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OLIGOPOLISTIC COMPETITION AND ECONOMIC WELFARE: A GENERAL EQUILIBRIUM ANALYSIS OF ENTRY REGULATION AND TAX-SUBSIDY SCHEMES*

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by

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1. Introduction

The purpose of this paper is to accomplish two contributions to the general equilibrium analysis of an oligopolistic economy with free entry.

In the first place, we establish a general equilibrium extension of the excess entry theorem due to Mankiw and Winston [1986] and Suzumura and Kiyono [1987], which states that a marginal decrease in the number of oligopolistic firms from the free-entry equilibrium level improves economic welfare in a partial equilibrium framework. It is generally recognized that the advantage of using a partial equilibrium analysis lies in its simplicity, which enables us to crystallize a new theoretical insight. As the new insight provided by the excess entry theorem is somewhat paradoxical, it is reassuring that the theorem is essentially kept intact even in the presence of general equilibrium interactions. In this paper, we prove that without factor intensity reversal, i.e., the oligopolistic sector using the same factor of production more intensively in the average sense as well as in the marginal sense, the partial equilibrium implication on the welfare effect of entry regulation in a free-entry oligopolistic economy is preserved in a general equilibrium setting.

However, the excess entry theorem may be criticized in that the oligopolistic firms may behave differently before and after the entry regulation. From such a viewpoint, we should search for other types of government intervention that will not alter the environment underlying the oligopolistic behaviour.

In the second place, we consider tax-subsidy schemes which assure an unambiguous Pareto improvement. Recall that the introduction of a tax-subsidy scheme into a perfectly competitive economy necessarily harms at least one economic agent unless it is of lump-sum variety. In contrast, the introduction of a tax-subsidy scheme can be welfare improving if the market economy is imperfectly competitive. However, knowing that a tax-subsidy scheme can be welfare-improving is quite different from knowing when and precisely what kind of tax-subsidy scheme is warranted to be welfare-improving. In this paper we present several self-financing tax-subsidy schemes that assure Pareto improvement. It is hoped that the present paper is a step forward to filling in a gap left open in the existing literature on the tax analysis in an oligopolistic economy.[1/]

2. The Model

We consider a closed economy producing two goods, X and Y, using two factors of production, capital and labour. The endowment of these factors is fixed exogenously, and they are freely mobile between two sectors. Good X is produced under increasing returns to scale due to the existence of fixed costs, which makes industry X oligopolistic. For simplicity, we assume that all firms in industry X are identical and behave as Cournot-Nash competitors, so that we can work with the symmetric Cournot-Nash equilibrium. Good Y is competitively produced under constant returns to scale. We also simplify our model by supposing a single representative consumer whose welfare is the central focus of our analysis. The consumer's income is taken as numeraire. Moreover, we confine our attention to the long run equilibrium where entry and exit are free in the oligopolistic sector as well as in the perfectly competitive sector. This completes our informal description of the model. Let us now make it precise.

2.1 Representative consumer

Let $V(p_X,p_Y)$ be the indirect utility function of the representative consumer, where p_X (p_Y, resp.) denotes the price of X (Y, resp.) and the consumer's income is taken as numeraire. We assume quasi-linearity of her preference, which enables us to write the inverse demand function for X as

(2.1) $p_X = p_Y\Phi(X), \quad \Phi'(X)<0.$[2/]

Moreover, for expositional convenience, price elasticity of the demand for X, denoted by ε, is assumed to be constant, i.e.,

(2.2) $\varepsilon = -\frac{\Phi(X)}{X\Phi'(X)} = \text{const.}$[3/]

2.2 Industry Y

Industry Y consists of perfectly competitive firms producing Y under constant returns to scale. Let $g(w,r)$ stand for the unit cost function of the representative firm where r and w are, respectively, the rental rate of capital and the wage rate. Needless to say, g is homogeneous of degree one with respect to r and w. The price of Y being p_Y, we should have

(2.3) $p_Y = g(w,r)$

at equilibrium. Industry Y is assumed to be an untaxed sector.

2.3 Industry X

Industry X consists of identical and oligopolistically competitive firms. Let the before tax-subsidy cost function of each firm be

(2.4) $C^*(q;w,r) = m^*(w,r)q + F^*(w,r),$

where q is each firm's output of good X. Clearly, $m^*(w,r)$ and $F^*(w,r)$ denote, respectively, the marginal cost and fixed cost functions which are homogeneous of degree one.

In this paper, we examine the welfare effects of various <u>infinitesimal</u> tax-subsidy schemes applied to the oligopolistic industry. Those tax-subsidy parameters are as follows:

s = production subsidy per unit output,

s_w = rate of subsidy on the wage expenditure component of marginal cost,

s_r = rate of subsidy on the capital expenditure component of marginal cost,

t = lump-sum subsidy,

t_w = rate of subsidy on the wage expenditure component of fixed cost,

t_r = rate of subsidy on the capital expenditure component of fixed cost.

Note that each of s, s_w, s_r, t, t_w and t_r can be negative, in which case we are referring to a tax, rather than to a subsidy. By the use of vector notations, let $\mathbf{S} = (s, s_w, s_r, t, t_w, t_r)$ be the overall tax-subsidy scheme. It is partitioned into the tax-subsidy scheme on the marginal cost part $\mathbf{s} = (s, s_w, s_r)$ and that on the fixed cost part $\mathbf{t} = (t, t_w, t_r)$.

Under a given tax-subsidy scheme, we can redefine the <u>after tax-subsidy</u> cost function for X industry firms:

$$C(q;w,r,\mathbf{S}) = m(w,r,\mathbf{s})q + F(w,r,\mathbf{t}),$$

where $m(w,r,\mathbf{s}) = m^*(w-s_w, r-s_r) - s$, and $F(w,r,\mathbf{t}) = F^*(w-t_w, r-t_r) - t$.

Throughout this paper, we assume that X industry is in Cournot competition in quantities. It follows that each firm solves the problem:

$$\max\ p_Y\Phi(X_i + q)q - m(w,r,\mathbf{s})q - F(w,r,\mathbf{t}), \tag{2.5}$$

taking the total output of other firms, X_i, the prices of the good Y, p_Y, and production factors, (w,r), and the tax-subsidy scheme, $\mathbf{S}$, as given. The first order condition for profit maximization becomes:

$$p_Y \Phi(X)\{ \frac{\Phi'(X)}{\Phi(X)} q + 1 \} = m(w,r,s).$$

Under the assumption of identical firms, X=nq holds at the symmetric Cournot-Nash equilibrium if there are n firms operating in industry X.

