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THE CASE OF THE VANISHING REVENUES: AUCTION QUOTAS WITH OLIGOPOLY

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ABSTRACT

This paper examines the effects of auctioning quota licenses when market power exists. The overall conclusion is that with oligopolistic markets, quotas, even when set optimally and with quota licenses auctioned off, are unlikely to dominate free trade. Moreover, auction quotas only strictly dominate giving away licenses which are competitively traded if the quota is quite restrictive.

When there is a foreign duopoly or oligopoly and domestic competition it is shown that such sales of licenses does not raise revenues unless they are quite restrictive.

An oligopoly example is explored to study the role of product differentiation, demand conditions and market conditions in determining the value of a license and the welfare effects of auctioning quotas. In this example, auction quotas are always worse than free trade.

Finally, when there is a home duopoly and foreign competition, the price of a quota license is shown to be positive when the home and foreign goods are substitutes but to be zero when they are complements.

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1. INTRODUCTION

In this paper I examine the case for auction quotas when there is either a foreign or domestic oligopoly. A companion paper[1] deals with monopoly.

One of the most common criticisms of voluntary export restrictions (VERS) and the way that quotas are currently allocated is that they allow foreigners to reap the rents associated with the quantitative constraints. It has been suggested that auctioning import quotas would remedy this. It is claimed that:

> "this would leave the price support features of quotas intact but deliver the higher profits to the U.S. economy instead of abroad."[2]

In an article in Business Week, Alan Blinder argues that:

> "Auctioning import rights is one of those marvelous policy innovations that create winners, but no losers, or, more precisely, no American losers. The big winner is obvious: the U.S. Treasury, . . ."[3]

An article in Time magazine quotes C. Fred Bergsten as saying that:

> "Quota auctions might bring in revenues as high as $7 billion a year."[4]

A Congressional Budget Office (CBO) memorandum[5] estimates quota rents possible in 1987 to be between 3 and 7 billion dollars. It compares this to the Bergsten et al. (1987) estimate for the Institute for International Economics (IIE) of 9 billion. Part of the difference, 2.2 billion, in the estimates arises because the CBO does not include a VER on automobiles while the IIE does. The remainder arises from differences in procedure. Both estimates assume perfect competition everywhere. Takacs (1987) points out that proposals to auction quotas have become increasingly frequent.[6] She states: "Commissioners Ablondi and Leonard of the U.S. International Trade Commission (ITC) recommended auctioning sugar quota licenses in 1977. The ITC recommended auctioning footwear quotas in 1985. Studies by Hufbauer and Rosen (1985) and Lawrence and Litan (1985) suggested auctioning quotas and earmarking the funds for trade adjustment assistance."[7]

Despite the importance of the issues involved, the intuition behind such statements and the procedure used in the estimates is based on models of perfect competition. In such models, the level of the quota determines the domestic price, and the difference between the domestic price and the world price determines the price of a license when auctioned. If the country is small, then the world price is given. If the country is large, then the world price does change with a quota. How the world price changes is determined by supply and demand conditions in the world market.

However, when markets are imperfectly competitive, this analysis may well be misleading. The reason is that in such environments, prices are chosen by producers, i.e. there is no supply curve and the response of producers to the constraint must be taken into account when determining the price of an auctioned license. For example, if the response of profit maximizing producers is to adjust their prices so that there is no benefit to be derived from owning a license to import, its auction price must be zero!

Therefore the question that needs to be addressed concerns the behavior of producers in response to quantitative constraints in such markets, and the impact of this on the price of a license. There has been relatively little work in this area. The work on the effects of quantitative restrictions in imperfectly competitive markets is linked to this question,[8] but to date, little analysis of what this might suggest about the price of a license seems to exist.[9]

In this paper, I develop a series of models of oligopoly which begin to address this issue. The models show how the way in which licenses are sold, demand conditions, and market structure influence the resulting price of a license. The results indicate that there is reason to expect that the price of a license may be much lower than that indicated by applying models of perfect competition. Thus, estimates such as those of the IIE and CBO may be far too large. Moreover, if no revenues are raised from auctioning quotas unless they are very restrictive, the profit shifting effect of such quotas, even when auctioned off, is unlikely to outweigh the loss in consumer surplus of such policies. For this reason, they tend to have adverse welfare consequences.

In Krishna (1988) it was shown that with a foreign monopoly the price of a license was likely to be zero. This was because with auction quotas the monopolist found it worthwhile to raise his price and thereby shift the demand for licenses inwards, until the price of a license reached zero. However, one might expect that with more foreign firms this would be less likely since such a policy would also shift demand towards the competing foreign firms. Thus, one might expect that if competition among firms is strong enough, the prices charged may not rise, so that the price of a license could be positive. Competition in price with differentiated products is assumed both for convenience, and because competition in price *a la* Bertrand is more intense than is competition in quantities[10]. Even in this case, however, licenses receive a zero price unless the quota is quite restrictive. This is because the effect of competition from other firms does not outweigh the incentive to strategically affect the price of a license on the part of a firm.

A model of a foreign duopoly is analyzed in Section 2 to illustrate this result in a simple framework. Section 3 works out an oligopoly example which allows parametrization of several important factors such as the degree of substitutability between foreign products, their own demand elasticity, and the number of foreign firms. This shows how such factors affect the desirability of auction quotas.

Section 4 considers the effect of imposing a quota on imports for the case of a home oligopoly and foreign competition. I consider both the case when foreign and domestic goods are substitutes for each other, as well as when they are complements. In Krishna (1988) it was shown that with a home monopoly and substitute goods, auctioning quota licenses creates an incentive for the home monopoly to raise its price which in turn raises the demand for both imports and their licenses, thereby creating a positive price for a license. The same result tends to go through with more home firms despite the fact that an increase in price of a home firm also shifts demand towards other home firms which works against a price increase of the home firm(s).

When home and foreign goods are complements, and there is a home monopoly, it is shown in Krishna (1988) that licenses have a zero price. The same result tends to carry over with more home firms. These results are illustrated using simple duopoly models. The results are summarized in Table 1.

Finally, in Section 5, I conclude by discussing the effects of having more firms at home and abroad, and directions for future research in this area.

2. FOREIGN DUOPOLY

In this section and the next I argue that even with many foreign firms, each with some market power, a quota on total imports implemented through the sale of licenses will tend to be welfare decreasing. The main results are:

Proposition 1. Auctioning quotas will not raise revenues for the home government unless the quota is set significantly below the free trade level of imports. Slightly restrictive quotas will only raise import prices and therefore reduce welfare from the free trade level. This tends to make quotas, even when auctioned off and set at optimal levels, worse than free trade. However, it is no worse to auction quotas than to impose a VER where quotas are given away. It is strictly better to auction quotas only if the quota is quite rstrictive.

In order to develop some intuition, I first analyze a model of foreign duopoly. For simplicity, assume that all foreign firms are identical, i.e., impose symmetry. Let $D^1(p^1,p^2)$ and $D^2(p^1,p^2)$ be the demand functions facing the two foreign firms. As usual, we will let subscripts denote partial derivatives and assume that $D^i_j > 0$ for $i \neq j$ and $D^i_j < 0$ for $i = j$ so that demand is downward sloping and foreign goods are substitutes for each other. Marginal costs of production are assumed to be constant at c for all firms.

In the absence of any quotas, each firm maximizes its profits, $\Pi^i(p^1,p^2) = (p^i-c)D^i(p^1,p^2)$ taking p^j, $i \neq j$ as given. The resulting first order condition, $\Pi^i_j(p^1,p^2) = 0$, defines the best response of each firm for any price by its competitors. $B^1(p^2)$ and $B^2(p^1)$ denote these best responses for the two firms. They are depicted in Figure 1. Their intersection gives the

Nash equilibrium prices (p^{1*}, p^{2*}), which in turn gives rise to the free trade level of imports denoted by V^F.

(FIGURE 1 here)

Now consider the effect of a quota at the free trade level, implemented by the sale of licenses. At this point it is important to be clear about exactly what constitutes a license, how licenses are sold, and what the timing of moves is. Throughout this paper a license is defined to be a piece of paper which entitles its owner to buy one unit of the product in question at the price charged by the seller.

The licenses are sold in a competitive market to either competitive domestic retailers with zero marginal costs of retailing or to consumers directly. I assume that the timing of moves is as follows. First, the government sets the quota. Then the firms set their prices. Finally, the market for licenses clears. This timing is consistent with the idea that the market for licenses clears more frequently than the monopolist sets prices, and that the government sets the quota even less frequently than the monopolist sets prices. Note that other assumptions about the market structure in the market for licenses can be made, and future work is planned in this direction.

