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ABSTRACT

This paper develops the idea that when markets are imperfectly competitive, final producers may gain from a joint venture that produces part of their input requirements even though marginal cost exceeds the input's market price. Production by the joint venture lowers the market price of the input and this can raise profits sufficiently from final product sales to make the joint venture 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.

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High-Cost Domestic Joint Ventures and International Competition: Do Domestic Firms Gain?

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. Components markets dominated by Japanese companies include semiconductor memory chips, flat panel displays, semiconductor lasers, electronic packaging and printed circuit boards. This has led U.S. firms to fear that Japanese companies will use their advantage in upstream components to obtain competitive advantages in downstream markets. In particular, American producers 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[1] 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 enjoyed a monopoly in one-megabit Dynamic Random Memories (DRAMs). Another example of this phenomenon is the recent 1992 decision by a U.S. consortium of electronics firms (with financial support from the

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[1] 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).

Pentagon's Defence Advanced Research Projects Agency (DARPA)) to develop and manufacture flat screen displays for portable computers. U.S. electronics firms are currently heavily dependent on flat screnes made in Japan[2]. Projected start-up costs were high for both these ventures and if production costs would also be high relative to foreign rivals, 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 production joint ventures have two crucial features that make them potentially profitable. First, even a high-cost joint venture may be worthwhile for final producers if it succeeds in reducing foreign monopoly power and import prices for key components. As the paper shows, domestic production of components depresses the price of imported components, simply because of its effect in cutting back demand for these imports. At the lower import price, domestic marginal costs are reduced, which can have a strategic effect in increasing domestic profits in an imperfectly competitive final goods market. Although production by a high-cost PJV would generally increase the total cost that domestic firms pay for any given quantity of components, the paper demonstrates that the above mentioned strategic effect can more than offset this. Thus a PJV's production of a key upstream product at high cost may confer a "strategic advantage" in a downstream market sufficient to make the PJV worthwhile for member firms. A well known advantage of joint ventures 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, the strategic gain

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[2] The consortium includes American Telephone and Telegraph, Xerox, the David Sarnoff Research Center, Optical Imaging Systems and Standish Industries (see Business Week (1992)).

identified in this paper arises even if the input is produced under constant costs. Indeed, relative to importing all components, a domestic gain is more likely if there are no up-front costs.

But why use a joint venture to reduce the import price for 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[3]. This leads to the second feature favouring 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 producers to co-ordinate and internalize the externality from this production. Hence a high-cost PJV may provide a useful vehicle to both co-ordinate and manage strategic advantage in high-tech good's markets.

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

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[3] 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.

provide an example in which the strategic gain from the reduction in the price of imported components is sufficiently great that domestic firms might gain even in this case.

Consideration is given to 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 domestic PJV and from these foreign sources. That firms may contract to produce some supplies domestically, yet also continue to rely on international market sources for a critical component, is an empirically important phenomenon in a number of high technology industries. For example, IBM produces 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.

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. Motivations for joint ventures include risk reduction; access to technology and markets; costs reductions in the presence of economies of scale, or scope; and as a response to government pressures. Questions have also been raised about the benefits of international partnerships among competitors.

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[4]. In the industrial organization area, some of the relevant literature deals with research joint ventures as opposed to PJVs[5]. Recently economists have begun to look at PJVs, particularly in the context of antitrust issues (see Shapiro and Willig (1990)). Horizontal joint ventures at the final product stage have also received some attention[6]. Perhaps of most relevance is the literature concerned with vertical integration. In Katz (1987), a chain store faced with an incumbent monopoly supplier considers backward vertical integration. In Sexton and Sexton (1987), consumers of a final product consider entry as a co-operative 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 co-operative as the case may be, the new entity (vertically integrated firm or co-operative) ceases to purchase from the incumbent supplier. By contrast, the sole rational for the formation of a PJV in our setting is to influence the terms at which member firms can purchase components from lower cost independent suppliers.

The paper is organized as follows. After presenting the general model structure in Section 2, Section 3 sets out the Cournot equilibrium for the final product, developing the comparative static effects of the price of components on output and domestic profits. Section 4 then considers the export decisions of the foreign suppliers of components, showing that production by the PJV will

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4 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.

5 See Grossman and Shapiro (1986), Katz (1986) and Ordover and Willig (1985).

6 Papers include Bresnahan and Salop (1986) and Kwoka (1992).

actually reduce the price of components in the domestic country. Subsequently, Section 5 links these results together, determining the conditions for the PJV to produce a positive output and raise overall domestic profit. These conditions are illustrated in Section 6 using two particular demand structures, linear demand and constant elasticity demand. Section 7 deals with extensions and finally, Section 8 contains concluding remarks.

2. Model Structure

The underlying market structure is 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 producers, both domestic and foreign, compete in the Cournot market for the final product (shown as the football shaped field). As indicated by the figure, 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 the home country. One interpretation 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. There are a number of other possibilities. For example, components could be 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

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[7] One could argue that the Japanese government helped co-ordinate an export cartel in semiconductors after a number of 1986 anti-dumping actions in the U.S. (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.

components at the competitive price. Another 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)).

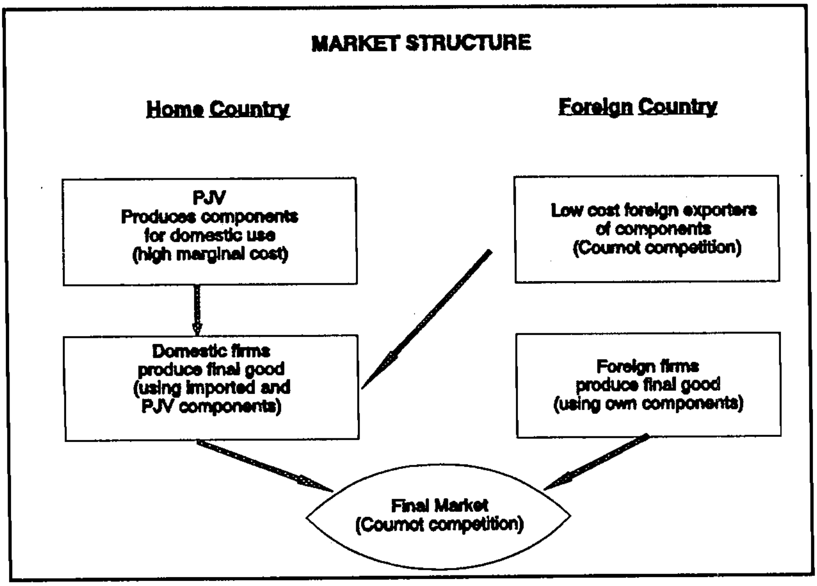

Figure 1

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 our 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 price of components possibly leading to vertical foreclosure, this would increase the incentive for home country production of components. If the price of imported components remains just as (or more) responsive to this domestic production, then the gain from a high-cost PJV would increase. Another possibility is that the foreign independent suppliers of components engage in unconstrained price discrimination between the foreign and home country producers of the final product[8]. 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, their are three stages of decision. In stage 1, the domestic firms set up a joint venture to produce the component if such a venture would raise the profits of member firms. The PJV also commits to its output of components at this stage. In agreeing to be a member of the PJV, each identical firm commits to purchase its share of the components produced by the PJV at a price equal to marginal cost. It also pays its share of the fixed set up cost (if any). In stage 2, the foreign suppliers, whether monopoly or Cournot, commit to the quantity of components that they will export to the domestic country. In making its export decision, each foreign supplier takes 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.

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[8] See Katz (1987) for an analysis of price discrimination for intermediate products.

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[9]. 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 would be in the domestic interest (see Section 5), one could also imagine that the domestic government helps co-ordinate the formation of the PJV, perhaps sweetening the deal with a subsidy[10].

The demonstration that domestic firms gain from the high-cost PJV is simplified in the basic model by the fact that the PJV's output decision is made

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[9] 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.

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

in stage 1 with full anticipation of its consequences for domestic profits. The PJV's output is set taking into account its effect on the equilibrium quantity of imported components (determined by the reactions of the foreign components suppliers in stage 2) and the further implications for the price of imported components and equilibrium profits determined at the third stage. This is convenient, but could be open to the criticism that the PJV may not have a first mover ability.