Using (2.2) and (2.3), we can derive one of the equilibrium conditions in industry X,

$$(2.6) \qquad \Phi(nq)(1-\frac{1}{n\varepsilon}) = \frac{m(w,r,s)}{g(w,r)},$$

where $n > 1/\varepsilon$ should be satisfied for the internal equilibrium solution to exist.

We also assume that entry and exit are free in industry X and focus on a long-run equilibrium of the economy. Thus, output level of each firm and the number of X-industry firms are important determinants of the allocational efficiency of the economy.

The equilibrium number of firms is determined at the level where the break even condition is satisfied. By the use of (2.3), this condition is reduced to:

$$(2.7) \qquad \Phi(nq)q = \frac{m(w,r,s)}{g(w,r)}q + \frac{F(w,r,t)}{g(w,r)}.$$

The integer problem on the equilibrium number of firms is assumed away. This is a customary practice in the literature (e.g., see Seade [1980], Suzumura and Kiyono [1987]).

2.4 Consumer's Income

Income of the representative consumer is taken as numeraire. Let K (L, resp.) be the fixed supply of capital (labour, resp.). Profit earned in industry X, if any, is distributed to the consumer. The resources, which are required to perform a tax-subsidy scheme with, are collected from the representative consumer in a lump-sum fashion. When tax is collected from the oligopolistic sector, its revenue is distributed to the consumer in the same manner. Letting T be the lump-sum subsidy (or tax; if it is negative),

$$T = n\{(s+s_w m_w+s_r m_r)q + (t+t_w F_w+t_r F_r)\}.$$

In the above expression, partial derivatives of the cost functions coincide with the levels of factor inputs utilized in the marginal and fixed cost parts by virtue of Shephard's lemma.4/

Then, the normalization of the consumer's income implies

(2.8) $$wL + rK + n\{g(w,r)\Phi(nq)q - m(w,r,\mathbf{s})q - F(w,r,\mathbf{t})\} - T = 1.$$

Note that the third term of LHS is equal to zero at equilibrium.

2.5 Factor Market Equilibrium

Capital and labour are allocated between industries through the adjustment of rental and wage rates, as they are freely mobile between sectors. Both factor markets are assumed to be perfectly competitive. By the use of Shephard's lemma, total factor use in each industry can be written as

$$K_X = m_r(w,r,\mathbf{s})X + nF_r(w,r,\mathbf{t}), \quad L_X = m_w(w,r,\mathbf{s})X + nF_w(w,r,\mathbf{t}),$$

$$K_Y = g_r(w,r)Y, \quad L_Y = g_w(w,r)Y.$$

Thus, the market clearing conditions become:

(2.9) $$K_X + K_Y = K,$$

(2.10) $$L_X + L_Y = L.$$

The above six equations, (2.3) and (2.6)-(2.10), complete the general equilibrium system of our economy. Market clearing condition for the good Y is omitted because of the Walras' law. There are six unknowns, q, n, p_Y, Y, w and r.

3. Welfare Criterion

In order to analyse this system, we shall first define the welfare criterion which is the basis for evaluating entry regulation policy and tax-subsidy schemes to be examined later.

Welfare of the representative consumer is written as:

$$(3.1) \qquad V(p_X, p_Y) = V(g(w,r)\Phi(nq),\ g(w,r)).$$

Total differentiation of (3.1) yields

$$(3.2) \qquad \frac{1}{\lambda}dV = -\ g(w,r)X\Phi'(X)dX\ -\ (X\Phi(X)+Y)(g_w dw+g_r dr),$$

where use is made of Roy's identity and λ represents the marginal utility of income ($\lambda>0$).

In addition, by total differentiation of (2.8), changes of variables are restricted because of the normalization of the consumer's income:

$$(3.3) \qquad \{L-n(m_w q+F_w)+\Phi(X)Xg_w\}dw + \{K-n(m\ q+F\ )+\Phi(X)Xg\ \}dr$$
$$+\ g(w,r)\Phi'(X)X(dX-dq) = 0,$$

where (2.6) and (2.7) are used. The terms related to the tax-subsidy parameters disappear as far as they are infinitesimal. Substituting (2.9) and (2.10), we can convert (3.3) into:

$$(3.4) \qquad (Y+\Phi(X)X)(g_w dw+g_r dr)\ +\ g(w,r)\Phi'(X)X(dX-dq) = 0.$$

Thus, using the restriction (3.4), we obtain a welfare criterion in our economy as:

$$(3.5) \qquad \frac{1}{\lambda}dV = -\ g(w,r)X\Phi'(X)dq.$$

The following useful theorem is now established:

Theorem 1 (Welfare Criterion):

The necessary and sufficient condition for a change in the number of oligopolistic firms and/or the imposition of an infinitesimal tax-subsidy scheme to be welfare improving is that it induces an increase in the output of each oligopolistic firm.

The assertion of the above theorem is intuitively clear. In a free-entry oligopolistic economy, average cost, which equals product price, exceeds marginal cost, which equals marginal revenue. It follows that there remains unexploited increasing returns. Hence, it is socially benefitial to expand production scale of each firm in the oligopolistic industry.

4. Perturbation of the General Equilibrium System

In this section, we analyse our general equilibrium system using the so-called hat-calculus and derive the equilibrium relations among the output level of each oligopolistic firm, the number of firms in the oligopolistic sector and the relative factor price.[5/] This is a customary procedure in the literature of tax incidence pioneered by Harberger [1962].[6/] First, we examine the effect of a change in the number of firms, and later, we investigate the effect of the introduction of a tax and subsidy scheme.

Consider (2.6), the Cournot-Nash equilibrium condition of industry X,and assume $S=0$. The RHS shows the relative marginal cost of industry X to that of industry Y. It is well known that the relative factor intensity between the two industries plays the central role in determining the relation between ω, the wage-rental ratio w/r, and the value of the RHS of (2.6); if marginal cost of industry X is more capital intensive than industry Y, an increase in ω decreases the value of the RHS, and vice versa.

Now we turn to the LHS of (2.6). This represents the marginal revenue of the oligopolist industry in terms of the good Y. Clearly it depends on the equilibrium number of firms as well as the equilibrium production level of each oligopolistic firm. Using hat-calculus, we obtain the equation of change:

$$-\frac{1}{\varepsilon}\hat{q} - \frac{1-(n-1)\varepsilon}{\varepsilon(n\varepsilon-1)}\hat{n} = \hat{m} - \hat{g}.$$

We now introduce an assumption on the strategic behavior of oligopolists; production levels are strategic substitutes. The property of strategic substitutes, first adopted by Bulow, et.al. [1985], implies downward-sloping reaction curve for each oligopolistic firm, or equivalently, negative partial derivative of the marginal revenue with respect to the quantity set by other firms. It is well-known that strategic substitutes property is a natural one in competition in quantities.