The model is then solved backwards as usual. Consider the market for licenses first. If the prices charged by the firms are (p^1, p^2) and the price of a license is L, then the demand for licenses must be the same as the demand for imports at (p^1+L, p^2+L), namely $D^1(p^1+L, p^2+L) + D^2(p^1+L, p^2+L)$. The supply of licenses is V, the level of the quota. Thus the equilibrium price of a license, when prices p^1 and p^2 are charged by the firms and V is the level of the quota, is given by $L(p^1, p^2, V)$ where $L(\cdot)$ is defined by the market for licenses clearing. Notice that if $D^1(p^1, p^2) + D^2(p^1, p^2) < V$, then $L(p^1, p^2, V) < 0$ as defined so far. However, since a quota is not binding if such a high price is charged, $L(\cdot)$ is defined to be zero in this case.

Also, $L(p^1, p^2, V)$ is decreasing in all its arguments so that $L_1(\cdot) < 0$, $L_2(\cdot) < 0$, $L_3(\cdot) < 0$. This implies that the combinations of p^1 and p^2 such that the license price is just equal to zero is given by a downward sloping line in Figure 1. This is depicted by the line $L(p^1, p^2, V^F) = 0$ when the quota is set at the free trade level. Naturally, this line goes through the Nash equilibrium point (p^{1*}, p^{2*}). For prices above and to the right of this line, prices are so high that the quota is not binding and a license has no value. For prices below and to the left of this line, the quota is binding so that the price of a license is positive.

Moving to the second stage, each firm's profit function is also altered by the quota. Consider firm 1. For any price charged by firm 2, if it charges a price above the line $L(p^1, p^2, V^F) = 0$, its profits are unchanged by the quota. However, if it charges a price below this line, $L(\cdot)$ is positive so that its profits are given by $\bar{\Pi}^1(p^1, p^2, V^F) = (p^1 - C)D^1(p^1 + L(p^1, p^2, V^F),\ p^2 + L(p^1, p^2, V^F))$. Notice that along the line $L(p^1, p^2, V^F) = 0$ $\bar{\Pi}^1(\cdot)$ equals $\Pi^1(\cdot)$, and that $\bar{\Pi}^1_1(\cdot) = \Pi^1_1(\cdot) + (p^1 - C)[D^1_1(\cdot) + D^1_2(\cdot)]L_1(\cdot)$.

Assume that $D^1_1(\cdot) + D^1_2(\cdot) < 0$; that is, the effect of all prices rising equally is a reduction in demand; i.e., own price effects outweigh cross price effects. It is clear now that $\bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot)$.

Therefore only three possible cases exist when considering the derivatives $\bar{\Pi}^1_1(\cdot)$ and $\Pi^1_1(\cdot)$ along $L(\cdot) = 0$. Either:

(a) $\bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot) \geq 0$, or

(b) $\bar{\Pi}^1_1(\cdot) > 0 > \Pi^1_1(\cdot)$, or

(c) $0 \geq \bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot)$.

Recalling that profits are given by $\bar{\Pi}^1(\cdot)$ below the line $L(p^1,p^2,V^F) = 0$, and by $\Pi^1(\cdot)$ above the line, this means that the composite profit function facing firm 1 with a quota, denoted by $\hat{\Pi}^1(\cdot)$, must look like that depicted in Figure 2(a), (b) and (c) in these three cases.

(FIGURE 2 here)

Assume that both $\bar{\Pi}^1(\cdot)$ and $\Pi^1(\cdot)$ are concave in p^1 given p^2. Let $\bar{B}^1(p^2)$ maximixe $\bar{\Pi}^1(\cdot)$ with respect to p^1. If we draw $\Pi^1(\cdot)$ and $\bar{\Pi}^1(\cdot)$, as in Figure 2, it is obvious that in case (a) it is best for firm 1 to price along $B^1(p^2)$, in case (b) to price along $L(\cdot) = 0$, and in case (c) to price along $\bar{B}^1(p^2)$.

Returning to Figure 1, the fact that $\bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot)$ means that $\bar{B}^1(p^2)$ lies to the right of $B^1(p^2)$ as shown. Similarly, $\bar{B}^2(p^1)$ lies above $B^2(p^1)$. Let their intersection be at $(\bar{p}^1,\bar{p}^2)$. The effect of the quota system on the best response of firm 1 is now apparent. Let $\bar{B}^1(p^2)$ intersect $L(\cdot)$ when $p^2 = \bar{p}^2$ and $\bar{B}^2(p^1)$ intersect $L(\cdot)$ when $p^1 = \tilde{p}^1$ as depicted. If p^2 exceeds p^{2*} then both $B^1(\cdot)$ and $\bar{B}^1(\cdot)$ lie above $L(\cdot) = 0$, so that $\Pi^1_1(\cdot)$ and $\bar{\Pi}^1_1(\cdot)$ are both positive along $L(\cdot) = 0$. Hence, we are in case (a). When p^2 lies between $\bar{p}^2$ and p^*_2, we are in case (b), and when p^2 lies below $\bar{p}^2$ we are in case (c). Therefore, the best response function for firm 1 given the quota is $\dot{B}^1(p^2)$ which is drawn as a dark line in Figure 1.[11]

Analogous arguments show that for firm 2 the best response function is given by $\dot{B}^2(p^1)$ depicted by the dark dotted line in Figure 1. Notice that the equilibrium is not affected when a quota at the free trade level is imposed. Since the equilibrium lies along $L(\cdot) = 0$ selling licenses does not raise revenues.

Another way of understanding why the free trade equilibrium remains the equilibrium is to note that given the price of the other firm, the quota makes the demand curve facing a firm more inelastic whenever the quota binds, and leaves it unaffected otherwise. However if $p^2 = p^{2*}$, the quota binds only if $p^1 < p^{1*}$ so that demand is more inelastic for price decreases but not for price increases. Thus, there is no incentive to change price from p^{1*}. Similarly, firm 2 also has no incentive to change its price from p^{2*} so that these original prices constitute a Nash equilibrium even with the imposition of the quota at the free trade level.

Now consider the effect of reducing the quota. This shifts $L(\cdot) = 0$ outwards. Corresponding to this quota are $\bar{B}^1(\cdot)$ and $\bar{B}^2(\cdot)$ analogous to those drawn in Figure 1. Figure 3 shows the effect of the lower quota on firms' reaction functions. It is easy to verify that this quota does affect the equilibrium.[12] In fact, there are a continuum of equilibria along the segment EF of $L(\cdot) = 0$ in Figure 3. However, all the equilibria correspond to $L(\cdot) = 0$ so that even if the quota is slightly restrictive, the license has no value in equilibrium.

(FIGURE 3 here)

Finally, if V is so small that the $L(\cdot) = 0$ line lies above the intersection of the $\bar{B}^1(\cdot)$ and $\bar{B}^2(\cdot)$ lines defined by that V, then the equilibrium is unique, and is given by the intersection of $\bar{B}^1(\cdot)$ and $\bar{B}^2(\cdot)$.[13] Again this comes from deriving $\dot{B}^1(\cdot)$ and $\dot{B}^2(\cdot)$ by comparing the derivatives of $\Pi(\cdot)$ and $\bar{\Pi}(\cdot)$ along $L(\cdot) = 0$. In this case, as prices are such that the quota binds in equilibrium, the licenses raise positive revenues. However, this occurs only when the quota is quite restrictive. In this event, the consumer surplus loss is large so that the optimal quota level when licenses are auctioned need not be a restrictive one since welfare first falls and only then rises as the quota falls.[14] Krugman and Helpman (1988), in studying the effects of a VER or quota with foreign duoply, show that for a linear example it is never optimal to set a restrictive quota.

A simple example is developed in the next section in order to better understand how market structure and demand conditions affect the welfare consequences of such quotas.

3. AN ILLUSTRATIVE EXAMPLE

The effects of the quota system as described in the previous section depend on substitutability between products, overall demand elasticity for the product group, and the number of firms in the market. The following example illustrates the influence of these parameters. The main results are summarized in Proposition 2.

