firm which is doing and learning the benefits of which accrue to other firms, that is, between dynamic internal and dynamic external economies of production, I argued that, under competitive conditions with complete knowledge by producers, dynamic internal economies could not serve to justify the protection of infant firms. I admitted that infants might lack the foresight and means to wait out the period of learning and, on social grounds, may deserve protection. However, I noted that the case for protection is then based not on dynamic internal economies but on the presence of uncertainty and the imperfection of capital markets.

During the intervening years this proposition has had its ups and downs. In particular it has been denied by Takashi Negishi [4], [5] and Michihiro Ohyama [6], and upheld by Ngo Van Long [3].

In the present note I propose to look again at the policy implications of dynamic internal economies without however burdening myself with the more special assumptions which pervade the infant-industry literature. In the context of a two-period model, I develop two general tests which may be applied to any proposal for intervention. The first test if failed disqualifies the proposal; the second test if passed justifies intervention. It is shown that the first test cannot be met if the policy-making country applies a system of optimal tariffs and if its producers have complete knowledge and are not myopic. The relevance of the analysis to economies with privately-owned wasting resources is noted.

II. THE MODEL

Consider a country (the "home" country) which potentially produces, consumes and trades (freely, with the rest of the world) n commodities. Time is

* The present note has its origin in talks given at the Delhi School of Economics in August 1967 and at the University of Essex in the spring of 1968. In its preparation I have been greatly influenced by the papers of Takashi Negishi [4] and Ngo Van Long [3]. For most useful comments I am indebted to Jagdish Bhagwati (in Delhi) and to Henry Y. Wan, Jr., Geoffrey Fishburn, Ngo Van Long and Michihiro Ohyama.

[1] The treatment in [2] is a refined version of that in [1].

divided into two periods, the present and the future. Symbols with the subscript 1 relate to the present, those with the subscript 2 to the future. Thus

c_1 is the present consumption vector of the home country;

e_1 is the present endowment vector of the home country;

y_1 is the present net production vector of the home country, with the ith element positive, negative or zero as the ith commodity is on balance an output, an input or neither;

m_1 is the present vector of net home imports with the ith element positive or zero as the ith commodity is on balance imported, exported or neither;

p_1 is the vector of present consumers' prices in the home country, equal to producers' gross prices (that is, gross of tax and subsidy), equal to world prices in the case of freely traded goods;

Y_1 is the set of feasible present production vectors in the home country.

The symbols c_2, e_2, y_2, m_2 p_2, Y_2 are defined analogously. It is possible that some elements of y_i are inherently non-positive and that some elements of m_i are inherently zero ($i=1, 2$). For example, given the home country's technology it may not be feasible to produce certain commodities in positive amounts, and some commodities may be non-tradeable.

In each period non-increasing returns prevail, so that the net production possibility sets Y_i are convex; in addition they are assumed to be closed. Since there are no externalities of production it is unnecessary to distinguish individual firms. To give expression to the possibility of learning, the set of future production possibilities is supposed to be conditional upon the present net output vector and is therefore written $Y_2(y_1)$. It follows that the set of feasible production vectors $\{(y_1, y_2)\colon y_1 \varepsilon Y_1 \;\; y_2 \varepsilon Y_2(y_1)\}$ need not be convex.

Individual preferences are strictly convex.[2] Moreover the distribution of income is so controlled that if interference with the allocation of resources leaves one individual better off (respectively, worse off) then it leaves no individual worse off (better off). It follows that the community behaves like a single individual with strictly convex preferences. The set $C(c_1, c_2)$ contains those two-period consumption vectors which are preferred to the given vector (c_1, c_2). The set $\bar{C}(c_1, c_2)$ contains those two-period consumption vectors which are preferred to or indifferent to (c_1, c_2).

Suppose that in an initial free-trade tax-free competitive equilibrium

$$\begin{aligned} c_i &= c_i^0 \\ e_i &= e_i^0 \\ y_i &= y_i^0 \qquad i = 1, 2 \\ m_i &= m_i^0 \\ p_i &= p_i^0 \end{aligned} \tag{1}$$

[2] For the necessary conditions derived in Sec. III even convexity can be dispensed with.