It follows that the LHS of (2.6) is decreasing in q because of the second order condition for profit maximization. Moreover in our formulation, an increase in the number of firms will induce, ceteris paribus, an increase in other firm's output. The assumption of strategic substitutes, then, implies that the LHS of (2.6) is decreasing in n. Thus the assumption of strategic substitutes and the existence of internal solution imply that the number of firms, n, must satisfy $\frac{1}{\varepsilon} < n < 1 + \frac{1}{\varepsilon}$ at the symmetric free entry equilibrium.

The implied relation of $(\hat{q}, \hat{n}, \hat{\omega})$ in (2.6) is now reduced into:

(4.1) $$-\frac{1}{\varepsilon}\hat{q} - \alpha\hat{n} + A\theta^M\hat{\omega} = 0,$$

where $A = \frac{wr}{c}m_w L_Y > 0$, $\alpha = \frac{(n-1)\varepsilon-1}{\varepsilon(n\varepsilon-1)} < 0$, and $\theta^M = (m_r/m_w) - (K_Y/L_Y)$.[7/] θ^M denotes the difference in marginal capital intensity between two industries. If θ^M is positive (negative, resp.), industry X's marginal cost is more capital (labour, resp.) intensive than industry Y. Hence, an increase in wage-rental ratio expands (contracts, resp.) the output of each oligopolist if industry X is marginally more capital (labour, resp.) intensive than industry Y. On the other hand, other things being equal, an increase in the number of firms in industry X reduces the output of each oligopolistic firm, regardless of the sign of θ^M.

Next, apply the same procedure as above to the break-even condition of industry X, (2.7). The RHS represents the total cost of an oligopolistic firm in terms of the good Y. Thus, the value of the RHS determines the overall factor intensity. The implied relation of $(\hat{q}, \hat{n}, \hat{\omega})$ becomes:

$$-\frac{1}{\varepsilon}\hat{X} + \hat{q} = \frac{mg}{C}\hat{q} + \frac{wr}{C}L_Y L_X\{(K_Y/L_Y) - (K_X/L_X)\}\hat{\omega}.$$

By the use of (2.6), $\frac{mg}{C} = 1 - \frac{1}{n\varepsilon}$, so that the above relation is reduced to:

(4.2) $$-\frac{n-1}{\varepsilon}\hat{q} - \frac{1}{\varepsilon}\hat{n} + B\theta^A\hat{\omega} = 0,$$

where $B = \frac{wr}{Cg}L_Y L_X > 0$ and $\theta^A = K_X/L_X - K_Y/L_Y$.

θ^A denotes the difference in <u>average</u> capital intensity between two industries.[8/] If it is positive, industry X is overall more capital intensive than industry Y, and vice versa. Note that in industry Y average capital intensity is equal to marginal intensity because the industry is under constant returns to scale. By (4.2) if industry X is overall more (less, resp.) capital intensive than industry Y, other things being equal, an increase in the output of each oligopolistic firm decreases the number of firms in industry X, and a rise in wage-rental ratio induces new entry (exit, resp.) to industry X.

Finally, we must derive the factor market equilibrium relation of $(\hat{q}, \hat{n}, \hat{\omega})$, which is given by totally differentiating (2.9) and (2.10), and then eliminating dY. However, the calculation procedure is rather convoluted and we shall state only the results in the main text. (For detailed derivation, see Appendix A.)

(4.3) $$\lambda^M\hat{q} + \lambda^A\hat{n} + \Delta\hat{\omega} = 0,$$

where λ^M and λ^A are positively related to the difference in marginal and average factor intensities, θ^M and θ^A. Δ represents what is usually called the factor substitution term and is always positive.

When the number of firms is fixed, interpretation of (4.3) is familiar in the theory of international trade and/or that of tax incidence. (For example, see the pioneering paper of the two-sector general equilibrium model, Jones [1965]). Consider an increase in wage-rental ratio. It induces firms in both industries to choose more capital intensive technology, which brings about excess demand in capital market and excess supply in labour market. For both factor markets to clear, the output of capital intensive industry must decrease and that of labour intensive industry increase; the renowned Rybczynski theorem. In our context, if industry X is marginally more capital intensive, the output of each oligopolistic firm must decrease, and vice versa.

What is rather unfamiliar in (4.3) is the effect of an increase in the number of firms on the output of each oligopolistic firm, when wage-rental ratio is constant. This depends not only on the difference in marginal factor intensities, but also on that in average factor intensities between industries. Let us say that there exists <u>factor intensity reversal</u> in industry X when θ^M and θ^A are of opposite signs. Figure 1a depicts the box diagram describing factor utilizations when there is no factor intensity reversal at the given wage-rental ratio. Note that, in this figure, industry X is assumed to be overall more capital intensive than industry Y.

****INSERT FIGURE 1a****

In Figure 1a, E denotes the initial equilibrium. 0^X and 0^Y denote the origin of industry X and Y, respectively. Factor utilization of industry X, represented by the vector 0^XE, can be decomposed into the fixed cost and the marginal cost part:

$$(K_X, L_X) = (m_r, m_w)X + (F_r, F_W)n.$$

In the figure, 0^XF corresponds to the fixed cost part and FE to the marginal cost part. Slopes of both 0^XE and FE are steeper than that of 0^YE, reflecting the assumption of no factor intensity reversal.

Now consider an increase in the number of firms in industry X. New equilibrium will occur at E' where factor utilization in the fixed cost part is expanded to $0^XF'$. However, if the production level of each oligopolistic firm were to remain the same as before, industry X would utilize factors of 0^XG. Hence, an increase in the number of firms leads to a fall in the output of oligopolists in industry X.

****INSERT FIGURE 1b****

Figure 1b depicts the case with factor intensity reversal; the slope of 0^YE is between those of 0^XE and FE. An increase in the number of firms changes the equilibrium from E to E' and individual production level of the oligopolists increases, because $F'G < F'E'$.

5. Excess Entry Theorem

We are now ready to solve the equations of change (4.1)-(4.3). In this section, we investigate the welfare effects of entry regulation.

Suzumura and Kiyono [1987], using a partial equilibrium framework, examined the welfare effects of entry regulation in a free-entry (quasi-)

Cournot oligopoly with fixed cost. They showed that a reduction in the number of firms leads to welfare improvement when the only available policy tool is a control of the number of firms in the oligopolistic industry. This result critically hinges on the assumption of strategic substitutability. Under this assumption, a reduction in the number of firms gives rise to an increase in the equilibrium output of each oligopolistic firm, which leads to a fall in the average cost of oligopolists due to the existence of unexploited increasing returns to scale.