Proposition 2. In the CES/CED formulation used below, the ratio of the free trade level of imports to the quota at which the license price becomes positive, $\frac{V^F}{V^*}$, is given by:

$$\frac{V^F}{V^*} = \left[\frac{(\sigma(n-1) - n)}{(\sigma(n-1)} \quad \frac{(\sigma(n-1) + \varepsilon)}{(\sigma(n-1) + \varepsilon - n)}\right]^{-\varepsilon}$$

As the number of firms, n, or substitutability between their products, σ, becomes infinite, this goes to 1 and the results approach those of the competitive case. Moreover, for this parametrization, auction quotas always reduce welfare below its free trade level.

Demand arises from utility maximization with the utility function given by:

$$u(S,n) = S^\alpha + N$$

where S should be thought of as the services provided by the various products consumed. Also, $S = F(x^1,..x^n)$, where $F(\cdot)$ is a standard constant returns to scale production function, which can be thought of as a household production function, and $(x^1,..x^n)$ are the quantities of the n differentiated products consumed. The function $F(\cdot)$ is assumed to take a CES form so that $S = [\Sigma(x^i)^r]^{\frac{1}{r}}$ where $r\varepsilon(-\infty,1)$. Recall that the elasticity of substitution

$\sigma = \frac{1}{1-\tau}$ and $\sigma \epsilon (0,\infty)$. The consumption of the numeraire good is denoted by N in the utility function. This parametrization draws attention to the crucial parameters, the substitutability between goods as given by α, and the demand elasticity for the aggregate good as caputed by α.

Since demand is for services produced, the demand for a particular variety of the good is a derived demand, derived from the demand for services. Because services are in essence produced by the consumer, the price of a service, P, equals the cost of production. Hence,

$$P = \delta(p^1,..p^n) = [\Sigma (p^i)^r]^{\frac{1}{r}}$$

where $r = \frac{\tau}{\tau-1} \epsilon (-\infty,1)$ for the CES case.

The demand for a particular variety is given by:

$$x^i(p^1,..p^n) = a^i(p^1,..p^n) D(\phi(p^1,..p^n)),$$

where $D(\cdot)$ is the demand for services, and $a^i(\cdot)$ is the unit input coefficient, i.e., it is the amount of variety i needed to make a unit of services given the prices of these varieties. The derivative of $\phi(\cdot)$ with respect to p^i is $a^i(\cdot)$ by Shephard's lemma.

The specification chosen, along with utility maximization yields:

$$D(p) = \left(\frac{\phi(\cdot)}{\alpha}\right)^{(1/(\alpha-1))} .$$

The elasticity of demand for services, ϵ, is thus a constant and equals $\frac{-1}{\alpha-1}$.

The key parameters of the model are σ, ϵ, and n. Assume that each variety is produced at a common marginal cost, c. The profits of the i^{th} firm are given by:

$$\Pi^i(p^1,..p^n) = (p^i - c)x^i(p^1,..p^n) .$$

Profit maximization by each firm, taking other prices as given, yields the first order condition:

$$x^i[1 - \frac{(p^i - c)}{p^i}(\mu^i_i + \varepsilon\theta^i)] = 0 \qquad (1)$$

for the i^{th} firm, where $\mu^i_i = -\frac{\delta a^i}{\delta p^i}\frac{p^i}{a^i}$ and $\theta^i = \frac{a^i p^i}{P}$, the share of the i^{th} variety in cost. For our specifications, $\theta^i = \frac{1}{n}$ and $\mu^i_i = \frac{(1-r)(n-1)}{n}$, while $\mu^i_j = \frac{\delta a^i}{\delta p^j}\frac{p^j}{a^i} = \frac{(1-r)}{n}$ in the symmetric equilibrium. In turn this gives:

$$p^i = p = \frac{c(\sigma(n-1)+\varepsilon)}{\sigma(n-1)+\varepsilon-n}$$

in the symmetric equilibrium[15]. Call this price p^F and let $nx(p^F,\dots, p^F) = V^F$.

Now consider the effect of a quota at V. As usual, the price of a license is given by $L(p^1,\dots, p^n,V)$ defined by the market clearing condition:

$$\sum_{i=1}^{n} x^i(p^1 + L,\dots, p^n + L) = V \qquad (2)$$

if the quota binds, and by zero if it does not. Therefore, if p is charged by all firms in the symmetric equilibrium, while $p^V(V)$ is the price needed for total demand to equal the quota, the license price is given by:

$$L(\bar{p},V) = \text{Max}[p^V(V) - p,\ 0] \quad . \qquad (3)$$

If the quota is binding, then each firm maximizes:

$$\bar{\Pi}^i(p^1,..p^n) = (p^i - c)x^i(p^1+L(\cdot),\dots,p^n + L(\cdot)) \quad .$$

This gives the first order condition:

$$x^i[1 -(\mu^i_i + \varepsilon\theta^i)\frac{p^i - c}{p^i + L}] + [L_i(p^i - c)\sum_{j=1}^{n} x^i_j] = 0 \quad .^{16}\text{b} \qquad (4)$$

The second term enters because of the effect of a change in a firm's price on the price of licenses. It is convenient to rewrite the second term of (4) as:

$$\frac{L_i p^i}{L}\ \frac{(p^i-c)}{p^i}\ \ Lx^i \sum_{j=1}^{n} x^i_j\ \ \frac{(p^j+L(\cdot))}{x^i(p^j+L(\cdot))} \quad .$$

However, recall that:

$$\frac{x^i_i}{x^i}(p^i + L(\cdot)) = -(\mu^i_i + \varepsilon\theta^i) \quad \text{and}$$

$$\frac{x^i_j}{x^i}(p^j + L(\cdot)) = \mu^i_j - \varepsilon\theta^j \quad .$$

Also, $-\mu^i_i + \sum_{j \neq i} \mu^i_j = 0$ since $a^i(\cdot)$ is homogeneous of degree zero. The above allows the second term of (4) to be written very simply in the symmetric equilibrium as:

$$[L_i(p^i - c) \sum x^i_j] = \beta \, \frac{(p-c)}{p} \, \frac{Lx}{(p+L)} \, \varepsilon \quad ,$$

where β is the elasticity of $L(\cdot)$ with respect to p, $\frac{-L_i p^i}{L}$, in the symmetric equilibrium. Moreover, using (2) shows that:

$$L_i = -\sum_{j=1}^{n} x^j_i \Big/ \sum_{j=1}^{n} \sum_{i=1}^{n} x^i_j \quad .$$

But with symmetry, $x^i_i = x^j_j \; \forall \; i,j$, and $x^i_j = x^R_s$ for $i \neq j$, $R \neq s$, so

$$L_i = -\frac{1}{n} \quad \text{and} \quad \beta = \frac{p}{Ln} \quad .$$

Using the expressions for μ^i_j and θ in the symmetric equilibrium gives (4) to be equivalent to:

$$1 - \left[\frac{\sigma(n-1)}{n} + \frac{\varepsilon}{n} - \frac{\varepsilon}{n}\right] \frac{(p-c)}{(p+L(\cdot))} = 0 \quad . \tag{5}$$

Solving for p in (5) gives a solution $p^*(V)$ where $L(\cdot)$ is defined by (3). Thus $p^*(V)$ is the equilibrium price with a quota at V.

We are interested, among other things, in the question of how restrictive the quota has to be for a license price to become positive. In Section 2 we showed that this corresponds to the quota being set so that it is just binding at the symmetric equilibrium assuming that the constraint is binding, i.e. set at demand when p solves (5) with $L(\cdot) = 0$.

Solving for p in (5) with $L(\cdot) = 0$ gives:

$$p^* = \frac{c(\sigma(n-1))}{\sigma(n-1)-n}, \quad \text{and} \quad V^* = (p^*)^{-\varepsilon}. \tag{6}$$

Thus, the ratio of the free trade level of imports, V^F, to the quota at which the license price is positive is:

$$\frac{V^F}{V^*} = \left[\frac{(\sigma(n-1) - n)}{\sigma(n-1)} \frac{(\sigma(n-1) + \varepsilon)}{(\sigma(n-1) + \varepsilon - n)}\right]^{-\varepsilon} .$$

Notice that p^* exceeds p^F, so that V^F exceeds V^*, and that as $n \to \infty$, $\frac{V^F}{V^*} \to 1$. As the number of firms or substitutability between their products becomes infinite, competition becomes intense and we aproach the results of the competitive case.