Consider now any alternative feasible pattern of production which, we suppose, can be imposed on the economy by some mixture of taxes and subsidies on production. We wish to rank the associated competitive equilibrium against the initial equilibrium. Quantities associated with the new equilibrium will be indicated by primes. For example, the new pattern of production is denoted by (y_1', y_2'), with $y_1' \in Y_1$ and $y_2' \in Y_2(y_1')$.

III. THE TESTS

A necessary condition

We begin by developing a condition which must be satisfied if the substitution of (y_1', y_2') for (y_1^0, y_2^0) is to be judged desirable. Now if the change is desirable, $(c_1', c_2') \in C(c_1^0, c_2^0)$ and $\sum p_i^0 c_i' > \sum p_i^0 c_i^0$. Noting that $c_i = y_i + e_i + m_i$ and that $e_i' = e_i^0$, this inequality may be written

$$\sum p_i^0 (y_i' - y_i^0) + \sum p_i^0 (m_i' - m_i^0) > 0 \tag{2a}$$

That is, interpreting m_i^0 and m_i' as input-output vectors of a special kind, if the change in allocation is desirable then it is profitable at the initial prices. Since $\sum p_i^0 y_i^0 \geqq 0$ (non-negative profits in a competitive equilibrium) and since $\sum p_i^0 m_i^0 = 0$ (the balance of payments is zero), (2a) reduces to

$$\sum p_i^0 y_i' + \sum p_i^0 m_i' > \sum p_i^0 y_i^0 \geqq 0 \tag{2b}$$

That is, if the change in allocation is desirable then the new allocation is profitable at the old prices. Of course, profitability at the old prices does not imply profitability at the new.

In the limiting small-country case the prices of tradeable goods (but not necessarily of non-tradeable goods) are independent of the allocation of resources in

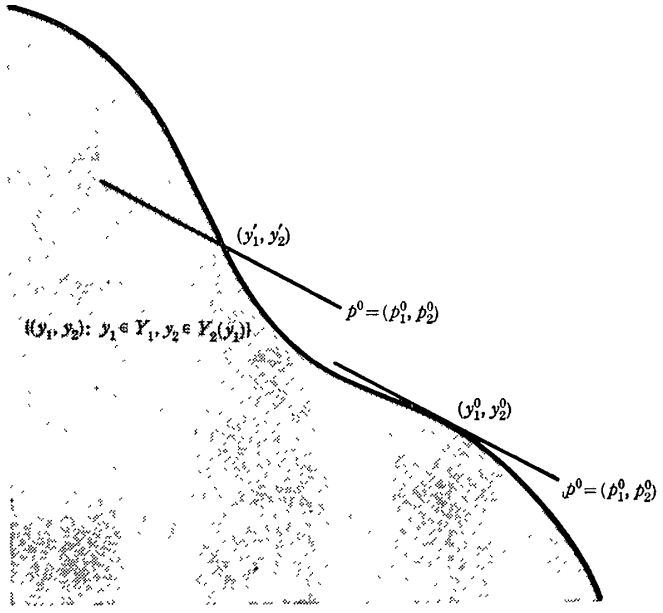

Fig. 1.

the home country. In another limiting case, $m_i' = 0$ $(i = 1, 2)$, that is, the home economy is closed after intervention (but not necessarily before intervention). In each case $\sum p_i^0 m_i' = 0$ and (2b) reduces to

$$\sum p_i^0 y_i' > \sum p_i^0 y_i' \geqq 0 \tag{2c}$$

That is, if the new consumption vector is preferred to the old then the new production vector is profitable at the old prices.

Suppose that producers have complete knowledge and are not myopic. Then at the old prices (y_1^0, y_2^0) is profit-maximizing and

$$\sum p_i^0 y_i^0 \geqq \sum p_i^0 y_i' \tag{3}$$

It follows that, for a small country or for one which after intervention would be autarkic, inequality (2c) can never be satisfied and intervention never justified.[3] For a large open economy it is still possible that (2a) may be satisfied in spite of (3). However this could be the case only if the home country had failed to take advantage (by tariffs on trade) of its monopoly-monopsony power in trade. The imposition of production taxes and subsidies might then be justified on second-best grounds.