However, such partial equilibrium results may not hold in a general equilibrium setting. One of our major aims of this paper is to show under what conditions entry regulation assures welfare improvement. In view of Theorem 1, we need only to know a sufficient condition for the output of each oligopolistic firm to increase when the number of firms is reduced marginally. Under entry regulation, n is fixed and the relation (4.2) no longer holds. Solving (4.1) and (4.3):

(5.1) $\hat{q} = -\frac{1}{\Omega}(\alpha\Delta + A\lambda^{A}\theta^{M})\hat{n},$

where $\Omega = \frac{1}{\varepsilon}\Delta + A\lambda^{M}\theta^{M} > 0$. Thus, barring factor intensity reversal, a marginal reduction in the number of firms from the free entry equilibrium level increases individual production in the oligopolistic sector. By invoking Theorem 1, we obtain:

Theorem 2 (Excess Entry Theorem in General Equilibrium):
Suppose strategic substitutability and no factor intensity reversal hold. Then a marginal reduction in the number of oligopolistic firms from the free-entry equilibrium level unambiguously improves economic welfare.

Diagramatical exposition of Theorem 2 is given in Figure 2, which depicts the case of θ^M, $\lambda^M>0$.

****INSERT FIGURE 2****

The downward sloping schedule FF and the upward sloping schedule PP are the implied relations of (q, ω) in the factor market (4.3) and the product market (4.1) with the assumption $\hat{n}=0$. The initial free-entry equilibrium is shown as E in the figure. When the number of firms in industry X is reduced marginally, the PP schedule moves to the right by the assumption of strategic substitutability in the oligopolistic competition. The shift of FF schedule depends on whether there exists factor intensity reversal. If there is no factor intensity reversal (θ^A, $\lambda^A>0$), the FF schedule also moves to the right so that an increase in q is always assured.

However, when there is a reversal (θ^A, $\lambda^A<0$), factor markets response to a reduction of the number of oligopolistic firms counteracts the expansion of the oligopolistic production. This is because a reduction of the number of firms induces a change in wage-rental ratio which worsens the marginal cost condition in industry X relative to that in industry Y. Thus, without factor intensity reversal, equilibrium moves to E' and an increase in q is assured, but equilibrium may move to E" and q may decrease with factor intensity reversal. The case of θ^M, $\lambda^M < 0$ can be examined similarly where the relative position of the FF and PP schedule is reversed.

Some criticisms may be cast on the implication of Theorem 2 to the effect that restricting the competitiveness of oligopolistic sector would contribute to welfare improvement. First, it may be infeasible for the government to regulate the number of firms in oligopolistic sectors. Second, although entry regulation will improve economic welfare, this improvement is brought forth by an increase in firms' profit that dominates the induced fall in consumer's surplus. In this sense, entry regulation may harm economic welfare from distributional viewpoint. Third and more importantly, it is theoreticaly plausible that oligopolistic firms under entry regulation may take strategic behaviors that are different from those under free entry. They might, for example, collude or behave cooperatively if the government imposes an exogenous entry barrier. In the next section, therefore, we shall analyze other policy measures on oligopolistic industry which are strategically-neutral; tax-subsidy schemes.

6. Welfare Improving Tax-Subsidy Schemes

To analyze the effect of a tax-subsidy scheme in our model, the equations of change, (4.1)-(4.3), must be modified to include the tax-subsidy parameters. In order to avoid needless complications, we will modify the equations of change with a familiar theoretical apparatus. Formal derivation is relegated to the Appendix A.

With (4.1), the Cournot-Nash equilibrium condition in industry X, tax-subsidy parameters are introduced into the marginal cost condition of the oligopolistic production. Thus, one of the equations of change under tax-subsidy schemes becomes:

$$(5.1) \qquad -\frac{1}{\varepsilon}\hat{q} - \alpha\hat{n} + A\theta^{M}\hat{\omega} = \frac{1}{m} m_S \cdot dS,$$

where $m_S = -(1, m_w, m_r; 0, 0, 0)$, $dS = (ds, ds_w, ds_r, dt, dt_w, dt_r)$. It is intuitively straightforward that subsidies on the marginal cost increase the equilibrium output of each oligopolistic firm when the number of firms and factor prices are fixed.

(4.2) is similarly modified to include tax-subsidy parameters:

(5.2) $$-\frac{n-1}{n\varepsilon}\hat{q} - \frac{1}{\varepsilon}\hat{n} + B\theta^A\hat{\omega} = \frac{1}{C} C_S \cdot dS,$$

where $C_S = -(q,\ qc_w,\ qc_r;\ 1,\ F_w,\ F_r)$. A cost reduction in the oligopolistic sector induced by the government subsidies brings about an increase in the number of firms when the individual production level and factor prices are fixed.

Effects of the introduction of taxes and subsidies into factor markets are familiar in the theory of tax incidence. For example, the number of firms and the production scale of each oligopolistic firm being fixed, a subsidy on the labour use in industry X, which brings about the factor substitution effect to cause the excess demand in labour market and the excess supply in capital market, increases the wage-rental ratio, and so forth. The modified equation of change in the factor market equilibrium becomes:

(5.3) $$\lambda^M\hat{q} + \lambda^A\hat{n} + \Delta\hat{\omega} = -\mathcal{B}\cdot dS,$$

where $\mathcal{B} = (0,\ \frac{1}{w}\Delta^M,\ -\frac{1}{r}\Delta^M;\ 0,\ \frac{1}{w}\Delta^F,\ -\frac{1}{r}\Delta^F)$. Δ^M and Δ^F represent what are to be called the substitution terms on the marginal cost and the average cost part, respectively. They are proved to be always positive.[9/] Clearly, the production subsidy and the lump-sum subsidy do not directly affect the factor market equilibrium. Noting that we confine our attention to the introduction of infinitesimal tax-subsidy schemes, the signs of λ^M and λ^A correspond to those of θ^M and θ^A, respectively.[10/] Derivation of the modified equations of change being now complete with (5.1)-(5.3), we now examine welfare implications of several tax-subsidy schemes.

