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INTERNATIONAL TRADE IN IDENTICAL COMMODITIES; COURNOT EQUILIBRIUM WITH FREE ENTRY

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ABSTRACT

The paper analyses intra-industry trade between economies containing an imperfectly competitive industry in which firms produce a homogeneous output, production is subject to increasing returns to scale, and there is free entry and exit of firms. Trade is shown to unambiguously increase welfare by reducing the degree of monopoly in each market, and increasing firm size. The effects of differences in technology and endowments on the pattern of trade and welfare are examined. Import tariffs are shown to raise welfare in the country employing the tariff, and the welfare implications of various types of industry subsidy are examined.

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SUMMARY

This paper analyses international trade between economies each containing an imperfectly competitive industry. All the firms in this industry produce an identical output under conditions of increasing returns to scale. Firms may enter and exit from the industry in response to profits, and the presence of increasing returns ensures that there are only a finite number of firms, each with some degree of monopoly power. Opening such economies to trade generally involves intra-industry trade. This unambiguously raises social welfare in both countries, despite the fact that resources appear to be wasted in cross-trading the same product. The welfare gains are due to the fact that trade reduces the degree of monopoly in each country and induces firms to increase output. This reduces average costs of the firm, since it can benefit from increasing returns to scale.

The division of the gains from trade depends on the two countries' relative size, technical efficiency, and tax and subsidy policy. It is established that the gains from trade are greater for a country which is large relative to its trading partner, and for a country with superior technology in its imperfectly competitive industry.

What are the effects of a positive import tariff? If retaliation does not occur, then such a tariff raises welfare in the country imposing the tariff. How does this come about? The import tariff is effectively a tax on foreign firms. They respond to this tax by reducing their output and this raises their costs (because of increasing returns to scale). Firms in the country imposing the tariff, on the other hand expand their output and this reduces their average costs.

What effect does a subsidy of domestic industry have? This depends on the nature of the subsidy employed. If the domestic producers receive a subsidy to their marginal cost of producing

output, this encourages firms to expand output and reduces their average cost, because of economies of scale. Foreign producers contract their output on the other hand and experience increasing average costs. However, a subsidy to fixed costs may not be desirable, since it reduces returns to scale for the firm, and so may be associated with a reduction in firm size. In this case the social average cost of production for the country employing the subsidy rises, reducing this country's welfare.

1. Introduction; This paper analyses trade between two countries each of which has an imperfectly competitive industry in which production takes place with increasing returns to scale. All firms in this industry produce a homogeneous output, and firms are assumed to make Cournot conjectures about their rivals' output. Hence, if they have non-infinitesmal market shares they perceive some monopoly power, and consequently choose output levels such that price exceeds marginal cost. The number of active firms in each economy is taken to be endogenously determined by the entry and exit of firms in response to profits. The number of firms is then determined essentially by the size of the market and the extent of increasing returns to scale. If such economies are opened to trade then, in general, each economy will both import and export the same product. Trade changes the size of the market so changing both the number of firms producing in each economy, and the number supplying each market. This change in the degree of concentration in each economy is associated with a change in the equilibrium price of output, and hence a change in welfare in each economy.

The model set out in this paper is similar to those of Brander [1981], Brander and Krugman [1980], and Dixit [1983], in that firms in each country follow Cournot behaviour and produce identical commodities, so giving rise to two way trade in identical commodities. However, these studies assume that the number of firms in each economy is arbitrarily fixed, and unchanged by trade. The welfare implications of trade when the number of firms is endogenously determined by free entry has been considered by Dixit and Norman [1980] and Brander and Krugman [1983], who point out that, with free entry, trade unambiguously increases welfare. This paper extends analysis of the trading equilibrium with free entry in several directions. In section 2 of the paper the model is set out, and a diagrammatic illustration of the equilibrium for the special case of linear demands is constructed in section 3. Section 4 undertakes a comparison of trade with autarky. The result concerning the welfare gains from trade is established, and the effect of trade on the number of firms and the degree of concentration is examined. Section 5 analyses the implications of differences between the two economies for the trading equilibrium. Differences in country size and technology are examined, and their implications for the pattern of trade and for welfare levels are established. Section 6 studies tariff and subsidy policy towards the imperfectly competitive industry. The desirability of positive tariffs is established, and the relative efficacy of different subsidy instruments is examined. Section 7 of the paper presents conclusions.

2. The model; The two economies will be labelled by subscripts $i = 1, 2$, and each economy has a single factor of production which produces, under conditions of constant returns to scale, a tradeable composite commodity. This commodity will be taken as the numeraire in both economies, so fixing the exchange rate between the two economies at unity. Additionally, each economy has an imperfectly competitive industry which produces a tradeable commodity under conditions of increasing returns to scale. The price of this commodity in country i will be denoted p_i, and the quantity sold Q_i. The

demand function takes the form,

$$Q_i = s_i q_i(p_i), \qquad q_i'(p_i) < 0, \qquad i = 1, 2, \tag{1}$$

where s_i is a parameter measuring the size of the market in country i.

