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HIGH-COST DOMESTIC JOINT VENTURES AND INTERNATIONAL COMPETITION: DO DOMESTIC FIRMS GAIN?*

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This paper develops the idea that when markets are imperfectly competitive, final-good producers may gain from a production joint venture (PJV) that produces part of their input requirements even though the PJV's marginal cost exceeds the input's market price. Production by the PJV lowers the market price of the input and this can raise final-good profits sufficiently to make the PJV worthwhile. Also, use of a joint venture internalizes the positive externality from a lower input price. These results are motivated by a setting in which domestic firms are dependent on foreign oligopolistic suppliers for a key input.

1. INTRODUCTION

American companies making electronics-based products, such as computers, have become increasingly dependent on their Japanese competitors for a wide variety of essential state-of-the-art components. Component markets dominated by Japanese companies include semiconductor memory chips, flat panel displays, semiconductor lasers, electronic packaging and printed circuit boards. This has led American firms to fear that Japanese firms will preferentially supply themselves with the most advanced components, set high prices on exported components, or demand technology licenses in return for supplying essential components.

In response to these fears, American firms have considered forming domestic production joint ventures (PJVs) to reduce their reliance on Japanese companies for critical components. An example of such a domestic PJV is the now defunct U.S. Memories, whose objective was the production of semiconductor memory chips. U.S. Memories was formed in 1989 by seven U.S. firms[2] as a response to the severe shortages and high prices faced by U.S. computer manufacturers for memory chips between 1987 and 1989. During that period Toshiba was a dominant producer of one-megabit Dynamic Random Memories (DRAMs). Another example of this phenomenon is the 1992 decision by a U.S. consortium of electronics firms, with financial support from the Pentagon's Defense Advanced Research Projects Agency

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[2] The original seven backers of U.S. Memories were three computer manufacturers (IBM, Digital Equipment Corporation, and Hewlett-Packard) and four chip suppliers (Advanced Micro Devices, Intel, LSI Logic, and National Semiconductor). For a fuller description see Hof (1990) and Shandle (1989).

(DARPA), to develop and manufacture flat screen displays for portable computers.[3] The U.S.A. was then heavily dependent on flat screens made in Japan. Projected start-up costs were high for both these ventures and if production costs were also high relative to foreign producers, as was the case with U.S. Memories, then conventional wisdom suggests that the ventures would not be good investments. Indeed government handouts would be necessary for survival.

While this reasoning may appear persuasive, we argue in this paper that high-cost PJV's have two crucial features that make them potentially profitable for member firms. First, domestic production of components by a PJV even at high cost may be worthwhile if it succeeds in reducing foreign monopoly power and import prices for key components. As the paper demonstrates, domestic production of components always reduces the price of imported components simply because of its effect in cutting back import demand. But why use a joint venture to reduce the import price of a key component? Potentially, each individual domestic firm could produce some of its own components, which would also serve to put downward pressure on the import price. Each firm could then satisfy its remaining needs for components, by importing at a lower cost. However, by producing the input itself, any single domestic firm confers an external benefit on rival domestic firms. All domestic firms experience the reduction in the price of imported components, but the domestic firm producing the component incurs the entire cost.[4] This leads to the second feature favoring high-cost joint ventures. If high-cost production of an input is worthwhile for a domestic final-goods industry, then a PJV would allow final-good producers to coordinate and internalize the externality from this production.

To capture the high-cost nature of the PJV, the PJV's marginal cost of production is assumed to be sufficiently high that it exceeds the price of imported components. Thus our analysis addresses such questions as: should competing computer manufacturers cooperate in the production of a critical component, such as a state-of-the-art memory chip, when it is known that domestic components will cost more than imported components of the same type and quality? Further, what if the cost of the PJV is so high that domestic firms make losses on final products produced from locally made components? We provide an example in which the increase in profit from the reduction in the price of imported components is sufficiently great that domestic firms might gain even in this case. As for fixed costs, a well known advantage of joint ventures relative to own production is to enable firms to share the costs of plant and equipment, and other up-front expenses that give rise to economies of scale. However, relative to importing all components, domestic firms are more likely to gain from the PJV if there are no fixed costs and, for ease of presentation, this is the initial case considered. We later relax this assumption so as to better examine the overall limitations to the cost of the PJV.

[3] The consortium included American Telephone and Telegraph, Xerox, the David Sarnoff Research Center, Optical Imaging Systems and Standish Industries (see Carey and McWilliams 1992).

[4] The implications for trade of a similar external economy (lowering the price of an input) is explored by Ethier (1979). However, the effect is due to economies of scale, not imperfect competition.

If a high-cost PJV is to be worthwhile because of its effect in reducing the price at which member firms purchase imported components, a critical requirement is that a reduction in marginal costs actually increase domestic profits in equilibrium. However, as demonstrated by Seade (1985) and Stern (1987) in the context of Cournot competition for a homogeneous product, when all firms experience a reduction in marginal costs, 'profit over-shifting' might occur in the sense that the price of the product might fall sufficiently to cause an overall fall in profit. Although we also (mostly) assume Cournot competition, our setting differs since only a subset of firms, the firms located in the domestic country, are directly affected by a fall in the price paid for imported components. Thus the paper extends this literature to allow for foreign or outside firms that are not directly affected by the change in input prices. Brief consideration is also given to showing that a high-cost PJV is a possibility under Bertrand competition with differentiated products and even pure competition if a specific factor earns scarcity rents. This latter case is relevant if a high-technology product is sold in a competitive market, yet workers with particular skills earn substantial rents. Moreover, we allow for two different market structures for the foreign exporters of components. A foreign monopoly firm could be the sole exporter of components, or alternatively, the foreign component producing industry could be made up of independent Cournot firms.

An important feature of the model is that individual domestic firms potentially purchase components both from their PJV and from these foreign sources. That firms may contract to produce a critical component domestically, yet also continue to rely on international market sources, is an empirically important phenomenon in a number of high-technology industries. For example, IBM has produced some of its own memory chips as well as purchasing some on the international merchant market. Another feature of the model is the presence of foreign as well as domestic firms in the Cournot market for the final product. International competition is a common phenomenon in many markets for high-technology products and while this competition turns out not to be essential for the existence of a high-cost PJV, it seems important to show the robustness of our results within this context.

Having argued that a domestic industry may potentially gain from a high-cost joint venture, there may nevertheless be other, possibly better ways to obtain imported components more cheaply. An obvious alternative mechanism would be for domestic firms to form joint ventures with low-cost foreign suppliers. However, the institutional and cultural barriers between countries could make such arrangements difficult. Also, if the foreign suppliers indeed have substantial monopoly power, they might not be willing to consider this option or, if they did, they would set terms that at least maintained their existing profits. Since the gain from a domestic joint venture involves shifting profits from the foreign suppliers to the domestic final-goods producers, a domestic joint venture may well be the better alternative despite the waste of resources in high-cost production. Another possibility is that the industry lobby the government to subsidize imports; but this would be politically unpopular and also the increase in demand for imports could increase the net price paid to the foreign suppliers, lowering domestic welfare. Applying political pressure on the foreign government is also a possibility, but there is no certainty that it will be effective.

Joint ventures have received a great deal of attention both in the business press and in the business strategy literature (see, for example, Kogut 1988). Interest in this topic was sparked by the proliferation since the 1970s of joint ventures and other forms of strategic alliances in a wide variety of industries. Although a number of motivations for joint ventures have been suggested, including access to technology and markets, risk reduction and achievement of economies of scale or scope, the idea that a PJV might be formed to reduce the price of externally available supplies appears to be new to the literature.

The broad setting of our paper is related to recent work in international trade dealing with a domestic dependence on a foreign vertically integrated firm for a critical input.[5] The paper is also related to work in the industrial organization area concerned with research joint ventures and more recently horizontal PJVs and associated antitrust issues,[6] but in addition, some of the literature on vertical integration is relevant. In Katz (1987), a chain store faced with an incumbent monopoly supplier considers backward vertical integration. In Sexton and Sexton (1987) final-good consumers consider entry as a cooperative producer. However, no consideration is given to the type of partial vertical integration that is our focus here. Both papers assume that after vertical integration or the formation of a cooperative as the case may be, the new entity (vertically integrated firm or cooperative) ceases to purchase from the incumbent supplier. By contrast, the sole rationale for the formation of a PJV in our setting is to influence the terms at which member firms can purchase components from lower cost outside suppliers.

Section 2 sets out the general model structure and Section 3, the Cournot equilibrium conditions for the final product. Section 4 then demonstrates the effect of the PJV's output in reducing the price of imported components, taking into account the export decisions of the Cournot foreign suppliers. The conditions under which domestic final-good producers gain from a reduction in the input price and the overall requirements for a gain from a high-cost PJV are developed in Section 5. Section 6 then introduces the possibility that a fixed cost is incurred in setting up the PJV and explores the limits to the high cost of the PJV. Section 7 deals with extensions. Finally, Section 8 contains concluding remarks.

