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## ABSTRACT

Almost all of the large literature on international trade with imperfect competition assumes exogenous market structures. The purpose of this paper is to develop a simple model that generates alternative market structures as Nash equilibria for different parameterizations of the basic model. Familiar configurations such as a duopoly competing in exports or a single multinational producing in both markets arise as special cases. Small tax–policy changes can produce large welfare effects as the equilibrium market structure shifts, implying discontinuous jumps in prices, quantities, and profits.

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**Natura non facit saltum**
**(Nature does not proceed by leaps)**

**Alfred Marshall 1890**[1]
**Title Page, Principles of Economics**

## 1. Introduction

There now exists a large literature on trade and trade policy under conditions of imperfect competition and increasing returns to scale. Almost all of this literature assumes an exogenously specified market structure. The situation in which a single domestic firm competes against a single foreign firm producing a perfect or imperfect substitute product is perhaps the best known of these market structures. Papers by Brander and Krugman (1983), Dixit (1984), Brander and Spencer (1985), Eaton and Grossman (1986), and Markusen (1981) are a few examples of this approach. Free entry versions of this model are found in Helpman (1981), Krugman (1979), Venables (1985), and Horstmann and Markusen (1986). Here again, though, the underlying structure of production is exogenous to the analysis. Markusen and Venables (1988) analyzes free entry versus oligopoly and segmented versus integrated markets, but does not attempt to analyze how these regimes might arise as equilibrium phenomena.

Most of the formal analysis of the multinational enterprise (MNE) can be characterized in a similar fashion. Helpman (1984) essentially imposes a structure of domestic and branch plant production (i.e., multinationality is assumed). Markusen (1984) considers a MNE monopoly with one plant in each of two countries versus a duopoly between two single–plant firms, but no attempt is made to establish which is the equilibrium market structure. In a previous paper (Horstmann and Markusen (1987)), we have partially endogenized market structure, but not in a way that permits the (non–MNE) oligopoly equilibria discussed in the previous paragraph to emerge. Levinsohn (1990) shows how a tariff or quota can induce a shift in market structure by causing an exporter to enter the market as a multinational, but the paper does not focus on the positive economics of what determines initial market structure in

[1]This quote is originally attributed to Carl von Linné Linnaeus (1707–1777) and in slightly different form to Jacques Tissot (1613).

the first place. Dixit and Kyle (1985) consider how policies can induce or prevent entry, but the option of serving a foreign market by a branch plant versus exports is not considered.

The purpose of this paper is two–fold: (i) to develop a simple model in which market structure is determined endogenously as the outcome of plant location decisions by firms, and (ii) to illustrate the impact on optimal trade policy analysis of endogenous market structure models. The model adopted is not completely general in that we restrict attention to a situation in which there are at most two firms in the relevant market, one from each country. Within this limited framework, however, a number of market structures are candidates for equilibria. One such structure involves a firm operating in each country, producing with a single home plant and serving the foreign market by exports. This yields the duopoly market structure discussed in the opening paragraph. Next, there may be an equilibrium in which both firms maintain plants in both countries, a MNE equilibrium similar to that in Helpman (1984). Finally, there may exist asymmetric equilibria (the countries are assumed to be identical) in which a single firm is supported, serving the other country's market by a branch plant (as in Markusen (1984)) or by exports.

The assumed production technology is similar to that in Markusen (1984) and Horstmann and Markusen (1987) in that production results in both firm–specific and plant–specific fixed costs. Firm–specific costs create assets that are joint inputs across plants (e.g., blueprints) in that additional plants may be opened for the plant–specific costs only. Marginal costs are constant and identical across countries, while exports bear a constant unit tariff/transport cost.

Given this technology, and Cournot–Nash behavior by firms, we demonstrate the existence of three equilibria: (1) the two–firm, single–plant (exporting) duopoly familiar from the literature, (2) the one–firm, two–plant (MNE) monopoly, and (3) the two–firm, two–plant (MNE) duopoly. We show that, roughly speaking, equilibrium (1) emerges when plant–specific costs are large relative to firm–specific costs and tariff/transportation costs. We switch to the asymmetric equilibrium (2) when firm–specific costs and tariff/transport costs are raised such that duopoly generates negative profits. Equilibrium (3) is obtained by lowering plant–specific costs (relative to equilibrium (1)) so that the MNE duopoly is both profitable and dominates the exporting duopoly.

Next we conduct a simple tax and welfare analysis of the model to illustrate the impact on optimal policy calculations of allowing the market structure to be endogenous. This analysis demonstrates that small policy changes can produce large welfare effects when equilibrium market structure shifts. Such shifts imply discontinuous jumps in prices, quantities, profits, and therefore welfare. Analysis of an import tariff shows that market structure shifts from the exporting duopoly one long before the "optimal" tariff and welfare levels are reached. Analysis of a producer excise tax shows three changes in market structure as the tax rate increases. In each case, the welfare effects of the tax are dramatically different from those obtained from traditional Pigouvian marginal analysis holding market structure fixed. Robustness of the results is discussed in the final section.

## 2. Technology and Equilibrium Market Structure

Suppose that the world consists of two countries, home and foreign (h and f), and that each country is endowed with an identical amount of a single homogeneous factor, labor. Each country can produce a homogenous good Z, with units chosen such that $Z = L_Z$. Z or labor is numeraire. A firm in country h can produce a good X with increasing returns to scale and a firm in country f can produce a symmetric substitute good Y. Scale economies are assumed to be large relative to demand such that the market will support at most one X and one Y firm. The (potential) X and Y producers have the following identical technologies, given as costs in units of labor (or Z).

(1) F – firm specific fixed costs

G – plant specific fixed costs

m – constant marginal cost

s – unit tariff/transport cost

The firm–specific fixed cost is intended to represent knowledge–based assets, such as those obtained from R and D, that are joint inputs across plants (Markusen, 1984). Multi–plant economies of scale arise in this formulation in that the fixed costs of a two–plant firm are 2G + F while the fixed costs of two one–plant firms are 2G + 2F. The MNE thus offers the world productive efficiency. This having been said, however, it should be noted that a MNE monopoly will also generally involve a larger market power distortion than a duopoly, so that the welfare effects of MNE production are not clear cut. Further, the mere fact that MNE production is technically efficient should not lead one to conclude that it must arise as an equilibrium industry structure (as will be illustrated below).

In order to bring out the important features of the analysis in as straightforward a fashion as possible, we adopt a very simple demand structure.[2] All consumers in both countries have identical quadratic utility functions given by

$$U(X,Y,Z) = aX - (b/2)X^2 + aY - (b/2)Y^2 - cXY + Z \tag{2}$$

with $p_x$ and $p_y$ giving the prices of X and Y in terms of Z (or L) respectively. Utility maximization results in inverse demand functions

$$p_x = a - bX - cY, \quad p_y = a - bY - cX \tag{3}$$

We assume that $b \geq c$, with $b = c$ being the case where X and Y are perfect substitutes. The technology in (1) combined with the demand functions in (3) and the resource constraint $L = L_z + L_x$ ($L_y$ for the foreign country) complete the specification of the general equilibrium model.

[2]Robustness of the results for more general demand structures is considered in Section 5 below.

The equilibrium market structure is determined in a two–step procedure corresponding to a two–stage game. In stage one, the two firms (X and Y producers) make a choice over three options: (A) no entry, referred to as the zero plant strategy, (B) serving both the home and foreign markets from one plant, referred to as the one–plant strategy, (C) becoming a MNE, by building plants in both countries, referred to as the two–plant strategy. In stage two, the X and Y producers play a one–shot Cournot game. Moves in stage one are assumed to be simultaneous.