The commodity may be supplied by firms from either the domestic or the foreign imperfectly competitive industry. It will be assumed that firms within each economy are identical, so if n_i is the number of firms in country i, y_i denotes a single reprentative firm's sales to the domestic market, and x_i denotes its exports then,

$$Q_i = n_i y_i + n_j x_j \qquad i, j = 1, 2, \quad i \neq j. \tag{2}$$

The quantities sold domestically and exported are chosen by firms to maximise profits. Firms have increasing returns to scale which are modelled by assuming that firms in country i have fixed cost f_i, and constant marginal cost c_i. Additionally it will be assumed that exports from i to j incur transport costs of t_i per unit. The profits of a firm in country i, denoted Π_i, are then given by,

$$\Pi_i = (p_i - c_i)y_i + (p_j - c_i - t_i)x_i - f_i. \tag{3}$$

It will be assumed that firms follow Cournot bahaviour, and are able to price discriminate between markets. If $Q_i(-)$ denotes the total supply of other firms to market i, then, by definition,

$$\begin{aligned} y_i &= s_i q_i(p_i) - Q_i(-) \\ x_j &= s_j q_j(p_j) - Q_j(-), \end{aligned} \tag{4}$$

and each firm chooses quantities y_i and x_i to maximize profits, holding $Q_i(-)$ and $Q_j(-)$ constant, but incorporating price changes through equations (4). The solution to this problem gives optimally chosen supplies,

$$(5) \qquad y_i = - s_i q_i'(p_i)(p_i - c_i) \geq 0$$

$$i, j = 1, 2, i \neq j.$$

$$(6) \qquad x_i = - s_j q_j'(p_j)(p_j - c_i - t_i) \geq 0.$$

If the equilibrium price is less than marginal cost (where appropriate, inclusive of transport costs), then the optimal supply is of course zero. Notice that if $c_i < c_j + t_j$ then $y_i > x_j$. Firms with different costs can survive in the same market as higher cost firms sell smaller quantities, and therefore perceive a more elastic demand curve.

The number of firms in each market adjusts in response to profits. At industry equilibrium, active firms make non-negative profits, but the entry of one further firm reduces profits below zero. If the number of active firms in a country is positive, this industry equilibrium condition will be expressed by setting the maximised profits of firms in that country equal to zero. If the number of active firms is zero, then profits are less than or equal to zero. Denoting maximised profits Π_i^*, and using equations (5) and (6) in (3), this gives,

$$(7) \qquad \Pi_i^* = - s_i q_i'(p_i)(p_i - c_i)^2 - s_j q_j'(p_j)(p_j - c_i - t_i)^2 - f_i \leq 0, \quad n_i \geq 0,$$

$$\text{complementary slack,} \qquad i, j = 1, 2, i \neq j,$$

where it is understood that the first two terms on the right hand side of (7) contain only positive parts. Setting maximised profits precisely equal to zero ignores the fact that the number of firms can only take on integer values, but is an approximation which will be good if the number of firms is large.

The number of active firms in each economy may be obtained explicitly from equations (2). We have, if $n_i > 0$,

$$(8) \qquad n_i = (y_j Q_i - x_j Q_j)/(y_1 y_2 - x_1 x_2).$$

and if $n_i = 0$,

$$n_j = Q_j/y_j = Q_i/x_j, \qquad i, j = 1, 2, \quad i \neq j.$$

Equations (1), (5), (6), (7), and (8) are ten equations in the unknowns n_i, Q_i, x_i, y_i, and p_i, $i = 1, 2$, and their solution is the equilibrium of the model. Notice that if the number of active firms is positive in both economies, the system is simplified considerably. Equilibrium prices can then be found directly from equations (7).

4. Linear demands. The equilibrium of the model may be illustrated most simply for the special case of linear demands. The demand functions will, for simplicity, be assumed to be the same in both countries, and will be written as,

$$(1') \qquad Q_i(p_i) = s_i\{D - p_i\} \qquad i = 1, 2,$$

where the coefficient of p_i has been normalized at unity. With these demand functions the supply equations (5) and (6), and the industry equilibrium conditions (7) become,

