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INTRA-INDUSTRY TRADE IN IDENTICAL COMMODITIES

BY

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Abstract

The usual approach to intra-industry trade is to assume that such trade arises because slightly different commodities are produced and traded to satisfy consumers' tastes for variety. In this paper it is shown that there are reasons to expect two-way trade even in identical products, due to strategic interaction among firms.[1]

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1. INTRODUCTION

We observe that a substantial portion of world trade is in similar products and between similar countries. (See Grubel and Lloyd (1975)). While such trade is not excluded by the Heckscher-Ohlin and Ricardian models of trade, neither is it well explained by them. The H-O and Ricardian models stress differences between countries as determinants of international trade. It is, however, possible to consider models that stress similarity among countries and increasing returns to scale as causes of trade. Such models are, perhaps, appropriate for analyzing this phenomenon known as intra-industry trade: trade in similar products.

Consider the export of ham from the United States to Denmark and from Denmark to the US. The natural argument is that American ham is slightly different from Danish ham, so it is not unreasonable that some consumers in each home market would prefer the foreign good.

What is not so widely recognized is that there are reasons to expect such trade even if the goods in question are identical. Two-way trade in identical products is sometimes referred to as cross-hauling and has been discussed in the basing-point-pricing literature (for example, J. M. Clark, 1943). The context here is completely different: we examine the possibility of cross-hauling in a Cournot setting.

By a Cournot setting we mean that each firm assumes the output of other firms remains the same in each market. It may certainly be argued that the Cournot strategy is naive and that firms are unlikely to use it in fact. On the other hand, very sophisticated strategies are unlikely because they require that firms incur high information-gathering and information-processing costs. Consequently, limiting our attention to simple strategies is not necessarily bad. It is by no means clear, of course, that the Cournot strategy is superior to other simple strategies. We shall see, however, that the Cournot strategy may at least be more profitable than the limit-pricing strategy. It is worth emphasizing that firms must follow some strategy. The most frequently assumed strategy is the competitive strategy: firms are assumed to believe that they can sell as much output as they like at the going price. This is highly inappropriate for many of the industries characterized by intra-industry trade.

This paper is, then, intended to contribute to the theory of trade between similar countries, such as trade within the European Economic Community (EEC). Accordingly, different countries are assumed to be identical and the pattern of trade is determined by the interaction of increasing returns to scale, transport costs, and firms' imperfectly competitive behaviour.

2. *THE MODEL*

Production and Cost

Increasing returns of a very simple form are assumed so that the cost function is:

$$C(x) = F + cx$$

where C = total cost

x = output

and c = marginal cost

Transport Costs

There are two countries, A and B. Transport costs are borne by producers. It is convenient to think of transport costs as shrinkage of the product (see Dornbusch and others, 1977) so that if the quantity x is exported from A to B, quantity gx arrives in country B where $0 \leq g \leq 1$. Equivalently, per unit transport costs are $(1 - g)/g$, using the commodity in question as the numeraire.

Firms' Strategy and Market Structure

Firms employ a Cournot strategy. That is, each firm maximizes profit assuming the output of other firms in each market remains the same. As pointed out by a referee, it is important to distinguish this case from the case in which firms take total output by other firms (domestic + export) as given, but not output in each market separately as given. The assumption made here is a very special one, and a very important one for the analysis.

Firms stay in business only so long as they make non-negative profits. Also, to begin, we assume that there is at most one firm in each country.

Demand

The industry in question is assumed to be sufficiently small that income effects are negligible. We can think of a gross surplus function whose derivative is the inverse demand function:

$$\text{surplus} \quad W = W(X)$$

$$\text{demand} \quad W' = W'(X)$$

W is assumed to be the same in both countries. W' is the price that clears quantity X.

The Problem

Each firm must decide how much of the commodity to produce for domestic consumption and how much to export. We shall refer to the firm in A as the home firm and the firm in B as the foreign firm.