The game is solved backwards in the usual fashion. We first solve for the maximized value of profits for each firm for each of the three "capacity" choices given the capacity choice of the other firm. We illustrate this procedure by solving for maximized profits under the assumption that both firms are MNEs; that is, they both choose to maintain plants in both countries. Let $X$ and $X^*$ denote the X firm's sales in the home and foreign markets respectively, and let $Y$ and $Y^*$ be similarly defined. Profits for the home firm are given by

$$\pi_x = (a - bX - cY)X + (a - bX^* - cY^*)X^* - m(X + X^*) - 2G - F \tag{4}$$

We assume that markets are segmented so that firms may price independently in each market. The first–order conditions corresponding to (4) under the Cournot assumption are then

$$\begin{aligned} \partial\pi_x/\partial X &= a - 2bX - cY - m = 0 \\ \partial\pi_x/\partial X^* &= a - 2bX^* - cY^* - m = 0 \end{aligned} \tag{5}$$

Similar equations hold for $Y$ and $Y^*$. Exploiting this symmetry, we can solve for Cournot outputs.

$$X = X^* = Y = Y^* = (a - m)/(2b + c) \tag{6}$$

Equation (6) allows us to solve for prices using (3) and then for profits using (4). Maximized profits under the two–plant strategies are

(7) $$\pi_x = 2b\left[\frac{a - m}{2b + c}\right]^2 - 2G - F$$

(8) $$\pi_y = 2b\left[\frac{a - m}{2b + c}\right]^2 - 2G - F$$

Should the X and Y producers each maintain only a single plant and export to the other market, then, profits and first–order conditions for the X producer are

(9) $$\pi_x = (a - bX - cY)X + (a - bX^* - cY^*)X^* - mX - (m + s)X^* - G - F$$

(10) $$\partial\pi_x/\partial X = a - 2bX - cY - m = 0$$

$$\partial\pi_x/\partial X^* = a - 2bX^* - cY^* - (m + s) = 0$$

Again exploiting the symmetry in the problem, Cournot outputs are given by

(11) $$X = Y^* = (a - m + cd)/(2b + c) \qquad d = s/(2b - c)$$

(12) $$X^* = Y = (a - m - 2bd)/(2b + c) \qquad d = s/(2b - c)$$

and equilibrium profits by $\pi_x = b(X^2 + X^{*2}) - G - F$ and $\pi_y = b(Y^2 + Y^{*2}) - G - F$. Relative to (7) and (8), variable profits here are lower due both to the transport cost $sX^*$ $(sY)$ and to the fact that the loss of sales on the foreign market outweighs gains domestically ($2b > c$). However, fixed costs are reduced by G from $(2G + F)$ to $(G + F)$. Thus the relationship between G and s will clearly influence whether the MNE duopoly or the exporting duopoly generates more profits.[3]

Other market configurations can be derived using (6), (11), and (12). For example, if X is a two–plant MNE while Y is an one–plant exporter, then (given segmented markets) X is given by (11) and $X^*$ by (6). $Y^*$ is given by (6) while Y is given by (12). Prices in the

[3]However, the relationship between these profit levels does not necessarily determine the equilibrium market structure as we shall show.

foreign market are those found in the MNE equilibrium (6) – (8) while prices in the home market are those found in the exporting duopoly (11) – (12).

This procedure allows us to derive the profits from the different choices over the number of plants. These profits, in turn, are the payoffs in the game for which the strategy space is the number of plants. The Nash equilibrium of this game in number of plants determines the equilibrium market structure for the model.

To obtain some insight into the types of market structures that may arise in equilibrium and what factors influence the equilibrium outcome, it is useful to consider first some example games. Table 1 provides four such games. In each the goods are assumed to be imperfect substitutes ($c = b/2$) and marginal cost is zero. Neither assumption is important to the results. The four examples hold s constant at $s = 2$, and vary the levels of F and G. The first number of each pair is the payoff to the home country firm (the X producer) while the second number is the payoff to the Y producer. Payoffs in each case are the equilibrium profits associated with the given market structure.

In case 1 of Table 1 (F=27, G=7), there is a single Nash equilibrium with each firm producing for both markets from a single plant. Neither firm can improve profits by building a branch plant or by exiting. Inspection will show that no other proposed solution has this best–response property.

In case 2, the firm–specific costs are increased to F=28 while G remains 7. Now there are three equilibria, the exporting duopoly as before but also the case in which X is a two–plant MNE and Y does not enter and the corresponding outcome with Y the MNE and X not entering. The difference from the previous case is now a firm makes negative profits playing one plant against a two–plant (MNE) rival. If X plays two plants, Y makes negative profits from either two or one plants, so the best response is to not enter. The equilibrium with Y as the monopoly MNE has the same property.

Table 1

Example: a=16, b=2, c=1, m=0, s=2

Case 1: G=7, F=27, Nash Equilibrium (1,1)

| | | Country F: 2 Plants | 1 Plant | 0 Plants |
|---|---|---|---|---|
| | 2 | (-.04, -.04) | (1.71, .74) | (23.0, 0) |
| Country H | 1 | (.74, 1.71) | (2.45, 2.45)* | (22.5, 0) |
| | 0 | (0, 23.0) | (0, 22.5) | (0, 0) |

Case 2: G=7, F=28, Nash Equilibria (1,1), (2,0), (0,2)

| | | Country F: 2 Plants | 1 Plant | 0 Plants |
|---|---|---|---|---|
| | 2 | (-1.04, -1.04) | (.71, -.26) | (22.0, 0)* ) |
| Country H | 1 | (-.26, .71) | (1.45, 1.45)* | (21.5, 0) |
| | 0 | (0, 22.0)* | (0, 21.5) | (0, 0) |

Case 3: G=6, F=29, Nash Equilibria (2,0), (0,2)

| | | Country F | | |
|---|---|---|---|---|
| | | 2 Plants | 1 Plant | 0 Plants |
| Country H | 2 | (-.04, -.04) | (1.71, -.26) | (23.0, 0)* ) |
| | 1 | (-.26, 1.71) | (1.45, 1.45) | (21.5, 0) |
| | 0 | (0, 23.0)* | (0, 21.5) | (0, 0) |

Case 4: G=5, F=30, Nash Equilibrium (2,2)

| | | Country F | | |
|---|---|---|---|---|
| | | 2 Plants | 1 Plant | 0 Plants |
| Country H | 2 | (.96, .96)* | (2.71, -.26) | (24.0, 0) ) |
| | 1 | (-.26, 2.71) | (1.45, 1.45) | (21.5, 0) |
| | 0 | (0, 24.0) | (0, 21.5) | (0, 0) |

In case 3, F is raised to 29 and G lowered to 6. The effect of this change is to increase the profitability of two–plant production while leaving the profitability of single plant production unchanged. The net effect is to eliminate the exporting duopoly as an equilibrium. At that allocation, X has an incentive to shift to branch–plant production and similarly for Y. The two MNE monopoly equilibria are the only Nash equilibria. It is interesting to note here that in a completely symmetric game, the only equilibria are non–symmetric in the sense that the market will only have a single firm. Prices for the good will be the same in the two countries but since profits of the single firm are positive (23.0 in the example), the firm's home country (assuming that is where the shareholders are located) will enjoy higher welfare. There will also be an asymmetry in production, with the home country (if X is produced) producing less Z and using the resources to finance F and G.

In case 4, the plant–specific cost is lowered to G=5. This allows the market to support two, two–plant MNEs and indeed this emerges as the only equilibrium. Note that in case 4 the MNE duopoly equilibrium is inferior from the point of view of both firms to the exporting duopoly (profits equal .96 at the former versus 1.45 at the latter). This emphasizes that we cannot ignore the strategic aspects of market structure and simply infer market structure by comparing profit levels under various strategies.

Moving through from cases 1 to 4 of Table 1, we see that these games suggest a certain relationship between equilibrium market structure and the relative sizes of firm–specific and plant–specific costs. Relatively low values of F and relatively high values of G generate an equilibrium market structure that corresponds to the export–duopoly case analyzed in the papers mentioned in the first paragraph of the introduction above. The asymmetric MNE monopoly of cases 2 and 3 results from increasing F relative to G, and corresponds to the situation analyzed by Markusen (1984) who compares this market structure from a welfare point of view to the exporting duopoly (case 1). The symmetric MNE duopoly of case 4 occurs from additional increases in F relative to G and corresponds closely to Helpman (1984).