2. MODEL STRUCTURE

As illustrated in Figure 1, domestic or home country firms may produce components through the PJV as well as import components from the low-cost foreign suppliers. Final-good producers, both domestic and foreign, compete in the Cournot market for the final product (shown as the oval-shaped field). Notice that there is no required connection (no arrow) between foreign exporters of components and foreign producers of the final good. This is the simplest formulation that captures the existence of foreign or outside producers that do not purchase components in

[5] Spencer and Jones (1991) and (1992) and Rodrik and Yoon (1989) develop trade policy in this context. However, the order of moves differ and joint ventures are not considered.

[6] For RJV's, see Grossman and Shapiro (1986), Katz (1986) and Ordover and Willig (1985). Papers on PJVs include Bresnahan and Salop (1986), Shapiro and Willig (1990) and Kwoka (1992).

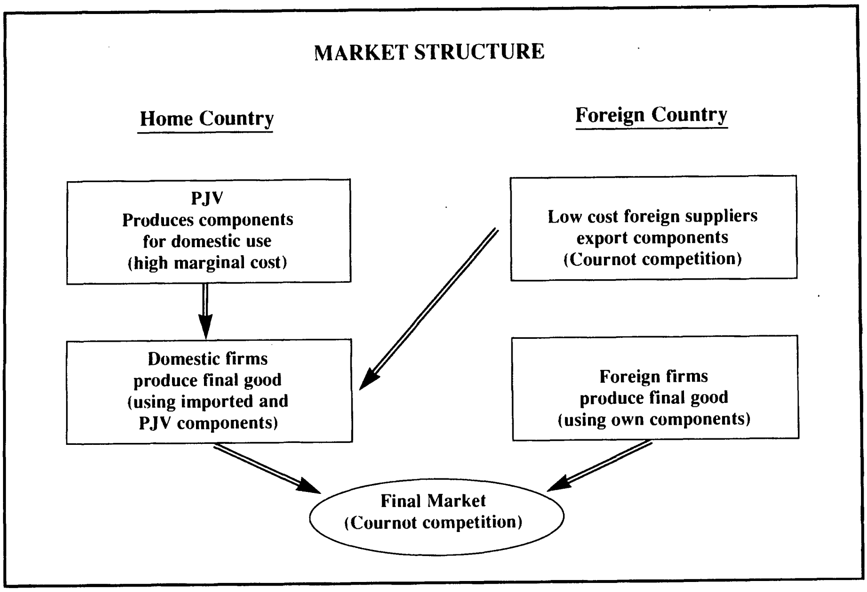

FIGURE 1

the home country. One possibility is that the foreign final producers produce their own supplies of components. They could be located in the same foreign country as the low-cost exporters of components or they could be located in another country. Generally, no restriction is placed on the level of marginal cost at which these outside final producers obtain components. Another possibility is that components are produced by a competitive industry in the foreign country and exported to the home country through a government-mandated export cartel.[7] Foreign final producers would then obtain components at the competitive price. A further possibility is that the foreign suppliers of components are constrained by regulation as to the price charged within the country, but not as to the price charged for export (see Krishna and Thursby 1991).

In considering extensions to this basic model, there are at least two natural ways in which the foreign firms supplying components could be connected with the foreign firms producing the final product. First, the foreign firms supplying components to the domestic country could be vertically integrated producers of the final product. This scenario would fit well with the U.S. Memories example, because firms such as Toshiba were suppliers of semiconductor chips as well as major sellers of computers. Since vertical integration would raise the export price of components, possibly leading to vertical foreclosure, this could increase the incentive for home

[7] It is possible that the Japanese government helped coordinate an export cartel in semiconductors after the 1986 anti-dumping actions in the U.S.A. (see Hughes, Lenway, and Rayburn 1992 for a description of the anti-dumping actions). See Krishna and Thursby (1992) for an analysis of export marketing boards.

country production of components. Another possibility is that the foreign independent suppliers of components price discriminate between the foreign and home country producers of the final product. Formation of the PJV would then affect the price of components in both markets and it is possible, but not necessary, that the foreign price falls (together with the home country price), reducing the incentive to form the PJV. Since the main aim of this paper is simply to demonstrate the existence of a potential gain from a high-cost PJV, we leave the detailed examination of the above extensions to future research.

Turning now to the order of moves in the game played between firms, we consider three possibilities, namely a basic model and two extensions. In the basic model, there are three stages of decision. In stage 1, the identical domestic firms producing the downstream product agree to set up a joint venture to produce the component if this would raise their profits. In setting up the PJV, each member firm commits to purchase its share of PJV produced components at a price equal to marginal cost and pays its share of the fixed set up cost (if any). In stage 2, each foreign supplier, whether monopoly or Cournot, commits to the quantity of its exports of components to the domestic country, taking the output of the production joint venture (set in stage 1) and the exports of its rivals (if any) as given. In stage 3, having met their contractual obligations to the PJV, domestic firms are free to buy imported components (or to sell PJV produced components) at the market clearing price. Each producer of the final product, whether domestic or foreign, earns revenues based on its Cournot equilibrium level of output.

The order of moves is partly dictated by the high-cost nature of the PJV. Since the marginal cost of PJV production strictly exceeds the price of imported components, an ability to commit to the PJV's output at the time of formation of the PJV (in stage 1 in the basic model) is essential for the PJV's existence. Without this commitment, problems of time consistency would make it impossible for a high-cost joint venture to cover its costs. Firms would subsequently have an incentive to purchase lower-priced imported supplies rather than the output of the joint venture and the PJV would fail. Commitment could be achieved by the use of binding contracts specifying the quantity that each firm agrees to purchase from the PJV. Minimum-purchase contracts are common in many supply arrangements. Alternatively, each firm could pay for its share of the PJV's production up front. The use of binding contracts could also help overcome the incentive for individual firms to free ride on the PJV by refusing to join.[8] The contracts could be signed simultaneously with the understanding that the PJV would be formed only if all the (identical) domestic firms agree to purchase the specified quantity of the PJV's output. We do not model government policy directly in this paper. Nevertheless, since a PJV that increases domestic profits could be in the domestic interest (see Section 5), one could also imagine that the domestic government helps coordinate the formation of the PJV, perhaps sweetening the deal with a subsidy.[9]

[8] For this reason the game is not necessarily sub-game perfect. If a firm believes the PJV will be set up whether or not it participates, then it may have an incentive to free-ride and not join the PJV.

[9] Both the U.S. flat panel consortium formed in 1992 and JESSI, a consortium of European firms producing semiconductor chips, were helped by government financing.

The demonstration that domestic firms gain from the high-cost PJV is simplified by the fact that the PJV's output decision is made in stage 1 with full anticipation of its consequences for the equilibrium quantity of imported components in stage 2 and the price of imported components and equilibrium profits in stage 3. This is convenient, but could be open to the criticism that the PJV may not have a first mover ability. To address this criticism, two extensions are considered in Section 7. In the first extension, both the PJV and the foreign suppliers of components set their outputs simultaneously, giving rise to a Cournot-Nash equilibrium in component production in stage 2 and, as in our basic model, a Cournot-Nash equilibrium in final outputs in stage 3. Interestingly, if the foreign suppliers would respond to PJV production by cutting back on their exports of components, this structure makes it more likely that home country firms would perceive a gain from a PJV. The second extension concerns the case in which an incumbent foreign monopoly supplier commits to its exports of components prior to the potential formation of the PJV in the domestic country. Here, the issue is whether domestic firms have a credible threat of forming a PJV, not whether it is actually formed. If the incumbent firm expands its exports of components so as to deter the PJV's entry, we show that this can be just as effective in reducing the home country price of components as a first mover ability by the PJV.

3. STAGE 3: FINAL PRODUCT EQUILIBRIUM

There are a total of N producers of the final product of which n^d are in the domestic or home country and n^f in the foreign country. Typical domestic and foreign firms produce outputs y^d and y^f, respectively, of the final product, giving rise to aggregate output $Y = Y^d + Y^f$ where $Y^d = n^d y^d$ represents total home country output and $Y^f = n^f y^f$ represents total foreign output. The price p of the final product is given by the inverse demand curve $p = p(Y)$ where $p'(Y) < 0$. There could be a unified world market for the final product or alternatively, it could be sold in a segmented domestic market. The final product is produced using a fixed proportion of both components and labor,[10] with unit labor costs, denoted w^d, assumed constant. Since, by an appropriate choice of units, just one component is used per unit of the final product, the derived demand for components is just the output of the final product.

In considering the home-country market for components, market segmentation is assumed. Thus, the price, denoted r, at which domestic final-good producers can purchase imported components in stage 3 is determined solely by equating their demand with the total domestic supply as given by the PJV's production and imports. With fixed costs initially assumed to be zero, the domestic PJV can produce components at a constant marginal cost c^h (where h stands for high), whereas the foreign Cournot firms supplying components to the home country have lower marginal costs, denoted c^l (l for low). Letting $r(0)$ denote the domestic price of

[10] This is a convenient as well as a reasonable assumption for many products produced with electronic components. However, the potential for a high-cost PJV would also arise if inputs were substitutable.

components when no PJV production takes place, the extent of the home country cost disadvantage is reflected by the assumption that

$$c^h > r(0).$$

We do not directly model the source of the cost differences across countries, but variations in technology and factor endowments are to be expected in an international context.