Consider the simultaneous equations system for $(\hat{q},\ \hat{n},\ \hat{\omega})$ defined by (5.1)-(5.3):

$$(6.1)\quad \begin{bmatrix} -\frac{1}{\varepsilon} & -\alpha & A\theta^M \\ -\frac{n-1}{n\varepsilon} & -\frac{1}{\varepsilon} & B\theta^A \\ -\lambda^M & -\lambda^A & -\Delta \end{bmatrix} \begin{bmatrix} \hat{q} \\ \hat{n} \\ \hat{\omega} \end{bmatrix} = \begin{bmatrix} \frac{1}{m} m_S \\ \frac{1}{C} C_S \\ -\beta \end{bmatrix} \cdot dS$$

and let H denote the determinant of the coefficient matrix in (6.1), i.e.;

$$H = -\frac{1}{\varepsilon}\left(\frac{1}{\varepsilon}\Delta + B\theta^A\lambda^A\right) + \frac{n-1}{n\varepsilon}(\alpha\Delta + A\theta^M\lambda^A) - \lambda^M(-\alpha B\theta^A + \frac{1}{\varepsilon}A\theta^M).$$

We prove, in Appendix B, that the general equilibrium system is locally stable if $H < 0$. The rest of the analysis proceeds with this assumption on local stability.

Solving (6.1) for $\hat{q}$, we obtain

$$(6.2)\quad \hat{q} = \frac{\Delta + \varepsilon B\theta^A\lambda^A}{\varepsilon cH} m_S \cdot dS - \frac{\alpha\Delta + A\theta^M\lambda^A}{CH} C_S \cdot dS - \frac{A\theta^M - \alpha\varepsilon B\theta^A}{\varepsilon H} \beta \cdot dS.$$

From the above equation, we can see how tax-subsidy schemes affect the equilibrium production scale of each oligopolistic firm. It is decomposed into three general equilibrium effects corresponding to those terms in (6.2). We call them marginal cost effect, total cost effect, and factor substitution effect, respectively. Let us discuss the nature of these effects intuitively.

Marginal cost effect refers to the first term of (6.2). The coefficient of $m_S \cdot dS$ appears to be always negative, so that, other things being equal, a tax-subsidy scheme which brings down the marginal cost induces an expansion of the individual production scale in the oligopolistic industry. It is intuitively clear within a partial equilibrium framework that a reduction in the marginal cost increases the output of each oligopolist when firms are symmetric. Even when the general equilibrium repercussions are taken into account, such a partial equilibrium result proves to be also valid as long as the general equilibrium system is stable.

Total cost effect of a tax-subsidy scheme is represented by the second term of (6.2). Suppose total cost is increased by the introduction of tax-subsidy. On the one hand, output level of each oligopolistic firm rises because some firms exit from the industry (the excess entry theorem). On the other hand, output level is affected also by an induced change in the factor price ratio; if X industry is more capital (labour, resp.) intensive in the average sense, wage-rental ratio goes up (down, resp.). Thus, without factor intensity reversal, an increase in individual output of the oligopolists is enhanced, while it is offset or upset when there is factor intensity reversal.

Finally, the third term corresponds to factor substitution effect. A change in the relative factor price through substitution between factors affects production level of each oligopolistic firm by changing the marginal cost condition and the number of firms. For example, consider the introduction of subsidy on the wage expenditure component of marginal cost. Since it induces the oligopolistic firms to substitute capital for labour, wage-rental ratio must rise so as to adjust the factor market equilibrium. When X industry firms are marginally more capital intensive but totally more labour intensive, i.e., factor intensity reversal is prevailing, a rise in wage-rental ratio necessarily expands the output of each oligopolistic firm as some firms are forced out of the industry. Without factor intensity reversal, however, it is ambiguous whether each oligopolist's production increases or not.

The following two observations are worth emphasizing in search for welfare-improving tax-subsidy schemes. First, those schemes that reduce total cost, i.e., $C_S \cdot dS < 0$, may not lead to welfare improvement, because they always induce new entry to X industry. Second, total cost effect and factor substitution effect may conflict each other in obtaining unambiguous effect, for the former gives rise to an unambiguous change in q only without factor intensity reversal, while the latter only with factor intensity reversal.

We call a tax-subsidy scheme to be self-financing if $C_S \cdot dS = 0$ holds.Note also that $\beta \cdot dS = 0$ if and only if the tax-subsidy is of lump-sum category. It then follows from the previous remark that a tax-subsidy scheme induces an unambiguous welfare improvement only if it is either self-financing or of lump-sum variety.

Invoking theorem 1, we may now assert the following:

Theorem 3 (Welfare Improving Tax-Subsidy Schemes):
Suppose strategic substitutability, quasi-linear preferences, and local stability hold simultaneously. Then, any tax-subsidy scheme which belongs to the following four fundamental categories are always welfare-improving:

(1) $m_S \cdot dS < 0$, $C_S \cdot dS = 0$, $\beta \cdot dS = 0$

(2a) $m_S \cdot dS < 0$, $C_S \cdot dS = 0$, $\beta \cdot dS > 0$, in the case of $\theta^M > 0$ and $\theta^A < 0$

(2b) $m_S \cdot dS < 0$, $C_S \cdot dS = 0$, $\beta \cdot dS < 0$, in the case of $\theta^M < 0$ and $\theta^A > 0$

(3) $m_S \cdot dS = 0$, $C_S \cdot dS > 0$, $\beta \cdot dS = 0$, in the case of $\theta^M \theta^A > 0$.

A typical scheme that belongs to the category (1) is an infinitesimal production subsidy accompanied by a self-financing lump-sum tax. This scheme improves welfare independent of factor intensity conditions.[11/]

A typical scheme that belongs to the category (3) is a lump-sum tax, which improves welfare when factor intensity reversal does not occur. This result is parallel to Theorem 2. What is added to the oligopolists' profit under entry regulation is transformed into tax revenue of the government.

Welfare-improving tax-subsidy schemes that belong to categories (2a) and (2b) are more complex. They assure welfare improvement when there exists factor intensity reversal. To illustrate, consider the case where industry X is marginally more capital intensive but totally more labour intensive (category (2a)). Accompanied by self-financing lump-sum tax, the introduction of infinitesimal labour subsidy, applied to both fixed cost and marginal cost at a uniform rate, is welfare-improving; if $d\mathbf{S} = (0, ds_W, 0; dt, ds_W, 0)$ with $ds_W > 0$ and $dt = -(qm_W + F_W)ds_W$, it belongs to the category (2a).

Even when self-financing lump-sum tax is not available to the government, it is possible to construct a welfare-improving tax-subsidy scheme if the government can distinguish between factors used in the marginal cost part and the fixed cost part. In the case of (2a), an introduction of production subsidy accompanied by self-financing tax on the wage expenditure component of fixed cost warrants welfare improvement. An infinitesimal subsidy on the capital expenditure component of marginal cost accompanied by the same self-financing tax as above also satisfies (2a). Readers are invited to examine the types of tax-subsidy schemes which satisfy (2b).