$$(5') \qquad y_i = s_i(p_i - c_i),$$

(6') $$x_i = s_j(p_j - c_i - t_i),$$

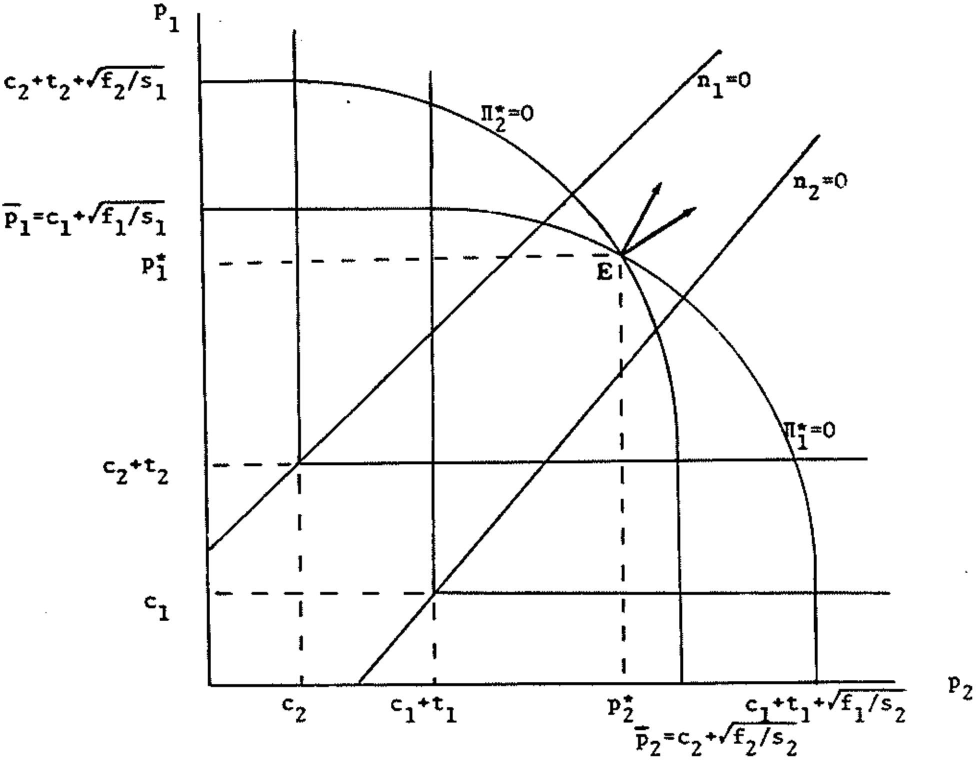
(7') $$\Pi_i^* = s_i(p_i - c_i)^2 + s_j(p_j - c_i - t_i)^2 - f_i \leqslant 0$$
$$n_i \geqslant 0$$
complementary slack, $\quad i, j = 1, 2, \quad i \neq j.$

Using (1'), (5') and (6') in equations (8) we find that $n_i = 0$ when,

(9) $$p_i\{D - c_j\} = p_j\{D - c_j - t_j\} + Dt_j.$$

This linear case may be readily illustrated diagrammatically, and since (7') are the equations of ellipses, the diagrams may easily be made precise. The model is illustrated on figure 1, which is drawn for the special case in which the two economies are symmetric, i.e., have the same size, technology and preferences.

The curves labelled $\Pi_1^* = 0$, $\Pi_2^* = 0$ are the zero profit loci for firms in each country. For the symmetric case they are circles centred at $(c_i, c_i + t_i)$ with radius $\sqrt{f_i/s_j}$. Along $\Pi_1^* = 0$ lower values of p_2 are associated with higher values of p_1 until $p_2 \leqslant c_1 + t_1$. At this point the contribution of exports to the profits of firms in country 1 is zero, so that firms in 1 cover their fixed costs from the domestic market alone, and do not export. $\bar{p}_1$ is therefore the autarky price in country 1. The relative magnitudes of a firm's domestic and export sales are illustrated on figure 1 by the gradients of the normals to the zero profit loci. This may be seen by totally differentiating (7') and using (5') and (6') to give the normal to Π_1^* gradient y_1/x_1, and the normal to Π_2^* gradient x_2/y_2. The lines labelled $n_1 = 0$, $n_2 = 0$ are obtained from equations (9). It can be shown that in the region between



p1
c2+t2+√f2/s1
p̄1=c1+√f1/s1
p1*
c2+t2
c1
Π2*=0
n1=0
n2=0
E
Π1*=0
p2
c2
c1+t1
p2*
c1+t1+√f1/s2
p̄2=c2+√f2/s2

Figure 1.

these lines both n_1 and n_2 are positive, whereas above $n_1 = 0$ we have $n_2 > 0$ and $n_1 = 0$. For this linear example it is of course the case that $n_1 = n_2 = 0$ at price $p_1 = p_2 = D$.

As illustrated in figure 1, the equilibrium of the model is at the point E, with prices p_1^*, p_2^*. At this point both countries have active firms and there is intra-industry trade. This remains true as parameters are varied, provided that the intersection of the zero profit loci, E, remains between $n_1 = 0$ and $n_2 = 0$. Notice that at all such equilibria the zero profit loci cross in the direction illustrated, so $y_1/x_1 > x_2/y_2$, that is, comparing a single firm from each country, each firm has a relatively larger share of its home market than it has of its export market.

If the model is perturbed such that the point E no longer lies between $n_1 = 0$ and $n_2 = 0$, then the nature of the equilibrium changes. Suppose E lies above $n_1 = 0$. The equilibrium is then at the intersection of $n_1 = 0$ with $\Pi_2^* = 0$. At this point $\Pi_1^* < 0$, production of the commodity under consideration is concentrated entirely in country 2, and there is no intra-industry trade.

Figure 1 is used to illustrate a number of arguments developed in the remainder of the paper. Although constructed for linear demand curves the basic structure of figure 1 generalizes, and this generalization is discussed in section 5 below.

4. Trade compared to autarky; A welfare comparison of trade and autarky is straightforward. Since there are no profits nor

any other type of transfer income, price is an (inverse) index of social welfare. We therefore have the following proposition.

Proposition 1. Welfare cannot be lower under free trade than under autarky, and for almost all parameter values is higher.

The proposition is proved by inspection of equation (7). $p_i > \bar{p}_i$ could not be an equilibrium as firms in country i would certainly be making positive profits. Examples can be constructed where $p_i = \bar{p}_i$ at equilibrium, but these occur only in a subset of parameter values of measure zero. The proposition is of course illustrated by figure 1.