The assumption that producers have complete knowledge and are not myopic is conventional in general economic theory, and also in the more rigorous treatments of the infant-industry dogma. However, in a context of learning-by-doing, where the hand teaches the brain and producers are of limited imagination, the assumption is not altogether plausible. Suppose then that producers are only local maximizers or are unaware that Y_2 depends on y_1. In the future producers must adjust to unforeseen changes in their production set Y_2. Present expectations of future spot prices will be falsified and any futures contracts concluded in the present will prove to be sub-optimal. If follows that one can no longer infer from $(c_1', c_2') \varepsilon C(c_1^0, c_2^0)$ that $\sum p_i^0 c_i' > \sum p_i^0 c_i^0$, so that (2a) ceases to be a necessary condition of intervention and intervention cannot be ruled out even in a small or autarkic country.

A sufficient condition

Let us suppose that the necessary condition (2a) is either satisfied or irrelevant. That is, our attention is for the time being restricted to an economy which either is large, free-trading and non-autarkic, or is guided by producers who are myopic or unaware of the learning process, or both.

For $(c_1^0, c_2^0) \notin \bar{C}(c_1', c_2')$ it suffices that $\sum p_i' c_i' > \sum p_i' c_i^0$ so that, following the reasoning behind (2a),

[3] Michihiro Ohyama [6, pp. 63–64] has argued that even in small countries (with non-myopic businessmen) intervention may be justiffed. However, there appears to be a slip in his reasoning. The inequality at the bottom of page 63 should be

$$p''(z'' - z') + p''(a'' - a') \geqq -p''(w'' - w')$$

The first term on the left may be positive since p'' is the vector of domestic consumers' prices which by assumption differs from the vector of prices received by producers in the infant industry. I am grateful to Professor Ohyama for his assistance in tracking down the slip.

$$\sum p_i' (y_i' - y_i^0) + \sum p_i' (m_i' - m_i^0) > 0 \tag{4a}$$

That is, if the change in allocatton is profitable at the new prices it is desirable. Alternatively, we may note that $\sum p_i' (m_i' - m_i^0)$ is positive or negative as the home country's terms of trade improve or deteriorate as a result of the change and say that the change is desirable if the additional loss on pure production, calculated at the new prices, is more than offset by the gains from improved terms of trade. Since $\sum p_i' m_i' = 0$ (the balance of payments is zero), (4a) reduces to

$$\sum p_i' (y_i' - y_i^0) - \sum p_i' m_i^0 > 0 \tag{4b}$$

Of course (4a) and (4b) are sufficient but (in general) not necessary. Figure 2 suggests the possibility that the change is desirable but (4a) and (4b) not satisfied.

In the limiting small-country case, $p_i' = p_i^0$ for tradeable goods and (4b) reduces further to

$$\sum p_i' (y_i' - y_i^0) > 0 \tag{4c}$$

In that case intervention is desirable if the new production vector is less unprofitable than the old when evaluated at the new prices. The same inequality is obtained if in the *absence* of intervention the home country is self-sufficient, so that $m_i^0 = 0$ $(i = 1, 2)$.

The conclusions reached so far are summarized in the following

PROPOSITION: *For intervention to be justified it is necessary that the inequality*

$$\sum p_i^0 y_i' + \sum p_i^0 m_i' > \sum p_i^0 y_i^0 \geqq 0 \tag{2b}$$

be satisfied. This inequality cannot be satisfied if the home country applies a system of optimal tariffs and if its producers have complete knowledge and are not myopic. Intervention is justified if the inequality

$$\sum p_i' (y_i' - y_i^0) - \sum p_i' m_i^0 > 0 \tag{4b}$$

is satisfied. If the home country is small or if after intervention it is self-

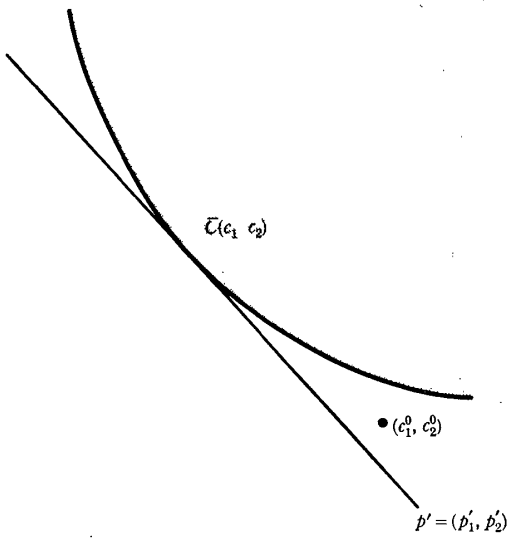

Fig. 2.