7. Concluding Remarks

It goes without saying that the first-best policy in an oligopolistic economy such as ours is to simultaneously enforce the marginal cost pricing and control the number of firms at the optimal level. However, this first-best policy is likely to be beyond the reach of the government. Still there might remain a room for the second-best policy if the government, which is unable to control prices, can nevertheless control the number of firms to improve economic welfare.

In the first part of this paper, we reexamined the excess entry theorem by allowing general equilibrium interactions. The assumptions of strategic substitutability and of quasi-linear preferences, upon which our generalization rests, are rather standard. Our main finding is that the validity of the theorem hinges critically on whether or not factor intensity reversal exists. If there is factor intensity reversal, entry regulation in the oligopolistic industry may decrease welfare.

We also emphasized that such a direct entry regulation by the government may alter behaviour of the incumbents in the oligopolistic industry. For example, firms facing potential entry may act competitively, while they may collude under entry regulation. In the second part, we analysed conditions for tax-subsidy schemes to be welfare-improving.[12/] We believe that these indirect non-discriminatory government measures are better instruments to achieve the same goal. First, they are less discriminatory and more neutral to the market economy. Second, they do not distort income distribution between firms and consumers, especially when they are accompanied by self-financing taxes. The second half of our analysis delineates several types of subsidy schemes which are unambiguously welfare-improving.

We should emphasize, however, that our model is based on several drastically simplifying assumptions such as Cournot-Nash quantity competition, single consumer (neglecting all the distributional issues), and the specific form of increasing returns to scale via the existence of fixed cost. It should also be stressed that the identifying capital (and wage) expenditures on marginal and fixed costs, which can be easily defined in theory, may be far from being obvious in reality. The robustness of our results should be carefully examined before extracting any serious policy implications.

APPENDIX A: Derivation of (4.3) and/or (5.3)

We use the following notation:

[cost shares]

θ^M_{XL} (θ^M_{XK}) = wm_w/m (rm_r/m) : marginal cost share of labour (capital) in industry X,

θ^F_{XL} (θ^F_{XK}) = wF_w/F (rF_r/F) : fixed cost share of labour (capital) in industry X,

θ^A_{XL} (θ^A_{XK}) = $w(m_wq+F_w)/F$ ($r(m_rq+F_r)/F$) : total cost share of labour (capital) in industry X,

θ_{YL} (θ_{YK}) = wg_w/g (rg_r/g) : cost share of labour (capital) in industry Y.

[factor shares]

λ^M_{XL} (λ^M_{XK}) = nqm_w/L (nqm_r/K) : share of total labour (capital) used as variable input in industry X,

λ^F_{XL} (λ^F_{XK}) = nF_w/L (nF_r/K) : share of total labour (capital) used as fixed input in industry X,

λ^A_{XL} (λ^A_{XK}) = L_X/L (K_X/K) : share of labour (capital) used in industry X,

λ_{YL} (λ_{YK}) = L_Y/L (K_Y/K) : share of labour (capital) used in industry Y.

[elasticities of substitution]

$\sigma^M_X = -(\hat{m}_w-\hat{m}_r)/\hat{\omega}$: elasticity of substitution between variable inputs in industry X,

$\sigma^F_X = -(\hat{F}_w-\hat{F}_r)/\hat{\omega}$: elasticity of substitution between fixed inputs in industry X,

$\sigma_Y = -(\hat{g}_w-\hat{g}_r)/\hat{\omega}$: elasticity of substitution in industry Y.

Total differentiation of (2.9) and (2.10) yields

$$\text{(A.1)}\quad \lambda_{XK}^{M}\hat{q} + \lambda_{XK}^{A}\hat{n} + \lambda_{YK}\hat{Y} - (\lambda_{XK}^{M}\theta_{XL}^{M}\sigma_{X}^{M} + \lambda_{XK}^{F}\theta_{XL}^{F}\sigma_{X}^{F} + \lambda_{YK}\theta_{YL}\sigma_{Y})\hat{\omega}$$
$$= \lambda_{XK}^{M}\theta_{XL}^{M}\sigma_{X}^{M}(\tfrac{1}{w}ds_{w} - \tfrac{1}{r}ds_{r}) + \lambda_{XK}^{F}\theta_{XL}^{F}\sigma_{X}^{F}(\tfrac{1}{w}dt_{w} - \tfrac{1}{r}dt_{r})$$

and

$$\text{(A.2)}\quad \lambda_{XL}^{M}\hat{q} + \lambda_{XL}^{A}\hat{n} + \lambda_{YL}\hat{Y} - (\lambda_{XL}^{M}\theta_{XK}^{M}\sigma_{X}^{M} + \lambda_{XL}^{F}\theta_{XK}^{F}\sigma_{X}^{F} + \lambda_{YL}\theta_{YK}\sigma_{Y})\hat{\omega}$$
$$= -\lambda_{XL}^{M}\theta_{XK}^{M}\sigma_{X}^{M}(\tfrac{1}{w}ds_{w} - \tfrac{1}{r}ds_{r}) - \lambda_{XL}^{F}\theta_{XK}^{F}\sigma_{X}^{F}(\tfrac{1}{w}dt_{w} - \tfrac{1}{r}dt_{r}),$$

respectively. Eliminating $\hat{Y}$ from the above two equations, we obtain:

$$\text{(5.3)}\quad \lambda^{M}\hat{q} + \lambda^{A}\hat{n} + \Delta\hat{\omega} = \mathbf{B}\cdot d\mathbf{S},$$

where $\lambda^{M} = \lambda_{XK}^{M}\lambda_{YL} - \lambda_{XL}^{M}\lambda_{YK} = \frac{1}{K}\lambda_{XL}^{M}\lambda_{YL}\{(m_{r}/m_{w}) - (K_{Y}/L_{Y})\}$,

$\lambda^{A} = \lambda_{XK}^{A}\lambda_{YL} - \lambda_{XL}^{A}\lambda_{YK} = \frac{1}{K}\lambda_{XL}^{A}\lambda_{YL}\{(K_{X}/L_{X}) - (K_{Y}/L_{Y})\}$,

$\Delta = \Delta^{M} + \Delta^{F} + \lambda_{YL}\lambda_{YK}\sigma_{Y}$,

$\Delta^{M} = \lambda_{XL}^{M}\lambda_{YK}\theta_{XL}^{M} + \lambda_{XK}^{M}\lambda_{YL}\theta_{XK}^{M}$ and $\Delta^{F} = \lambda_{XL}^{F}\lambda_{YK}\theta_{XL}^{F} + \lambda_{XK}^{F}\lambda_{YL}\theta_{XK}^{F}$.

Taking $d\mathbf{S} = \mathbf{0}$ yields (4.3) and this completes the derivation of (4.3) and (5.3).