Letting Z represent the output of the domestic PJV, a typical domestic final-good producer will have committed to purchase Z/n^d components in stage 1 at an excess cost of $(c^h - r)Z/n^d$ over the resale value of these components in stage 3. Since each firm satisfies its remaining need for components by purchasing the quantity $y^d - Z/n^d \geq 0$ of imports in stage 3, its profit is given by

$$\pi^d \equiv V - (c^h - r)Z/n^d \text{ for } V \equiv \left(p(Y) - w^d - r\right)y^d, \tag{1}$$

where V (V for variable) represents the stage 3 variable profit. If domestic firms rely entirely on imported components, then $r = r(0)$ and profit is just the variable profit $V = (p - w^d - r(0))y^d$.

When a firm purchases imported components in stage 3 at a price r, it is obvious that its marginal cost is just $r + w^d$. But what if a firm commits to purchase sufficient components from the PJV that it needs no imported components? Could such a commitment be used as a vehicle to shift the entire cost of components to the fixed category, so as to reduce the stage 3 marginal cost of components to zero and expand final-good output? If so, this would give firms a strong motive to form a PJV even if it were very high cost. However, this is ruled out in our model because a commitment to purchase does not imply a commitment to produce. Since firms can potentially resell PJV produced components in stage 3, PJV produced components also command a marginal opportunity cost in stage 3 equal to the market price r.

Foreign firms producing the final product face a constant marginal cost of production c^f that includes the cost of a component as well as labor costs. Thus each foreign firm earns profit

$$\pi^f = (p - c^f)y^f.$$

As previously mentioned, the magnitude of c^f is not restricted. It is possible (but not necessary) that foreign final-good producers pay a price c^l for components, but it is also possible that domestic final-good producers face lower marginal costs than their foreign counterparts (i.e. $w^d + r < c^f$) or vice versa.

At the Cournot equilibrium, each producer of the final product sets its output, taking the outputs produced by its rivals as given. Thus the first order conditions for profit maximization by each of the n^d domestic firms and each of the n^f foreign firms are, respectively,

$$\partial\pi^d/\partial y^d = p + y^d p' - (w^d + r) = 0 \text{ and } \partial\pi^f/\partial y^f = p + y^f p' - c^f = 0. \tag{2}$$

The second order conditions are assumed to be satisfied: i.e. $2p' + y^d p'' < 0, 2p' + y^f p'' < 0$. Also, letting $\sigma^f \equiv Y^f/Y$ and $\sigma^d \equiv Y^d/Y$ (σ or Greek s for share) respectively represent the domestic and foreign shares in the final-good market and $E \equiv -Yp''/p'$ represent the elasticity of the slope of the inverse demand curve, the following conditions are assumed to hold globally.[11]

$$(3) \quad \gamma^d \equiv n^d + 1 - \sigma^d E > 0, \; \gamma^f \equiv n^f + 1 - \sigma^f E > 0 \text{ and } \psi \equiv N + 1 - E > 0.$$

A common assumption is that Cournot reaction functions in output space are negatively sloped, or equivalently, that outputs are strategic substitutes: i.e. that $p' + y^d p'' < 0$ and $p' + y^f p'' < 0$. The conditions (3) are more general since outputs may be either strategic substitutes or complements.[12]

Solving the first order conditions (2) simultaneously defines the Cournot equilibrium output levels denoted $y^d(r)$ and $y^f(r)$ for a domestic and foreign firm, respectively, where other arguments such as w^d and c^f are omitted for convenience. Using subscripts to denote partial derivatives, from (A.3) and (A.4) of the Appendix, the comparative static effects of an increase in the price r on final output are given by:

$$(4) \quad y_r^d(r) = \gamma^f Y_r/n^d < 0, \; y_r^f(r) = -(p' + y^f p'')Y_r/p' \text{ and } Y_r(r) = n^d/p'\psi < 0,$$

where $\gamma^f > 0$ and $\psi > 0$ from (3). Thus the higher input price reduces both domestic and overall output of the final product. The output of a typical foreign firm rises if the outputs are strategic substitutes for the foreign firm and falls if they are strategic complements.

4. Stage 2: foreign exports of components to the home country

This section links the output of the PJV to the quantity and price of components exported by n^s (s for supply) foreign suppliers of components to the home country in stage 2. If a single foreign monopoly exports components, then $n^s = 1$, but otherwise the foreign suppliers act as Cournot competitors. Each foreign supplier exports the quantity x, giving rise to a total quantity $X \equiv n^s x$ of component exports.

In setting its exports in stage 2, each foreign supplier fully anticipates the aggregate derived demand for components $Y^d(r)$ by home-country firms arising from the third stage Cournot equilibrium for final output. Letting $r = g(Z + X)$ represent the inverse demand curve for components determined by equating de-

[11] These conditions are more commonly expressed as: $(n^d + 1)p' + Y^d p'' < 0$, $(n^f + 1)p' + Y^f p'' < 0$ and $(N + 1)p' + Yp'' < 0$. The first two conditions are used to sign the comparative statics and the last is needed for uniqueness and stability of equilibrium (see Seade 1980 and 1985).

[12] It is possible to have $\gamma^d \equiv n^d + 1 - (Y^d/Y)E = [n^d(p' + y^d p'') + p']/p' > 0$, yet $p' + y^d p'' > 0$. Outputs are strategic substitutes (complements) for a given firm if an increase in the output of another firm reduces (increases) the marginal profitability of an increase in own output (see Bulow et al., 1985).

mand with supply (i.e. $Y^d(r) = Z + X$) in stage 3, it follows that

$$(5) \qquad g'(Z+X) = 1/Y_r^d < 0 \text{ and } g''(Z+X) = -Y_{rr}^d/\left(Y_r^d\right)^3.$$

A typical foreign supplier earns profit $\pi^s \equiv (g(Z+X) - c^l)x$, where c^l (l for low) is the constant marginal cost of production of components in the foreign country.

Since each supplier sets its exports to maximize profit, taking the output of rival exporters, as well as the output of the PJV, as given, profit maximization gives rise to n^s first order conditions:

$$(6) \qquad d\pi^s/dx = g(Z+X) - c^l + xg' = 0,$$

with second order and stability conditions: $2g' + xg'' < 0$ and $(n^s+1)g' + Xg'' < 0$. Letting $E^s \equiv -Xg''/g'$ represent the elasticity of the slope of the derived demand curve for imported components, these conditions can be conveniently expressed as

$$(7) \qquad 2n^s - E^s > 0 \text{ and } \psi^s \equiv n^s + 1 - E^s > 0.$$

Assuming (7) holds, the n^s first order conditions (6) define the quantity $x = x(Z)$ of components that will be exported by a typical foreign supplier as a function of the output of the PJV.

By satisfying part of the domestic requirement for components, production by the PJV shifts the demand curve for imported components in towards the origin. The effect of Z on the total quantity of imports $X(Z) \equiv n^s x(Z)$ is then determined by the reactions of the foreign suppliers. From total differentiation of the first order conditions (6) allowing all n^s outputs to vary, this effect is given by:

$$(8) \qquad X'(Z) = -n^s(g' + xg'')/[(n^s+1)g' + Xg''] = -(n^s - E^s)/\psi^s,$$

where $\psi^s > 0$ from (7). As is often the case in oligopoly or monopoly models, the sign of $X'(Z)$ is in general ambiguous, depending on demand conditions. For example, imports can increase with Z if demand is constant elastic,[13] but if the foreign suppliers view their outputs as strategic substitutes (i.e. $g' + xg'' < 0$), which includes the linear demand case, then $X'(Z) < 0$ as one might normally expect.

However, as shown in Proposition 1, an increase in the PJV's output always reduces the price of imported components. Letting $r(Z) \equiv g(Z + X(Z))$ represent this price as a function of Z, it follows that $r'(Z) < 0$ because, taking account of the response of imports, an increase in the PJV's production always raises the total supply of components in the home country.

PROPOSITION 1. *Suppose $X > 0$. An increase in PJV's production of components always reduces the price paid for imported components.*

[13] If ϵ is constant, $n^s = 1$ and $n^f = 0$, then $X'(0) > 0$ from (8) using (7), $E^s = E$ from (A.15) and $1 - E = -1/\epsilon$ from (A.12).

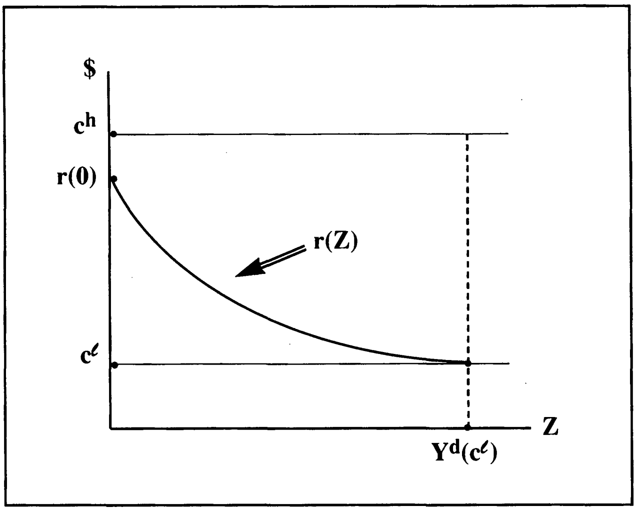

FIGURE 2

PROOF. From $r(Z) \equiv g(Z+X(Z))$, (8), (7) and $g' = 1/Y_r^d$ (from (5)), we obtain

$$r'(Z) = g'(1+X'(Z)) = 1/Y_r^d \psi^s < 0. \tag{9}$$ Q.E.D.