Let x = production by the home firm for domestic consumption

y = production by the foreign firm for export to A

u = production by the home firm for export to B

v = production by the foreign firm for consumption in B

X = total consumption in A

and V = total consumption in B

Then $$X = x + gy$$

and $$V = gu + v$$

Let π = profits of the home firm

and π^* = profits of the foreign firm

then $$\pi = xW'(x+gy) - F - cx + guW'(gu+v) - cu \qquad (1)$$

and $$\pi^* = gyW'(x+gy) - F - cy + vW'(gu+v) - cv \qquad (2)$$

The home firm takes y and v as given and maximizes expression (1) with respect to x and u ; the foreign firm takes x and u as given and maximizes expression (2) with respect to y and v . The four first order conditions are the reaction functions and constitute four equations in four unknowns. Solutions to this system are Cournot equilibria, provided the second order conditions are satisfied. The first order conditions are:

$$\pi_x = 0 \rightarrow xW''(x+gy) + W'(x+gy) - c = 0 \quad (3)$$

$$\pi^*_y = 0 \rightarrow g^2yW''(x+gy) + gW'(x+gy) - c = 0 \quad (4)$$

$$\pi_u = 0 \rightarrow g^2uW''(gu+v) + gW'(gu + v) - c = 0 \quad (5)$$

$$\pi^*v = 0 \rightarrow vW''(gu+v) + W'(gu+v) - c = 0 \quad (6)$$

This system of four equations in four unknowns can be partitioned into two separable subsystems. Equations (3) and (4) are two equations in two unknowns, x and y. Similarly, (5) and (6) are two equations in u and v. This separability property depends on the assumption of constant marginal cost, forif marginal cost depended on output, u would enter equation (3), v would enter equation (4), x would enter equation (5) and y would enter equation (6), so all four equations would be linked.

Also, the two subsystems are perfectly symmetric, so the set of solutions to the first is also the set of solutions to the second with $x = v$ and $y = u$. Therefore, we need consider only one subsystem. Let us consider the subsystem consisting of equations (1) and (2), which corresponds to the market in country A. We shall not consider the second order conditions except to note that they are satisfied if the profit functions are continuous and concave. Given constant marginal cost, this is true in the positive quadrant if marginal revenue in each own product is downward sloping, which is certainly what we would expect. The only problem arises because profit is not continuous at zero output, due to fixed costs. Consequently, the local first and second order conditions are not sufficient to insure a global maximum over the entire feasible range. Instead, each firm will calculate its local optimum and compare it with zero output. More simply, firms obey the first-order conditions provided that profits and output are non-negative at the solution. For most of the paper we shall assume this is the case.

We have two equations in two unknowns:

$$xW'' + W' - c = 0 = f(x,y)$$

$$g^2yW'' + gW' - c = 0 = h(x,y)$$

f and h are two reaction functions in implicit form. There is no way of telling how many solutions exist, if any, and which are stable, if any, because the surplus function is unspecified. There are two strategies open. Either an explicit functional form for W may be specified or we can try to determine which minimum sets of restrictions on W imply which properties for the system. We shall follow the former course, chiefly because it is simpler.

Example

Assume W is quadratic. Then W' is linear and the two equations have a solution if the Jacobian matrix, J, associated with f and h, is non-singular.

$$J = \begin{bmatrix} f_1 & f_2 \\ h_1 & h_2 \end{bmatrix}$$

where the subscripts denote partial derivatives.

$$\text{surplus } W = aX - bX^2/2$$

where a and b are greater than zero.

$$\text{inverse demand } W' = a - bX$$

$$W'' = -b$$

From the reaction functions, f and h, we have, using $X = x + gy$:

$x + gy/2 + (c-a)/2b = 0 \quad : \quad f(x,y) = 0$

$x/2g + y + (c-ga)/2bg^2 = 0 \quad : \quad h(x,y) = 0$

$$J = \begin{bmatrix} 1 & g/2 \\ 1/2g & 1 \end{bmatrix}$$

Because the determinant of J is not zero, the equations have a solution.

We have $$J \cdot \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} (a-c)/2b \\ (ga-c)/2bg^2 \end{bmatrix}$$

This Jacobian matrix is nothing more than the coefficient matrix of a linear system; the condition that the Jacobian be non-singular means that the two equations must be independent. We can solve the system using Cramer's rule:

$$x = (ga + c - 2gc)/3gb$$

$$y = (ga + gc - 2c)/3g^2b$$

The only meaningful solutions are in the positive quadrant. Because negative production is ruled out we should have truncated the reaction functions at 0 . We can at least read off the conditions on g and the parameters of the surplus function that imply a positive soltution. For y to be positive we must have:

$$g > 2c/(a+c)$$

Transport costs must be below a certain level before invasion will take place. (Transport costs fall as g rises.) If marginal cost were high relative to demand, $2c/(a+c)$ could be greater than one, in which case there would be no range of g that allowed invasion. However, if $2c/(a+c)$ actually were to exceed one, home production would not be profitable either. In other words, there is a range of g for which the home market is subject to invasion for any relevant level of demand.