To see the effect of this, two extensions are considered in Section 7. In the first extension, both the PJV and the independent foreign suppliers 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 and if there is no fixed cost of entry by the PJV, this structure makes it more likely that home country firms would perceive a gain from a PJV.

As a further extension, we briefly consider the possibility that an incumbent foreign supplier might have the ability to commit to its exports of components prior to the decision by firms in the home country whether to form the PJV. In this setting, 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 formation of the PJV, 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, n^d 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, the output could be sold in a segmented domestic market. In the latter case, we assume domestic firms sell only in their home market.

For simplicity, we assume that the production technology for the final product requires a fixed proportion of the input as well another factor, which we refer to as labor[11]. Labor is supplied to the industry at a constant wage cost, denoted w^d, per unit of final output. Also, by an appropriate choice of units, we can ensure that one unit of the component together with the appropriate quantity of labor is required to produce one unit of the final product. Consequently, a firm's derived demand for the input is just its output of the final product.

Components can be produced domestically by the PJV at a constant marginal cost c^h (where h stands for high) by incurring a fixed (and sunk) cost F of plant and equipment in stage 1. Home country firms can also obtain imported components in stage 3 at a market price r from oligopolistic foreign suppliers who produce at a lower marginal cost, denoted c^ℓ (ℓ for low). The extent of the home country cost disadvantage is reflected in the assumption that c^h actually exceeds the price r(0) of imported components, where the zero indicates that no PJV production takes place: i.e.

$$c^h > r(0). \tag{3.1}$$

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.

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[11] This is a reasonable assumption for many products produced with electronic components. Also, allowing for substitutability between inputs would not remove the motive for the joint venture.

When a domestic final goods producer purchases imported components in stage 3 to expand its output beyond the level implied by its stage 1 purchase of components from the PJV, it is obvious that its marginal cost is just the market price r of components plus w^d. But what if a firm had committed to purchase sufficient components from the PJV that it would need no imported components? Could such a commitment be used as a vehicle to shift the entire cost of components to the fixed category, reducing the stage 3 marginal cost of components to zero? If this were credible, domestic output could be expanded to the "Stackelberg" level for the group of domestic firms simply by committing jointly to purchase the appropriate quantity of components from the PJV in stage 1. If so, this would make a strong case for a PJV even if it were very high cost. However this is ruled out because domestic final producers can potentially resell their allocation of PJV produced components in stage 3. This possibility means that PJV produced components command an opportunity cost in stage 3 equal to the market price r. Thus a commitment to purchase "excess" components from the PJV would not allow a firm to increase output above the Cournot equilibrium level associated with a marginal cost of $r + w^d$.

The corresponding marginal cost for foreign producers of the final product is denoted by the constant c^f, which includes the cost of a component as well as foreign labor costs. As previously mentioned, the magnitude of c^f is not restricted. It is possible (but not necessary) that foreign final producers pay a price c^f for components, but it is also possible that domestic final producers face lower marginal costs than their foreign counterparts (i.e. $w^d + r < c^f$) or vice versa. The levels of marginal cost faced by domestic and foreign producers determine the Cournot equilibrium output levels (see the first order conditions (3.4) below). Omitting w^d and c^f for convenience, these outputs are denoted by $y^d(r)$ and $y^f(r)$ for a domestic and foreign firm respectively, with aggregate output represented by Y(r).

To determine the profit earned by domestic final producers, let Z represent the output of the domestic PJV. A typical domestic firm will have committed to purchase Z/n^d units of the component in stage 1 at an excess cost of $((c^h-r)Z + F)/n^d$ over the resale value of its components in stage 3. Each firm then produces $y^d(r)$ of the final product in stage 3, satisfying its remaining need for components (if any) by purchasing the quantity $y^d(r) - Z/n^d \geq 0$ at the market price r. Thus in equilibrium a typical domestic firm would earn an overall profit given by

$$\pi^d(r,Z;F) \equiv V(r) - ((c^h-r)Z + F)/n^d \text{ for } V(r) \equiv (p(Y(r))-w^d-r)y^d(r) \tag{3.2}$$

where V(r) represents stage 3 variable profit (V for variable) at a marginal cost r for components. By contrast, if domestic firms rely entirely on imported components, then since F is not incurred and $Z = 0$, profit is given by $V(r(0)) = (p-w^d-r(0))y^d(r(0)$. Finally, the Cournot equilibrium profit of a typical foreign producer of the final product is given by

$$\pi^f(r) = (p-c^f)y^f(r). \tag{3.3}$$

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,

$$\partial\pi^d/\partial y^d = p+y^dp'-(w^d+r) = 0 \text{ and } \partial\pi^f/\partial y^f = p+y^fp'-c^f = 0. \tag{3.4}$$

The second order conditions are assumed to be satisfied: i.e. $2p'+y^dp'' < 0$, $2p'+y^fp'' < 0$. Also, letting $E \equiv -Yp''/p'$ represent the elasticity of the slope of the inverse demand curve, the following conditions are assumed to hold globally[12]:

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12 These conditions are more commonly expressed as: $(n^d+1)p'+Y^dp'' < 0$, $(n^f+1)p'+Y^fp'' < 0$ 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.

$$n^d+1-(Y^d/Y)E > 0,\ n^f+1-(Y^f/Y)E > 0 \text{ and } N+1-E > 0. \qquad (3.5)$$

A common assumption is that Cournot reaction functions in output space are negatively sloped, or equivalently, that outputs are strategic substitutes: i.e. that $p'+y^dp'' < 0$ and $p'+y^fp'' < 0$. The conditions (3.5) are more general since outputs may be either strategic substitutes or complements[13].

The comparative static effects of an increase in the price of imported components on final output are (see (A3) and (A4) of the Appendix) are: using subscripts to denote partial derivatives,

$$y^d_r(r) = \gamma Y_r/n^d < 0,\ y^f_r = -(p'+y^fp'')Y_r/p' \text{ and } Y_r(r) = p'n^d/H < 0 \quad (3.6)$$

where $\gamma \equiv n^f+1-(Y^f/Y)E > 0$ and $H \equiv (p')^2[N+1-E] > 0$ from (3.5). Thus an increase in the price r reduces both domestic and overall output of the final product. Also, 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.

The central point of this paper is to demonstrate that a high-cost domestic PJV could be profitable because of its effect in reducing the price of imported components and thus the domestic marginal cost of final goods production. Hence, if a PJV of this type is to be worthwhile it is necessary that a reduction in domestic marginal cost actually increase domestic profits. On the surface it might seem that a decrease in marginal cost would always raise domestic profits. However, Seade (1985) and Stern (1987) show that when all firms experience a reduction in marginal costs it is possible that the price of the product might fall sufficiently to cause an overall fall in profits. This is known

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[13] For example, it is possible to have $n^d+1-(Y^d/Y)E = [n^d(p'+y^dp'') + p']/p' > 0$, yet $p'+y^dp'' > 0$. 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, Geanakoplos and Klemperer (1985)).

as "profit over-shifting". Our situation differs since only a subset of firms, the firms located in the domestic country, are directly affected by a change in the price paid for imported supplies. Thus we extend the literature to allow for foreign or outside firms that are not directly affected by the change in input prices.