As Figure 2 shows, the domestic price $r = r(Z)$ of components falls continuously from $r(0)$ to c^l as the PJV's output rises from zero to $Y^d(c^l)$, the quantity of components needed to supply the entire domestic market based on a price c^l. Foreign suppliers cease exporting components at the price c^l, since if they exported even a small quantity, price would fall further, causing losses.[14] Since imports of components play no role when $Z > Y^d(c^l)$, we restrict attention[15] to the region of interest $Z \in [0, Y(c^l)]$.

Competition between the foreign component suppliers also affects the price of components.

PROPOSITION 2. *Suppose $X > 0$. Holding Z constant, the greater the number n^s of foreign suppliers of components, the lower the domestic price of imported components.*

PROOF. From (6), (7) and $X = n^s x$, we obtain $\partial x/\partial n^s = -x(g' + xg'')/g'\psi^s$ and hence $\partial X/\partial n^s = x/\psi^s$ using $\partial X/\partial n^s = x + n^s(\partial x/\partial n^s)$. Since $r = g(Z + X(Z; n^s))$, this implies $\partial r/\partial n^s = xg'/\psi^s < 0$. Q.E.D.

[14] This follows since (6) implies $x = X = 0$ when $r = g(Z+X) = c^l$.

[15] Since $r'(Z) = g'(Z) < 0$ for $X \equiv 0$, the price r would fall below c^l for $Z > Y^d(c^l)$ if the domestic market for components remains segmented. However, it might be more reasonable to relax the restriction against domestic export of components in this low price region. If so, this would ensure $r \geq c^l$.

5. STAGE 1: OUTPUT AND GAIN FROM THE PJV

This section is concerned with the PJV's output and overall profitability. Expressing variable profit at the stage 3 Cournot equilibrium as $V(r) \equiv (p(Y(r)) - w^d - r)y^d(r)$, the overall profit $\pi^d = \pi^d(r(Z), Z)$ of a typical domestic final-good producer is given by (1) evaluated at $V = V(r)$ where $r = r(Z)$ for $Z \in [0, Y^d(c^l)]$. Since $Z = 0$ if the PJV is not formed, each domestic firm gains $G(Z) \equiv \pi^d(r(Z), Z) - V(r(0))$ from forming a PJV in stage 1, where, using (1),

$$(10) \quad G(Z) = V(r(Z)) - V(r(0)) - (c^h - r(Z))Z/n^d \text{ for } Z \in \left[0, Y^d(c^l)\right].$$

As (10) reveals, the possibility of a domestic gain from the PJV arises only because its production reduces the import price of components (i.e. because $r(Z) < r(0)$ for $Z > 0$). However, unless 'profit over-shifting' is ruled out, a lower import price does not necessarily ensure that $V(r(Z)) - V(r(0)) > 0$.

To examine the conditions under which a lower import price (or indeed any reduction in marginal cost) raises variable profit, first differentiate $V(r)$ from (1) using (2) to obtain

$$(11) \qquad V_r(r) = -y^d(r)\left[1 - p'\left(Y_r - y_r^d\right)\right] = -y^d(r)(1 + \alpha)$$

where $\alpha \equiv -p'(Y_r - y_r^d)$ is a strategic term representing the effect of r on the price of the final product through changes in the outputs of all other firms but one's own. Since α is defined to be positive when a reduction in r cuts back the aggregate output of other firms (which tends to raise price), there is a beneficial strategic effect from a reduction in r if $\alpha > 0$ and vice-versa if $\alpha < 0$. Using (4), we obtain $\alpha = (p'Y_r/n^d)(\gamma^f - n^d) = (\gamma^f - n^d)/\psi$ and it follows that α can be expanded into the form

$$(12) \quad \alpha \equiv -p'\left(Y_r - y_r^d\right) = \left(\gamma^f - n^d\right)/\psi = \left[n^f\left(p' + y^f p''\right)/p' + 1 - n^d\right]/\psi.$$

This shows the result, familiar from strategic trade policy analysis, that the strategic effect from a reduction in marginal cost can be beneficial only if foreign firms view the outputs as strategic substitutes (i.e. if $p' + y^f p'' < 0$) and if the relative number of foreign firms is sufficiently large, for example, $n^f + 1 > n^d$ in the linear demand case. Using (12) in (11) proves Proposition 3.

PROPOSITION 3. *A reduction in r raises variable profit (ruling out profit over-shifting) if and only if*

$$(13) \quad 1 + \alpha = \left[2(n^f + 1) - E(1 + \sigma^f)\right]/\psi = \left[2 - E + n^f\left(2p' + y^f p''\right)/p'\right]/\psi > 0.$$

Since $p'' \leq 0$ implies $E \leq 0$, it follows from (13) that variable profit is never over-shifted when the inverse demand curve is concave or linear. Also, if there are no foreign firms ($n^f = 0$) then (13) implies $V_r(r) < 0$ if and only if $E < 2$, which is the condition derived by Seade (1985) ruling out profit over-shifting when all firms in an industry experience a reduction in marginal cost. In addition, since $(2p' + y^f p'')/p' > 0$ from the second order condition for the choice of y^f, (13) implies that the presence of foreign or outside firms experiencing no change in the input price increases the range of cases in which final-good producers gain from a fall in the input price.[16] For example, suppose that the elasticity of demand, denoted by $\epsilon \equiv -p/Yp' > 0$, is constant. In this case $E = 1 + 1/\epsilon > 0$ (see (A.12)), so from (13) variable profit is not over-shifted if and only if

$$\epsilon > 1/\left[1 + n^f(2p' + y^f p'')/p'\right].$$

If $n^f = 0$, the stronger condition $\epsilon > 1$ is required.

As we show in Proposition 4, when there is more than one domestic firm (which is our case of interest), the requirement that variable profit not be over-shifted actually rules out the possibility that all firms view outputs as strategic complements. Interestingly, it is still possible that domestic firms gain when outputs are strategic complements for the larger firms (those with lower marginal costs) but are strategic substitutes for the smaller firms.[17] Also note that if $n^d \geq 3$, profit over-shifting cannot be ruled out just by assuming that all outputs are strategic substitutes.[18]

PROPOSITION 4. *Suppose* $n^d \geq 2$. *If* $V_r(r) < 0$,
(i) *then all final-good producers cannot view their outputs as strategic complements*;
(ii) *and if* $w^d + r = c^f$, *then all final-good producers must view their outputs as strategic substitutes*;
(iii) *and if* $w^d + r \neq c^f$, *then the group of final-good producers* (*domestic or foreign*) *with the higher marginal costs must view their outputs as strategic substitutes*.

PROOF. Using $E = -(Y^d + Y^f)p''/p'$ in (13), we have $V_r(r) < 0$ if and only if

$$1 + \alpha \equiv \left[2n^f(p' + y^f p'')/p' + n^d(p' + y^d p'')/p' + (2 - n^d)\right]/\psi > 0.$$

Suppose $n^d \geq 2$. (i) If $p' + y^f p'' > 0$ and $p' + y^d p'' > 0$ then $1 + \alpha < 0$ and $V_r(r) > 0$. (ii) If $w^d + r = c^f$, then $y^d = y^f$ and $1 + \alpha < 0$ unless all outputs are strategic substitutes. (iii) If $w^d + r > c^f$, then $y^f > y^d$. If $p' + y^d p'' > 0$, then $p'' > 0$ and, with $y^f > y^d$, this implies $p' + y^f p'' > 0$ making $1 + \alpha < 0$. Hence $V_r(r) > 0$ unless $p' + y^d p'' < 0$ if $w^d + r > c^f$ and $p' + y^f p'' < 0$ if $w^d + r < c^f$. Q.E.D.

Turning to the PJV's choice of output, the identical domestic final-good producers maximize profit by choosing (perhaps through Nash bargaining) the joint profit-maximizing level of output. Denoting this output by Z^* and noting that $G(0) = 0$, it follows that domestic firms will want to form the PJV if and only if $G(Z^*) > 0$ for $Z^* \in (0, Y^d(c^l)]$. Thus $Z^* > 0$ is both necessary and sufficient for domestic final-good producers to gain from the PJV. One implication of this is that

[16] Since, from (A.5), $1 - dp/dr \geq 0$ iff $E \leq n^f + 1$, the existence of foreign firms also increases the range of cases in which price is not over-shifted.

[17] If $y^f > y^d$ and $p'' > 0$, it is possible $p' + y^f p'' > 0$ yet $p' + y^d p'' < 0$. See Bulow et al. (1985).