Several remarks may be made about proposition 1. In this model trade involves what is, superficially, a totally unproductive activity, the cross-hauling of identical commodities, and since there are transport costs, this cross-hauling has a real resource cost. However, despite the fact that trade is costly, it increases welfare. The intuition here is that exporting will be undertaken by a firm only if it yields non-negative profits, and therefore (to maintain the zero profit condition), exporting must reduce price in the domestic market. Notice that because of zero profits this price reduction is also a reduction in average costs of supply. The welfare result of proposition 1 may be contrasted with the case when the number of firms is fixed (see Brander and Krugman [1980]). The welfare effects of trade cannot then be unambiguously signed. Trade reduces price, but may, because of competition from imports, reduce the profits of firms, so creating the possibility of a net welfare reduction. The essential difference between the two cases is that, when n_i adjusts we can be certain that trade reduces both price and average cost of supply. However, if n_i is fixed then transport costs may increase the average cost of supplying the commodity, and (despite the benefits associated with the reduction in prices), reduce welfare.

The reduction in prices remains consistent with profit maximization because trade reduces the degree of monopoly power in each market, thereby reducing the profit maximizing differential between price and marginal cost. This reduction in concentration may be investigated further by considering the number of active firms at the autarky equilibrium, and at the equilibrium with trade. Variables at the autarky equilibrium will be denoted $\bar{}$, so, from equations (5) and (8),

$$(10) \qquad \bar{n}_i = \bar{Q}_i/\bar{y}_i = -\bar{q}_i/\bar{q}_i'(\bar{p}_i - c_i)$$

If the two countries have identical size, technology and preferences the trading equilibrium will be symmetric, and each country will have n_i firms given by (from (5) and (8)),

$$(11) \qquad n_i = Q_i/(y_i + x_i) = -q_i/q_i'\{2(p_i - c_i) - t_i\}.$$

Defining the price elasticity of demand as $\varepsilon_i(p_i) = -p_i q_i'/q_i$ gives,

$$(12) \qquad \bar{n}_i = \bar{p}_i/\bar{\varepsilon}_i(\bar{p}_i - c_i)$$

and

$$(13) \qquad n_i = p_i/\varepsilon_i\{2(p_i - c_i) - t_i\}$$

Comparison of these two equations, noting that $p_i < \bar{p}_i$, gives the following proposition.

Proposition 2. If the two countries are identical, and $\varepsilon_i(p_i)$ is a non-decreasing function of p_i, then trade increase the total number of firms supplying each market, i.e., $2n_i > \bar{n}_i$.

The proviso that ε_i be a non-decreasing function of p_i is necessary because, if ε_i were to increase significantly as a consequence of the reduction in prices associated with trade, then the degree of monopoly power possessed by each firm would decrease independently of the number of firms in each market.

Proposition 2 establishes that the number of firms supplying each market is increased by trade. Even in the case where the two economies are identical we cannot however establish the effect of trade on the number of firms producing in each economy. Firm size is certainly increased by trade (since price is reduced, and average costs are a decreasing function of size), but, since price has fallen, the size of the market has increased. Without restricting the magnitude of the elasticity of demand, the number of firms producing may be either increased or decreased by trade.

5. Differences in endowments and technology. The remainder of the paper examines the effect on the equilibrium of small changes in parameters of the model. In this section comparative static techniques are used to examine the implications of differences between the two economies for the

pattern of trade and for welfare levels in each country. To undertake the comparative static analysis we may consider first the effect of price changes on firms' supplies. Defining the variable $a_i(p_i)$ as,

$$(14) \qquad a_i(p_i) = q_i''(p_i)/q_i'(p_i)^2 \qquad i = 1, 2.$$

we have, from firms' supply functions (5) and (6),

$$(15) \qquad \partial y_i/\partial p_i = q_i'(p_i)\{a_i(p_i)y_i/s_i - 1\} \qquad i = 1, 2.$$

$$(16) \qquad \partial x_i/\partial p_j = q_j'(p_j)\{a_j(p_j)x_i/s_j - 1\} \qquad i,j = 1,2,\ i \neq j.$$

We shall assume that each of these terms are positive, i.e.,

$$(17) \qquad 1 > a_i(p_i)y_i/s_i, \qquad 1 > a_j(p_j)x_i/s_j.$$

These conditions imply that the marginal revenue of each firm decreases as the output of any other firm supplying the same market increases, and are of course the Hahn [1962] stability conditions. We shall also assume that demand curves are convex, so $a_i(p_i) > 0$, for $i = 1, 2$.

Throughout this section it will be assumed that both countries' imperfectly competitive industries contain a positive number of active firms. Equilibrium prices are then given directly by the zero maximised profit equations, (7). The response of equilibrium prices to exogenous changes may be obtained by totally differentiating these equilibrium conditions. If an exogenous change to the right hand side of equations (7) is denoted $d\Phi_i$, then,

$$
(18) \quad \begin{bmatrix} -d\Phi_1 \\ \\ -d\Phi_2 \end{bmatrix} = \begin{bmatrix} (2-a_1y_1/s_1)y_1 & (2-a_2x_1/s_2)x_1 \\ \\ (2-a_1x_2/s_1)x_2 & (2-a_2y_2/s_2)y_2 \end{bmatrix} \begin{bmatrix} dp_1 \\ \\ dp_2 \end{bmatrix}
$$