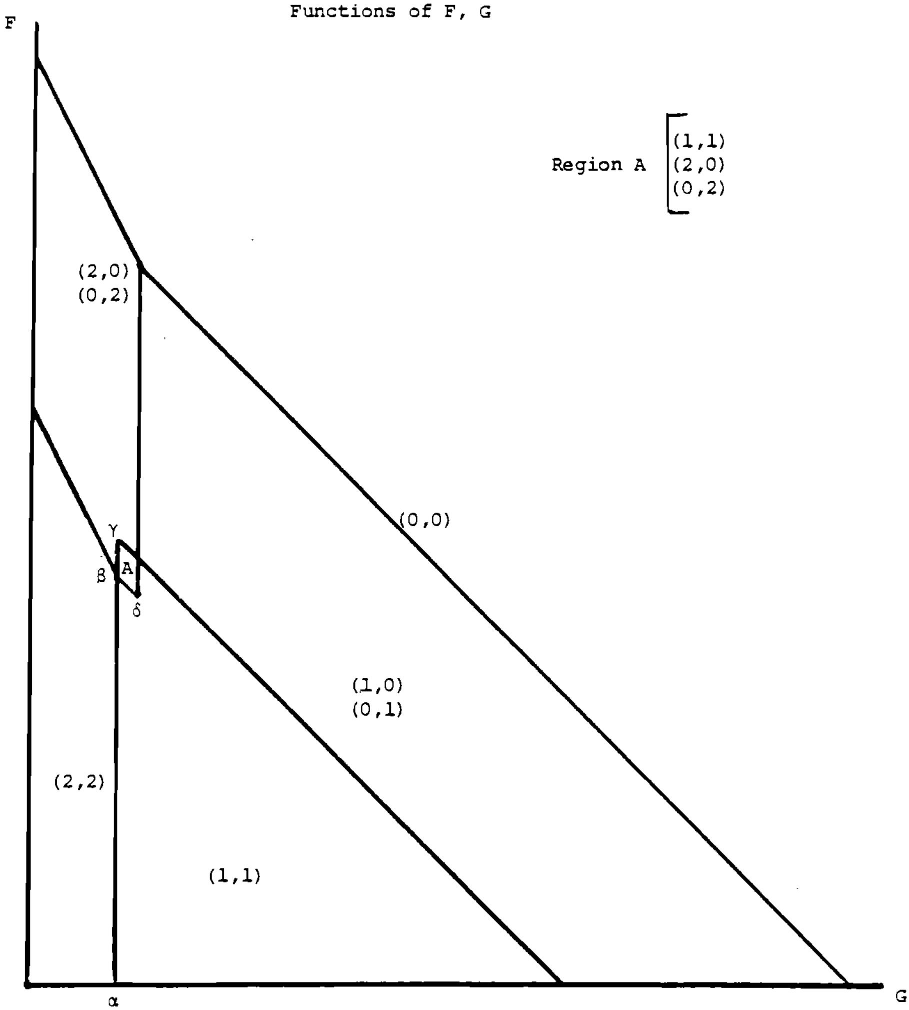
An analysis of the set of equilibrium market structures for arbitrary parameter values reveals that the properties of the equilibrium structures illustrated by the example games are quite general. In particular, with the exception of an added one–plant monopoly structure, the set of possible equilibrium structures in the general case is exactly that illustrated by the above games. In addition, the impact on market structure of changes in the relevant plant location costs (F,G,s) given market size (a–m,b,c) is also essentially as illustrated by these games.

The results of this analysis are summarized in Figures 1 and 2 which show the possible equilibrium market structures for various (F,G) and (F,s) pairs respectively. To understand the way that these two diagrams work, it is simplest to consider the way in which the various boundaries are generated. Consider, for instance, Figure 1. The boundary between the regions (2,2) and (1,1) gives the (F,G) for which the home (foreign) firm is indifferent between one–plant and two–plant production. More specifically, this boundary defines the (F,G) for which the home firm is indifferent both between the market structures (2,2) and (1,2) and between the structures (2,1) and (1,1). In both cases, the difference in home–firm profits between two–plant and one–plant production is $\pi_x(2,2) - \pi_x(1,2) = b\left[\left(\frac{a-m}{2b+c}\right)^2 - \left(\frac{a-m-2bd}{2b+c}\right)^2\right] - G = \pi(2,1) - \pi_x(1,1)$. As this expression is independent of F, the boundary is a vertical line with $\alpha = 2b\left[\left(\frac{a-m}{2b+c}\right)^2 - \left(\frac{a-m-2bd}{2b+c}\right)^2\right] > 0$. For (F,G) pairs to the left of the boundary, the home (foreign) firm prefers two plant production to one–plant production whether the foreign (home) firm has one or two plants. Therefore, subject to non–negative profit considerations, only (2,2) can be an equilibrium. To the right of the boundary, one–plant production is preferred to two–plant production so only (1,1) can be an equilibrium (again subject to the structure generating non–negative profits).

The (F,G) pairs for which the structure (1,1) and (2,2) result in non–negative profits are delineated by the northern boundaries of these two regions respectively. That is, the northern boundary of the region (2,2) gives the (F,G) for which $\pi_x(2,2) = \pi_y(2,2) = 0$. This boundary will also be a straight line but with slope –2. Similarly the northern boundary of (1,1) gives

FIGURE 1

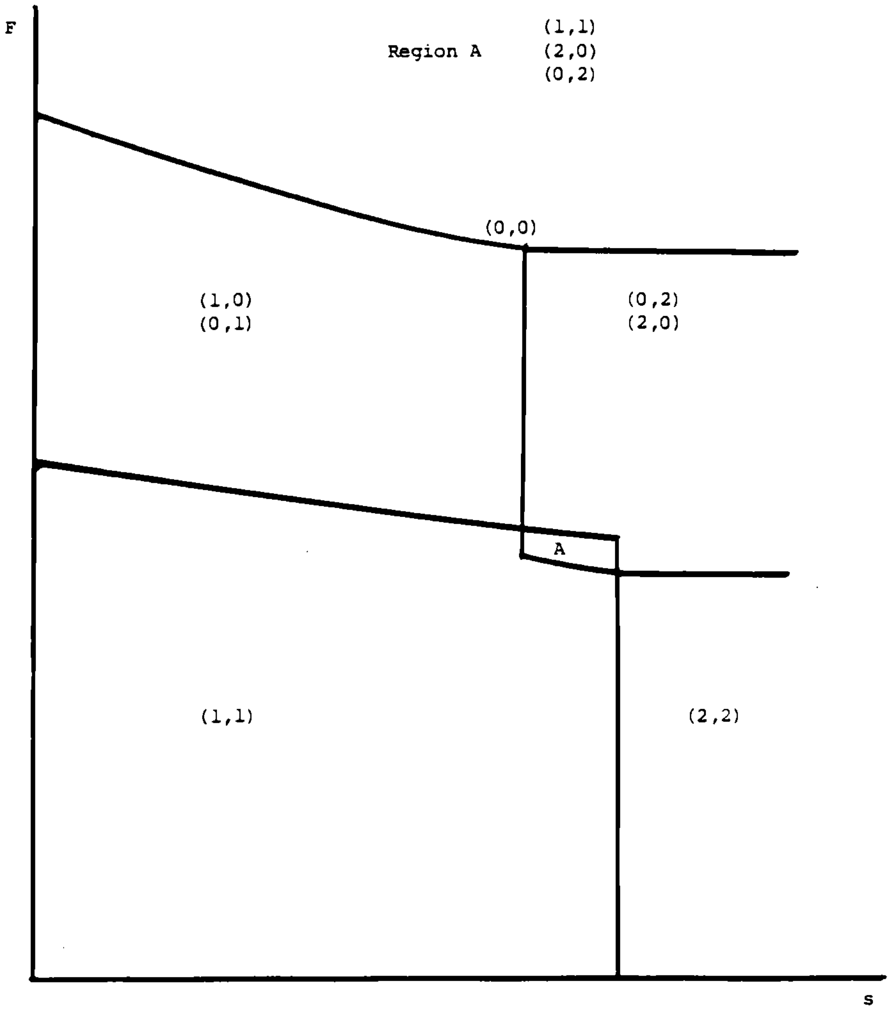
The General Case: Nash Equilibrium Market Structures as Functions of F, G




Note: Figure 1 is drawn for the parameter values of Table 1, but the existence, shape, and relative position of the regions are valid for all admissible parameter values (a,b,c,m,s).