[18] See the expression for $1 + \alpha$ in the proof of Proposition 4.

just having the potential to produce is not enough; the PJV must actually produce some high-cost output. Also, a sufficient condition for $Z^* > 0$ and hence for the overall profitability of the high-cost PJV is that there be a positive gain from the first unit of the PJV's output, i.e. that $G'(0) > 0$.[19]

From (10), the effect of the PJV's output on the gain from the PJV is given by

$$G'(Z) = \left[V_r(r(Z)) + Z/n^d\right]r'(Z) - \left(c^h - r(Z)\right)/n^d \tag{14}$$

and setting $Z = 0$ in (14), it can be shown using (11) and then $y^d(r(0)) = X(0)/n^d$ that

$$\begin{aligned} G'(0) &= -y^d(1+\alpha)r'(0) - \left(c^h - r(0)\right)/n^d \\ &= \left[-X(0)r'(0) - \left(c^h - r(0)\right)\right]/n^d - y^d\alpha r'(0). \end{aligned} \tag{15}$$

As shown by the first expression for $G'(0)$ in (15), $G'(0)$ is positive if the fall in the import price of components from the first unit of the PJV's production sufficiently increases profits to overcome the cost disadvantage due to $c^h > r(0)$. The second expression for $G'(0)$ emphasizes the role played by the PJV's output in reducing overall costs. As the term in square brackets reveals, firms compare the reduction in the cost of purchasing the quantity $X(0)$ of imported components with the additional cost of production by the PJV.[20] However, if $\alpha > 0$ (a reduction in r raises the final-good price) it is possible that $G'(0) > 0$ even when overall costs rise.

Next, taking account of the corner with $Z = Y^d(c^l)$, equilibrium occurs at an internal point with the PJV satisfying only part of the domestic demand when $G'(0) > 0$ and $G'(Y^d(c^l)) < 0$. Setting $Z = Y^d(c^l)$ in (14) and using (11) and $r(Y^d(c^l)) = c^l$, it follows that

$$G'\left(Y^d(c^l)\right) = -\left[\alpha Y^d(c^l)r'\left(Y^d(c^l)\right) + \left(c^h - c^l\right)\right]/n^d < 0 \tag{16}$$

if the strategic effect is *not* beneficial (i.e. if $\alpha \leq 0$ from (12)), or if the strategic effect is beneficial but not sufficiently large to overcome the higher cost disadvantage associated with the larger output at the corner. In general, the gain $G(Z)$ from the PJV need not be concave so there may be more than one internal equilibrium. However, since $G(Z)$ is strictly concave for linear demand,[21] the equilibrium is unique in this case. Noting that (15) and (16) place bounds on the magnitudes of $c^h - r(Z)$, $r'(Z)$ and α at $Z = 0$ and $Z = Y^d(c^l)$ respectively, Proposition 5 follows.

[19] $G'(0) > 0$ is not necessary for $Z^* > 0$ since $G(Z)$ is not necessarily concave.

[20] Equivalently, this term measures the difference between the price $r(0)$ and the marginal cost, $c^h + X(0)r'(0)$, of a unit of the PJV's production, taking into account its effect in lowering the import price.

[21] From (14), $G''(Z) = r'(Z)[2/n^d + V_{rr}r'(Z)] + (V_r + Z/n^d)r''(Z)$. If $p'' = 0$, then $G''(Z) < 0$ since $r''(Z) = 0$ and, using (9), (11) and (13), $2/n^d + V_{rr}r'(Z) = 2/n^d[1 - (n^f + 1)/(n^s + 1)(N + 1)] > 0$.

PROPOSITION 5. *(i) A sufficient condition for domestic final-good producers to gain from a high-cost PJV is* $G'(0) > 0$ *which holds iff* $-(1+\alpha)X(0)r'(0) > c^h - r(0)$.

(ii) If $-(1+\alpha)X(0)r'(0) > c^h - r(0)$ *and* $-\alpha Y^d(c^l)r'(Y^d(c^l)) < c^h - c^l$ *then there exists an internal equilibrium (not necessarily unique) in which the PJV produces a positive output and some components are imported. At an internal equilibrium the PJV's output* Z^* *satisfies* $G'(Z^*) = 0$.

PROOF. See the text. That $G'(Z^*) = 0$ at an internal equilibrium follows from the continuity of $G(Z)$ on $[0, Y^d(c^l)]$. Q.E.D.

The case of linear demand provides a useful illustration. In this case, from Proposition 5(i) and the strict concavity of $G(Z)$, domestic final-good producers gain from the PJV if and only if[22]

$$(17)\quad G'(0) = \{2[p(Y(r(0))) - w^d - c^h] - (n^s - 1)(c^h - r(0))\}/n^d(n^s + 1) > 0.$$

As (17) shows, if demand is linear, a requirement for the PJV to raise domestic profits is that the profit margin, $p(Y(r(0))) - w^d - c^h$, based on the marginal cost c^h of the PJV's production, be strictly positive. Thus c^h cannot be so high that domestic firms would make a direct loss on the first unit of the PJV's production. Also, since a reduction in the number of foreign component suppliers would raise $r(0)$ reducing the excess cost $c^h - r(0)$ of PJV production (see Proposition 2), greater foreign monopoly power makes it more likely that there is a gain from the PJV.[23] At the extreme, if the foreign component suppliers act as a pure monopoly, condition (17) becomes strikingly simple: setting $n^s = 1$, domestic firms gain from the PJV if and only if $p - w^d - c^h > 0$ where $p = p(Y(r(0)))$. As for the PJV's output, at an internal equilibrium with linear demand,[24] it can be shown (see (A.19)) that

$$Z^*/n^d = -(n^f + 1)\{2(p - w^d - c^h) - (n^s - 1)(c^h - r)\}/p'(N + 1).$$

The above analysis assumes that the formation of the PJV does not facilitate collusion in the final product market. This is plausible since antitrust legislation could make collusion difficult and moreover, in the presence of foreign competition, a collusive agreement to reduce domestic output might not succeed in raising domestic profit.[25] In the absence of collusion it is interesting to note that whenever the PJV raises domestic profits consumers also gain, giving rise to an overall improvement of welfare. This result follows because the lower price paid for imported components always raises the output of the final good (see (4)), reducing the consumer price. If collusion would raise domestic profit and if the PJV would facilitate collusion, this would clearly strengthen the case for the PJV from the industry viewpoint, but taking consumer welfare into account, it is no longer obvious that domestic welfare would rise.

[22] Expression (17) can be obtained by setting $Z = 0$ in (A.19) of the Appendix.

[23] From (17), $\partial G'(0)/\partial n^s = [(2p'Y_r + n^s)\,\partial r/\partial n^s - (c^h - r(0))]/n^d < 0$.

[24] From (16), (2), (4) and (9), $G'(Y^d(c^l)) < 0$ iff $\alpha\psi = n^f + 1 - n^d < (c^h - c^l)(n^f + 1)(n^s + 1)/(p - w^d - r)$.

[25] Foreign firms would respond by expanding their output in the strategic substitutes case.

A further question of interest is whether the potential for gain from a high-cost PJV extends to other market structures such as Bertrand competition with differentiated products or even pure competition in which scarcity rents are earned by a specific factor. As we have argued, the critical issue is whether profits, or rents in the latter case, rise in response to a fall in the price of imported components. Even though outputs are strategic complements in the Bertrand case, having differentiated products reduces the scope for profit over-shifting and, as shown in Section 9 of the Appendix, profit is not over-shifted in a Bertrand model with linear and symmetric demand and $n^f = 0$. Rather remarkably, this linear Bertrand case gives rise to the *same* necessary and sufficient condition for a PJV as in (17). However, if demand is non-linear or if $n^f > 0$, the condition differs because it depends on the magnitudes of direct and cross-price effects of demand and on the response of the price charged by foreign firms.

In the specific factors model, sketched out in Section 10 of the Appendix, the competitive final-goods producers earn infra-marginal rents giving rise to positive variable profits, which increase as the price of components falls. However, since these rents are captured in payments to the specific factor as firms attempt to enter the industry, one should think of the PJV as including the owners of the specific factor. Overall, these results show that a high-cost PJV formed for the purpose of reducing the price of an imported intermediate product is a possibility under a wide range of industry structures.

Production of Components by Individual Firms. A possible alternative to the PJV is for individual firms to vertically integrate and produce some of their own components in-house. However, unlike typical settings in which firms produce their own inputs because it is cheaper, the potential gain from own production arises entirely from its effect in reducing the price of externally available supplies (as it does for the high-cost PJV). This motive can give an individual firm an incentive to partially produce the input in-house, but it also creates a positive (pecuniary) externality because the price of imported components is lowered for all domestic firms in the industry, not just for the firm itself. Since this externality would not be taken into account by an individual firm when it makes its output decision, in aggregate, individual firms would produce less than the number of components that maximize joint profits of the domestic industry. Since joint production through the vehicle of a domestic PJV would internalize this externality, use of a PJV has a clear advantage over production by individual firms in this setting.

Another point in favor of a PJV rather than production at the individual firm level is the obvious one that if fixed costs are positive, a PJV spreads these costs over all domestic firms. However, if fixed costs are important, this can significantly raise total domestic costs of production, making both of these options less attractive relative to importing. Fixed costs are introduced in the next Section.

6. LIMITS TO HIGH COST

In practical decision-making as to whether a PJV is too costly, a natural benchmark is whether member firms would be able to make a 'direct profit' on sales of units of the final product incorporating PJV produced components when both fixed and variable costs are taken into account. Allowing for the possibility that a fixed cost, denoted F, is incurred in setting up the PJV, this section focuses on the question as to whether achievement of this benchmark could reasonably be used as a minimal requirement that a proposed high-cost PJV must meet before firms in the industry give it serious consideration.