APPENDIX B: Local Stability of the System

To simplify the stability analysis, we assume that the wage and the rental rate are adjusted instantly to equate the demand and supply for factors. Similarly, the market for Y is assumed to be cleared immediately. Thus, (2.3), (2.9) and (2.10) always hold on any adjustment path. We further assume that $\mathbf{S}=0$.

We denote by ω^{*}, q^{*} and n^{*} the equilibrium value of the wage rental ratio, the individual production scale of oligopolists and the number of firms, respectively. Assumptions on the adjustment process in the markets for factors and for good Y warrants:

$$\text{(B.1)}\quad \frac{\omega - \omega^{*}}{\omega^{*}} = -\frac{1}{\Delta}\{\lambda^{M}\frac{q - q^{*}}{q^{*}} + \lambda^{A}\frac{n - n^{*}}{n^{*}}\},$$

(B.2) $p_Y = g(w, r)$

hold in the neighbourhood of equilibrium.

Define next a dynamic adjustment process by:

$$\text{(B.3)} \qquad \dot{q} = \kappa\{\Phi(nq)(1 - \frac{1}{n\varepsilon}) - \frac{m(w,r,\mathbf{0})}{g(w,r)}\}$$

$$\text{(B.4)} \qquad \dot{n} = \eta\{\Phi(nq)q - \frac{m(w,r,\mathbf{0})}{g(w,r)}q - \frac{F(w,r,\mathbf{0})}{g(w,r)}\},$$

where $\dot{q}$ and $\dot{n}$ denote the time derivative of q and n, and $\kappa>0$ and $\eta>0$ are adjustment coefficients.

Linearly approximating (B.3) and (B.4) around the free entry equilibrium and using (B.1), we obtain

$$\text{(B.5)} \qquad \dot{q} = \kappa^*\{(-\frac{1}{\varepsilon} - \frac{A}{\Delta}\theta^M\lambda^M)\frac{q - q^*}{q^*} + (-\alpha - \frac{A}{\Delta}\theta^M\lambda^A)\frac{n - n^*}{n^*}\},$$

$$\text{(B.6)} \qquad \dot{n} = \eta^*\{(-\frac{n^*-1}{n^*\varepsilon} - \frac{B}{\Delta}\theta^A\lambda^M)\frac{q - q^*}{q^*} + (-\frac{1}{\varepsilon} - \frac{B}{\Delta}\theta^A\lambda^A)\frac{n - n^*}{n^*}\},$$

where $\kappa^* = \kappa\Phi(n^*q^*)(1 - \frac{1}{n^*\varepsilon}) > 0$ and $\eta^* = \eta\Phi(n^*q^*)q^* > 0$. Observe from these adjustment equations that the equilibrium is locally stable if

$$-\frac{1}{\varepsilon} - \frac{A}{\Delta}\theta^M\lambda^M < 0$$

and

$$-\frac{H}{\Delta} = (-\frac{1}{\varepsilon} - \frac{A}{\Delta}\theta^M\lambda^M)(-\frac{1}{\varepsilon} - \frac{B}{\Delta}\theta^A\lambda^A) - (-\alpha - \frac{A}{\Delta}\theta^M\lambda^A)(-\frac{n^*-1}{n^*\varepsilon} - \frac{B}{\Delta}\theta^A\lambda^M) > 0.$$

First inequality is always satisfied. Hence H < 0 is sufficient for local stability of the equilibrium.[13/]

FOOTNOTES

1/ The existing literature on the tax analysis in an imperfectly competitive economy includes Anderson and Ballentine [1976], Atkinson and Stiglitz [1980, Lecture 7], Besley and Suzumura [1988], Higgins [1959], Katz and Rosen [1985], Robinson [1933, Ch.5], Seade [1985] and Stern [1987], among others.

2/ Quasi-linearity is a strong assumption which makes our analysis almost a partial equilibrium analysis. However, this setup still allows us to discuss key general equilibrium adjustments in factor markets, which are the crucial element of our analysis, in a straightforward way. In fact, weakening her preference to being homothetic will not alter any essential result of this paper as we showed in Konishi, Okuno-Fujiwara and Suzumura [1988]. This paper is available to any interested reader on request.

3/ The assumption of constant elasticity is made only to simplify our presentation. Our results are valid even without the assumption as is clearly seen in Konishi, Okuno-Fujiwara and Suzumura [1988].

4/ Throughout this paper, a subscript to a function signifies partial derivative with respect to the specified variable. For example, if the relevant function is f(x,y), we denote $f_x = \partial f/\partial x$, $f_{xy} = \partial^2 f/\partial x \partial y$, and so on.

5/ For any variable x, we denote $\hat{x} = dx/x$.

6/ See also Atkinson and Stiglitz [1980] and Kotlikoff and Summers [1987] for useful survey.

7/ Note that, in the derivation of (4.1), the homogeneity property of cost function is used.

8/ The distinction between marginal and average factor intensity is due originally to Jones [1968].

9/ Formal derivation of (5.3) is contained in Appendix A.

10/ For the introduction of non-infinitesimal tax-subsidy scheme, see Atkinson and Stiglitz [1980, ch.5] and the papers cited there.

11/ Though our analysis here is confined to the class of infinitesimal schemes, a combination of non-infinitesimal production subsidy and self-financing lump-sum tax appears to attain the first-best resource allocation. See Konishi [1988].

12/ The second-best tax-subsidy scheme, rather than welfare-improving infinitesimal tax-subsidy schemes, is analysed in Konishi [1988].

13/ Note that the asterisks are omitted in the main text.