In order to get some idea of the magnitude of $\frac{V^F}{V^*}$, consider its value for $\varepsilon = 2$, $\sigma = 2$, $n = 4$. Here it equals $(1.5)^2$, so that imports must be more than halved in order to make the license price positive.[17] If auction quotas do not raise revenue, they must reduce welfare as they further restrict consumption without shifting profits. Since welfare falls as V is reduced from V^F to V^*, and only rises after that, even optimally set auction quotas are unlikely to raise welfare. In fact, for the example developed here, auction quotas can <u>never</u> raise welfare. An outline of the proof follows.

Welfare under free trade, W^F, is given by:

$$W^F = (S^F)^{\alpha} - nP^F x^F = (S^F)^{\alpha} - P^{SF} S^F$$

where the superscript "F" denotes free trade. The second equality arises since $x^F = aS^F$, and $naP^F = P^{SF}$ where P^{SF} is the price of S under free trade. W^F therefore equals the area of the shaded region in Figure 4.

(FIGURE 4 here)

Welfare under the quota V is given by W^V where:

$$W^V = [(S^V)^{\alpha} - n(P^*(V) + L(\cdot))x^V] + nL(\cdot)x^V$$

where S^v is the level of S, x^v is the level of a firm's output, and $P^*(V)$ is the equilibrium price charged by a firm, when the quota is V. The price consumers pay for x is $P^*(V) + L(\cdot)$, so that the first term in W^v is consumer surplus, while the second is license revenues.

Since $x^v = aS^v$, we know that $naP^*(V) = P^{*S}(V)$, and the price charged by producers for a service is $naL(\cdot) = L^S(\cdot)$, the implicit price of a license to import a service. Also, $[P^{*S}(V) + L^S(\cdot)] = P^{*SC}(V)$, the price to consumers of a service with a quota of V. Thus W^v can be rewritten as:

$$W^v = [(S^v)^{\alpha} - P^{*SC}(V)S^v] + L^S(\cdot)S^v .$$

W^v is thus depicted by the cross-hatched area in Figure 4. Clearly, welfare cannot rise due to a quota unless the price charged for a service by firms $P^{*S}(V)$ falls below P^{SF}. Since $P^{*S}(V) = naP^*(V) = n^{-(1/r)}P^*(V)$ this cannot occur unless $P^*(V)$ falls as V falls, i.e. $\frac{dP^*(V)}{dV} > 0$ for some V. However, $dP^*(V)/dV$ is negative in our example, as shown below.

Recall that $P^*(V)$ was defined by (5) when $L(\cdot)$ was defined by (1). Using (5) gives:

$$(P^*(V) + L(\cdot)) = \frac{\alpha(n-1)}{n}(P^*(V) - C).$$

However, as all demand is met at $P^*(V) + L(\cdot)$ by the definition of $L(\cdot)$, and as $V = nx^v = naD = n^{-(1/r)}\left[\frac{(P+L)n^{\frac{1}{r}}}{\alpha}\right]^{\frac{1}{\alpha-1}}$ in equilibrium,

$$(P+L) = [\alpha V n^{\frac{-1}{r}}]^{\alpha-1} n^{\frac{-1}{r}}$$

$$= (\alpha V)^{\alpha-1} n^{-\alpha/r} .$$

Using this in the above expression derived from (5) gives:

$$(P^*(V)-C) = \frac{(\alpha V)^{(\alpha-1)} n^{(1-\alpha/r)}}{\alpha(n-1)} .$$

Thus:

$\frac{dP^*(V)}{dV} < 0$, so that the price charged by the firm _must_ rise as V falls. Hence, welfare cannot increase when quotas are auctioned off.

4. DUOPOLY AT HOME

In the previous sections we considered the effect of the quota system on the price of licenses when there were many foreign firms. Here we see what happens when there is foreign competitive supply but market power on the part of home firms. The case of duopoly is considered for convenience here. The main results are summarized in Proposition 3.

Proposition 3. With home duopoly and foreign competitive supply, a license has a positive price in the pure strategy equilibrium if home and foreign goods are substitutes and the quota is at or close to the free trade level. If they are complements, a license has a zero price. In either case, such a quota system is unlikely to raise welfare.

In Krishna (1988) it was shown that with a home monopoly and foreign competitive supply, a license has a positive price when the home and foreign goods are substitutes and the quota is close to the free trade level. However, because of the absence of profit shifting effects and because prices to consumers rise, there is only a dead weight loss from such policies. When goods are complements, a license has zero price. Again, quotas are welfare decreasing. It is worth asking whether similar results would be obtained when a home firm has competitors who are also unrestricted by a quota and have market power.

4.1 The Model

Consider a market in which differentiated products are sold. There are two firms with market power which are not subject to a quota, which I call home firms.[18] Let (p^1, p^2) be the prices of the home firms, and p^* be the price of the competitive foreign firms who make a homogeneous product. All firms have identical constant marginal costs of production, C. The home firms make products which differ both from each other and from the goods produced by the foreign firms. The case of symmetric firms will be considered here in order to focus on the effects of the quota system. $D^1(p^1,p^2,p^*)$, $D^2(p^1,p^2,p^*)$ and $D^*(p^1,p^2,p^*)$ are the demands facing the two home firms and the foreign firms. Since the foreign firms are competitive, $p^* = C$.

In the absence of any quotas the home firms maximize profits, $D^i(p^1,p^2,C)(p^i - C)$ for $i = 1,2$ by choosing p^i, taking as given p^j, $j \neq i$, and C.[19] This results in two best response functions, $B^1(p^2,C)$ and $B^2(p^1,C)$ whose intersection gives the Nash equilibrium N as shown in Figure 5. These equilibrium prices are labeled (p^{1N},p^{2N}). $D^*(p^{1N},p^{2N},C) = D^{*F}$ gives the level of imports under free trade.

(FIGURE 5 here)

4.2 Effect of a Quota

Now consider the effects of a quota on imports at the free trade level so that $V = D^{*F}$. The case when imports and domestic goods are substitutes is discussed first. As usual, the market for licenses determines their price; this market clears when:

$$D^*(p^1,p^2,C + L) = D^{*F} . \qquad (7)$$

The license price is then implicitly defined by this to be $Max[0,L(p^1,p^2,V)]$ where V is the level of the quota.

Notice that $L(\cdot)$ is increasing in p^1 and p^2 but decreasing in V. Raising the price of substitutes for imports shifts the demand for imports (and thus licenses) outward, thereby raising their price. Raising the quota level shifts the supply of licenses outwards, reducing their price. Also, for a given p^* and V, the combinations of p^1 and p^2 that keep $D^*(p^1,p^2,C) =$

V is downward sloping. An increase in p^1 raises $D^*(\cdot)$ and a decrease in p^2 is required to keep $D^*(\cdot)$ equal to V. If $V = D^{*F}$, this line along which the market for licenses clears also passes through the free trade equilibrium. This is shown in Figure 5, where the line $D^*(p^1,p^2,C) = D^{*F}$ goes through N. Points above and to the right of this line are points where the quota is binding, and the license price is positive. At points below and to the left of the line, the license price is zero.

Now consider the effect of the quota on the second stage of the game where firms choose prices. The first question to ask is how the quota affects the demand curve facing a firm. Let $p^1 = p^1(p^2,C^*,V)$ and $p^2 = p^2(p^1,C^*,V)$ be two ways of denoting the line where the quota just binds. Given p^2, if p^1 exceeds $p^1(\cdot)$, then the license price becomes positive and demand facing firm 1 is given by $D^1(p^1,p^2,C + L(p^1,p^2,C,V) \equiv \bar{D}^1(p^1,p^2,C,V)$. If p^1 is less than $p^1(\cdot)$, demand is unaffected by the quota. Let $\hat{D}^1(p^1,p^2,C,V)$ be the demand facing firm 1 under a quota. Then,

$$\begin{aligned} D^1(p^1,p^2,C,V) &= D^1(p^1,p^2,C) \quad \text{if } p^1 \leq p^1(p^2,C,V) \\ &= \bar{D}^1(p^1,p^2,C,V) \quad \text{if } p^1 \geq p^1(p^2,C,V) \end{aligned}$$

Now notice that at $p^1 = p^1(\cdot)$, $D^1(\cdot) = \bar{D}^1(\cdot)$ and that $\bar{D}^1_1(\cdot) = D^1_1(\cdot) + D^1_3(\cdot)L_1(\cdot)$. Since $D^1_3L(\cdot)L_1 > 0$, $\bar{D}^1_1(\cdot)$ exceeds $D^1_1(\cdot)$, so that the inverse demand curve facing firm 1 is steeper for price increases above $p^1(\cdot)$ than for price decreases. This creates an incentive for firm 1 to raise its price.