With $F \geq 0$, the direct profit that each domestic firm earns on the Z/n^d units of the final product that directly incorporate PJV produced components is given by

$$(18) \qquad D(Z,F) \equiv \left(p(Y(r(Z))) - w^d - c^h\right)Z/n^d - F/n^d,$$

with the remainder of the firm's profit, denoted $\phi(Z) \equiv [p(Y(r(Z))) - w^d - r(Z)]X(Z)/n^d$, coming from the $X(Z)/n^d$ units of the final product incorporating imported components. Now from (18) and (10), since $\phi(0) = V(r(0))$ in the absence of a PJV, domestic firms gain from the PJV if and only if

$$(19) \qquad G(Z^*) - F/n^d = D(Z^*,F) + \phi(Z^*) - \phi(0) > 0.$$

As can be seen from (19), if $\phi(Z^*) - \phi(0) < 0$, then direct profits $D(Z^*,F)$ must be positive for any possibility of a gain from the PJV.[26] Taking this approach, Proposition 6 shows that a rule of rejecting PJVs whenever member firms would make losses (or just break even) from their direct use of PJV-produced components would result in the right decision under linear demand. Furthermore, if there are no foreign firms, this result extends to demand curves satisfying $dE/dY \leq 0$. This holds for both linear and constant elasticity demand since $dE/dY = 0$ in both cases. More generally, if $E \leq 2$, then $dE/dY \leq 0$ if $d\epsilon/dY \leq 0$ and $d^2\epsilon/dY^2 \leq 0$, that is if both the elasticity of demand ϵ and the rate of change of ϵ are decreasing or constant with respect to output (see (A.12)). Hence if $n^f = 0$, a rule of rejecting PJV's whenever $D(Z^*,F) \leq 0$ would be correct under a wide range of demand conditions.

PROPOSITION 6. *If (i) $p'' = 0$ or (ii) $n^f = 0$ and $dE/dY \leq 0$, the PJV increases the profits of domestic final-good producers only if $D(Z^*,F) > 0$.*

PROOF. From (19), we have to show $\phi(Z^*) - \phi(0) < 0$. Taking an exact Taylor's expansion, we obtain $\phi(Z^*) - \phi(0) = \phi'(\hat{Z})Z^*$ for some $\hat{Z}$ where $\hat{Z} \in (0, Z^*)$. (i) If $p'' = 0$, then from (A.20),

$$(20) \qquad \phi'(Z) = \left[y^d(n^s - 1) + \left(Z/n^d\right)\right]p'/n^d(n^s + 1) < 0 \text{ for } Z > 0.$$

(ii) If $n^f = 0$ and $dE/dY \leq 0$, then from (A.21),

$$(21) \qquad \phi'(Z) = \left\{y^d(n^s - 1) - y^d X(dE/dY)/\psi + \left(Z/n^d\right)\right\}r'(Z)/\psi < 0 \text{ for } Z > 0. \qquad \text{Q.E.D.}$$

[26] Production by the PJV tends to reduce the profit $\phi(Z)$ earned from imported components if imports $X(Z)$ fall or if $p(Y(r(Z))) - w^d - r(Z)$ falls (due to price being over-shifted as r is reduced).

However there are exceptions to this rule. By developing an example based on constant elasticity demand, Proposition 7 shows that with foreign competition in the final-good market, a directly unprofitable PJV could indeed benefit domestic firms.

PROPOSITION 7. *Suppose* ϵ *constant*, $n^s = 1$, $p(Y(r(0)) - w^d - c^h = 0$ *and* $F = 0$. *If* $n^f \geq 1$, *then the PJV raises domestic profits even though* $D(Z^*, 0) < 0$.

PROOF. Setting $Z = 0$ in (A.6), we obtain

$$(22) \qquad G'(0) = p(Y(r(0))) - w^d - c^h)/n^d + \left[V_r(r(0))r'(0) + y^d p'/n^d\right],$$

where, from Section 3 of the Appendix (after (A.11)),

$$(23) \qquad V_r(r(0))r'(0) + y^d p'/n^d = y^d\left[\gamma^f(n^s - 1) - \gamma^f E^s + \sigma^d E\right]r'(0)/\psi.$$

With ϵ constant and $Z = 0$, (A.17) implies $E^s = \sigma^d E[1 + n^f c^f/p\gamma^f]/\gamma^f$. Thus at $n^s = 1$, (23) reduces to $-y^d r'(0)\sigma^d E n^f c^f/p > 0$ so (22) then implies $G'(0) > 0$ at $p(Y(r(0))) - w^d - c^h = 0$. Hence $Z^* > 0$ from Proposition 5(i) and $D(Z^*, 0) = [p(Y(r(Z^*)) - w^d - c^h)]Z^* < 0$ from $dp/dZ = p'Y_r r'(Z) < 0$. Q.E.D.

It is hard to explain why the existence of foreign competition makes a difference when demand is constant elastic, but not if demand is linear, except to say that it fundamentally depends on the curvature of the demand curves for component imports and the final product as represented by E^s and E, respectively, in expression (23). In any case, the conditions required for domestic firms to gain while making direct losses using PJV produced components are rather restrictive. First, the example in Proposition 7 depends on both foreign competition and special demand conditions. In addition, a foreign monopoly is assumed to supply the input. This helps because with $r(Z)$ higher (see Proposition 2), this reduces the excess cost $c^h - r(Z)$ of PJV produced components. Finally, since the existence of direct losses would restrict the PJV to a relatively small output (see (A.23)), the presence of any significant fixed costs would make the PJV untenable. Given all these special conditions, the requirement that a PJV meet the minimal condition of positive direct profits would seem a reasonably good rule of thumb in rejecting excessively high cost PJVs.

7. EXTENSIONS

We now relax the assumption that the PJV has a first-mover ability by considering two additional games based on different orders of moves. As we demonstrate in both new settings, there continues to be a potential for a high-cost PJV to increase the profits of member firms. Thus the basic insight that a PJV can be profitable even if its marginal cost strictly exceeds the price of components available from independent producers would seem not to be particularly sensitive to the assumed order of moves.

Consider first the possibility that the PJV determines its output simultaneously with the foreign exporters of components in stage 2 (rather than in stage 1), giving rise to a Cournot Nash equilibrium in component production. To overcome the time consistency problem, the decision to form the PJV must also be made in stage 2, but, for simplicity, we again assume that this involves no fixed cost. The stage 3 Cournot output equilibrium for the final good is unchanged. Since stage 1 is irrelevant, we refer to this model as the *Two-Stage Cournot* model.

Using superscript c to distinguish this Two-Stage Cournot case, the equilibrium quantity of imported components is given by $X^c = X(Z)$, determined by (6) as before. Taking imports X^c of components as given, domestic firms view the price of imported components to be related to the PJV's output on the basis of the function $r = g(Z + X^c)$, giving rise to a perceived gain from the PJV of

$$(24) \qquad \Gamma(Z; X^c) \equiv V(g(Z + X^c)) - V(g(X^c)) - (c^h - r)Z/n^d.$$

Setting $Z = Z^c$ to maximize $\Gamma(Z; X^c)$, the PJV will be formed if and only if $\Gamma(Z^c; X^c) > 0$. Now, taking into account that $X^c = X(Z)$ actually varies with Z so the actual variable profit at $Z = 0$ is $V(g(X(0))) = V(r(0))$, not $V(g(X(Z^c)))$, and noting $r(Z) = g(Z + X^c)$ for $X^c = X(Z)$, the actual gain from the PJV is given by $G(Z^c)$, the same function as in (10) for our base model. It then follows that if imports of components actually fall with Z, then the perceived gain from the PJV exceeds the actual gain (and vice versa if imports of components rise): i.e. using $V_r < 0$ and $g' < 0$,

$$(25) \quad \Gamma(Z, X(Z)) - G(Z) = V(g(X(0))) - V(g(X(Z))) > 0 \text{ iff } X(0) > X(Z).$$

Proposition 8 shows that if foreign suppliers of components respond to the PJV's output by reducing their own production of components (the strategic substitutes case) then, relaxing the assumption that the PJV is a first mover, makes it no less likely that the PJV will be formed. Indeed, the PJV produces an equal or higher output in the "Two-Stage Cournot" setting than it would in the base model.

PROPOSITION 8. *Suppose $X'(Z) < 0$ and $F = 0$. If a high-cost PJV would be formed in the base model, then it will also be formed in the "Two-Stage Cournot" model. The PJV's output Z^c in this latter setting equals or exceeds Z^*, its output in the base model.*

PROOF. Comparing $\Gamma_Z(Z, X) = (V_r(r) + Z/n^d)g'(Z + X) - (c^h - r)/n^d$ with (14) and using (9), we obtain

$$(26) \qquad \Gamma_Z(Z, X) = G'(Z) - \left(V_r(r) + Z/n^d\right)g'(Z + X)X'(Z).$$

To show $Z^c \geq Z^*$, suppose first that $0 < Z^c < Y^d(c^l)$. In this case, $\Gamma_Z(Z^c, X^c) = 0$ and $V_r(r) + Z^c/n^d < 0$. Using $X'(Z^c) < 0$, (26) then implies $G'(Z^c) < 0$, proving

$Z^c > Z^*$. If $Z^c = 0$ then $X(Z^c) = X(0)$ and from (25), $\Gamma(0, X(0)) = G(0) = 0$, ensuring $Z^* = 0$. If $Z^c = Y^d(c^l)$, then $Z^c \geq Z^*$. The first part of the proposition also follows since with $F = 0$, it is sufficient that $Z^c > 0$ whenever $Z^* > 0$. Q.E.D.