This is a manifestation of the general result that, in a Cournot industry, low cost firms do not drive out high cost firms. In addition, as g approaches 1 (transport costs approach 0), x and y approach the Cournot equilibrium:

$$x = y = (a - c)/3b$$

It is easy to check the following derivatives:

$$dx/dg < 0$$

$$d(gy)/dg > 0$$

$$dX/dg > 0$$

and that $x > gy$.

Thus as transport costs fall, goods produced abroad make up a greater and greater share of domestic consumption, with the share approaching 1/2 as g appoaches 1; also, total consumption rises as transport costs fall. As demand grows (a rises), the range of g for which invasion takes place increases, making cross-hauling more likely. Therefore, we can expect an increase in world income to increase the incidence of cross-hauling.

The two markets, one in country A and the other in country B, represented by the two subsystems of equations, are symmetric, as proven earlier. Therefore, there is two-way trade in this commodity despite the existence of transport costs. As pointed out by a referee, trade is arising from a "dumping" or "price discriminating" motivation. Imperfectly competitive firms set marginal revenue, not price, equal to marginal cost. Since each firm has a smaller share of the foreign market than of its domestic market, marginal revenue in the foreign market can exceed marginal revenue in the domestic market even when price is the same in both markets.

Thus the firm can tolerate the higher effective marginal cost (including transport costs) of export production. This works in both directions, leading to cross-hauling. We shall now use this example to illustrate four characteristics of such trade.

1. cross-hauling
2. inefficient scale
3. degree of competition
4. variety

3. *CHARACTERISTICS OF INTRA-INDUSTRY TRADE*

Cross-hauling

As just mentioned, the situation in country B is symmetric to that in A. The firm located in A exports to B and produces for its home market, while the firm in B exports to A and produces for its home market. In other words, the market equilibrium involves trade in spite of the fact that both countries produce exactly the same commodity, and there is an obvious loss due to transport costs. (We are assuming here that $2c/(a+c) < g < 1$ and that profits for each firm are non-negative. Clearly there are parameter values for which these assumptions are valid.) This is the phenomenon of cross-hauling.

The same total consumption for each country could be achieved at lower total cost if each firm produced solely for its home market, which we might think of as a planning solution.

market solution   total cost, $TC_m = 2F + 2(x + y)c$

planning solution: total cost, $TC_p = 2F + 2(x + gy)c$

The difference between the two, $TC_m - TC_p$, is easily seen to be:

$$(1 - g)2y$$

which is positive.

Allowing free entry has no particular bearing on the relevance of this result. Suppose, for example, that the two-firm equilibrium allowed, by coincidence, exactly normal profits. (There are certainly parameter values for which this is true.) Then there would be no incentive to enter and cross-hauling would exist even though there were no barriers to entry.

Inefficient Scale

Average cost is strictly declining for both firms, yet there are two firms operating rather than one. If transport costs were sufficiently low the same consumption could be achieved at lower cost by concentrating all production in one country. Let the total costs in the market solution and the concentration solution be denoted TC_m and TC_c, respectively. Then:

$$TC_m = 2F + 2(x + y)c$$

$$TC_c = F + (x + gy)c + (x + gy)c/g$$

$$TC_m > TC_c \iff F > c(gy + x/g - x - y)$$

The greater start-up costs are and the less transport costs are, the more likely concentration is to be efficient.

Degree of Competition

It is fairly striking that trade is apparently inefficient and welfare-reducing. This welfare loss is with respect to a planning solution, however, and planning solutions generally have many hidden costs, not the least of which is the cost of gathering relevant information. If we compare market outcomes before and after trade, we find that trade can be welfare-improving because of increased competition.