Each element of the above matrix is positive, and it will be assumed that the determinant of the matrix is positive. This assumption is of couse crucial in signing comparative static changes, and may be interpreted as follows. Consider first a case in which demand curves in each country are linear, so $a_i = 0$. The determinant is then positive if $y_1/x_1 > x_2/y_2$, that is, if comparing a single firm from each country, the firm from country 1 has a relatively larger share of country 1's market than it has of country 2's. If $a_i > 0$, then, (with inequalities (17)), a sufficient condition for the determinant to be positive is that $y_i > x_j$, $i, j = 1, 2, i \neq j$. This states that there is a `home market bias' such that in each market the sales of a single domestic firm exceed those of a single exporting firm. As discussed above, these conditions will certainly be satisfied if (from (5) and (6)), $c_i < c_j + t_j$, $i, j = 1, 2$. The force of the assumption is of course to ensure that the zero profit loci intersect in the configuration illustrated at point E on figure 1.

The effects on trade and welfare of differences in the technologies of firms in the two countries may now be examined. Suppose there is some technical improvement in country 1. Technical change in country 1 has no direct effect on the profits of firms in country 2, so $d\,\Phi_2 = 0$. Inspection of the maximised profit equations (7), together with supply equations (5) and (6), indicates that, at unchanged relative prices, the impact effect of a reduction in either fixed or marginal costs of firms in country 1 is to raise the profits of firms in country 1 according to,

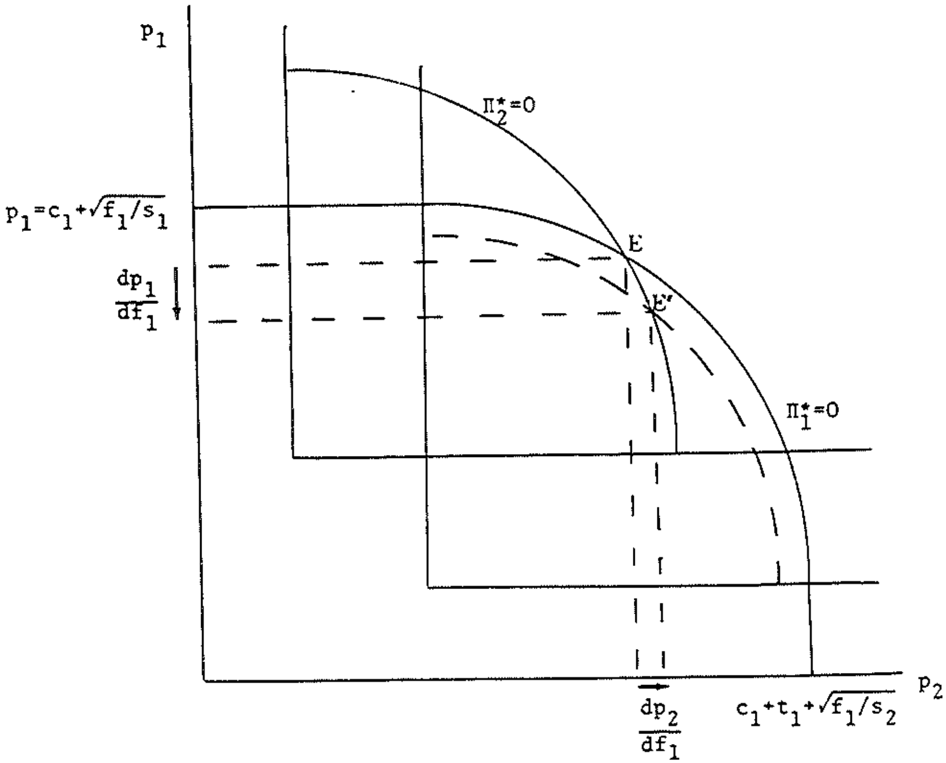
$$d\Phi_1 = -2(y_1 + x_1)dc_1$$

$$d\Phi_1 = -df_1.$$

Profits are restored to zero by changes in the numbers of firms, and the associated price changes required to restore equilibrium are found by using $d\Phi_1$ and $d\Phi_2$ in equations (18). By Cramer's rule we have immediately, $dp_1/dc_1 > 0$, $dp_1/df_1 > 0$, $dp_2/dc_1 < 0$, $dp_2/df_1 < 0$, and, since price is an inverse index of welfare, the following proposition.

Proposition 3. Technical progress in country 1 raises welfare in country 1 and reduces welfare in country 2.

Proposition 3 is illustrated on figure 2, which is constructed in the same way as figure 1. Suppose the technical change takes the form of a reduction in f_1. The radius of the quadrant $\Pi_1^* = 0$ is then reduced, so raising the equilibrium value of p_2 and reducing the equilibrium p_1 with the welfare implications described in the proposition. We may use this diagram to compare the effects of the technical change (and hence technical differences) under trade and under autarky. Under autarky a reduction in fixed costs in country 1 reduces p_1 by an amount equal to the change in radius of the quadrant $\Pi_1^* = 0$, and leaves p_2 unchanged. With trade, inspection of figure 2 demonstrates that not only does technical change in 1 raise p_2, but it also reduces p_1 by more than the change in



p_1
$\Pi_2^*=0$
$p_1=c_1+\sqrt{f_1/s_1}$
E
$\frac{dp_1}{df_1}$
E'
$\Pi_1^*=0$
p_2
$\frac{dp_2}{df_1}$
$c_1+t_1+\sqrt{f_1/s_2}$

Figure 2.

radius, and therefore by more than under autarky. International trade therefore has the effect of magnifiying welfare differences associated with differences in technology, and ensuring that the gains from trade are relatively greater for the country with superior technology. The reason for this is essentially that, with trade, firms in the country with superior technology can expand at the expense of foreign firms, so moving down and along their average cost curves, and forcing foreign firms back and up their average cost curves.