FIGURE 2

The General Case: Nash Equilibrium Market Structures as Functions of F, s (G constant)




Note: Figure 2 is drawn for the parameter values of Table 1 but the existence, shape, and relative position of the regions are valid for all admissible parameter values (a,b,c,m,G).

the (F,G) for which $\pi_x(1,1) = \pi_y(1,1) = 0$. This boundary will also be a straight line but with slope –1. For (F,G) below the respective boundaries, profits for the given market structure are positive, while for (F,G) above the boundary profits are negative.

Much of the remainder of the diagram is straightforward. If neither of the structures (2,2) or (1,1) yield non–negative profits, then the only possibility left is a monopoly market structure (one of (1,0), (0,1), (2,0), (0,2)). Whether a firm chooses a one–plant or two–plant monopoly structure depends on whether the difference $\pi_x(2,0) - \pi_x(1,0)$ $(\pi_y(0,2) - \pi_y(0,1))$ is positive or negative. The eastern boundary between the regions (2,0) and (1,0) given the (F,G) for which the difference is zero. As this difference is also independent of F, the boundary will be vertical with $\delta = b\left[\left(\frac{a-m}{2b}\right)^2 - \left(\frac{a-m-s}{2b}\right)^2\right] > 0$. To the left of this boundary, $\pi_x(2,0) > \pi_x(1,0)$ so that (2,0), (0,2) is the market structure while to the right $\pi_x(1,0) > \pi_x(2,0)$ giving (1,0),(0,1) as the structure. Again, this result is subject to a non–negative profit constraint. This constraint defines the northernmost boundary of the diagram.

One qualification to these results is necesary. Some tedious algebra shows that, in this model, $\delta > \alpha$. This fact means that, for (F,G) with $\alpha < G < \delta$, $\pi_x(2,2) = \pi_y(2,2) < 0$ is not sufficient to guarantee that (2,0) ((0,2)) is an equilibrium. Because the foreign firm, for instance, finds the market structure (2,1) more profitable than (2,2) when $G > \alpha$, the fact that $\pi_y(2,2) < 0$ does not rule out the possibility that $\pi_y(2,1) > 0$. Clearly, should $\pi_y(2,1)$ be positive, then (2,0) would not be an equilibrium market structure.

Therefore, for (F,G) with $\alpha < G < \delta$, it is necessary to check whether $\pi_x(1,2)$ is positive or negative. The southern boundary of the region A gives the (F,G) for which $\pi_x(1,2) = 0$. This boundary is a straight line with slope –1. Further, since competing against exports is more profitable than competing against a domestic producer, the boundary must be everywhere below the $\pi_x(1,1) = 0$ locus (implying that $\gamma > \beta$ in Figure 1). Finally, since at $G = \alpha$, $\pi_x(1,2) = \pi_x(2,2)$, this boundary lies above the $\pi_x(2,2) = 0$ locus whenever $\alpha < G < \delta$.

Together, These facts imply the existence of a region like A, characterized by (F,G) for which (1,1) (below the $\pi_x(1,1) = 0$ locus) and (2,0) (above both the $\pi_x(1,2) = 0$ and $\pi_x(2,2) = 0$ loci) are equilibrium market structures. Thus the region A of Figure 1 is the region of multiple equilibria illustrated by Case 2 of Table 1.

A similar process can be employed to constuct the boundaries for Figure 2 in (F,s) space. The two vertical boundaries are the same as in Figure 1 in that they define the points of indifference between one–plant and two–plant production. Similarly, the other boundaries are the appropriate zero–profit loci.

A moment's consideration of Figure 1 serves to confirm the intuition gained from Table 1 regarding the relationship between market structure and the costs F and G. For a given s, MNE's arise when F is large relative to G, with the asymmetric MNE monopoly occurring when F becomes sufficiently large. Exporting equilibria arise when G is large relative to F, with the asymmetric monopoly emerging when G (or F+G) becomes sufficiently large.

Figure 1 is also useful in that it illustrates the asymmetric roles of the fixed costs F and G. Suppose we begin with F and G both small such that (2,2) is the initial equilibrium. Increases in F increase the cost of existing as a firm but do not affect the attractiveness of branch–plant production versus exporting. Thus the changes in structure as F increases are to (2,0)/(0,2) and then to (0,0). Increases in G affect the relative cost of branch–plant production versus exporting as well as the cost of existing as a firm. Thus the changes in structure as G increases (for small F) are to (1,1), then (1,0)/(0,1) and eventually (0,0).

Figure 2 provides insight into the impact of transport costs on the equilibrium market structure. Specifically, as firm–specific costs (F) and transport costs (s) are small relative to plant–specific costs (G), exporting is the equilibrium structure. When F and s are both large relative to G then the asymmetric MNE monopoly structure arises. These results are analogous to those reported in Horstmann and Markusen (1987).

Of course, both Figures 1 and 2 are constructed for specific values of s and G respectively. It is easy to illustrate, however, the way that various assumptions about the size of s or G affect the various regions in each diagram. Figures 3 and 4 illustrate the impact of increases in s and G on the equilibrium regions in Figures 1 and 2 respectively. As might be expected, increases in s increase the MNE region relative to exporting regions in Figure 1 while increases in G have the opposite effect in Figure 2.

## 3. Welfare

The welfare implications of having each of the possible market structures in this model are easily determined. Specifically, it is assumed that consumers maximize the utility function in (2) subject to an income constraint given by labor endowment L and profits.

$$(22) \qquad U = U(X) + U(Y) - cXY + Z$$

$$L + \pi_x = p_x X + p_y Y + Z$$

where $U(X) = aX - (b/2)X^2$ and $U(Y) = aY - (b/2)Y^2$. Substituting for Z from the budget constraint and for $p_x$ and $p_y$ from (3), utility is given by

$$(23) \qquad U = aX - (b/2)X^2 + aY - (b/2)Y^2 - cXY - (aX - bX^2 - cXY)$$

$$- (aY - bY^2 - cXY) + L + \Pi_x = (b/2)X^2 + (b/2)Y^2 + cXY + L + \pi_x$$

The only other restriction is that L must be set high enough such that consumption of Z is positive. By substituting the different equilibrium outcomes for X, Y and $\pi_x$ into (23) one obtains a welfare ranking for each of the market structure alternatives given in section 2.

The welfare results corresponding to the four cases in Table 1 are given in Table 2. Again, the first number of each pair is the home country utility level and the second is the foreign country utility level. Payoffs are found for the two–plant, one–plant, and no–entry strategies as before. L is set at 50 in each country to guarantee a positive level of Z