Suppose initially that $g = 0$, so there is no trade. Perhaps there are prohibitive tariffs. Each firm takes the other's output as zero and acts as a monopolist:

$$\pi = xW'(x) - F - cx$$

$$\pi' = 0 \rightarrow x = (a - c)/2b$$

Assuming that a exceeds c and that profits are nonnegative, the total consumption in A (and in B for that matter) under autarky, X_a, is $(a - c)/2b$. Suppose now that g rises to a level at which trade is feasible. The total amount consumed in A under trade, X_t, is $x + gy$, where x and y are the solution values to the original problem.

$$X_t = x + gy = (ga + c-2gc)/3gb + g(ga+gc-2c)/3bg^2$$

$$= (2ga-gc-c)/3gb$$

$$X_t - X_a = (2ga-gc-c)/3gb - (a-c)/2b$$

$$= gy/2$$

In the range where $y > 0$, the trading range, we have $X_t > X_a$, so consumption of the commodity is unambiguously increased by trade. That is, trade has a production creating effect which is welfare improving. A lower bound on the welfare improvement is $(p-c/g)gy/2$, using surplus measures. However, trade also has a production diverting effect in that domestic production falls and is replaced by higher cost foreign production. The amount of production diversion is also $gy/2$ and the welfare cost is $(c/g - c)gy/2$. Therefore, a lower bound on the net welfare improvement is

$$(p - c/g)\ gy/2 - (c/g - c)\ gy/2$$

$$= pgy/2 - cy(2-g)/2$$

This must exceed 0 if $g > 2c/p+c$

Since $2c/p+c < 1$, there is a range of g for which trade is definitely welfare-improving.

To restate, trade increases quantity consumed and decreases price, and consequently reduces the monopoly distortion. Welfare increases for sufficiently low transport costs despite the existence of cross-hauling. This can be offered as a possible justification of the claim that tariff reductions, within the EEC for example, have increased welfare by increasing the level of competition.

Variety

So far we have not been concerned about whether the commodity will be produced at all. It is quite possible that under autarky neither location could support production of the commodity by itself, but that after trade, one firm could be supported. In order to interpret this as an increase in variety, suppose that there are several products under consideration and that the surplus function is additive:

$$W(X_1, \ldots, X_n) = W_1(X_1) + \ldots + W_n(X_n)$$

In this context, the emergence of X_1 after trade opens can be interpreted as an increase in product variety. Such an increase unambiguously increases welfare: gross surplus exceeds gross revenue to the firm (revenue is taken from the surplus), and revenue must exceed cost in order for the firm to stay in business. Therefore, surplus exceeds cost and welfare is improved.

Limit-pricing

In this section we see that the Cournot strategy may yield higher profits to both firms than another strategy, the limit pricing strategy. The limit pricing strategy involves having the domestic firm set price sufficiently low that the foreign firm cannot compete. In order to set the limit price efficiently the domestic firm would like to know the foreign firm's strategy. However, if the domestic firm remains agnostic about the foreign firm's strategy it can prevent invasion by setting price at the foreign firm's marginal cost of selling one unit in the domestic firm's country. In our example, this marginal cost is c/g. That is, to sell a unit in the home country the foreign firm must produce $1/g$ units because only $g(1/g) = 1$ unit survives transport. The marginal cost of producing $1/g$ units is, of course, $1/g$. Note that if the foreign firm follows the Cournot strategy then c/g is the true limit price.

Assume that the domestic firm sets price at c/g as its limit-pricing strategy. We have:

$$\pi = xW'(x) - F - cx$$

where $W' = c/g$. We can calculate the implied x and π :

$$x = (ga - c)/bg$$

$$\pi = c((1/g) - 1)(ga - c)/bg - F$$

Observe that as g approaches 1 , profits approach $-F$, because the limit price approaches marginal cost. Thus it shouldn't surprise us that the limit pricing strategy should be inferior to the Cournot strategy for some parameter values. For example, suppose

$c = .1$

$g = .9$

$a = 1.0$

$b = .1$

Under the limit-pricing strategy profits are $.1 - F$. (Assuming both firms limit price)

Under the Cournot strategy we have:

$$x = v = 3.04$$

$$gy = gu = 2.93$$

$$X = V = 5.97$$

$$W' = .4$$

$$\pi = 1.76 - F$$

Accepting the Cournot equilibrium is far better for the firms than limit pricing. This will be the case whenever (a-c) is large, b is small, and g is close to 1 . This is given as a (slight) defense of the Cournot strategy.