This change in the demand curve facing firm 1 affects its profit function. Let $\hat{\Pi}^1(p^1,p^2,C,V)$ denote its profits function under the quota. Clearly

$$\begin{aligned} \hat{\Pi}^1(p^1,p^2,C,V) &= \Pi^1(\cdot) = (p^1 - C)D^1(p^1,p^2,C) \quad \text{if } p^1 \leq p^1(p^2,C,V) \\ &= \bar{\Pi}^1(\cdot) = (p^1 - C^1)\bar{D}^1(p^1,p^2,C,V) \quad \text{if } p^1 \geq p^1(p^2,C,V) \end{aligned}$$

since the profit function $\dot{\Pi}(\cdot)$ is made up of pieces of $\Pi^1(\cdot)$ and $\bar{\Pi}^1(\cdot)$. Similarly demand under the quota is also made up of two component parts. Also, $\bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot)$, and $\Pi^1(\cdot) = \bar{\Pi}^1(\cdot)$ at $p^1 = p^1(p^2,C,V)$.

Hence, three possibilities exist. Either (a) $\bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot) \geq 0$ or (b) $\bar{\Pi}^1_1(\cdot) > 0 > \Pi^1_1(\cdot)$ or (c) $0 \geq \bar{\Pi}^1_1(\cdot) > \Pi^1_1(\cdot)$ when evaluated at $p^1 = p^1(\cdot)$. Assuming that both $\Pi^1(\cdot)$ and $\bar{\Pi}^1(\cdot)$ are concave, $\dot{\Pi}^1(\cdot)$ can be traced out by drawing the analogue of Figure 2. In contrast to the $\dot{\Pi}$'s depicted in Figure 2 for which the lower of the two profit functions applies, here the upper portion is relevant, so that $\dot{\Pi}(\cdot)$ is given by the upper parts of the curves in the three cases. Note that $\dot{\Pi}(\cdot)$ is <u>not</u> concave in this case as the quota binds for high, not low values of p^1. If we are in case (a) the maximum of $\dot{\Pi}^1(\cdot)$ occurs at $\bar{B}^1(\cdot)$, the peak of $\bar{\Pi}^1(\cdot)$. If we are in case (b) it then occurs at either $B^1(\cdot)$ or $\bar{B}^1(\cdot)$ depending on whether $\bar{\Pi}^1(\cdot)$ or $\Pi^1(\cdot)$ has a higher maximum point. In case (c) it occurs at $B^1(\cdot)$. Let $\dot{B}^1(p)$ denote the maximum points of $\dot{\Pi}^1(\cdot)$.

Now looking at Figure 5, note that if p^2 is less than $\bar{p}^2$ (where $\bar{B}^1(\cdot)$ cuts the constraint line) both $\Pi^1(\cdot)$ and $\bar{\Pi}^1(\cdot)$ are decreasing in p^1 when evaluated at $p^1 = p^1(\cdot)$, i.e. along the constraint line. Hence we are in case (c) and $\dot{B}^1(\cdot) = B^1(\cdot)$. Similarly, if p^2 exceeds p^{2*}, then we are in case (a) and $\dot{B}^1(\cdot) = \bar{B}^1(\cdot)$. If p^2 lies between $\bar{p}^2$ and p^{2*}, $\dot{B}^1(\cdot)$ could be either $\bar{B}^1(\cdot)$ or $B^1(\cdot)$ or both. Indeed, it could jump any number of times in this region. For this reason $\dot{B}^1(\cdot)$ is not drawn in the figure in this interval and is depicted by the dark lines in Figure 5 for the other intervals.

Similar arguments for firm 2 give its best response function $\dot{B}^2(\cdot)$. Again, $\dot{B}^2(\cdot)$ is not drawn for p^1 in between $\bar{p}^1$ and p^{1*} but is given by the dark line in the other intervals. Since both $\dot{\Pi}^1(\cdot)$ and $\dot{\Pi}^2(\cdot)$ are non-concave, there can be a number of mixed strategy equilibria. However, only one pure strategy equilibrium exists; this occurs at E, the intersection of $\bar{B}^1(\cdot)$ and $\bar{B}^2(\cdot)$. Since E lies above the $D^*(\cdot) = D^{*F}$ line, the price of a license must be positive in equilibrium.[20]

4.4 Welfare

The fact that selling licenses raises revenues does not, however, mean that this policy leads to an improvement in welfare. Because the foreign supply is competitive, the quota system does not shift profits, so that the gain in revenue comes at the expense of consumer surplus. A quota thus results in a dead weight loss, despite the positive license price and revenue thereby derived. This argument is made a bit more formally in what follows.

Assuming the existence of a numeraire good and an aggregate consumer who gets all profits and license revenues, welfare is:

$$W = [u(x^1,x^2,x^*) - p^1x^1 - p^2x^2 - (C^*+L)x^*]$$

$$+ (p^1x^1 - Cx^1) + (p^2x^2 - Cx^2) + Lx^*$$

where x^1, x^2 and x^* are the consumption levels of the two home and one foreign good. The first term in brackets gives consumer surplus, the second and third give profits of the two home firms, and the last gives license revenues. License revenues are a transfer from consumers to the government, and thus net out of welfare, as do the revenues of the domestic firms, which equal consumer expenditure. Thus:

$$\Delta W \tilde{=} (u_1 - C)dx^1 + (u_2 - C)dx^2 + (u_3 - C)dx^* \quad .$$

As u_1 and u_2 equal the price consumers pay by utility maximization, and since this exceeds C, the first two terms will reduce welfare if a quota reduces the consumption of the home goods, since the home firms' market power means that too little is being consumed to begin with. Furthermore, u_3 equals $C + L$ by utility maximization. Also, as the quota is at the free trade level, $dx^* = 0$. A quota at the free trade level therefore reduces welfare if consumption of both home goods falls. As the consumption of imports remains constant, and the price to consumers of all goods has risen, this drop in consumption of the home good is to be expected.

Finally, it is worth noting the effect of a quota set close to the free trade level. It is easy to see that by continuity arguments a slightly restrictive quota has similar effects on prices and welfare as a quota at the free trade level.[21]

4.5 Complements versus Substitutes

One might ask whether licenses command a positive price in equilibrium when the domestic products are complements for the imported good. In Krishna (1988), it was shown that with home monopoly and complementarity between the home good and imports, the price of licenses was zero. It is easy to see that the same result is obtained with more home firms.

Suppose that the quota is set at the free trade level. The price of a license is again implicitly defined as before by $L(p^1,p^2,V)$. However, $L(\cdot)$ is decreasing in p^1 and p^2 as the goods are complements. $L(\cdot)$ is also decreasing in V. As before, the line along which the license price just equals zero is downward sloping in the (p^1,p^2) space. However, with complementarity, the license price is positive below and to the left of this line and is zero at points above and to the right of this line.

This defines $\dot{D}^1(p^1,p^2,C,V)$, the demand facing firm 1 under the quota system, as:

$$\dot{D}^1(p^1,p^2,C,V) = D^1(p^1,p^2,C) \quad \text{if} \quad p^1 \geq p^1(p^2,C,V)$$

$$= \bar{D}^1(p^1, p^2, C, V) \text{ if } p^1 \leq p^1(p^2, C, V)$$

Also, since $\bar{D}^1_1(\cdot) = D^1_1(\cdot) + D^1_3(\cdot)L'(.)$ as before, and as $D^1_3(\cdot)L'(.) > 0$, the inverse demand curve corresponding to $\bar{D}^1(\cdot)$ is steeper than that corresponding to $D^1(\cdot)$. However, since $\dot{D}^1(\cdot)$ equals $\bar{D}^1(\cdot)$ only for low enough prices, this does not create any incentive for firm 1 to change its price from p^{1N} if firm 2 charges p^{2N}. The same goes for firm 2, so that the free trade equilibrium remains an equilibrium. Hence the price of a license is zero.

It should be clear by now that this case can be analyzed exactly as was the case of foreign duopoly and home competition with substitute goods. Again, Figure 2 represents the three possible cases and Figure 1 the equilibrium with and without a quota at the free trade level.[22] If the quota is set below the free trade level, then the line such that the license price is just zero moves outward as higher domestic prices lead to lower demand for the complementary import. This quota level in turn gives rise to best response functions analogous to those for the case of a quota with foreign duopoly and home competition. Figure 3 therefore depicts the best response functions. Again, any point between EF is an equilibrium, and at all of these points the license price is zero. If the quota is set below the free trade level, then it has no effect. When the quota is set at the free trade level, the license price remains zero, and the quota does not change welfare. Quotas set below this level tend to reduce welfare because of the absence of any profit shifting effects. In essence, the loss to consumers outweighs the sum of the gains to home producers and the license revenue raised.