Differentiating (3.2) using the first order condition (3.4), the effect of the input price r on a typical domestic firm's variable profit from final output is given by

$$V_r(r) = -y^d(r)(1-\alpha) \text{ where } \alpha \equiv p'(Y_r-y^d_r) \tag{3.7}$$

represents the effect of the input price r on the price of the final product due to the equilibrium changes in the outputs of all other firms but one's own. Thus for a reduction in r to raise variable profits, the induced change in the total output of all other firms must lower the final good price by less than r making $1-\alpha > 0$. Hence from (3.7) and (A7) in the Appendix, it follows that

$$V_r(r) < 0 \text{ iff } 1-\alpha = [2 + n^f(2p'+y^f p'')/p' - E]/(N+1-E) > 0. \tag{3.8}$$

If all final producers experience the reduction in marginal cost, then setting $n^f = 0$ in (3.8), profits would rise if and only if $E < 2$, the condition derived in Seade (1985). Since the term involving n^f in (3.8) is positive from the second order condition for the choice of y^f, it follows that the presence of foreign or outside firms not affected by the change in the input price tends to increase the range of cases in which final producers gain from a fall in the input price. The intuition is simply that firms tend to do better from a fall in an input price if they can expand at the expense of rivals who do not experience a cost reduction. Since profit is never over-shifted when the inverse demand curve is concave or linear ($p'' < 0$) making $E \leq 0$, the presence of outside firms is significant in preventing profit over-shifting only if the inverse demand curve is convex ($p'' > 0$). To take an example, suppose that the elasticity of demand, denoted by $\epsilon \equiv -p/Yp' > 0$, is constant. In this case[14] $E = 1 + 1/\epsilon > 0$ and from (3.8), a reduction in the input price would increase domestic profit if

$$\epsilon > 1/[1 + n^f(2p'+y^f p'')/p']. \tag{3.9}$$

If $n^f = 0$, the stronger condition $\epsilon \geq 1$ is required to prevent profit over-shifting.

4. Stage 2: Foreign Exports of Components

Having examined the relationship between the price of components and domestic profits, this section is concerned with linking the output of the PJV to the quantity and price of components exported by n^s (s for supply) foreign firms to the home country in stage 2. If a single foreign monopoly exports components, then $n^s = 1$, but otherwise the foreign suppliers of components act as Cournot competitors. Each foreign firm 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 associated with the third stage Cournot equilibrium for final output. Letting $r = g(Z+X)$ represent the inverse demand curve for components determined by equating demand with supply (i.e. $Y^d(r) = Z + X$) in stage 3, it follows that

$$g'(Z+X) = 1/Y^d_r < 0 \text{ and } g''(Z+X) = -Y^d_{rr}/(Y^d_r)^3. \tag{4.1}$$

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

Since each firm 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:

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[14] When ϵ is constant $p = aY^{-1/\epsilon}$ and $E = -Yp''/p' = 1 + 1/\epsilon$ as shown in (A14) of the Appendix.

$$d\pi^{s}/dx = g(Z+X) - c^{f} + xg' = 0, \tag{4.2}$$

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

$$2n^{s}-E^{s} > 0 \text{ and } n^{s}+1-E^{s} > 0. \tag{4.3}$$

Assuming (4.3) holds, the n^{s} first order conditions given by (4.2) define the quantity $x = x(Z)$ of components that will be supplied by a typical firm 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 (4.2) allowing all n^{s} outputs to vary, this effect is given by:

$$X'(Z) = -n^{s}(g'+xg'')/[(n^{s}+1)g'+Xg''] = -(n^{s}-E^{s})/(n^{s}+1-E^{s}). \tag{4.4}$$

The denominator of $X'(Z)$ is signed from (4.3), but, as is often the case in oligopoly or monopoly models, the sign of the output effect is ambiguous in general. If demand is constant elastic, $n^{s} = 1$ and $n^{f} = 0$, then imports of components are actually increased by an increase in Z making $X'(Z) > 0$[15]. However 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.

By contrast, an increase in the output of the PJV always reduces the

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[15]. If $n^{f} = 0$, ϵ is constant and $Z = 0$, then $E^{s} = E$ from (A17) of the Appendix. Since $1-E = -1/\epsilon$ from (A14), it follows from (4.4) that $X'(Z) > 0$ at $n^{s} = 1$.

domestic price of components. An increase in the PJV's production raises the total home country supply of components, reducing price, because the reduction in imports (if any) is always less than the increase in Z. Letting $r(Z) \equiv g(Z+X(Z))$ represent the price of imported components as a function of Z, this result is demonstrated in Proposition 1.

__Proposition 1__. Suppose $X > 0$. An increase in the output of the domestic PJV allowing the quantity of imported components to vary, reduces the domestic price of components.

__Proof__: From (4.4), using $g' = 1/Y^d_r$ (from (4.1)), we obtain

$$r'(Z) = g'(1+X'(Z)) = 1/Y^d_r(n^{*}+1-E^{*}) < 0. \tag{4.5}$$

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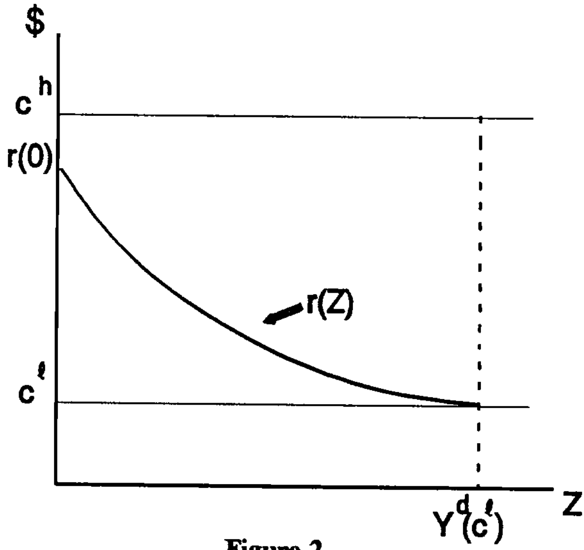

Figure 2

The reduction in the home country price of components is illustrated in Figure 2. As the Figure shows, the price falls from $r(0)$ to c^ℓ as the PJV's output Z rises from zero to $Y^d(c^\ell)$, the quantity of components needed to supply the entire domestic market based on a price c^ℓ for components. Foreign firms cease exporting components at the price c^ℓ, since if they exported even a small quantity, price would fall further, causing losses[16]. Under the reasonable assumption that PJV produced components could be exported at the price c^ℓ, the price c^ℓ becomes a floor to the marginal cost of components faced by domestic final producers in stage 3. Hence if the PJV expands its output above $Y^d(c^\ell)$, the Cournot equilibrium output of the final product remains at $Y^d(c^\ell)$ with the excess of components being exported. In the subsequent analysis, we restrict attention to the region of interest in which $Z \leq Y^d(c^\ell)$.

Considering now the effect of a variation in the number n^s of foreign suppliers of components, Proposition 2 shows that provided $X > 0$, greater competition in component supply always reduces the price of components in the home country. If demand is linear, then an increase in n^s also makes the home country price of components less responsive to production by the PJV.

<u>*Proposition 2*</u>*: Suppose $X > 0$. Holding Z constant, an increase in the number n^s of foreign suppliers of components (i) reduces the domestic price of components and (ii) makes the input price less responsive to Z when demand is linear.*

<u>Proof</u>: (i) From (4.2) and $X = n^s x$, it follows that $\partial x/\partial n^s = -x(g'+xg'')/[(n^s+1)g'+Xg'']$. Since $\partial X/\partial n^s = x + n^s(\partial x/\partial n^s)$, this implies $\partial X/\partial n^s = x/(n^s+1-E^s)$ and using $r = g(Z+X(Z;n^s))$, we then obtain $\partial r/\partial n^s = xg'/(n^s+1-E^s) < 0$. (ii) (a). If $p'' = 0$, then from (3.6) and (4.5), $r'(Z) = p'(N+1)/n^d(n^f+1)(n^s+1)$ so $\partial r'(Z)/\partial n^s > 0$. ***

5. <u>Stage 1: Output and Profitability of the PJV</u>

This section sets out the stage 1 conditions that determine the PJV's output and overall profitability. Setting $r = r(Z)$ in (3.2), each domestic firm

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16 This follows since (4.2) implies $x = 0$ and $X = 0$ when $r(Z) = g(Z) = c^\ell$.

would earn profit $\pi^d(r(Z),Z;F)$ if the PJV is formed, whereas domestic profit in the absence of a PJV is given by $V(r(0))$. Thus the gain to domestic firms from forming a PJV in stage 1 is given by $G(Z,F) \equiv \pi^d(r(Z),Z;F) - V(r(0))$ which, using (3.2), can be expressed as

$$G(Z,F) = V(r(Z)) - V(r(0)) - [(c^h-r(Z))Z + F]/n^d. \qquad (5.1)$$

Letting Z^* denote the PJV's chosen level of output if it is set up, domestic firms will form the PJV if and only if the overall gain $G(Z^*,F) > 0$ from the PJV is strictly positive. As can be seen from (5.1), a necessary condition for this is that output Z^* be positive. However, except when $F = 0$, $Z^* > 0$ is not sufficient for a gain since variable profits need to be high enough to cover the set-up cost. These results are summarized in Proposition 3.