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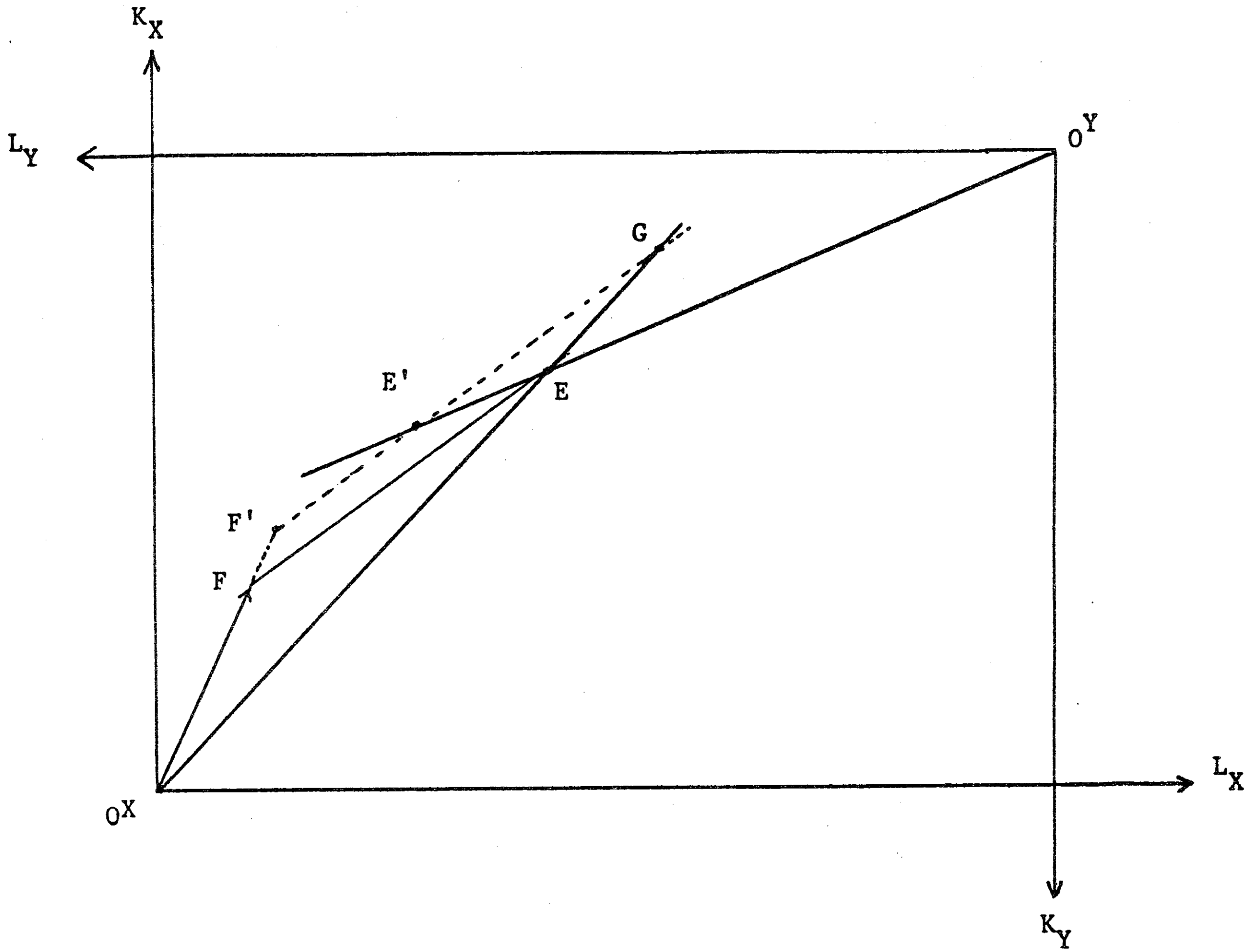

Figure 1a

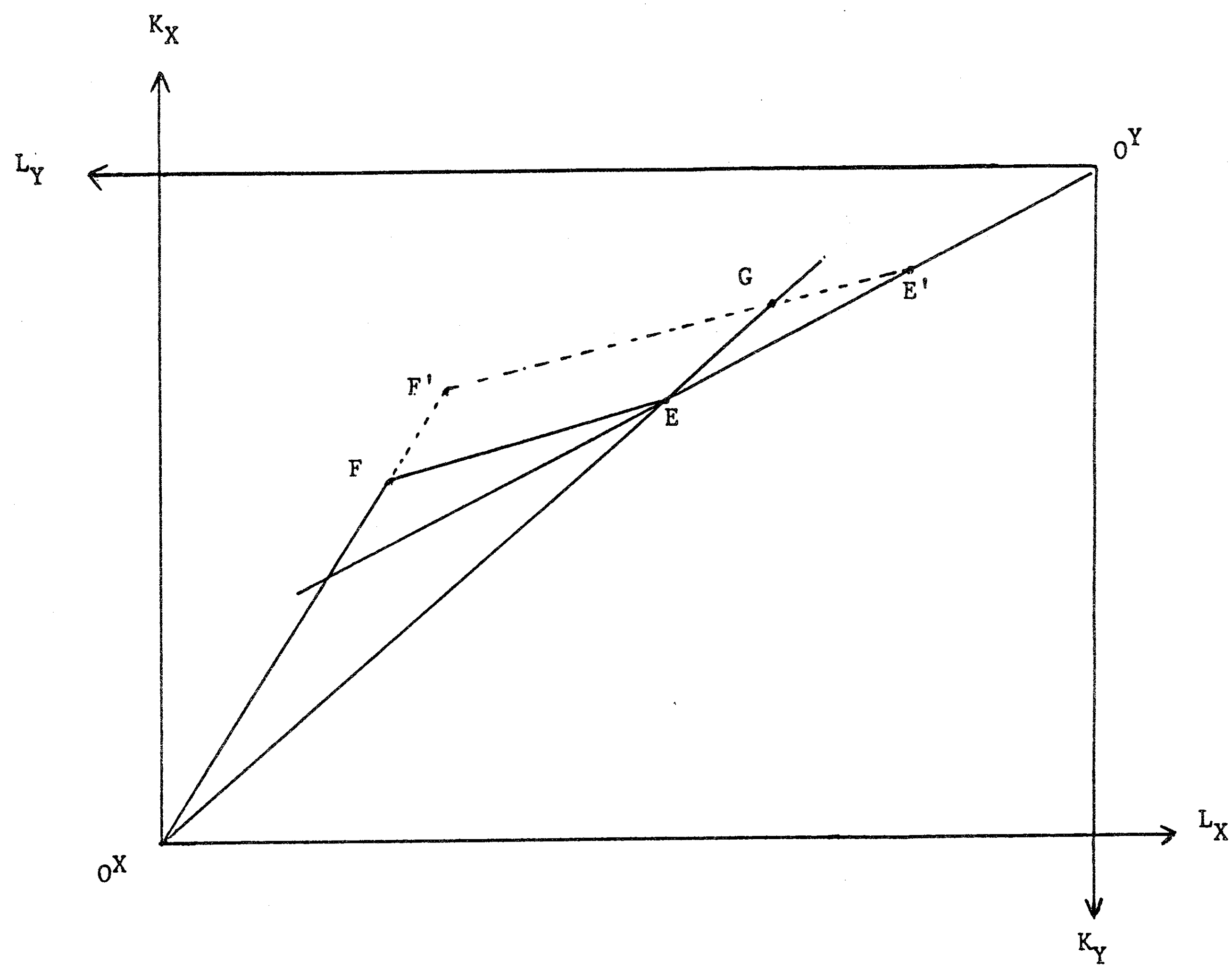

Figure 1b

FIGURE 2