FIGURE 3

Increase in s

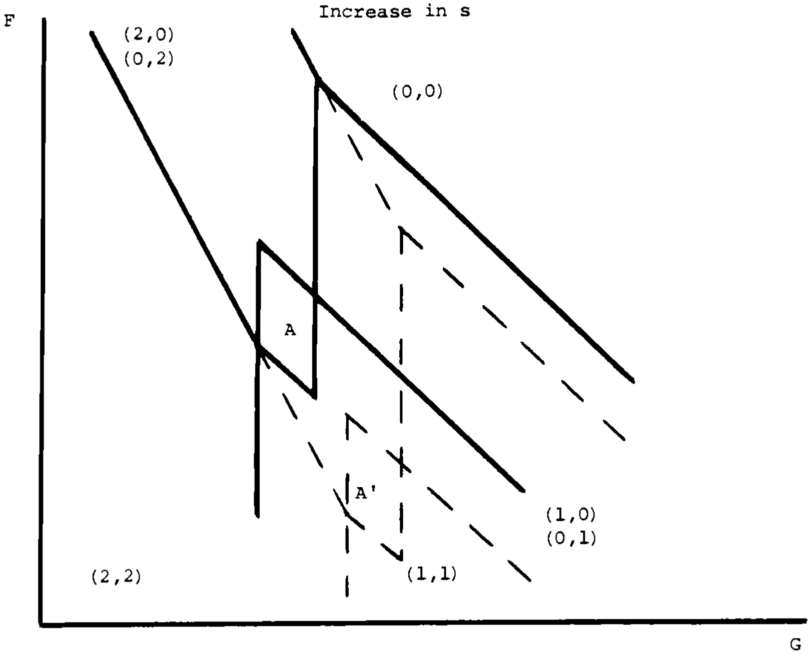
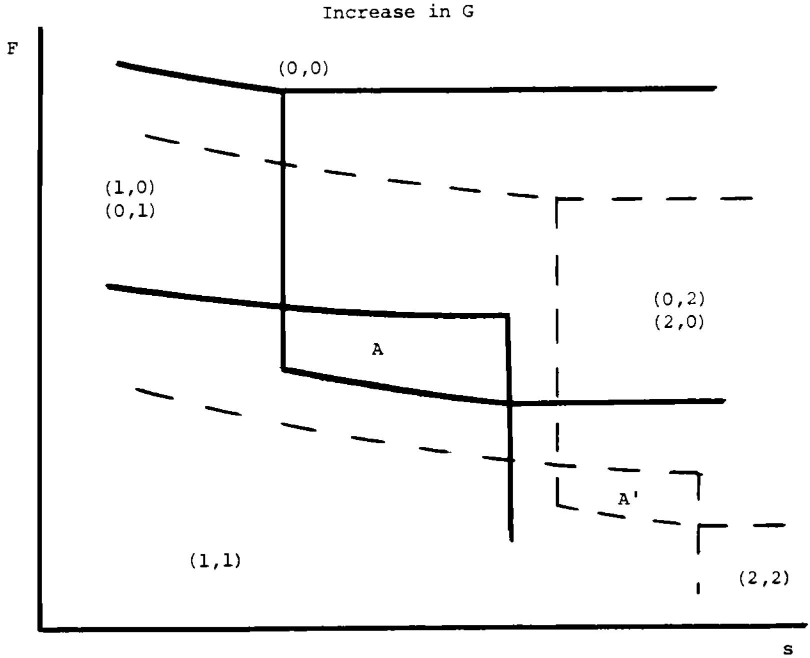



FIGURE 4

Increase in G



consumption.

The results of Table 2 show that, among these industry structures, the symmetric two–plant MNE allocation is Pareto optimal and Pareto superior to the exporting duopoly in all cases (the optimum for each country individually is to have a monopoly two–plant MNE). As (1,1) is the equilibrium market structure in cases 1 and 2, this result illustrates the possibility that the equilibrium market structure is not the optimal one (among those available). While we make no claims of generality for this result, it does provide an interesting contrast to the effects of fixed–cost parameter changes on private profits. In particular, with L fixed the welfare expression in (23) can be thought of as the sum of consumer surplus and profits. Compare the (2,2) allocation in welfare terms to the allocation (1,1) in Case 1 of Table 2. Although firm profits are higher at the latter, the loss of consumer surplus from paying higher import prices due to transport costs outweighs the profit difference. Conversely, welfare for country H is lower at the duopoly outcome (2,2) than if it had a monopoly MNE (allocation (2,0)) even though consumer surplus is much lower at the latter. The domestic consumer surplus loss at the monopoly equilibrium has two parts: (1) the loss due to the higher price of X, and (2) the loss of product Y. This consumer surplus loss is outweighed by the large profit gain in moving from (2,2) to (2,0), indicating that it is optimal to drive the foreign firm out if possible.

## 4. Trade Policy and Equilibrium Market Structure

As noted in the introduction, there have been many papers written on the topic of commercial policy in the presence of imperfect competition over the past few years. To the best of our knowledge, all of these papers assume an exogenous market structure (although not always an exogenous number of firms; e.g., Venables (1985), Horstmann and Markusen (1986), and Markusen and Venables (1988)). In this section, we analyze the effect of a tariff and a production tax/subsidy with market structure endogenous. The tariff question in particular has attracted a great deal of attention in the imperfect competition literature; e.g.,

Table 2

Welfare Results for Table 1

Case 1

| Country H \ Country F | 2 | 1 | 0 |
|---|---|---|---|
| 2 | (80.68, 80.68) | (78.73, 77.76) | (89.0, 66.0) |
| 1 | (77.76, 78.73) | (79.47, 79.47) | (88.5, 62.25) |
| 0 | (66.0, 89.0) | (62.25, 88.5) | (50.0, 50.0) |

Case 2

| Country H \ Country F | 2 | 1 | 0 |
|---|---|---|---|
| 2 | (79.68, 79.68) | (77.73, 76.76) | (88.0, 66.0) |
| 1 | (76.76, 77.73) | (78.47, 78.47) | (87.5, 62.25) |
| 0 | (66.0, 88.0) | (62.25, 87.5) | (50.0, 50.0) |

Case 3

| Country H \ Country F | 2 | 1 | 0 |
|---|---|---|---|
| 2 | (80.68, 80.68) | (78.73, 76.76) | (89.0, 66.0) |
| 1 | (76.76, 78.73) | (78.47, 78.47) | (87.5, 62.25) |
| 0 | (66.0, 89.0) | (62.25, 87.5) | (50.0, 50.0) |

Case 4

| Country H \ Country F | 2 | 1 | 0 |
|---|---|---|---|
| 2 | (81.68, 81.68) | (79.73, 76.76) | (90.0, 66.0) |
| 1 | (76.76, 79.73) | (78.47, 78.47) | (87.5, 62.25) |
| 0 | (66.0, 90.0) | (62.25, 87.5) | (50.0, 50.0) |

Brander and Spencer (1985), Dixit (1984), Eaton and Grossman (1986) and the papers using the free entry assumption just mentioned.

The analysis in this section is carried out in the context of two of the games given in Table 1. The results derived for these games regarding the impact of specific policies on market structure can be generalized by methods analogous to those used for Figures 1–4. The welfare results are, of course, much more specific to the actual parameter configurations assumed. Nonetheless, we believe these examples illustrate the importance of endogenizing market structures when undertaking policy studies.

To proceed, let T denote a specific import tariff on Y in the home country. Assume the parameter values of Case 1 of Tables 1 and 2 so that the symmetric exporting duopoly is the initial unique Nash equilibrium market structure. Expressions for utility, income, and profits are repeated as follows.

(24)
$$U = U(X) + U(Y) - cXY + Z$$

$$L + \pi_x + TY = p_x X + p_y Y - Z$$

$$\pi = p_x X + p_x^* X^* - m(X+X^*) - sX^* - G - F$$

Substitute the latter two equations into the utility function and recall that, with segmented markets and constant marginal cost, foreign prices and sales will not be affected by the home–country import tariff. Differentiating, we have

(25)
$$\frac{dW}{dT} = (a-bX-cY)\frac{dX}{dT} + (a-bY-cX)\frac{dY}{dT} - mdX - (p_y-T)\frac{dY}{dT} - Y\frac{dp_y}{dT} + Y\frac{dT}{dT}$$

$$\frac{dW}{dT} = (p_x-m)\frac{dX}{dT} + T\frac{dY}{dT} - Y\frac{d\hat{p}_y}{dT}$$

where the second equation follows from $p_y = a-bY-cX$, $p_x = a-bX-cY$ and $p_y - T = \hat{p}_y$. The three terms in the second equation of (25) are familiar from the imperfect competition literature. The first is the excess of price over marginal cost (marginal cost is zero in our numerical examples) times the change in output. This is a "Harberger triangle" effect: with price in excess of marginal cost, increases in output are beneficial. The second term is a volume–of–trade effect: with domestic price in excess of the cost of imports ($T = p_y - \hat{p}_y$), increases in imports increase welfare at constant terms of trade. The third term is the terms–of–trade effect. Solving for X and Y as functions of T (the same as (11) and (12) with d = (s+T)/(2b–c)) and differentiating, we get

$$(26) \qquad dX/dT = 1/15, \qquad dY/dT = -4/15, \qquad d\hat{p}_y/dT = -8/15$$

for the parameter values of Table 1: b=2, c=1, m=0. Substituting these expressions and the values of X and Y into (25), the optimal tariff sets (25) equal to zero, yielding a value of T = 4.67 (converts to 178% in ad valorem terms). The welfare function yields a value of 83.93 at the optimal tariff assuming that the exporting duopoly continues to be the equilibrium market structure.