Proposition 3: *A necessary condition for a high-cost PJV to increase domestic profits is that once set up, it would produce a strictly positive output. If $F = 0$, then $Z^* > 0$ is both necessary and sufficient for a high-cost PJV to increase domestic profits.*

Proof: If $Z^* = 0$, then (5.1) implies $G(0,F) = -F/n^d$, proving necessity. If $F = 0$, then $G(Z^*) > 0$ if $Z^* > 0$, proving sufficiency. ***

From (5.1), the effect of an increase in the PJV's output on $G(Z,F)$ is given by:

$$G_Z(Z,F) = [V_r(r(Z)) + Z/n^d]r'(Z) - (c^h-r(Z))/n^d. \qquad (5.2)$$

As (5.2) reveals, the PJV's output potentially raises domestic profits only through its effect in reducing the domestic price of components. Further, for a reduction in this price to be beneficial, then the term in square brackets in (5.2), representing the strategic effect of a reduction in domestic marginal cost, must be negative. Using (3.7), we can express this strategic term as:

$$V_r(r(Z)) + Z/n^d = -X/n^d + \alpha y^d(r) \qquad (5.3)$$

where $\alpha \equiv p'(Y_r-y^d_r) = [n^d - 1 - n^f(p'+y^fp'')/p']/(N+1-E)$ from (A6) in the

Appendix. As shown by (5.3), a reduction in marginal cost has two effects on domestic profit: it reduces the cost of a given quantity of imports X, which tends to raise profit, but in addition it changes equilibrium outputs with an effect on profit $\alpha y^d(r)$, which, as can be seen from the expression for α, may take either sign. In the special case in which $Z = 0$, using $X = Y^d(r(0)$ in (5.3), the strategic term reduces to $V_r(r(0)) = -y^d(r(0))(1-\alpha)$, which is negative under the conditions set out in (3.8).

Turning now to the determination of the PJV's output, since domestic firms are identical, there is no conflict as to optimal output, so Z^* can be determined by Nash bargaining between member firms or by any other procedure that leads to the joint profit maximizing level of output. Thus, in stage 1, the PJV sets Z^* to maximize the gain G(Z,F) in the region $Z \leq Y^d(c^f)$. Assuming that G(Z,F) is strictly concave[17] in Z, maximization of the Lagrangian $L \equiv G(Z,F) + \lambda(Y^d(c^f) - Z)$ where λ denotes the Lagrange multiplier, gives rise to the Khun Tucker first order conditions:

$$\partial L/\partial Z = G_Z(Z;F) - \lambda \leq 0 \text{ and } \partial L/\partial\lambda = Y^d(c^f) - Z \geq 0, \tag{5.4}$$

where $(\partial L/\partial Z)Z = 0$ and $(\partial L/\partial\lambda)\lambda = 0$. Proposition 4 sets out the implications of (5.4) for the PJV's choice of output and the nature of the solution whether internal or at a corner.

<u>Proposition 4</u>: *Suppose the PJV has been set-up.*

(i) The output Z^* of the PJV is strictly positive iff

$$G_Z(0,0) = V_r(r(0))r'(0) - (c^h-r(0))/n^d > 0, \tag{5.5}$$

where $V_r(r(0)) = (p-w^d-r(0))(1-\alpha)/p'$.

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[17] From (5.2) this implies $G_{ZZ}(Z,F) = r'(Z)[2/n^d + V_{rr}r'(Z)] + (V_r + Z/n^d)r''(Z) < 0$. In the linear demand case, using $r''(Z) = 0$ and $2/n^d + V_{rr}r'(Z) = 2/n^d[1 - (n^f+1)/(n^*+1)(N+1)] > 0$ (from (4.5) and (A6)), this imposes no further restrictions on the model.

(ii) A corner solution in which the PJV produces all components used domestically exists iff

$$G_Z(Y^d(c^f),0) = \alpha y^d(c^f)r'(Y^d(c^f)) - (c^h-c^f)/n^d \geq 0. \qquad (5.6)$$

(iii) An internal equilibrium in which $Z^* > 0$ satisfies $G_Z(Z^*,0) = 0$ and some components are imported exists iff both $G_Z(0,0) > 0$ and $G_Z(Y^d(c^f),0) < 0$.

Proof: (i) Setting $Z = 0$ in (5.4), and recognizing $G_Z(Z,F) = G_Z(Z,0)$, it follows using $G_{ZZ} < 0$ that $Z^* > 0$ if and only if $G_Z(0,F) > 0$. The expression for $G_Z(0,0)$ follows from (5.2) and for $V_r(r(0))$ from (3.7) using $y^dp' = -(p-w^d-r)$ from (3.4). (ii) Conditions (5.4) imply that $Z^* = Y^d(c^f)$ if and only if $G_Z(Y^d(c^f),0) \geq 0$. Now from (5.2) and $V_r(c^f) + Y^d(c^f)/n^d = \alpha y^d(c^f)$ from (5.3), we obtain $G_Z(Y^d(c^f),0)$ as in (5.6). (iii) If $0 < Z^* < Y^d(c^f)$, then from (5.4), $\lambda = 0$ and $G_Z(Z^*,0) = 0$. The conditions $G_Z(0,0) > 0$ and $G_Z(Y^d(c^f),0) < 0$ follow from parts (i) and (ii). ***

Condition (5.5) in Proposition 4(i) shows that for the PJV to produce a positive output, the first unit of production must have a sufficient effect in raising domestic profits through a reduction in the import price of components that it overcomes the cost disadvantage due to $c^h > r(0)$. As the expression for $V_r(r(0))$ indicates, the magnitude of the allowable cost disadvantage is limited by the size of the domestic profit margin $(p - w^d - r(0))$ earned on final product sales at $Z = 0$. Thus a greater cost disadvantage from PJV production is sustainable when this profit margin is high.

Correspondingly condition (5.6) in Proposition 4(ii) shows that for the corner solution at $Z = Y^d(c^f)$ to obtain, all units of production by the PJV including the last one at $Z = Y^d(c^f)$ must produce a profit increase that exceeds (or equals) the cost disadvantage. Since (5.6) holds only if $\alpha < 0$, an examination of (5.3) reveals that this corner solution cannot occur if foreign firms view outputs as strategic complements (i.e. if $p' + y^fp'' > 0$). Thus this corner solution is less likely if $p'' > 0$ as in the constant elasticity case. To have

$\alpha < 0$, there must also be a significant number of outside (foreign) firms not enjoying the price fall, for example, $n^f + 1 > n^d$ is required in the linear demand case. Finally Proposition 4(iii) implies that at an internal equilibrium[18] output Z^* satisfies $G_Z(Z^*,0) = 0$, where it follows from (5.2) that the strategic term $V_r(r(Z^*)) + Z^*/n^d < 0$.

It is interesting to note that whenever the PJV raises domestic profits, it also raises welfare in the domestic country. This result follows because the increase in domestic profits is achieved through a reduction in the marginal cost at which domestic firms produce final product. The total output of the final product always rises (see (3.6)), so that the price of the final product must fall. Since the profit increase is always associated with a consumer gain, domestic welfare must rise.

Production of Components by Individual Firms

An important alternative to a domestic 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 intermediate products 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 individual firms an incentive to engage in partial in-house production, but if each firm manufactures some of its own components, then each firm would lower the price of imported components for all domestic firms in the industry, not just for itself. Thus self manufacture by each individual firm results in a positive (pecuniary) externality

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[18] Since in general $\alpha y^d(r) \neq 0$, taking into account the effect of Z ir reducing r, it follows from (5.2) that Z^* does not equalize marginal cost across the two sources of supply (i.e. $c^h + Xr'(Z) \neq r$).

for all domestic firms[19]. This externality would not be taken into account by an individual firm when it makes its output decision, so that 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[20].