Behaviour as the Number of Firms Increases

So far the analysis has been carried out under the assumption that there is exactly one firm in each country. We might wonder about the effects of assuming that more firms might enter. The behaviour of Cournot industries as the number of firms increases has been carefully studied. Friedman (1977) summarizes the results and has an extensive bibliography. Of particular interest is an article by Ruffin (1971), in which the conditions under which Cournot industries converge to competitive equilibria are examined. Ruffin makes clear that the question of convergence to the competitive position should be distinguished from the question of quasi-competitiveness. An industry is said to be quasi-competitive if increasing the number of firms causes the quantity sold to increase (and the price to fall). Very few completely general things can be said about Cournot industries. They do not necessarily converge to competitive equilibria, they are not necessarily quasi-competitive, equilibria may not exist, and even if equilibria do exist they may not be stable. General statements can be made for certain classes of cost and demand functions, and the reader is referred to Friedman (1977) and the references cited there for further discussion of general results. Cournot industries are usually quasi-competitive in the relevant ranges but rarely converge to competitive equilibria.

We shall now examine the properties of the particular model under consideration here. Suppose, first, that we allow free entry in each country before trade takes place. Each firm sets marginal revenue equal to marginal cost and firms enter until profits are driven to their normal level.

Let x = output of a representative firm

n = the number of firms

$X = nx$ = total output

We shall examine the problem of a representative firm, assuming that the equilibrium is symmetric. Finding such an equilibrium insures that a symmetric equilibrium exists, but does not rule out the possibility that asymmetric equilibria may exist. However, the solution to our model is the solution to n independent linear equations in n unknowns; consequently, the symmetric equilibrium is the only equilibrium. The solution is:

$$x = (a-c)/b(n+1)$$

$$X = n(a-c)/b(n+1)$$

$$n = (a-c)/(bF)^{1/2} - 1$$

At this equilibrium each firm equates marginal cost and marginal revenue, which is below price, so price exceeds marginal cost.

Let $h = MC/p$

Each country has the same equilibrium. If we now admit the possibility of trade, we observe that for sufficiently low transport costs, specifically for $g > h$, each firm has an incentive, under the Cournot perception, to invade the market in the other country. Therefore, the free entry no trade position cannot be an equilibrium. The new equilibrium will involve cross-hauling.

The next step is to consider the behaviour of the after-trade equilibrium as the number of firms increases. Consider a representative firm. The profit of this firm is:

$$\pi = px + gp^*x^* - cx - cx^* - f$$

where $p = a - bX$ = domestic price , p^* = foreign price

x = output for domestic market

x^* = output for foreign market

Consider a representative domestic firm and a representative foreign firm operating in the domestic market. (The two markets can be considered separately.) We can write down the appropriate first order condition for each: (By symmetry, x^* also equals the output of the foreign firm for export to the domestic market.)

$$p + xdp/dx - c = 0 \quad : \text{domestic firm}$$

$$gp + gx^*dp/dx^* - c = 0 \quad : \text{foreign firm}$$

We can solve these two equations for x and x^* given $X = n(x + gx^*)$. The solution has the following properties:

1. $x^* > 0$ (for $g > c(n+1)/(a+nc)$)

2. $dX/dn > 0$

3. $d(gx^*/x)/dn < 0$

The first property indicates that cross-hauling may exist even if n is large. Property 2 shows that this model is quasi-competitive: as n increases quantity consumed increases and price falls. However, property 3 shows that the ratio of cross-hauling to domestic production falls as n increases. As transport costs fall, of course, the portion of cross-hauling rises. Thus if we interpret a fall in transport costs as an increase in the extent of the market, we can say that cross-hauling increases as the extent of the market increases.

Conclusions

It is sometimes argued that trade in similar goods arises because of minor product differences, differences that are too fine to show in international trade data, but which are significant to consumers. Presumably France and Germany exchange Renaults and Porsches because the products are slightly different. For the sake of clarity, however, we should first consider whether trade might arise even in identical commodities. Apparently it might.

Finally, there are some caveats. The model here has been described and interpreted as a model of trade. However, as pointed out by a referee, we would obtain precisely the same result if each firm operated a low cost plant at home and a high cost plant abroad, without trade taking place.

Secondly, the assumption that each firm assumes the other firm keeps output in each of its markets constant is crucial and perhaps not realistic. An alternative assumption that could lead to different results is that firms expect other firms to keep total output fixed and divide total output in the most profitable way between the two markets.

Nevertheless, the paper demonstrates that if firms do act as Cournot firms in each market separately, cross-hauling can emerge even in identical products and also, that such trade can be welfare-improving.

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