These results are shown in Figures 5 and 6 where the heavy and then light curve gives welfare as a function of the specific rate of tariff T (ad valorem rate in parenthesis) for the exporting duopoly market structure. But with market structure endogenous, we have to check if the reduced profits to the Y producer cause him to change strategies. Indeed they do change and two cases are considered in Figures 5 and 6. In Figure 5, we assume that the foreign firm must have a plant in its own country. For the Case 1 parameters, profits of the Y producer fall to 1.71 when the tariff reaches .26 (5.4%). Referring back to Table 1, Case 1, we see that at this point the Y producer will enter the home market with a branch plant (the 1,2) allocation). The X producer will not have an incentive to alter its one–plant strategy, so (1,2) is the new Nash equilibrium. Referring to Case 1 of Table 2, we see that the home country's welfare is reduced to 77.76, a level lower than what it was at the initial zero–tariff equilibrium. At the new equilibrium, lower X profits outweigh an increase in consumer's surplus so that the home country loses. Home country welfare is thus given by the (discontinuous) heavy line in Figure 5: welfare initially rises and then falls when market structure switches and remains constant thereafter (further increases in the tariff are irrelevant).

Figure 6 considers the case where we do not constrain the foreign firm to have to produce in its own market. In this case, it may pursue a strategy not considered before because it was always irrelevant: the Y producer can maintain one plant in the home country and serve its own country by exports. Using Case 1 parameters, the profits from this strategy (the home firm also maintains a single plant in the home country) are 2.16. At a tariff rate of only 1.3%, the Y producer thus abandons his base and produces from a single home–country plant. For Case 1 parameters, the home firm has no incentive to change its strategy, so this new allocation is the Nash equilibrium. Figure 6 graphs welfare as a function of the specific tariff rate as in Figure 5. At a rate of 1.3%, the foreign firm enters the home market and welfare jumps up to 82.88 and remains constant thereafter. There is no difference in consumer surplus after the market structure changes in Figures 5 and 6. The difference lies in profits earned by the home firm in the foreign market. In Figure 5, the profits are lower because the X producer is competing with a domestic (low cost) Y producer whereas in Figure 6, the Y producer bears the transport cost to the foreign market as well and hence produces a lower quantity.

Now consider a producer excise tax in the home country. Producers of X and Y inside the country bear the tax, while we assume that import of Y and possibly X are not taxed (i.e., there is no import duty). We assume the parameter values of Case 4 of Tables 1 and 3 so that the symmetric two–plant MNE market structure is the Nash equilibrium. Home–country welfare as a function of the specific excise tax is shown in Figure 7. The initial welfare level is 81.68 from Case 4 of Table 2. The tax is distortionary and reduces welfare despite the fact that there is a positive terms–of–trade effect forcing the import price of Y down.

When the tax reaches a level of .38 (12.1%), profits for both X and Y producers are reduced to zero. Invoking a "tie breaking" rule in favor of the domestic firm, the Y producer

FIGURE 5

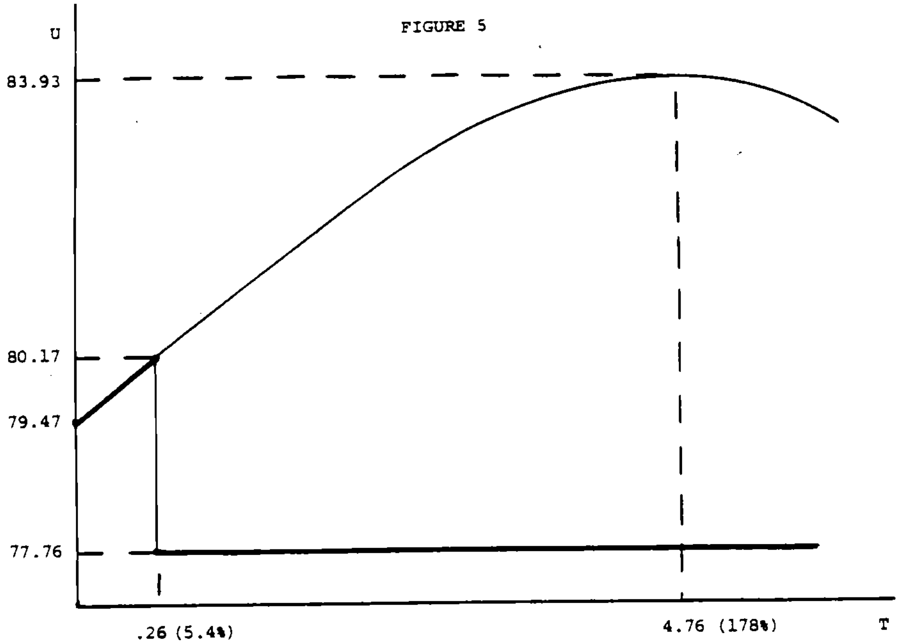
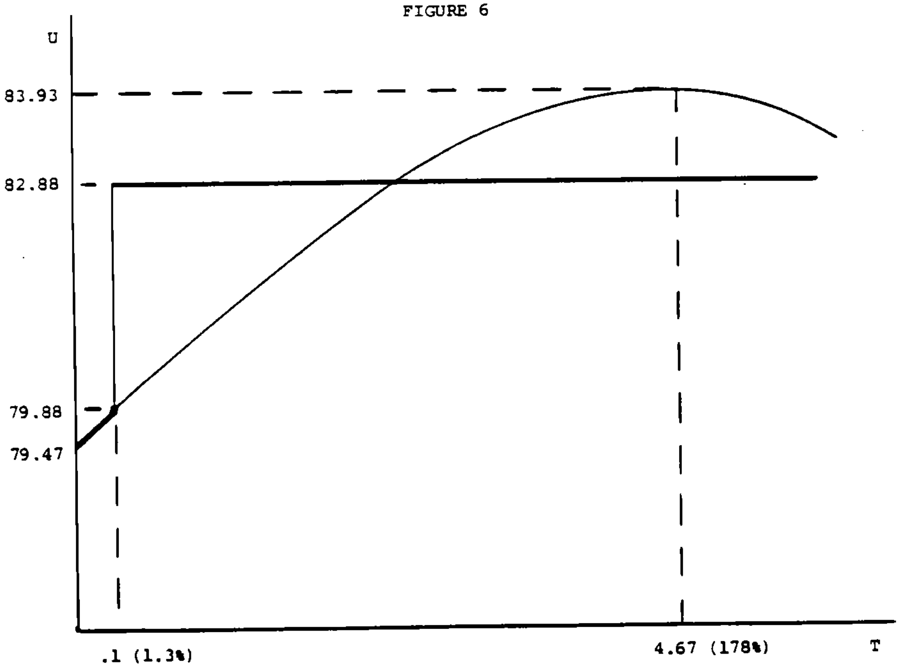
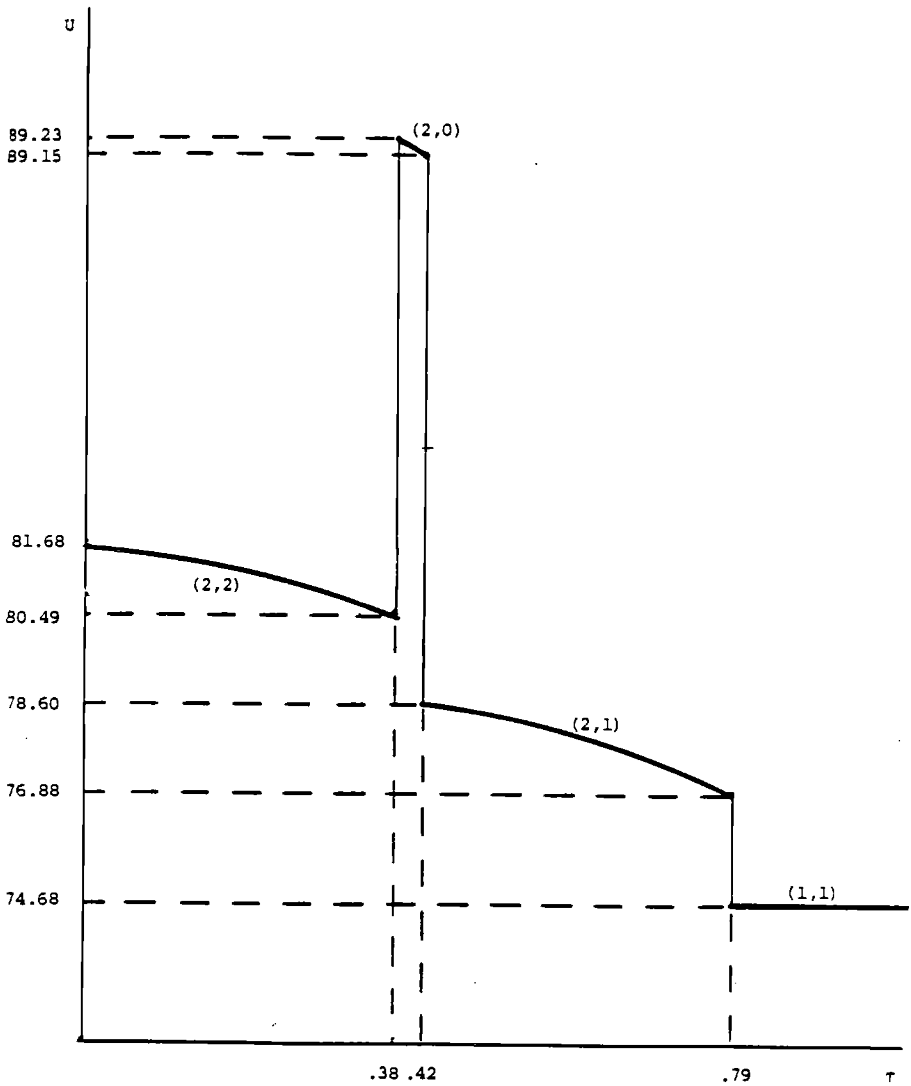