Another point in favour of a PJV is the obvious one that if fixed costs are positive, a PJV spreads these costs over all domestic firms. Thus each firm only has to invest F/n^d instead of F. Although the fixed cost gives the PJV an advantage relative to production at the individual firm level, it also raises the cost of domestic production of components, making both of these options less attractive relative to importing. Our argument that a PJV has an advantage over self manufacture because of its effect in internalising an externality does not depend on the existence of fixed costs.

6. Illustrative Examples

Further insight into the potential profitability of the PJV is obtained using two illustrative examples: linear demand and constant elasticity demand. Proposition 5 explores the implications of linear demand for the PJV's output.

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[19] Katz (1987) makes a similar point with respect to the incentives for vertical integration.

[20] When considering production by individual firms, the ability of a domestic firm to commit to its output of components prior to output decisions of foreign component suppliers becomes rather less credible. However, as we argue in Section 7, changing the order of moves to allow domestic production of components to occur simultaneously with foreign production or even subsequent to foreign production, does not remove the domestic incentive for high cost production of components. Because a PJV internalizes the pecuniary externality, it would also dominate in house production by individual firms in these perhaps more appropriate settings.

<u>*Proposition 5*</u>*: Suppose demand is linear and the PJV has been set up.*

(i) The PJV would produce a strictly positive output if and only if

$$(c^h-r(0))(n^s-1) < 2[p(Y(r(0)))-w^d-c^h].$$

(ii) If $n^s = 1$, the PJV would produce a strictly positive output if and only if

$$p(Y(r(0)))-w^d-c^h > 0.$$

(iii) A corner solution with $Z = Y^d(c^f)$ occurs if

$$(n^f+1-n^d)(p-w^d-c^h) - (c^h-c^f)(n^s(n^f+1) - n^d) > 0.$$

(iv) At an internal equilibrium, Z^* satisfies,

$$Z^*/n^d = -(n^f+1)\{2(p-w^d-c^h) - (n^s-1)(c^h-r)\}/p'(N+1). \qquad (6.1)$$

<u>Proof</u>: If $p'' = 0$, then $r'(Z) = p'(N+1)/n^d(n^f+1)(n^s+1)$ from (3.6) and (4.5), $\alpha = (n^d-(n^f+1))/(N+1)$ and $1-\alpha = 2(n^f+1)/(N+1)$ from (3.8). The results then follow from Proposition 4 and (5.2). ***

The result in Proposition 5(ii) is somewhat striking. In the special case where a foreign monopoly supplies the component, the necessary and sufficient condition for the PJV to produce a positive output once it has been set up is simply that the profit margin, $p(Y(r(0)))-w^d-c^h$, based on the marginal cost c^h of the PJV's production and evaluated at $Z = 0$ be strictly positive. Combining this result with Proposition 3, it follows that if there is no set-up cost, the condition $p(Y(r(0)))-w^d-c^h > 0$ is both necessary and sufficient for an overall gain from the PJV. Since, from Proposition 2, greater numbers of foreign component suppliers make the price r of components less responsive to the PJV's output, it is understandable that when $n^s \geq 2$, the condition $p(Y(r(0)))-w^d-c^h > 0$ is necessary but no longer sufficient for $Z^* > 0$. The profit margin condition $p(Y(r(Z^*)))-w^d-c^h > 0$ also holds in equilibrium.

A natural next question is whether taking into account the set-up cost F, a typical domestic firm needs to make a positive 'direct profit', denoted D(Z,F), on sales of final outputs that directly incorporate PJV produced components where

$$D(Z,F) \equiv (p(Y(r(Z)))-w^d-c^h)Z/n^d - F/n^d. \qquad (6.2)$$

The remainder of a typical domestic firm's profit, denoted $\phi(Z)$, comes from the use of imported components: i.e. from (3.2) and (6.2),

$$\phi(Z) \equiv [p(Y(r(Z)))-w^d-r(Z)]X(Z)/n^d, \qquad (6.3)$$

where (6.3) reveals that $\phi(Z)$ depends on the PJV's output through the effect of Z on both the quantity of imports X(Z) and the price r. The gain G(Z,F) from the PJV is just the sum of $D(Z^*,F)$ and the change $[\phi(Z^*) - \phi(0)]$ in the profits earned from imports due to the PJV's entry: from (5.1) and $\phi(0) = V(r(0))$,

$$G(Z^*,F) = D(Z^*,F) + [\phi(Z^*) - \phi(0)]. \qquad (6.4)$$

As can be seen from (6.4), if $[\phi(Z^*) - \phi(0)] < 0$, then direct profits $D(Z^*,F)$ must be positive for any possibility of a gain from the PJV. Taking this approach, we are able to show in Proposition 6(i) that direct profits must indeed be positive in the linear demand case. In addition, by obtaining a lower bound for the magnitude of $[\phi(Z^*) - \phi(0)]$, Proposition 6(ii) develops a simple sufficient condition for the overall profitability of the PJV in the presence of a fixed cost F.

__Proposition 6__:

(i) If demand is linear, the PJV increases domestic profits only if $D(Z^*,F) > 0$.

(ii) If $\phi''(Z) \leq 0$, a sufficient condition for the PJV to increase domestic profits is $(Z^*)^2 \geq F/(-p')Y_r r'(Z^*)$. If demand is linear, the condition reduces to $(Z^*)^2 \geq (n^d+1)(n^e+1)F/(-p')$.

<u>Proof</u>: (i) Taking an exact Taylor's expansion, we obtain $\phi(Z^*) - \phi(0) = \phi'(\hat{Z})Z^*$ for some $\hat{Z}$ where $\hat{Z} \in [0,Z^*]$. Thus the result follows from (6.4) if $\phi'(Z) < 0$ for all $Z \in (0,Z^*)$. If demand is linear, it follows from (A21) in the Appendix that

$$\phi'(Z) = [y^d(n^e-1) + (Z/n^d)]p'/n^d(n^e+1) < 0. \qquad (6.5)$$

(ii) If $\phi''(Z) \leq 0$, then $\phi(Z^*)-\phi(0) \geq \phi'(Z^*)Z^*$ for $Z^* > 0$. Also from (6.4) and (5.4), $G_Z(Z^*,0) = D_Z(Z^*,F) + \phi'(Z^*) \geq 0$ when $Z^* > 0$. Thus $\phi(Z^*)-\phi(0) \geq \phi'(Z^*)Z^* \geq -D_Z(Z^*,F)Z^*$ so (6.4) implies $G(Z^*,F) > D(Z^*,F) - D_Z(Z^*,F)Z^*$. Next, we obtain $D(Z^*,F) - D_Z(Z^*,F)Z^* = -(Z^*)^2p'Y_r r'(Z^*)/n^d - F/n^d$ from (6.2). Hence $G(Z^*,F) > 0$ if $(Z^*)^2 \geq F/(-p')Y_r r'(Z^*)$. If $p'' = 0$, then $F/(-p')Y_r r'(Z^*) = (n^f+1)(n^s+1)F/(-p')$ and since $\phi''(Z) = [(1/n^d)+y^d_r r'(Z)(n^s-1)]p'/n^d(n^s+1) < 0$ from (6.5), the result follows. ***

As the sufficient condition for overall profitability of the PJV developed in Proposition 6(ii) indicates, the threshold output Z^* at which the PJV raises domestic profits is increased by a positive value of F. When Z^* is large, this increases the magnitude of the fall in the price of imported components and thus the magnitude of the strategic gain in the final output market, which helps to offset the set-up cost. Since it can be shown[21] that Z^* is increased by a reduction in n^s (for linear demand) or a reduction in c^h, it also follows that both lower domestic costs and greater foreign monopoly power in input supply tend to increase the likelihood that a high-cost PJV is a worthwhile venture.

But what about robustness? This is explored in Proposition 7 allowing for general demand in 7(i) and constant elasticity demand, with $\epsilon \equiv -p/Yp' > 0$ in 7(ii). It is well known that in an imperfectly competitive environment, a shift from linear to constant elasticity demand can significantly affect results.