sufficient, (2b) *reduces to*

$$\sum p_i^0 y_i' > \sum p_i^0 y_i^0 \geqq 0 \tag{2c}$$

and (4b) *reduces to*

$$\sum p_i'(y_i' - y_i^0) > 0 \tag{4c}$$

Suppose that the home country is small but its producers myopic or ill-informed. They must be dislodged from (y_1^0, y_2^0) and driven to a preferred point (y_1', y_2'). Suppose that (y_1', y_2') is a global optimum for the community. Since the learning process is supposed to be internal to the firm, that point is also a global optimum for each firm. Suppose further that firms adjust without delay to price stimuli. Then the optimal tax-subsidy intervention is very short-lived, a series of mere flash signals following closely one upon the other, each designed to move producers one step closer to (y_1', y_2'). Strictly, under the extreme conditions assumed, intervention spanning any finite interval of time results in sub-optimal transitional production. In fact, of course, adjustment is not instantaneous; the optimal policy takes time to do its work and itself varies with time, in a manner determined by the speed with which firms react to price stimuli and by the properties of the production set.

In the more recent literature on infant industries it has been customary to "decompose" the production set into two sets one of which (that of the infant industry) incorporates learning, the other not. See, for example, [3]–[7]. Producers employing activities included in the latter set are neither taxed nor subsidized; the pattern of their production is the same whether or not the infant industry is supported, provided only that prices do not change. Evidently this technology is a special case of that described in Section II. Let α and β relate production sets to the non-learning and learning (infant) sectors, respectively. Then we may write

$$Y_1 = Y^\alpha + Y_1^\beta$$

$$Y_2 = Y^\alpha + Y_2^\beta\,(y_1^\beta)$$

The reader may develop the specialized forms of tests (2a) and (4a) without difficulty.

The argument of this section has been developed in terms of a model with just two periods, the present and the future. However, there is no difficulty in extending the argument to cover any number of periods. In general, the production set of the jth period is denoted by $Y_j(y_1, \ldots, y_{j-1})$ for $j > 1$; then the key formulae (2a) and (4a) carry over unchanged, with the summations running over the number of periods.

Finally it may be noted that the description of the home country's technology offered in Section II is sufficiently general to accommodate privately owned wasting resources not included in the endowment vectors e_i. The case for intervention in a context of wasting resources is identical (except for trivial matters of sign) with the case for intervention in a context of learning by doing.

IV. PERSPECTIVE

The scope for potentially helpful intervention in the face of learning by doing may appear to be quite restricted. However, the analysis of Section III, like that of [1]–[6], has been based on the assumption that there exists an initial free-trade tax-free competitive equilibrium. This is not an innocuous assumption. Indeed, it is a very simple matter to construct plausible models in which the assumption is not met.[4] Nor should this be surprising. For the "dynamic" model of production developed in this paper differs from the familiar static model only in its allowance for increasing returns. The possibility that increasing returns may be incompatible with competitive equilibrium is well known. It is also well known that an appropriate subsidy to an increasing-returns industry may ensure the existence of an equilibrium with the characteristics of an optimum.

While the present analysis casts no light on the scope for potentially helpful intervention, it does, I think, clarify the logic of the case of intervention. In particular, the logic is revealed to be of a completely familiar kind. Intervention may be helpful if producers are ill-informed or myopic, or if increasing returns threaten the existence of competitive equilibrium; and it may be helpful as a second-best measure if the government is unable to impose an optimal set of tariffs on foreign trade. But all of this we knew before the phenomenon of learning began to occupy our attention.

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[4] One need only consider the familiar two-by-two model of production, extended to allow for the possible dependence of future production functions on present inputs and outputs. See, for example, Yabushita [7].