FIGURE 6




Scale on horizontal axis $T^{.75}$ in Figures 1 and 2

FIGURE 7



exits, and the equilibrium moves to (2,0) as shown in Case 4 of Table 1. Welfare rises to 89.231 due to the large increase in profits that outweighs the loss of consumer surplus. Further increases in the tax reduce the output of X and hence domestic welfare. But this reduction in X means that the demand price of Y is rising. At a tax rate of .42 (5.4% of the monopoly price), the foreign firm can profitably export to the home country (recall that imports bear no tax) and so the equilibrium in Table 1 shifts a second time, in this case to (2,1). This has an unfavorable welfare effect as the loss in profits to the X producer outweighs the gain in consumer surplus.

Increases in the tax beyond .42 continue to reduce welfare and the profits of the X producer. At a tax rate of .79 (6.3% of $p_x$), the X producer abandons his home country plant and serves the home market from his plant in the foreign country. The equilibrium involves two, one–plant firms, both located in the foreign country. Welfare falls further as shown in Figure 7 due to the higher price of X and corresponding loss of consumer surplus.

## 5. Robustness of Results

The model used in this paper is obviously restrictive in its use of functional forms. In this section, we will briefly describe how alternative assumptions affect the results. We will do this in terms of Figure 1, the "general case" given the demand and cost functions assumed in the paper. Three alternative assumptions will be considered individually: (A) non–linearity of the demand curves, (B) increasing marginal cost, and (C) a positive income elasticity of demand for X and Y. The fixed–cost assumptions and the assumption of Cournot behavior in the post–entry game are retained.

The first result to note is that none of these three alternative assumptions affect the shape and general position of the zero–profit boundaries in Figure 1 (the sloping "northern" boundaries of the regions). As we noted in connection with this diagram, the slope of those boundaries are determined entirely by the tradeoff between firm–specific and plant–specific costs. Thus the boundary between (2,2) and (2,0)/(2,0) and that between (2,0)/(0,2) and (0,0) have a constant slope of $-2$: with 2 plants, a decrease in F of 2 cancels an increase in G of 1. The boundary between (1,1) and (1,0)/(0,1) and that between (1,0)/(0,1) and (0,0) similarly have a constant slope of $-1$.

The second result is that assumptions (A) does not affect the fact that the boundary between regions (2,2) and (1,1) is vertical in Figure 1 and that there is no region in between. The same result applies to the boundary between regions (2,0)/(0,2) and (1,0)/(0,1). The "eastern" boundary of region (2,2) is deterimed by the equality $\pi_x(2,2) = \pi_x(1,2)$. Alternative assumption (A) does not affect the fact that the solution to this equation is found at a unique value of G that is independent of F, hence the vertical boundary (nor does assumption (B) for that matter. Alternative assumption (C) does change this result as we will indicate below). The "western" boundary of region (1,1) in Figure 1 is defined by the equality $\pi_x(1,1) = \pi_x(2,1)$ and is again found at a unique value of G that is independent of F. Finally, the result shown in Figure 1 that the eastern boundary of region (2,2) and the western boundary of region (1,1) are the same is also independent of alternative assumption (A) (but not (B), see below). This boundary is defined by indifference between exporting to the other country or serving it by a branch plant. Given the segmented markets assumption (which does matter) and constant marginal cost, this indifference is independent of the market structure is in one's own country.

There are two qualitative difference that alternative assumptions (A) and (B) introduce into Figure 1. First, assumption (A) alone may result in the relative positions of the (2,2) – (1,1) and (2,0)/(0,2) – (1,0)/(0,1) boundaries being reversed, with the latter now occurring at the lower value of G. This leaves a parallelogram similar to A in Figure 1. Points within this new parallelogram will have the following characteristics:

(i) $\pi_x(1,0) > \pi_x(2,0) > 0$.

(ii) $\pi_x(1,1) > 0$.

(iii) $\pi_x(2,1) > \pi_x(1,1) > 0.$

(iv) $\pi_x(1,2) < \pi_x(2,2) < 0.$

Similar inequalities apply to Y (i.e., replace $\pi_x$ with $\pi_y$).

Given these inequalities, it is then relatively easy to see that the new equivalent to parallelogram A in Figure 1 is a region of non–existence of (pure strategy) equilibrium rather than a region of multiple equilibrium. Suppose, for example, that we start with an allocation (1,0). Y will enter with one plant moving the allocation to (1,1) ((ii) above). X will in turn shift to branch plant production abroad, moving the allocation to (2,1) ((iii) above). Y now makes negative profits from either one or two plants and exits ((iv) above), making the market structure (2,0). But now X eliminates the branch plant moving back to the starting allocation (1,0) ((i) above).

Assumption (B), either alone or in conjunction with (A), will in general result in there being a region between the (2,2) and (1,1) regions in Figure 1. This additional region arises due to the fact that, while the equation $\Pi_x(2,2) = \Pi_x(1,2)$ has a unique solution in G, the value of G that solves the equation is generally different from the one that solves $\Pi_x(2,1) = \Pi_x(1,1)$ when costs are increasing. That is to say, when marginal cost is not constant, profitability of an additional plant depends on the number of plants the competing firm operates. The reason for this outcome is simple. Consider a situation in which the foreign firm operates two plants rather than one. Then, marginal cost at a given level of foreign country production is smaller in the two plant case than in the one plant case (assuming the foreign firm also produces for the home country market). This lowered marginal cost in turn implies that the foreign firm's equilibrium output, even in its own market, will differ when it operates two plants rather than one. This fact, in turn, means that the profitability of an additional plant for the home firm will differ depending on whether the foreign firm operates one or two plants.

The form of the equilibrium in the new region is relatively easy to determine. Should an additional plant be more profitable when the competing firm operates a single plant rather than two plants (i.e. the G that solves $\Pi_x(2,1) = \Pi_x(1,1)$ is larger than the G solving $\Pi_x(1,2) = \Pi_x(2,2)$, then the new region has the property that, for all (F,G) pairs in the region, the configuration (1,2), (2,1) is the unique equilibrium configuration. Should the reverse be true, then both (2,2) and (1,1) become equilibrium configurations. In any event, asumption (B) makes possible the asymetric configuration (1,2) (2,1) as an equilibrium outcome.