<u>*Proposition 7:*</u> *(i) If $n^f = 0$ and $dE/dY \leq 0$, the PJV raises domestic profits only if $D(Z^*,F) > 0$.*

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[21] Since $\partial(G_Z(Z,0))/\partial c^h = -1/n^d < 0$ from (5.2), it follows that $dZ^*/dc^h = 1/n^d(d^2\pi^d/dZ^2) < 0$. For the linear demand case, using (6.1) and $\partial r/\partial n^s < 0$ from Proposition 2, it follows that
$dZ^*/dn^s = -n^d(n^f+1)\{[2p'Y_r+(n^s-1)](\partial r/\partial n^s) - (c^h-r)\}/p'(N+1) < 0$.

(ii) Suppose ϵ is constant, $F = 0$ and $n^s = 1$. Then (a) If $n^f = 0$, then $p(Y(r(0)))-w^d-c^h > 0$ is necessary and sufficient for the PJV to increase domestic profits. (b) If $n^f \geq 1$, then $p(Y(r(0))-w^d-c^h \geq 0$ is sufficient, but not necessary for the PJV to raise domestic profits.

Proof (i) If $n^f = 0$, then from (A22) in the Appendix,

$$\phi'(Z) = \{y^d[n^s - 1 - X(dE/dY)/(N+1-E)] + (Z/n^d)\}r'(Z)/(N+1-E), \qquad (6.6)$$

where $n^s+1-E^s > 0$ from (4.3). If $dE/dY \leq 0$, (6.6) implies $\phi'(Z) < 0$ for all $Z > 0$. Thus $\phi(Z^*) - \phi(0) < 0$ and the result follows from (6.4).

(ii) Assuming $F = 0$, it follows from Propositions 3 and 4(i) that $G_Z(0,0) > 0$ is necessary and sufficient for the PJV to raise domestic profits. Setting $Z = 0$ in (A8) in the Appendix, we obtain

$$G_Z(0,0) = p(Y(r(0)))-w^d-c^h)/n^d + [V_r(r(0))r'(0) + y^d p'/n^d], \qquad (6.7)$$

where, from (A10), $V_r r'(0) + y^d p'/n^d = y^d[\omega-(1-\alpha)]r'(Z)$. If ϵ constant and $n^s = 1$, then from (A23), $\omega-(1-\alpha) = -n^f(c^f/p)(Y^d/Y)E/\gamma(N+1-E) \leq 0$ at $Z = 0$. (a). If $n^f = 0$, then $\omega-(1-\alpha) = 0$ and (6.7) implies $G_Z(0,0) > 0$ if and only if $p(Y(r(0)))-w^d-c^h > 0$. (b) If $n^f \geq 1$, then $\omega-(1-\alpha) < 0$ so since $r'(Z) < 0$, (6.7) implies $G_Z(0,0) > 0$ if $p(Y(r(0)))-w^d-c^h \geq 0$. Also $\omega-(1-\alpha)$ may be sufficiently negative that $G_Z(0,0) > 0$ when $p(Y(r(0)))-w^d-c^h < 0$. ***

Interestingly, Proposition 7(i) shows that the requirement that direct profit $D(Z^*,F)$ be positive for a gain from the PJV is quite robust to the nature of demand. The only restrictions are that there be no foreign firms producing the final product ($n^f = 0$) and that $dE/dY \leq 0$. As (A14) of the Appendix shows, this last condition holds if $d\epsilon/dY \leq 0$ and $d^2\epsilon/dY^2 \leq 0$, that is, if the elasticity of demand and the rate of change of the elasticity of demand are decreasing or constant as output is increased along the demand curve. If demand is linear or constant elastic then $dE/dY = 0$, so Proposition 7(i) applies to both these cases. Turning to Proposition 7(ii) referring to constant elasticity demand, part (a) shows that if $n^f = 0$, $n^s = 1$ and there is no set-up cost ($F = 0$), then a positive profit margin $p(Y(r(0))-w^d-c^h > 0$ is both necessary and sufficient for the PJV to be worthwhile for domestic firms. Remarkably, this is the same condition as in the linear demand case (see Proposition 5(ii)).

This brings to the question as to whether a PJV could ever increase domestic profits if domestic firms make direct losses using PJV produced components. If there is no set up cost, it is easy to show that direct profit $D(Z^*,0)$ is negative if the profit margin $p(Y(r(0)))-w^d-c^h$ evaluated at $Z = 0$ is negative[22]. Thus Proposition 7(ii), part (b) indicates that such a directly unprofitable PJV could indeed benefit domestic firms when demand is constant elastic. However, the conditions required for this result are rather restrictive. First, if domestic firms are to gain while making losses using PJV produced components, then the output of the PJV needs to be small[23]. Also, we know from Proposition 7(i) that at least one foreign firm must produce the final product and from Proposition 6(i), that the result does not hold for all demand conditions. Finally, it helps if a foreign monopoly supplies the input, because greater numbers of suppliers tend to make the price of the input less responsive to an increase in the PJV's output (see Proposition 2 for a proof in the linear demand case).

To help explain why $n^f \geq 1$ is critical to the result of Proposition 7(ii)(b), first note that from (6.7) using (A10) and (A12), the PJV would produce a positive output when $p(Y(r(0)))-w^d-c^h < 0$ only if the first unit produced by the PJV would sufficiently raise variable profits that

$$V_r(r(0))r'(0) + y^d p'/n^d = y^d r'(0)[\gamma(n^s-1)-\gamma E^s+(Y^d/Y)E]/(N+1-E) > 0. \quad (6.8)$$

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[22] Since $r(Z^*) < r(0)$, direct profit $D(Z^*,0) = (p(Y(r(Z^*))-w^d-c^h)Z^* < (p(Y(r(0))-w^d-c^h)Z^* < 0$.

[23]. That $p-w^d-c^h < 0$ reduces the PJV's output can be seen from (A25) in the Appendix.

If $n^* = 1$, (6.8) is satisfied if $-\gamma E^* + (Y^d/Y)E < 0$, a condition which fundamentally depends on the curvatures of the demand curves for component imports and the final product. If demand is linear, then $E = E^* = 0$ with the result that $p(Y(r(0)))-w^d-c^h > 0$ is always necessary for $Z^* > 0$. However, if ϵ is constant, having $n^f \geq 1$ increases E^*, which makes an increase in Z more effective in reducing the domestic price of components (see (4.5)). More specifically, from (A17), $E^* = (Y^d/Y)E[1 + n^f c^f/p\gamma]/\gamma > 0$ at $Z = 0$ ensuring that (6.8) is positive for $n^f \geq 1$, ϵ constant and $n^* = 1$.

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 in stage 2 (rather than in stage 1) simultaneously with the foreign exporters of components. There is a Cournot Nash equilibrium in component production. To overcome the time consistency problem, formation of a high-cost PJV still requires a simultaneous commitment to its output. Thus the PJV must also be formed (sinking the fixed cost) in stage 2. The stage 3 Cournot Nash equilibrium structure for the production of the final good is unchanged. Since stage 1 is irrelevant, we refer to this model as the "Two Stage Cournot" model.

Taking imports X 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 $r = g(Z+X)$. Thus the perceived gain from formation of the PJV, denoted $\Gamma(Z,X;F)$, is given by:

$$\Gamma(Z,X;F) \equiv \pi^d(g(Z+X),Z,F) - V(g(X)). \tag{7.1}$$

Using superscripts c to distinguish this "Two Stage Cournot" case, the Nash equilibrium quantity of imported components is given by $X^c = X(Z^c)$, determined by (4.2) as before. Consequently, the PJV will be formed if and only if the perceived gain $\Gamma(Z^c,X(Z^c),F) > 0$. Now, taking into account that X does not actually remain fixed as Z is changed, the actual gain from the PJV is given by $G(Z^c,F) \equiv \pi^d(g(Z^c+X(Z^c)),Z^c;F) - V(g(X(0)))$. Since $g(X(0)) = r(0)$, this is the same function G(Z,F) given in (5.1) 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):

$$\Gamma(Z,X(Z),F) - G(Z,F) = V(g(X(0)) - V(g(X(Z)) > 0 \text{ iff } X(Z) < X(0). \tag{7.2}$$

The PJV sets its output, denoted Z^c to maximize the Lagrangian $L^c \equiv \Gamma(Z,X;F) + \lambda^c(Y^d(c^f) - Z)$ taking X as given. Thus if $Z^c > 0$ it satisfies:

$$dL^c/dZ = \Gamma_Z(Z,X;F)-\lambda^c = (V_r(r)+Z/n^d)g'(Z+X) - (c^h-r)/n^d - \lambda^c = 0. \tag{7.3}$$

Proposition 8 compares outcomes in the "Two Stage Cournot" model with the base model.