5. CONCLUSION

The previous sections analyzed the effects of a quota auction system for both competitive home and foreign supply, and duopoly or oligopoly abroad or at home. The main conclusion was that even when licenses do bring in revenues, welfare is likely to fall. A final case to consider is that of one home and one foreign firm. Even here, the incentive exists for the firms to appropriate license rents by raising their prices. The domestic firm can increase the demand for the foreign product by raising its price. This causes the quota to bind, which makes the demand function for the domestic firm less elastic for price increases. There is thus an incentive for the domestic firm to raise its price. This in turn makes it optimal for the foreign firm to raise its price when the goods are substitutes since an increase in the domestic price shifts out demand for the foreign good. Because a quantitative constraint acts like a capacity constraint on the foreign firm, there is no pure strategy equilibrium in the game with a quantitative constraint. See Krishna (1984) for a more detailed analysis.

The absence of pure strategy equilibria in such games has been known since the time of Edgeworth's classic criticism of Bertrand. The mixed strategy equilibrium involves the domestic and foreign firms charging prices such that demand for the foreign firm exceeds the level of the constraint with a non-zero probability. In this event, a license is valuable and for this reason, the price of a license, even when the quota is set at the free trade level, is positive. However, as the level of the quantative constraint falls, the equilbrium prices charged tend to rise so that there seems to be no reason to expect the price of a license to rise as the constraint becomes more restrictive.

Thus, with substitute goods, the price of a license may well be positive even when the constraint is set above the free trade level, and may not even be related to the restrictiveness of the constraint!

When the foreign and domestic goods are complements, the effects of a quantitative constraint are quite different. The domestic firm can make the constraint bind on the foreign firm by charging a low price. This raises the demand for the foreign firm above the level of the constraint and thereby raises the effective price of the foreign good, which is what enters the domestic demand function when there is excess demand for imports. However, this does not benefit the domestic firm since the goods are complements. For this reason, the domestic firm chooses not to try and make the quota bind strictly on the foreign firm. A quantitative constraint on the foreign firm thus leads to a pure strategy equilibrium in which prices charged are such that the demand for the foreign product exactly equals the level of the constraint. For this reason, the price of a license is zero, even when the constraint is set below the level of imports under free trade. These ideas are formalized in Krishna (1987).

The price of a license under duopoly is therefore zero when goods are complements, and positive when goods are substitutes. In addition, the price of a license in the latter case need not depend upon how restrictive the quantitative constraint is since the equilibrium prices also tend to rise as the quota is made more restrictive. Welfare is unlikely to rise in either case.

While simple models such as these help illustrate why auctioning quotas may not raise much revenue in imperfectly competitive markets, it would be useful for policy purposes to determine empirically the welfare consequences of such schemes. Recent studies by Dixit (1985), Venables and Smith (1986), and Krugman (1986) on computable partial equilibrium models hold much promise, and work on this front is under way.

Another area where work is needed concerns the determinants of market structure in the market for licenses itself. In this paper I assume this market is competitive. It is worth exploring when this is likely to occur, when there will be incentives for agents to cartelize this market, and who will have the greatest incentive to do so.

FOOTNOTES

1.See Krishna (1988), "The Case of the Vanishing Revenues: Auction Quotas with Monopoly."

2.Business Week, March 16, 1987, p. 64.

3.Ibid, March 9, 1987, p. 27.

4.Time, March 16, 1987, p. 59.

5.Memorandum of February 27, 1987, from Stephen Parker on revenue estimates for auctioning existing import quotas (publicly circulated).

6.The interested reader should consult Bergsten et al. (1987) and Takacs (1987) for a historical and institutional perspective of work in this area.

7.See Takacs (1987), footnote 7.

8.See Krishna (1987) for a survey of this work. In particular, Krishna (1984) and Krugman and Helpman (1988) on quotas and VERS with oligopoly are related to the question of the effects of auctioning quotas with oligopoly.

9.Krugman and Helpman (1988), chapter 4, contains a linear example of the model presented in the next section. Krugman and Helpman work through a linear example using marginal revenue and cost curves to study the effect of a VER. The focus here is on auction quotas rather than VERS, the exposition differs from theirs, and I do not assume that demand is linear. I am grateful to them for allowing me access to their manuscript.

10.See Eaton and Grossman (1986) for a discussion of the role of the strategic variable.

11.Although, for convenience, the Figures, 1, 3 and 5 depict the linear demand case, the arguments do not rely on linearity, only on uniqueness and stability of the equilibria.

12. Note that $\hat{B}^1(\cdot)$ is defined by looking at $\tilde{\Pi}^1_1(\cdot)$ and $\Pi^1_1(\cdot)$ along $L(\cdot) = 0$ to determine whether case (a), (b), or (c) is the relevant one. The same procedure applies for $\hat{B}^2(\cdot)$.

13. I am assuming that $\bar{B}^1(\cdot)$ and $\bar{B}^2(\cdot)$ have a unique intersection.

14. Although Figures 1 to 3 depict upward sloping best response functions, the same results are obtained if they are downward sloping The symmetry assumption is likewise made for convenience but is not crucial to the results.

15. As expected, p rises with c but falls with σ and ε so that as goods get better substitutes or demand for services gets more elastic, prices fall. p also falls with n if $\sigma > \varepsilon/c$. Also, $\sigma(n-1) + \varepsilon$ must be positive for p to be positive.

16. Note that goods could be substitutes or complements for each other as

$$\frac{\delta x^i}{\delta p^j}\frac{p^j}{x^i} = \frac{\sigma-\varepsilon}{n}$$

in the symmetric equilibrium. If $\sigma > \varepsilon$, goods are substitutes, while if $a < \varepsilon$ they are complements.

17. Notice that if σ is small relative to n, V^* becomes negative so that <u>any</u> quota gives a zero license price and quotas are always harmful.

18. They could be foreign ones that are not subject to a quota as would be the case with country specific quotas such as the voluntary export restraints on automobiles in 1981, aimed at Japan.

19. We are considering a Bertrand Nash equilibrium with differentiated products both for convenience and because price competition is regarded as more intense than quantity competition, so that the effect of having competitors who are not subject to a quota will be greater here.

20. Although Figure 5 depicts upward sloping best response functions, the same results are obtained when they are downward sloping.

21.By varying the quota one can construct examples where there are two pure strategy equilibria, at E and at N, as well as ones where there is only one at N.

22.Similar results are obtained with downward sloping best responses.