The quantity changes associated with the technical change may be examined as follows. Country 1's net exports of the commodity under consideration are $n_1x_1 - n_2x_2$ which may, using (8), be written as,

$$\text{(19)} \qquad n_1x_1 - n_2x_2 = \left[\frac{x_1x_2}{y_1y_2 - x_1x_2}\right]\left[Q_1\left\{\frac{y_2}{x_2} + 1\right\} - Q_2\left\{\frac{y_1}{x_1} + 1\right\}\right]$$

The following proposition may now be obtained.

> Proposition 4. If one country has lower costs in its imperfectly competitive industry than the other, then the low cost country is a net exporter of the output of its imperfectly competitive industry.

The proposition is proved by noting that $\partial Q_i/\partial p_i < 0$, and, from equations (15) and (16), $\partial y_i/\partial p_i > 0$ and $\partial x_i/\partial p_j > 0$. For $dp_1 < 0$ and $dp_2 > 0$ and evaluating changes around the symmetric equilibrium, we certainly have,

$$n_1x_1 - n_2x_2 > 0.$$

Notice that the proposition evaluates intra-industry trade in physical units. However, the commodity under consideration is also relatively cheaper in the economy with the superior technology, so this country's exports have higher price than do its imports. In value terms the proposition is therefore reinforced.

We may now analyse the implications of size differences for the equilibrium. A change in the size of the market for the imperfectly competitive commodity in country 1 is represented by a change in s_1. This affects the profits of firms in both countries, so differentiating the equilibrium conditions (7), and using firms' supply functions, equations (5) and (6), we obtain.

$$d\Phi_1 = -(y_1/s_1)^2 ds_1/q_1'$$
$$d\Phi_2 = -(x_2/s_1)^2 ds_1/q_1'.$$

The effects of these changes on the equilibrium are obtained by using equations (18) and Cramer's rule. If the determinant of the matrix of coefficients is denoted Δ, we obtain,

$$\text{(20)} \qquad \frac{dp_1}{ds_1} = \frac{1}{\Delta q_1' s_1^2}\left[\left(2 - \frac{a_2 y_2}{s_2}\right) y_1^2 y_2 - \left(2 - \frac{a_2 x_1}{s_2}\right) x_1 x_2^2\right]$$

$$\text{(21)} \qquad \frac{dp_2}{ds_1} = \frac{2 y_1 x_2 (x_2 - y_1)}{\Delta q_1' s_1^2}$$

$y_1 > x_2$ is clearly sufficient for $dp_2/ds_1 > 0$ since $q_1' < 0$ and $\Delta > 0$. $y_i > x_j$ can also be shown to be suficient to ensure that $dp_1/ds_1 < 0$. We therefore have the following proposition.

Proposition 5. If $y_i > x_j$, growth of country 1's market raises welfare in country 1 and reduces welfare in country 2.

The change in market size in country 1 may of course be caused by a number of different factors. It may be noted that if the change is due to population growth then, because p_1 has fallen, per capita welfare in country 1 is increased. We have therefore established that, if economies differ only in size, per capita utility is higher in the country with the larger population.

A further corollary of proposition 5 is that, if countries differ only in size, a country's gains from trade are smaller, the larger is its trading partner.

The effect of size differences on the direction of net intra-industry trade cannot be unambiguously signed. This is because a change in s_1 changes demands and supplies directly (see equations (1), (5), and (6)), and these effects may outweigh changes induced through price movements. However, the effects of size differences on relative degrees of import penetration in each market may be readily obtained as follows. The share of imports in country i is $n_j x_j / Q_i$ and using (8), we have,

$$(22) \qquad \frac{n_1 x_1}{Q_2} - \frac{n_2 x_2}{Q_1} = \frac{x_1 x_2}{y_1 y_2 - x_1 x_2} \left[\frac{y_2 Q_1}{x_2 Q_2} - \frac{y_1 Q_2}{x_1 Q_1} \right]$$

Terms on the right hand side of (22) are ratios which do not depend directly on s_1, (see (1), (5), and (6)), so we obtain the following proposition.

Proposition 6. If countries differ only in size, the share of imports in each market is smaller in the larger economy.

The proposition is proved by noting the dependence of supplies and demands on prices (as for proposition 4), together with the fact that $dp_1 < 0$ and $dp_2 > 0$ (from equations (20) and (21)), and evaluating equation (22) around the symmetric equilibrium.