Finally, the assumption that there is a positive income elasticity of demand for X and Y makes more of a difference to the map shown in Figure 1. Not only may the (2,2) – (1,1) and (2,0) – (1,0) boundaries be reversed as just discussed, but they are clearly not vertical. An increase in F for constant G reduces the maximum possible quantities of X, Y, and Z that can be produced and thus reduces income. At constant prices, demand for all three will fall, which is like contracting the size of the market for X and Y. This in turn implies that the critical value of G at which $\pi_x(2,2) = \pi_x(1,2)$ and $\pi_x(2,0) = \pi_x(1,0)$ falls as we increase F. The (2,2) – (1,1) and (2,0) – (0,2) boundaries in Figure 1 are negatively sloped with unknown curvature. These boundaries must however, have a slope less than minus two (more negative), since at this value income is not in fact falling in two–plant production (the changes in G and F cancel). They thus continue to intersect the zero–profit boundaries "from below" as shown in Figure 1.

We confirmed this intuition by replacing Z in (2) above with $(Z - (e/2)Z^2)$. The boundaries just mentioned are negatively sloped, with the (2,0) – (1,0) boundary steeper (i.e., its slope is more negative) than the (2,2) – (1,1) boundary. The latter boundary lies to the right of the former as in Figure 1, although we were able to prove this only for small values of e. In summary, for small values of e and U quadratic in Z as well as in X and Y, Figure 1 remains qualitatively similar except that the (2,2) – (1,1) and (2,0) – (1,0) boundaries are negatively sloped (less than minus two) and non–linear.

## 6. Summary and Conclusions

The purpose of this paper is to show via a simple model and associated numerical examples how imperfectly competitive market structures can be endogenized in trade models. In keeping with some of the literature, the world is assumed to consist of two identical countries so that no comparative–advantage basis for trade exists. Each country produces a homogeneous consumption good with constant returns and perfect competition and one good with increasing returns to scale. There are firm–specific fixed costs as well as plant–specific fixed costs, with the former acting as joint inputs across plants (Markusen, 1984). The single (due to the size of the market) imperfectly competitive firm in each country chooses among three options in the first stage of a two–stage game: (A) maintaining a plant in both countries, i.e., becoming a MNE; (B) serving both markets from a single home plant; and (C) not entering the market at all. If firms enter in both countries, they play a Cournot–Nash game in outputs in the second stage given their first–stage choice of modes.

Market structure (B), the two–firm, exporting duopoly is probably the most familiar in the trade literature (references noted in the introduction). We show that this structure tends to arise as the equilibrium when plant–specific fixed costs are large relative to firm–specific fixed costs and tariff/transport costs. Two equilibria of type (A) can exist: one with only a single firm entering with two plants (as in Markusen (1984)) and one with both firms entering (similar to Helpman (1984)). Both type (A) equilibria arise when plant specific costs are low relative to firm–specific costs, with the second arising when the total of the two is relatively lower (so that the market can support two, two–plant firms).

Several general points arise from these results and examples. The first is an elementary point from simple game theory, but perhaps not sufficiently appreciated in trade theory. Equilibrium market structure cannot be inferred from profit levels in this type of non–cooperative game (as in the simple prisoners' dilemma). In one situation (case 4 of Table 1) the equilibrium is not the profit–maximizing choice of structure. The equilibrium depends in particular on the payoffs associated with non–equilibrium strategies. Payoffs from all strategies must be evaluated in order to solve the game.

Second, the results emphasize that non–symmetric outcomes are possible in an initially perfectly symmetric game. Cases 2 and 3 of Table 1 have equilibria with a single firm producing from plants in both countries. Although the countries and (potential) firms are identical, the equilibrium involves countries having different income levels and different production plans.

Sections 3 and 4 apply the positive analysis to questions of welfare and tax policy. Two results emerge from the welfare analysis, at least for the numerical examples chosen. First, the MNE duopoly with each firm maintaining a plant in the foreign market is Pareto superior to the exporting duopoly in which each firm served the other market by exports. Higher consumer surplus at the MNE equilibrium outweighs the higher fixed costs relative to the latter. But higher private revenues in the MNE market structure do not compensate the firms themselves for the higher fixed costs, hence the MNE allocation may or may not be the Nash equilibrium market structure. Second, the welfare superior outcome emerges as the equilibrium when plant–specific costs are low relative to firm–specific costs.

The tax analysis shows that small tax changes can generate large welfare changes by changing equilibrium market structure. The market structure changes involve large, discontinuous changes in prices, outputs, profits, and hence welfare. In an import tariff example with an exporting duopoly as the initial market structure, the foreign firm switches to serving the domestic market with a branch plant long before the "optimal" import tariff is reached. In one case (Figure 5), this shift causes domestic welfare to fall below the initial no–tariff level.

An example of a producer excise tax with the MNE duopoly as the initial market structure is more complex. We present an example in which there are three changes in industry structure as the tax rate increases. First, the foreign firm exits production entirely.

Second, the foreign firm re–enters the domestic market by exporting to it. Third, the domestic firm abandons the domestic market, produces in the foreign country and exports back home.

In all these cases, the welfare consequences of taxes are dramatically different from those obtained from traditional Pigouvian marginal analysis with market structure exogenous. The negative point for public policy is that the ability of firms to change plant configurations seriously limits the applicability of "optimal" tax results found in public finance and international trade theory. A more positive implication, not explored here, is that manipulating industry structure can itself become a tool of public policy in addition to the more traditional tool of manipulating marginal price/output decisions.

## References

Brander, J.A. and P.R. Krugman (1983), "A Reciprocal Dumping Model of International Trade", Journal of International Economics 15, 313–321.

Brander, J.A. and B.J. Spencer (1985), "Export Subsidies and International Market Share Rivalry", Journal of International Economics 18, 83–100.

Dixit, A.K. (1984), "International Trade Policy for Oligopolistic Industries", Economic Journal, Supplement, 1–16.

Dixit, A. K. and A. S. Kyle (1985), "The Use of Protection and Subsidies for Entry Promotion and Deterrence," American Economic Review 75, 139–152.

Eaton, J. and G.M. Grossman (1986), "Optimal Trade and Industrial Policy Under Oligopoly", Quarterly Journal of Economics, 383–406.

Helpman, E. (1981), "International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition. A Chamberlinian–Heckscher Ohlin Approach," Journal of International Economics 11, 304–340.

Helpman, E. (1984), "A Simple Theory of International Trade with Multinational Corporations," Journal of Political Economy 92, 451–471; reprinted in J. Bhagwati (ed.), International Trade: Selected Readings, second edition (Cambridge: MIT Press).

Horstmann, I.J. and J.R. Markusen (1986), "Up the Average Cost Curve: Inefficiency Entry and the New Protectionism," Journal of International Economics 20, 225–248.

Horstmann, I.J. and J.R. Markusen (1987), "Strategic Investments and the Development of Multinationals," International Economic Review, 109–121.

Krugman, P.R. (1979), "Increasing Returns, Monopolistic Competition, and International Trade", Journal of International Economics 9, 469–479.

Levinsohn, J. A. (1990), "Strategic Trade Policy When Firms Can Invest Abroad," Journal of International Economics, forthcoming.

Markusen, J.R. (1981), "Trade and the Gains from Trade with Imperfect Competition," Journal of International Economics 11, 531–551.

Markusen, J.R. (1984), "Multinationals, Multi–Plant Economies, and the Gains from Trade," Journal of International Economics 16, 205–226; reprinted in J. Bhagwati (ed.), International Trade: Selected Readings, second edition (Cambridge: MIT Press).

Markusen, J.R. and A.J. Venables (1988), "Trade Policy with Increasing Returns and Imperfect Competition: Contradictory Results from Competing Assumptions", Journal of International Economics 24, 299–316.

Venables, A.J. (1985), "Trade and Trade Policy with Imperfect Competition: The Case of Identical Products and Free Entry", Journal of International Economics 19, 1–20.