<u>*Proposition 8*</u>*: Suppose $X'(Z) < 0$. In the "Two Stage Cournot" model,*

(i) the PJV's output Z^c equals or exceeds Z^*, its output in the base model.

(ii) if $F = 0$, the PJV enters whenever it would enter in the base model.

<u>Proof</u>: Comparing (7.3) with (5.2) and using (4.5), we obtain

$$\Gamma_Z(Z,X,F) = G_Z(Z,F) - (V_r(r) + Z/n^d)g'(Z+X)X'(Z). \tag{7.4}$$

(i) If $0 < Z^c < Y^d(c^f)$, then $\Gamma_Z(Z,X,F) = 0$ and (7.4) implies $G_Z(Z^c,F) = (V_r(r)+Z/n^d)g'(Z^c+X)X'(Z^c) < 0$, proving $Z^c > Z^*$ for $X'(Z^c) < 0$. If $Z^c = 0$ then, from (7.2), $\Gamma(0,X(0);F) = G(0,0) \leq 0$ ensuring $Z^* = 0$. If $Z^c = Y^d(c^f)$, then $Z^* \leq Z^c$. (ii) If the PJV enters in the base model, then $Z^* > 0$ and $G_Z(0,0) > 0$. Since $X'(Z) < 0$, (7.4) implies $\Gamma_Z(0,X(0),0) > G_Z(0,0) > 0$, entry also occurs in the "Two Stage Cournot" model if F = 0. ***

As Proposition 8(i) shows, 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, actually increases its equilibrium output. It follows (see Proposition 8(ii)) that if there were no set-up cost F, the PJV would enter in the "Two Stage Cournot" setting whenever it would enter in the original model in which the PJV has a first mover ability.

Now consider the possibility that there is a single incumbent foreign supplier with a first mover ability to commit its output[24] in stage 1. Domestic firms get to move second, determining whether to set up the PJV as well as choosing the PJV's output in stage 2. Stage 3 is as before. This order of moves seems more justifiable in the monopoly case because co-ordination between suppliers is not necessary.

In this setting, domestic firms may have a credible threat of forming a high-cost PJV because domestic production of components depresses the market price. However, the incumbent supplier may also choose to deter entry by raising quantity to make domestic firms at least indifferent between forming the PJV and importing all their supplies. 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

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[24] Note that a stage 1 commitment to the price (not quantity) of components by the foreign monopoly supplier would remove the motive for the PJV. However it is likely to be difficult to make a fixed price credible in the event of the PJV's subsequent entry.

above the "two stage Cournot" level.

The credibility of entry deterrence in this context can be understood from a general point made by Sexton and Sexton (1987) in the context of a limit pricing model. They argue that, in contrast to the traditional limit price model of Bain (1956), the entry decision of a consumer cooperative (which our PJV essentially is) hinges on the cooperative's payoff in the no-entry environment as well as the payoff subsequent to entry. Thus a consumer cooperative may credibly be deterred from entry by a limit pricing strategy in the no-entry environment, whereas in the Bain setting, limit pricing is ineffective because it cannot credibly affect the post-entry game. In our setting of quantity rather that price commitment, an increase in the quantity of components exported by the incumbent lowers the price of imports in the no-entry environment, making this environment more profitable for domestic firms. Since the marginal cost of domestic production is unchanged at c^h, entry by the PJV tends to become relatively less profitable[25].

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 semiconductors. 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.

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[25] The assumption that the incumbent maintains its exports even if the PJV enters is a useful simplification but it is not critical for entry prevention. If entry occurs at the limit output of the incumbent and the incumbent acquiesces to this, the incumbent's profit maximizing level of exports of components would fall, reducing the domestic gain from the PJV's entry.

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.

8. Concluding Remarks

We began this paper by asking the question as to whether domestic producers of a final product could ever gain from a PJV that produces components at a marginal cost strictly exceeding the price of imported components. As we have shown, the answer is yes. In an oligopolistic setting, production of part of the domestic requirement for the input at this high cost can sufficiently reduce the price of imported supplies that domestic profits rise. Moreover, since a PJV of this type can be profitable under both linear and constant elasticity demand, the potential for a gain is relatively robust in the sense that it does not depend on some highly special demand conditions. If there is no fixed cost of entry by the PJV and if a foreign monopolist is the sole source of supply of components, then the requirement for a gain is particularly simple: for both linear and constant elasticity demand, the PJV raises the profits of domestic final producers if they would earn a positive profit margin using PJV produced components.

The joint venture form of organization as compared to individual vertical integration is needed if the external benefits arising from the reduced price for imported supplies are to be fully internalized. Consequently if individual firms vertically integrate so as to each produce some of their own components, too few components would be supplied from the domestic industry point of view. Indeed it is possible, but not necessary, that in-house production could be unprofitable even though a joint venture would serve to raise domestic industry profits. Furthermore, 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 could not attract any other companies besides the original seven founding members[26]. It 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[27]. Furthermore, U.S. Memories included both semiconductor manufacturers as well as computer firms. 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.

Fundamentally, this paper makes the point that, when markets are imperfectly competitive, final producers can potentially gain by producing some of an input at a marginal cost exceeding the market price of the input because even high cost production lowers the market price of externally available supplies. We develop this idea to explain the potential gain from a high-cost joint venture, but it could also have relevance for the decision by some firms to maintain some high cost capacity for in-house production of a critical input, while purchasing most supplies on the outside. In the special case where there is only one downstream firm or if the downstream firm is sufficiently dominant

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[26] Apple, Tandy, Sun Microsystems and Unisys were among those refusing to join U.S. Memories.

[27] Of course if there is some positive probability of the PJV catching up to foreign competitors, even if only in later generations, this will increase the incentives to form a domestic PJV.

that the spillover effects on other firms are small, our results would apply directly to the decision to produce in-house.

APPENDIX

1. Comparative Statics: the price of imported components

Totally differentiating (3.4) with respect to the n^d domestic outputs and the n^f foreign outputs, and recognizing that all domestic firms are identical and all foreign firms are identical, we obtain

$$[(n^d+1)p' + Y^d p'']dy^d + n^f(p'+y^d p'')dy^f = dr \qquad \text{(A1)}$$

$$n^d(p'+y^f p'')dy^d + [(n^f+1)p'+Y^f p'']dy^f = 0. \qquad \text{(A2)}$$

Applying Cramer's rule to (A1) and (A2) and using $E \equiv -Yp''/p'$ and (3.5), the comparative static effects of r on y^d and y^f are

$$y^d_r = p'[n^f+1-(Y^f/Y)E]/H < 0 \text{ and } y^f_r = -n^d(p'+y^f p'')/H, \qquad \text{(A3)}$$

where $H \equiv (p')^2[N+1-E] > 0$. Letting $\gamma \equiv (n^f+1-(Y^f/Y)E)$ and using $Y_r(r) = n^d y^d_r + n^f y^f_r$ and (A3), it follows that:

$$y^d_r = \gamma Y_r/n^d,\ y^f_r = (1-(y^f/Y)E)Y_r \text{ and } Y_r = p'n^d/H < 0. \qquad \text{(A4)}$$

2. Price Over-shifting: It follows using (A4) that

$$d(p(Y(r))-w^d-r)/dr = p'Y_r-1 = ((p')^2n^d/H)-1 = -(n^f+1-E)/(N+1-E). \text{(A5)}$$

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

3. Profit Over-shifting: Differentiating V(r) as in (3.2) using $p-w^d-r = -y^d p'$, it follows that $V_r(r) = -y^d(r)(1-\alpha)$, where using (A3) and (A4),

$$\alpha \equiv p'(Y_r-y^d_r) = (p'Y_r/n^d)(n^d-\gamma) = [n^d - 1 - n^f(p'+y^f p'')/p']/(N+1-E). \text{(A6)}$$