Now consider the possibility that the Cournot foreign suppliers have an ability to commit to their exports in stage 1 prior to the formation of the PJV and the determination of its output by domestic firms in stage 2. Final output is produced in Stage 3 as in the base model. Since X does not vary with Z, $\Gamma(Z, X)$ as given by (24) now represents the actual gain from the formation of the PJV, not just the perceived gain. Letting X^1 represents the stage 1 equilibrium level of component exports, with $F = 0$, it follows that high-cost production by the PJV will raise domestic profits whenever $\Gamma_Z(0, X^1) > 0$.

When a foreign monopoly (or a foreign cartel) is the sole exporter of components, entry deterrence is also a possibility. By raising the quantity of its exports, the foreign incumbent supplier could reduce the domestic price of components sufficiently to make domestic firms at least indifferent between forming the PJV and importing all their supplies. The reduction in price increases the gap $c^h - r$, making production by the PJV relatively less profitable. Entry deterrence is credible in this context since if the incumbent would reduce its exports in the face of the PJV's entry, this would actually make the PJV less profitable.[27] It is easy to see that if the incumbent's exports are set at the same level as in the Two-Stage Cournot setting, then the decision to form a PJV is unchanged from that setting. It follows that if the PJV would be formed in the Two-Stage Cournot setting, then the incumbent's entry-deterring level of output must exceed its output at the Two-Stage Cournot equilibrium. Thus deterrence of the PJV would actually raise domestic profits above the Two-Stage Cournot level.[28]

In the light of this entry deterrence model, it is suggestive that the original announcement of the formation of U.S. Memories was followed by a drop in the price of imported one-megabit memory chips. This could partly be explained by the cooling of the economy and government action (a tariff on imported computers). However, it is also possible that Japanese firms increased production with the aim of undermining the profitability of U.S. Memories. It is also suggestive that immediately after U.S. Memories failed, the major Japanese producers announced they were cutting back output so as to raise price. Presumably U.S. Memories or another organization like it was no longer credible. No doubt there are other possible explanations for this, but at least from some newspaper accounts at the time (see, for example, Sanger (1990)), this would seem to be a reasonable candidate.

[27] Since entry deterrence works by raising domestic profits in the absence of the PJV, this is an example of a point made by Sexton and Sexton (1987). They argue in the context of a limit-pricing model that a consumer cooperative (which our PJV essentially is) may credibly be deterred from entry because limit pricing changes the cooperative's payoff in the no-entry environment.

[28] Rodrik and Yoon (1989) show a related result in which a home firm is benefitted if a foreign vertically integrated supplier commits to a low price so as to deter it from producing its own supplies. Interestingly, if the foreign monopoly were able to commit to price rather than quantity in our setting, there would be no motive for the PJV and the monopoly price would result. However, maintaining this monopoly price might not be credible in the event of the PJV's entry.

8. CONCLUDING REMARKS

The central point of this paper has been to demonstrate that a final goods industry facing high import prices for a critical component can benefit from the formation of a PJV in which the marginal cost of production strictly exceeds the import price. In the face of foreign monopoly or oligopoly behavior, production of part of the domestic requirement for the input at this high cost can reduce the price of imported components sufficiently that domestic profits rise. Moreover, the potential for gain is quite robust in the sense that it does not depend on highly special demand conditions and it applies to a number of different market structures for the final product, including Cournot oligopoly, Bertrand oligopoly with differentiated products and pure competition in which a specific factor earns scarcity rents. Also, although the existence of a fixed cost of PJV production reduces the potential for gain, domestic final-good producers may nevertheless still benefit. Supposing that a foreign monopolist is the sole source of supply of components and there is no fixed cost, then the requirement for a gain is quite simple: for Cournot competition with both linear and constant elasticity demand and Bertrand competition with linear demand and no outside firms, domestic final-good producers just need to earn a positive profit margin using the first unit produced by the PJV.

By contrast with a joint venture, a stand-alone company producing components at a marginal cost above the market price of components would obviously be a losing proposition. This point could have some relevance in explaining the failure of U.S. Memories. U.S. Memories was promoted as a profitable stand-alone investment, a company that would become a competitive merchant market producer of semiconductors. It seemed highly unlikely to industry experts that such a new venture, even using existing IBM technology, would succeed in catching up and achieving the low production costs of its Japanese counterparts in its first generation of products.[29] In addition, U.S. Memories included both semiconductor as well as computer manufacturers. Our model suggests that U.S. Memories is more likely to have succeeded if it had been targeted at computer companies and promoted as a vehicle for reducing the costs of their imports of semiconductors from Japan.

The paper could also have relevance in a purely domestic context, helping to explain why a firm might maintain some high-cost capacity for in-house production of a critical input, while purchasing most of its supplies on the outside. Although the joint venture form of organization is needed to fully internalize the external benefits arising from a reduced market price, in-house high-cost production could nevertheless raise profit, particularly for a very large or dominant firm. Moreover, if a firm is able to make an individual contract with suppliers, as is common in many manufacturing industries, in-house production might then directly influence the terms of this contract so as to reduce the price paid by the individual firm but not the price paid by its rivals.

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[29] Of course if there were a chance of the PJV catching up, this would raise the gain from the PJV.

APPENDIX

1. *Comparative Statics: the price of imported components.* Totally differentiating (2) with respect to the n^d identical domestic outputs and the n^f identical foreign outputs, we obtain

$$\text{(A.1)} \qquad \left[(n^d+1)p' + Y^d p''\right] dy^d + n^f(p' + y^d p'')\, dy^f = dr$$

$$\text{(A.2)} \qquad n^d(p' + y^f p'')\, dy^d + \left[(n^f+1)p' + Y^f p''\right] dy^f = 0.$$

Applying Cramer's rule to (A.1) and (A.2) and using $E \equiv -Yp''/p'$ and (3), it can be shown that

$$\text{(A.3)} \qquad y_r^d = \gamma^f/p'\psi < 0 \text{ and } y_r^f = -n^d(p' + y^f p'')/(p')^2\psi$$

where $\gamma^f \equiv n^f + 1 - \sigma^f E$ and $\psi \equiv N + 1 - E > 0$. Now, from $Y_r(r) = n^d y_r^d + n^f y_r^f$ and (A.3), we obtain:

$$\text{(A.4)} \qquad Y_r = n^d/p'\psi < 0,\ y_r^d = \gamma^f Y_r/n^d \text{ and } y_r^f = -(n^f - \sigma^f E)Y_r/n^f.$$

2. *Price Over-Shifting.* It follows using (A.4) and $\psi \equiv N + 1 - E$ that

$$\text{(A.5)} \qquad d(p(Y(r)) - w^d - r)/dr = p'Y_r - 1 = -(n^f + 1 - E)/\psi.$$

Thus, price is not over-shifted (i.e. $dp/dr - 1 \leq 0$) if and only if $E \leq n^f + 1$.

3. *Evaluate $G'(Z)$ and solve for Z^*.* Using $-(c^h - r) = p - w^d - c^h + y^d p'$ from (2) in (14) we obtain

$$\text{(A.6)} \quad G'(Z) = (p - w^d - c^h)/n^d + \left[V_r(r(Z)) + Z/n^d\right]r'(Z) + y^d p'/n^d.$$

A useful expression is $\omega \equiv p'/n^d r'(Z)$, where using (7), (9) and (A.4), it follows that

$$\text{(A.7)} \qquad \omega \equiv p'/n^d r'(Z) = \gamma^f(n^s + 1 - E^s)/\psi > 0.$$

Next, using $V_r r'(Z) + y^d p'/n^d = y^d[\omega - (1+\alpha)]r'(Z)$ from $\omega \equiv p'/n^d r'(Z)$ and (11) in (A.6), we obtain

$$\text{(A.8)} \quad G'(Z) = (p - w^d - c^h)/n^d + y^d[\omega - (1+\alpha)]r'(Z) + (Z/n^d)r'(Z).$$

A useful alternative formulation of (A.8) (using $y^d p' = -(p - w^d - c^h) - (c^h - r)$ and (A.7)) is

(A.9)

$$G'(Z) = \{(p - w^d - c^h)(1+\alpha) - (c^h - r)[\omega - (1+\alpha)] + (Z/n^d)p'\}r'(Z)/p'.$$

Setting $G'(Z)=0$ in (A.8) and using (A.7), it follows that at an internal equilibrium,

$$Z^*/n^d = -\{(p-w^d-c^h)\,\omega + y^d p'[\omega-(1+\alpha)]\}/p'. \tag{A.10}$$

Also, from (A.7) and $1+\alpha=(n^f+1+\gamma^f-E)/\psi$ (from (12)), we obtain

$$\omega-(1+\alpha)=\left[\gamma^f(n^s-1)-\gamma^f E^s+\sigma^d E\right]/\psi. \tag{A.11}$$

Hence $V_r r'(0)+y^d p'/n^d = y^d[\gamma^f(n^s-1)-\gamma^f E^s+\sigma^d E]r'(0)/\psi$ as in (23) of the text.