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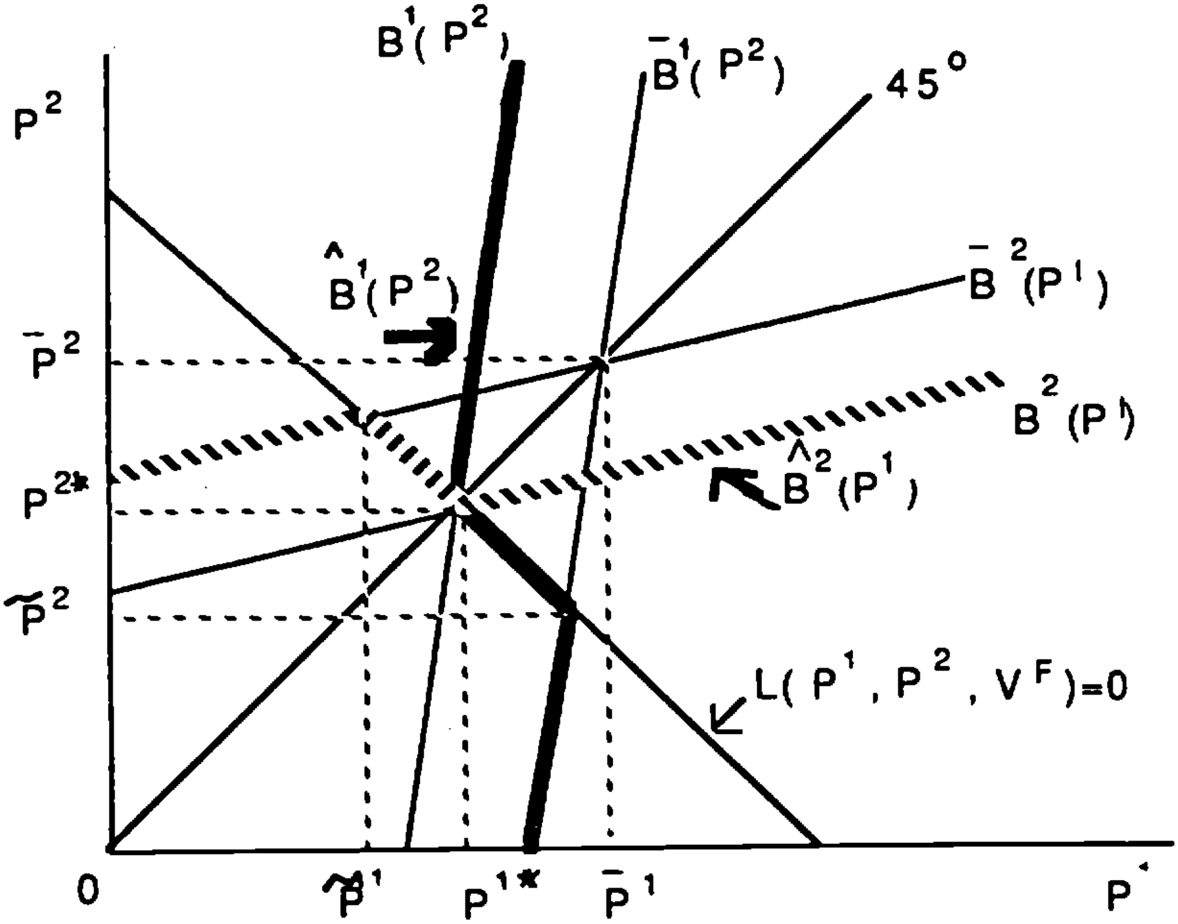

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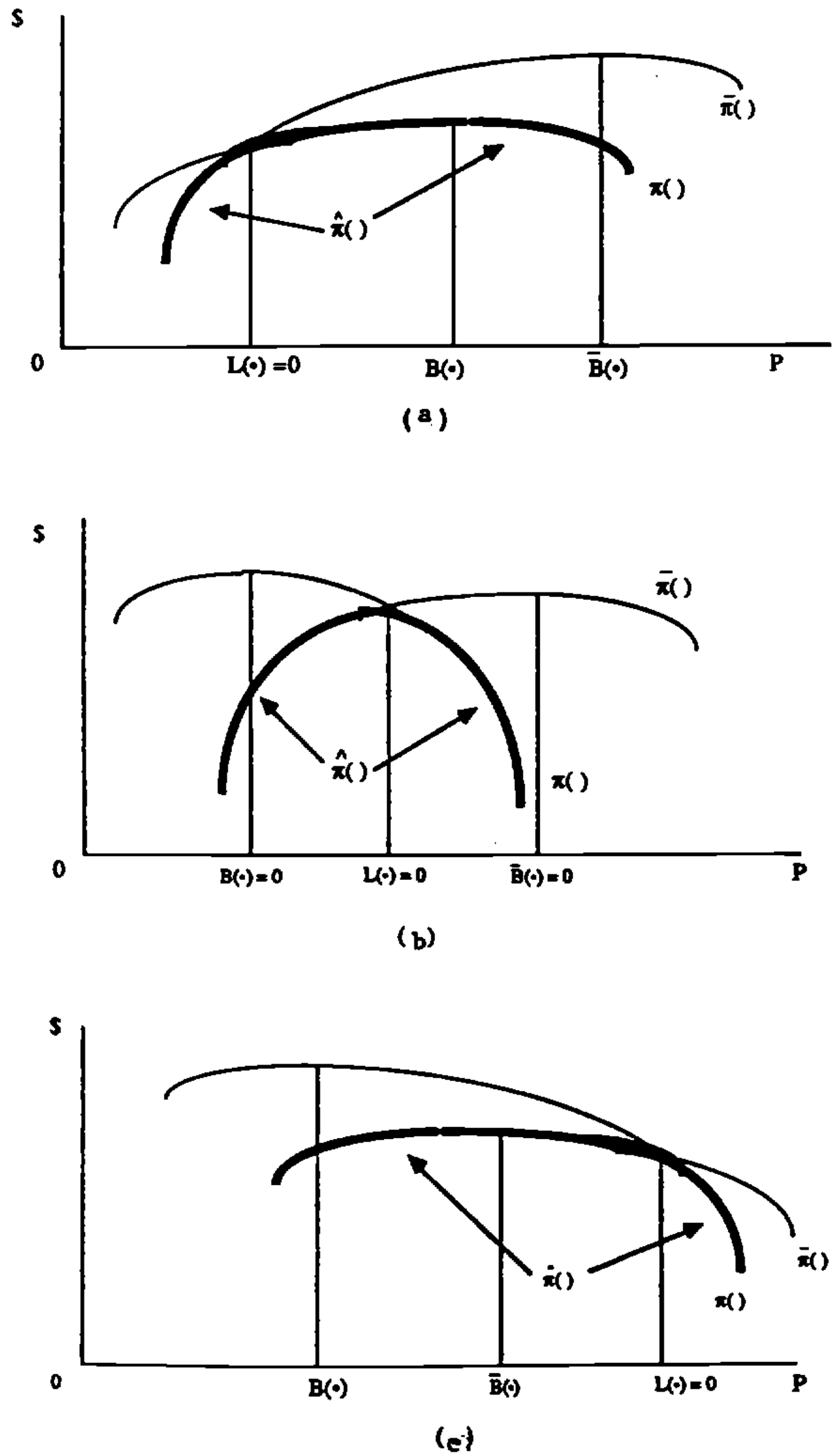
$L(P^1, P^2, V^F)=0$
0
$\tilde{P}^1$
P^{1*}
$\bar{P}^1$
P^1

Figure 1 $V = V^F$

Figure 2



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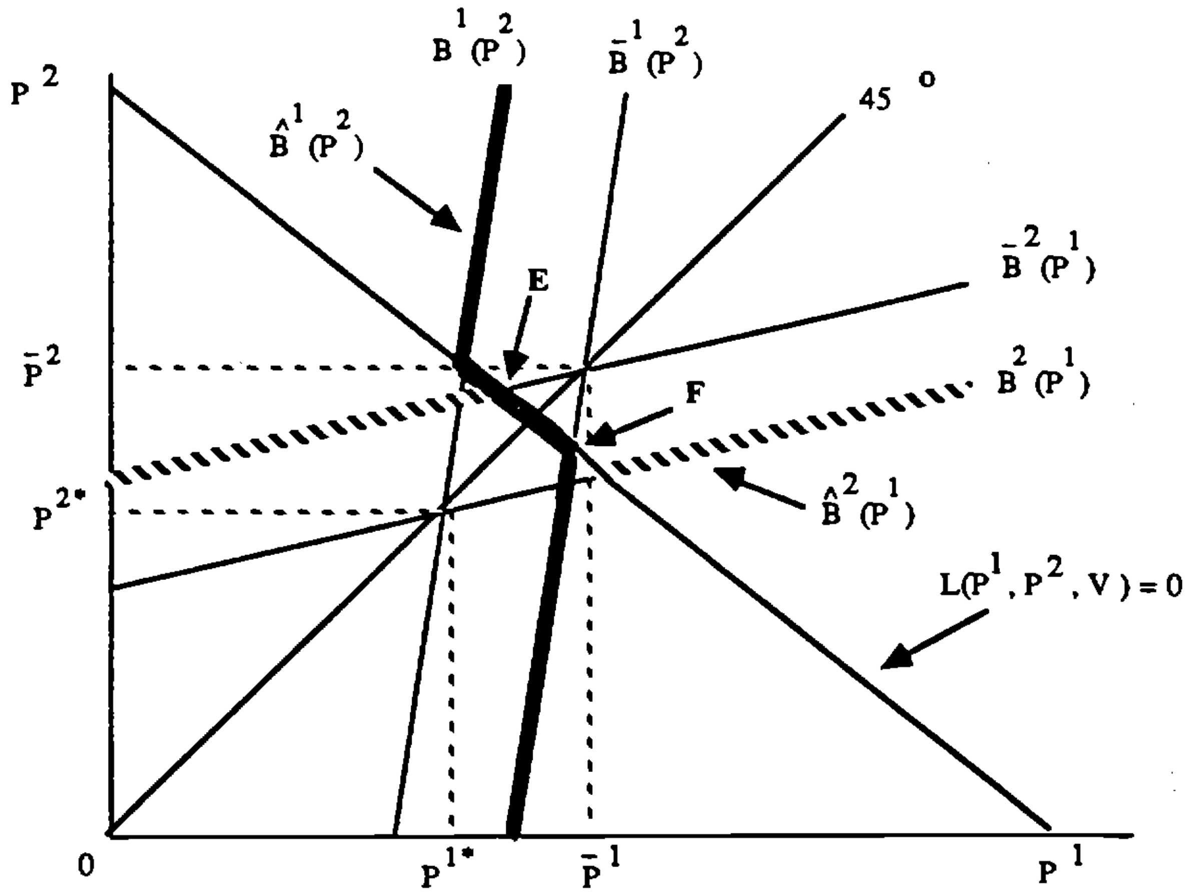
P
(c)