6. Tax and tariff policy. We may now consider the implications of small changes in commercial policy variables on the equilibrium. Consider first the effects of changing t_2, the cost to firms in country 2 of exporting a unit of output from country 2 to country 1. Changes in t_2 may occur for three reasons. Technological change may alter transport costs; country 1 may impose a tariff on its imports; country 2 may tax its exports. The first of these is easiest to examine, and may be done by straightforward comparative static techniques. If t_2 changes because of the imposition of taxes or tariffs we must consider, in addition to the effect of the change on firms' profits, its implications for government revenue in the country imposing the tax or tariff.

A change in t_2 has no direct effect on profits of firms in country 1, but (from equations (7) with the supply functions (6)) changes the profits of firms in country 2 according to,

$$d\phi_2 = - 2x_2 dt_2.$$

Using this in equations (18), with Cramer's rule, the associated price changes are,

(23) $dp_1/dt_2 = - 2x_1x_2(2 - a_2x_1/s_2)/\Delta < 0$

(24) $dp_2/dt_2 = 2x_2y_1(2 - a_1y_1/s_1)/\Delta > 0.$

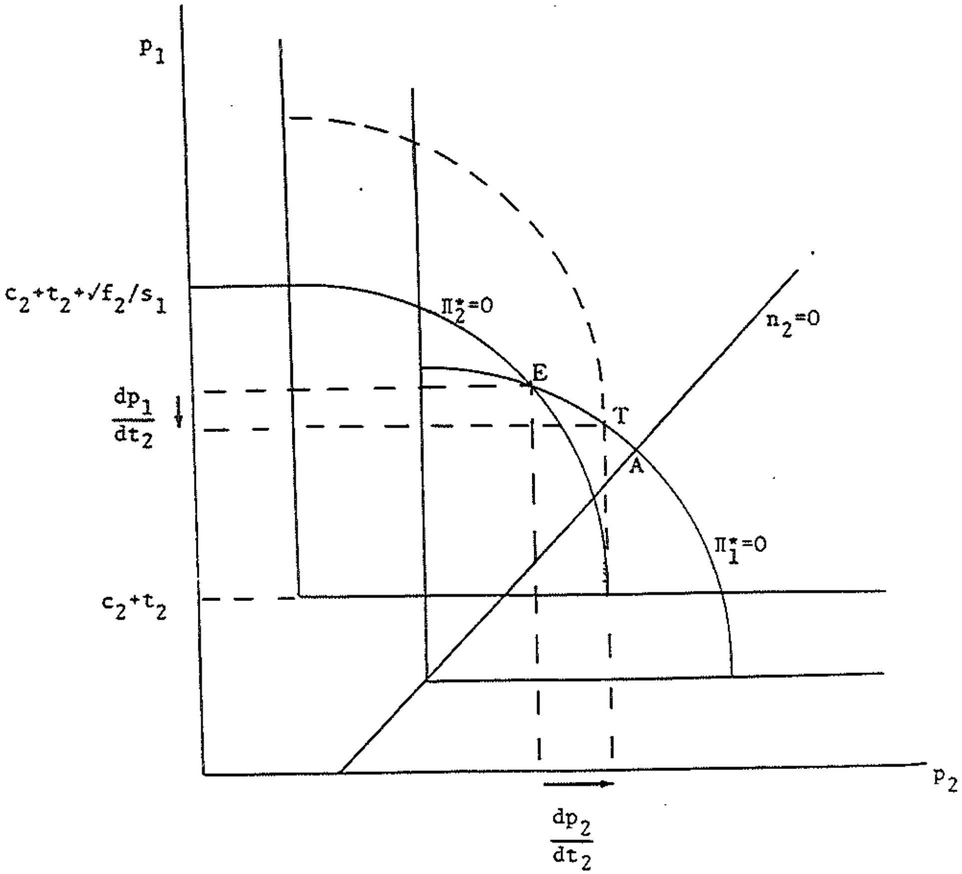
The signs of these equations give proposition 7.

Proposition 7. An increase in the costs of transporting output from country 2 to country 1 raises welfare in 1 and reduces welfare in 2.

This result may be explained as follows. The welfare gains from trade come from the possibility of covering some fixed costs by export revenue. The increase in transport costs from 2 to 1 reduces the profits earned on exports by firms in 2, and hence raises p_2. Given a higher value of p_2 the export earnings of firms in country 1 are increased, so p_1 is reduced. Proposition 7 has an immediate corollary.

Proposition 8. If tariff revenue is of zero social value in country 1, then country 1's welfare is raised by an increase in its tariff, and the optimal tariff is prohibitive, so that imports are zero.

Proposition 8 is illustrated on figure 3. Increasing t_2 shifts $\Pi_2^* = 0$ upwards, so reducing p_1 and raising p_2. As illustrated, the minimum value of p_1 which is attainable is that associated with the point T. When $\Pi_1^* = 0$ intersects $\Pi_2^* = 0$ at this point, the normal to $\Pi_2^* = 0$ is horizontal, so that exports from country 2 to country 1 are zero. Alternatively figure 3 could



p_1
$c_2+t_2+\sqrt{f_2/s_1}$
$\Pi_2^*=0$
$n_2=0$
E
T
A
$\frac{dp_1}{dt_2}$
$\Pi_1^*=0$
c_2+t_2
p_2
$\frac{dp_2}{dt_2}$

Figure 3.

have been constructed with the point A above and to the left of T. In this case the minimum attainable value of p_1 is at A; tariff policy has then been employed to drive the number of active firms in country 2's imperfectly competitive industry to zero.