4. *Expressions for E and E^s.* From $E\equiv -Yp''/p'$, $\epsilon\equiv -p/Yp'$ and $d\epsilon/dY=-[1+\epsilon(1-E)]/Y$, we have

$$E=1+1/\epsilon+Y(d\epsilon/dY)/\epsilon \text{ and} \tag{A.12}$$

$$dE/dY=\left[(d\epsilon/dY)(2-E)+Yd^2\epsilon/(dY)^2\right]/\epsilon.$$

Thus if $E\le 2$ (which holds if $1+\alpha>0$ at $n^f=0$) then $dE/dY\le 0$ if $d\epsilon/dY\le 0$ and $d^2\epsilon/(dY)^2\le 0$. To expand $E^s=-Xg''/g'=XY^d_{rr}/(Y^d_r)^2$ from (5), first differentiate (from (A.4)) $Y^d_r=\gamma^f Y_r$ where $\gamma^f\equiv n^f+1-\sigma^f E$ and $Y_r=n^d/p'\psi$ where $\psi\equiv N+1-E$ to obtain

$$Y^d_{rr}=\gamma^f Y_{rr}-(Y_r)^2\left[E(d\sigma^f/dr)/Y_r+\sigma^f(dE/dY)\right], \tag{A.13}$$

$$Y_{rr}=(Y_r)^2[E/Y+(dE/dY)/\psi].$$

Next, since $d\sigma^f/dr=(Y^f_r-(Y^f/Y)Y_r)/Y$ it follows using (A.4) and then (A.12) that

$$d\sigma^f/dr=-\left[n^f-\sigma^f(E-1)\right]Y_r/Y \tag{A.14}$$

$$=-\left[n^f-\sigma^f/\epsilon-\sigma^f Y(d\epsilon/dY)/\epsilon\right]Y_r/Y.$$

Letting $\beta\equiv n^f-\sigma^f/\epsilon$, since $p(n^f-\sigma^f/\epsilon)/n^f=c^f$ from (2), this implies $\beta=n^f c^f/p>0$. Also letting $\theta\equiv\sigma^f E(d\epsilon/dY)/\epsilon-(\gamma^f/\psi-\sigma^f)(dE/dY)$, it can be shown, using (A.13) and (A.14), that

$$E^s=XY^d_{rr}/\left(Y^d_r\right)^2 \tag{A.15}$$

$$=(X/Y)E\left(1+\beta/\gamma^f\right)/\gamma^f-X\theta/\left(\gamma^f\right)^2 \quad \text{for } \beta=n^f c^f/p>0.$$

5. *Derivation of $\phi'(Z)$ where $\phi(Z)\equiv(p-w^d-r(Z))X(Z)/n^d$.* Since $\phi'(Z)=G'(Z)-D_Z(Z,F)$ from (19) and $D_Z(Z,F)=(p-w^d-c^h)/n^d+(Z/n^d)p'Y_r r'(Z)$ from (18), it follows using (A.8) that

$$\phi'(Z)=\left\{y^d[\omega-(1+\alpha)]+(Z/n^d)(1-p'Y_r)\right\}r'(Z). \tag{A.16}$$

Now substituting E^s as given by (A.15) in (A.11), we obtain

$$\text{(A.17)} \quad \omega - (1+\alpha) = \{\gamma^f(n^s - 1) - (X/Y)E\beta/\gamma^f + X\theta/\gamma^f + (Z/Y)E\}/\psi$$

Hence from (A.17), (A.16) and (A.5),

(A.18)

$$\phi'(Z) = \{y^d[\gamma^f(n^s - 1) - (X/Y)E\beta/\gamma^f + X\theta/\gamma^f] + (Z/n^d)\gamma^f\}r'(Z)/\psi.$$

6. *Linear Demand.* $p'' = 0$ implies $E = E^s = 0$. Using $1 + \alpha = 2(n^f + 1)/(N+1)$ from (13), $r'(Z) = p'(N+1)/n^d(n^f+1)(n^s+1)$ from (4) and (9) and $\omega - (1+\alpha) = (n^f+1)(n^s-1)/(N+1)$ from (A.11) in (A.9),

$$\text{(A.19)} \quad G'(Z) = \{2(p - w^d - c^h) - (n^s - 1)(c^h - r(Z)) + (Z/n^d)p'(N+1)/(n^f+1)\}/n^d(n^s+1).$$

Also, since $\theta = 0$ and $\gamma^f = n^f + 1$, (A.18) reduces to (A.20), which is (20) of the text:

$$\text{(A.20)} \qquad \phi'(Z) = [y^d(n^s - 1) + (Z/n^d)]p'/n^d(n^s+1) < 0.$$

7. *General Demand with* $n^f = 0$. If $n^f = 0$ then $\beta = Y^f = 0$, $\gamma^f = 1$ and $\theta = -(dE/dY)/\psi$ so from (A.18), we obtain (21) of the text:

$$\text{(A.21)} \quad \phi'(Z) = \{y^d(n^s - 1) - y^d X(dE/dY)/\psi + (Z/n^d)\}r'(Z)/\psi.$$

8. *Constant Elasticity Demand.* If $\epsilon \equiv -p/Yp' > 0$ is constant, then $E = 1 + (1/\epsilon)$ from (A.12) and $\theta = 0$. Thus, from (A.17), $X = Y^d - Z$ and $\beta \equiv n^f c^f/p \geq 0$, it follows that

$$\text{(A.22)} \quad \omega - (1+\alpha) = \{\gamma^f(n^s-1) - \beta\sigma^d E/\gamma^f + (\gamma^f + \beta)(Z/Y)E/\gamma^f\}/\psi.$$

If $n^s = 1$, using (A.22) and (A.7) in (A.10), the PJV's output at an internal equilibrium is given by

(A.23)

$$Z^*/n^d = -\{(p - w^d - c^h)\gamma^f(2 - E^s) - y^d p'\beta\sigma^d E/\gamma^f\}/p'[n^d + \gamma^f + \beta\sigma^d E/\gamma^f].$$

9. *Bertrand Competition.* With $n^f = 0, n^d = N$ domestic firms each set a price p^i for $i = 1, 2 \ldots N$ for a differentiated product under Bertrand Competition. Demand is given by the symmetric linear functions:

$$\text{(A.24)} \qquad y^i = A - a^0 p^i + b^0\left(\sum_{j\neq i}^{N} p^j\right) \quad \text{where } a^0 > (N-1)b^0.$$

From maximization of profits as in (1) with $p(Y)$ replaced by p^i and p^j taken as given, we obtain

$$\text{(A.25)} \quad \partial\pi^i/\partial p^i = \partial V^i/\partial p^i = y^i - a^0(p^i - w^d - r) = 0 \quad \text{for } i = 1, 2 \ldots N,$$

which imply $p^i = p^j = [A + a^0(w^d + r)]/\delta^0$ with $\delta^0 \equiv 2a^0 - (N-1)b^0 > 0$. Profit is not over-shifted since, using $V^i(r) = [p^i(r) - w^d - r)]y^i$, (A.25), $dp^i/dr - 1 = -[a^0 - (N-1)b^0]/\delta^0$ and $dy^i/dr = -[a^0 - (N-1)b^0]a^0/\delta^0 < 0$,

$$\text{(A.26)} \quad V_r^i = (p^i - w^d - r)\left[dy^i/dr + a^0(dp^i/dr - 1)\right]$$
$$= 2(p^i - w^d - r)(dy^i/dr) < 0.$$

Hence, using $r'(Z) = 1/n^d(dy^i/dr)(n^s + 1)$ from (9) and (A.26) in (14), $G'(0)$ takes the same form as (17):

$$\text{(A.27)} \quad G'(0) = \left[2(p^i - w^d - c^h) - (n^s - 1)(c^h - r(0))\right]/n^d(n^s + 1).$$

10. *Pure Competition.* Assume $n^f = 0$. Suppose that a competitive firm must purchase one unit of a specific factor (of which there are n^d units) at a price τ to enter (in stage 0) as a domestic final-good producer. The two other factors are labor at a total cost $C(y^d)$ (with $C''(y^d) > 0$) and components, with one component required per unit of final output, giving rise to a variable profit $V = (p(Y) - r)y^d - C(y^d)$ for $Y = n^d y^d$. The first order condition, $p - r - C'(y^d) = 0$ defines $y^d = y^d(r)$ where $y_r^d = 1/\delta^c$ *for* $\delta^c \equiv p'n^d - C''(y^d) < 0$. Variable profit is not over-shifted since $V_r(r) = -(1 - p'Y_r)y^d = -C''(y^d)y^d/\delta^c < 0$. Since free entry makes profit $\pi^d = V(r) - \tau - (c^h - r(Z))Z/n^d = 0$, this implies $\tau(Z) = V(r(Z)) - (c^h - r(Z))Z/n^d$. Hence the specific factor gains $G(Z) \equiv \tau(Z) - \tau(0)$ from the PJV where $G(Z)$ is the same as in (10). Using $r'(Z) = \delta^c/n^d\psi^s$ from (9) in (14), there is a gain from the PJV if $G'(0) = C''(y^d)y^d/n^d\psi^s - (c^h - r(0))/n^d > 0$.

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