Figure 3



$V < V^F$

Figure 4

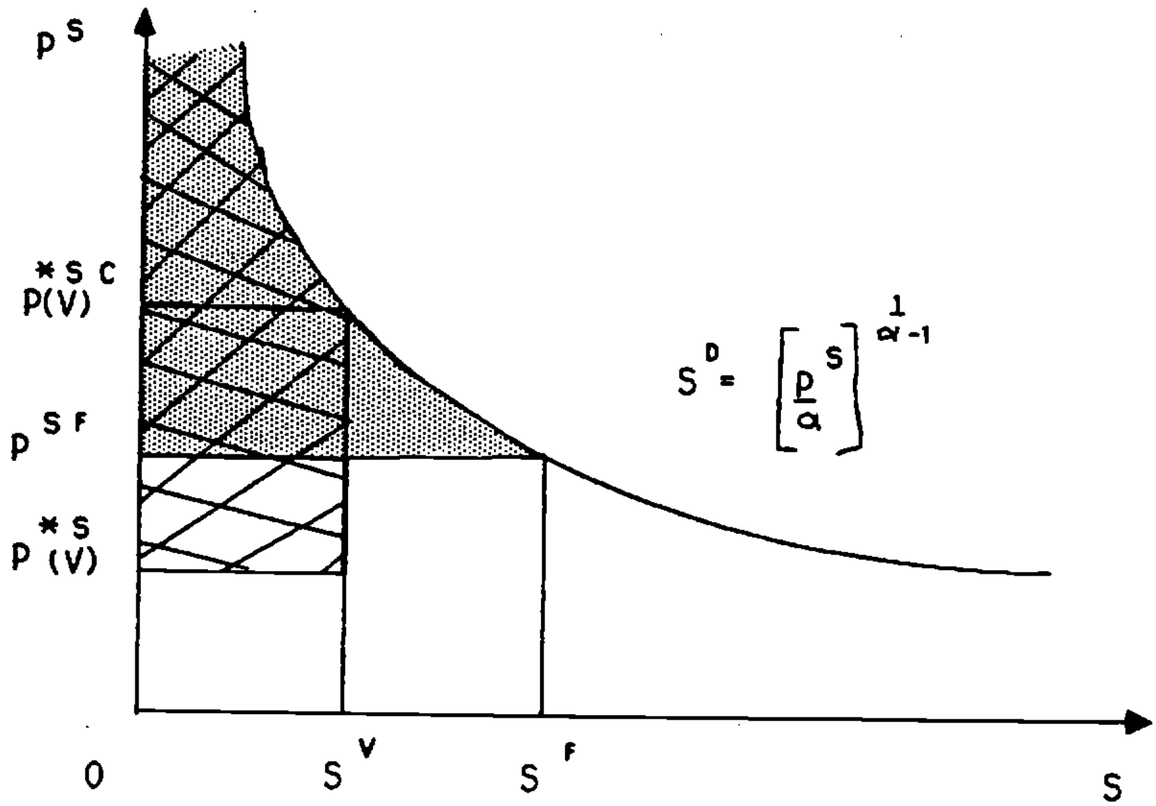
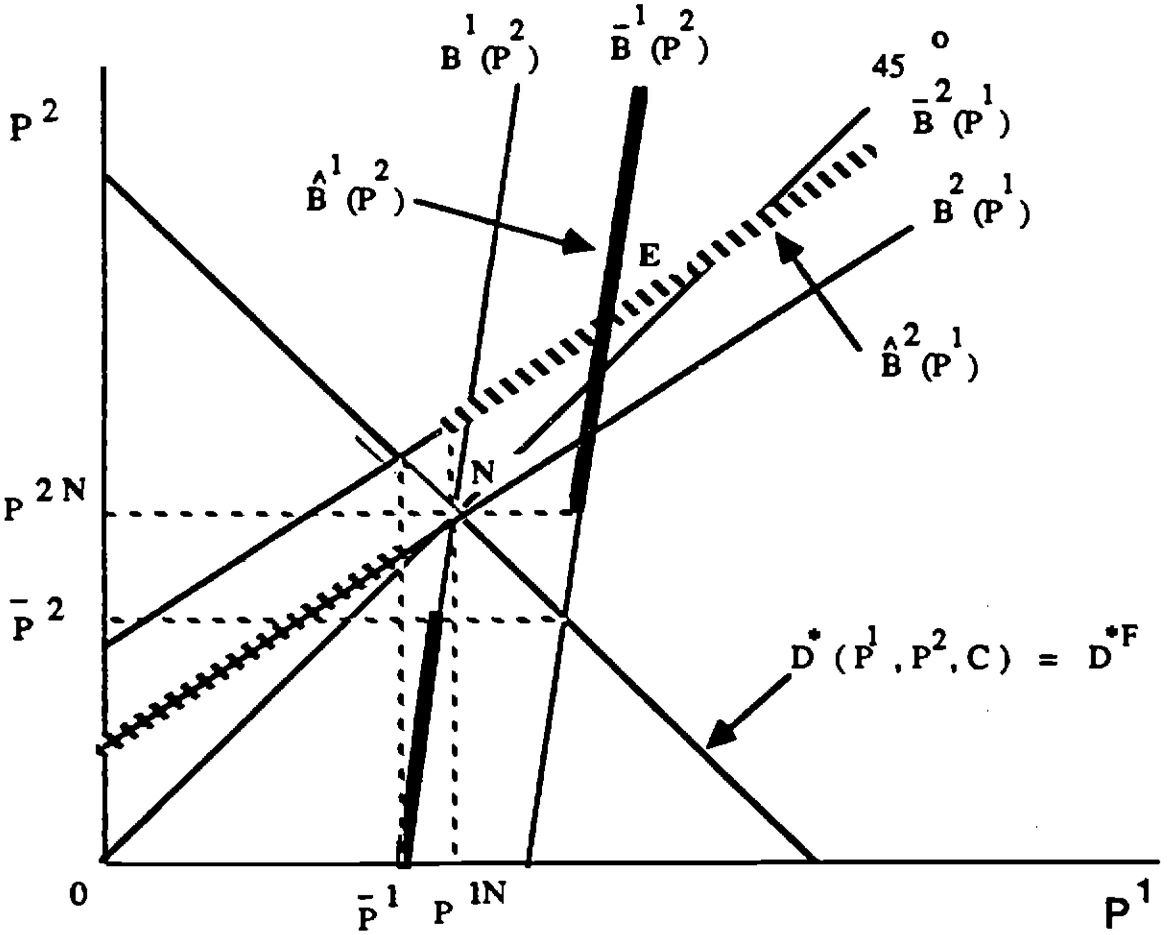


Figure 5



$B^1(P^2)$
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P^2
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E
$\hat{B}^2(P^1)$
N
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$\bar{P}^2$
$D^*(P^1, P^2, C) = D^{*F}$
0
$\bar{P}^1$
P^{1N}
P^1

Table 1

Effects of Quota Auctions at or close to Free Trade Levels

<table>
<tr><th></th><th>Complements</th><th>Substitutes</th></tr>
<tr><td>Home Duopoly</td><td>$L(.) = 0$
Welfare Falls</td><td>$L(.) > 0$
Welfare Falls</td></tr>
<tr><td>Foreign Duopoly/Oligopoly</td><td colspan="2">$L(.) > 0$
Welfare Falls</td></tr>
<tr><td>One Home Firm
One Foreign Firm</td><td>$L(.) = 0$
Welfare Falls</td><td>$L(.) > 0$
Welfare Falls</td></tr>
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