If tariff revenue is of positive social value, then the desirability of employing positive tariffs is increased still further. However, it no longer follows that the optimal tariff is prohibitive. Loss of tariff revenue as the tariff approaches the prohibitive level means that the optimal tariff will generally be some level at which imports are positive.

It may be noted that the effects of the tariff in this case of free entry are significantly different from its effect when the number of firms is fixed (see for example Dixit [1983]). With a fixed number of firms a tariff will raise price in the country imposing the tariff; any beneficial welfare effects follow solely through the tariff's effects on government revenue and the profits of firms in the country imposing the tariff.

If the change in t_2 is due to export taxes (or subsidies), then the revenues associated with the tax accrue to country 2. We may establish the following proposition.

Proposition 9. A small subsidy on exports from country 2 to country 1 raises welfare in country 2 and reduces welfare in country 1.

The effect of the subsidy on country 1 is of course a corollary of proposition 7. The effect of the subsidy on country 2 may be established as follows. Country 2's export tax will be denoted dt_2, (so, for a subsidy $dt_2 < 0$), and the welfare change in country 2 will be denoted dw_2. To a first order approximation, the change in country 2's welfare associated with an export tax is then given by,

$$(25) \qquad dw_2 = - Q_2 dp_2 + n_2 x_2 dt_2.$$

The first term on the right-hand side of equation (25) measures the welfare change due to a price change, and the second gives the revenue impact of the tax. Using (24) and (8) we have,

$$(26) \qquad \frac{dw_2}{dt_2} = x_2 \left[\frac{y_1 Q_2 - x_1 Q_1}{y_1 y_2 - x_1 x_2} - \frac{2 Q_2 y_1}{\Delta} \left\{ 2 - \frac{a_1 y_1}{s_1} \right\} \right]$$

If demands are linear then (from equations (18)), $\Delta = 4(y_1 y_2 - x_1 x_2)$, and $a_i = 0$, so

$$(27) \qquad dw_2/dt_2 = - x_2 x_1 Q_1/(y_1 y_2 - x_1 x_2) < 0,$$

so establishing that , for the linear case, a small export subsidy increases welfare in the country providing the subsidy. For general demands (26) does not simplify so readily. It can however be shown that a sufficient condition for $dw_2/dt_2 < 0$ is once again, that $y_i > x_j$. With this condition we can therefore be sure that a small export subsidy increases the welfare of the country providing the subsidy.

Proposition 9 is concerned with an export subsidy, i.e., a reduction in t_2. Country 2 could alternatively subsidize its industry through production subsidies. A subsidy on marginal costs, $dc_2 < 0$ has the same welfare effects as the export subsidy described in proposition 9. The effects of a subsidy to fixed costs, $df_2 < 0$ on country 2's welfare are however ambiguous. These facts may be established by noting that both an export subsidy and production subsidies enter the model by changing profits of firms and government revenue in the country employing the subsidies. The magnitudes of these effects (to a first order approximation) are set out below (where changes in profits are obtained by differentiating (7) and using the supply functions (6)).

	dt_2	dc_2	df_2
$d\Phi_2$	$-2x_2dt_2$	$-2(x_2+ y_2)dc_2$	$- df_2$
Revenue;	$n_2x_2dt_2$	$n_2(x_2+ y_2)dc_2$	n_2df_2

Inspection indicates that an export subsidy and a subsidy to marginal costs both have the same effect on profits (and hence through (18) on prices) per unit revenue cost. However, for a given revenue cost a small subsidy to fixed costs has only half the impact on profits and hence equilibrium prices. The intuition here is that a subsidy to marginal costs is associated with an increase in firm size and a reduction in average costs, which is absent in the case of a subsidy to fixed costs. The fact that subsidies to fixed costs are a comparatively expensive way of reducing the equilibrium price means that the welfare effects of a fixed cost subsidy are ambiguous.

Propositions 8 and 9 provide strong arguments for the use of tariffs and subsidies to strengthen the position of a country's industry, and thereby reduce average costs and increase welfare in that country. The propositions are of course based on the assumption of no retaliation. As would be expected, it can be shown that tariff increases which are reciprocated (and which are around a point at which $t_2 > 0$), reduce welfare in both countries.

7. Conclusions. The paper has developed a model of trade between economies which have an imperfectly competitive industry producing identical commodities, and in which the number of firms is endogenously determined by free entry. It was shown that opening such economies to trade raises welfare levels. The welfare gains arise essentially because, by exporting, firms expand their output and so produce at lower average cost. This remains consistent with profit maximisation as trade reduces the degree of monopoly in each economy, so reducing the difference between price and marginal cost. However, the model suggests that there is a very direct conflict of interest between the two countries. Essentially any change which has a positive direct effect on the profits of firms in country 1, or a negative direct effect on profits of firms in 2 increases welfare in 1 and reduces welfare in 2. Thus, technical change in 1 raises welfare in 1, but reduces welfare in 2. Growth in 1 benefits firms in both countries, but if it benefits firms in 1 more than those in 2, then welfare in 1 increases and in 2 decreases. Finally, the adversarial nature of trade is such that, provided retaliation is not anticipated, imposition of a tariff raises welfare in the imposing country, even if the tariff revenue is of no social value.

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