Thus using (A6), we obtain (3.8) of the text:

$$V_r(r) < 0 \text{ iff } 1-\alpha = [2 + n^f(2p'+y^f p'')/p' - E]/(N+1-E) > 0. \qquad \text{(A7)}$$

4. Evaluate $G_Z(Z;0)$ and solve for Z^*_r: Using $-(c^h-r) = p-w^d-c^h + y^d p'$ from (3.4) in (5.2) we obtain

$$G_Z(Z,0) = (p-w^d-c^h)/n^d + [V_r(r(Z)) + Z/n^d]r'(Z) + y^d p'/n^d \qquad \text{(A8)}$$

Let ω such that $r'(Z) = p'/n^d\omega$, then from (4.5), using (A4),

$$\omega \equiv p'y^d_r(n^e+1-E^e) = \gamma(n^e+1-E^e)/(N+1-E) > 0, \qquad \text{(A9)}$$

for $\gamma \equiv (n^f+1-(Y^f/Y)E)$. Expressions (A10) and (A11) then follow using (3.7), (A9) and (A8):

$$[V_r(r(Z)) + Z/n^d]r'(Z) + y^d p'/n^d = y^d[\omega-(1-\alpha)]r'(Z) + (Z/n^d)r'(Z) \qquad \text{(A10)}$$

$$G_Z(Z,0) = (p-w^d-c^h)/n^d + y^d[\omega-(1-\alpha)]r'(Z)] + (Z/n^d)r'(Z). \qquad \text{(A11)}$$

Now from $\alpha = p'(Y_r-y^d_r)$ and (A9), we obtain $\omega-(1-\alpha) = p'y^d_r(n^e-E^e)-(1-p'Y_r)$ and from (A5) and (A9)

$$\omega-(1-\alpha) = [\gamma(n^e-1) - \gamma E^e + (Y^d/Y)E]/(N+1-E). \qquad \text{(A12)}$$

To solve for an internal equilibrium with $0 < Z^* < Y^d(c^f)$, set $G_Z(Z,0) = 0$ in (A11) to obtain,

$$Z^*/n^d = -\{(p-w^d-c^h)\omega + y^d p'[\omega-(1-\alpha)]\}/p'. \qquad \text{(A13)}$$

<u>5. Expressions for E and E^e.</u> From $\epsilon \equiv -p/Yp'$ and $E \equiv -Yp''/p'$, we obtain $d\epsilon/dY = -[1 + \epsilon(1-E)]/Y$, which implies:

$$E = 1+1/\epsilon+Y(d\epsilon/dY)/\epsilon \text{ and } dE/dY = [(d\epsilon/dY)(2-E) + Yd^2\epsilon/(dY)^2]/\epsilon. \qquad \text{(A14)}$$

If $n^f = 0$, then $2-E > 0$ from (A7), so $dE/dY \leq 0$ if $d\epsilon/dY \leq 0$ and $d^2\epsilon/(dY)^2 \leq 0$. Now considering $E^e = -Xg''/g' = XY^d_{rr}/(Y^d_r)^2$ from (4.1), differentiation of $Y^d_r = \gamma Y_r$ where $\gamma \equiv n^f+1-(Y^f/Y)E$ implies

$$Y^d_{rr} = \gamma Y_{rr} - Y_r[E(d(Y^f/Y)/dr + (Y^f/Y)(dE/dY)Y_r]. \qquad \text{(A15)}$$

To expand $d(Y^f/Y)/dr = (Y^f_r - (Y^f/Y)Y_r)/Y$, we use $Y^f_r = -(n^f-(Y^f/Y)E)Y_r$ from (A4), (A14) and $n^f - Y^f/Y\epsilon = n^f c^f/p$ (which follows since (3.4) implies $p[1-(y^f/Y\epsilon)] = c^f$) to obtain

$$d(Y^f/Y)/dr = -[n^f - (Y^f/Y)(E-1)]Y_r/Y = -[n^f c^f/p - Y^f(d\epsilon/dY)/\epsilon](Y_r/Y). \qquad \text{(A16)}$$

Also from $Y_r = n^d/p'(N+1-E)$ it can be shown that $Y_{rr} = (Y_r)^2(E/Y + (p'Y_r/n^d)(dE/dY))$. Hence from (A15) and (A16), letting $\psi \equiv (Y^f/Y)E(d\epsilon/dY)/\epsilon - (\gamma p'Y_r/n^d - Y^f/Y)(dE/dY)$ and $\beta \equiv n^f c^f/p$,

$$E^{*} = (X/Y)E(1 + \beta/\gamma)/\gamma - X\psi/\gamma^{2}. \tag{A17}$$

6. Derivation of $\phi'(Z)$ where $\phi(Z) \equiv (p\text{-}w^{d}\text{-}r(Z))X(Z)/n^{d}$.

From (6.4), we obtain $\phi'(Z) = G_Z(Z,F) - D_Z(Z,F)$. Since $D_Z(Z,F) = (p\text{-}w^{d}\text{-}c^{h})/n^{d} + (Z/n^{d})p'Y_r r(Z)$ from (6.2), it follows using (A11) that

$$\phi'(Z) = \{y^{d}[\omega\text{-}(1\text{-}\alpha)] + (Z/n^{d})(1\text{-}p'Y_r)\}r'(Z). \tag{A18}$$

Now substituting E^{*} as given by (A17) in (A12), we obtain

$$\omega\text{-}(1\text{-}\alpha) = \{\gamma(n^{*}\text{-}1) - (X/Y)E\beta/\gamma + X\psi/\gamma + (Z/Y)E\}/(N+1\text{-}E) \tag{A19}$$

Then from (A19), (A18), (A5) and (A9),

$$\phi'(Z) = \{y^{d}[\gamma(n^{*}\text{-}1) - (X/Y)E\beta/\gamma + X\psi/\gamma] + (Z/n^{d})\gamma\}r'(Z)/(N+1\text{-}E). \tag{A20}$$

Linear Demand: If $p'' = 0$, then $E = E^{*} = 0$, $\gamma = n^{f} + 1$ so $\omega\text{-}(1\text{-}\alpha) = (n^{f}+1)(n^{*}\text{-}1)/(N+1)$ from (A19) and $r'(Z) = p'(N+1)/n^{d}(n^{f}+1)(n^{*}+1)$ from (3.6) and (4.5). Since $\psi = 0$, (A20) reduces to:

$$\phi'(Z) = [y^{d}(n^{*}\text{-}1) + (Z/n^{d})]p'/n^{d}(n^{*}+1) < 0. \tag{A21}$$

General Demand with $n^{f} = 0$: If $n^{f} = 0$ then $\beta = Y^{f} = 0$, $\gamma = 1$ and $\psi = -(dE/dY)/(N+1\text{-}E)$ so from (A20), we obtain (6.6) of the text:

$$\phi'(Z) = \{y^{d}[n^{*} - 1 - X(dE/dY)/(N+1\text{-}E)] + (Z/n^{d})\}r'(Z)/(N+1\text{-}E). \tag{A22}$$

Constant Elasticity Demand: If $\epsilon \equiv -p/Yp' > 0$ is constant, then $E = 1+(1/\epsilon)$ from (A14) and $\psi = 0$. From (A19) and $X = Y^{d} - Z$, it follows that

$$\omega\text{-}(1\text{-}\alpha) = \{\gamma(n^{*}\text{-}1) - \beta(Y^{d}/Y)E/\gamma + (\gamma+\beta)(Z/Y)E/\gamma\}/(N+1\text{-}E) \tag{A23}$$

for $\beta \equiv n^{f}c^{f}/p \geq 0$. Also using $X = Y^{d} - Z$ and $\psi = 0$ in (A20), we obtain:

$$\phi'(Z) = \{y^{d}[\gamma(n^{*}\text{-}1)\text{-}\beta(Y^{d}/Y)E/\gamma] + (Z/n^{d})(\gamma+\beta(Y^{d}/Y)E/\gamma\}r'(Z)/(N+1\text{-}E) \tag{A24}$$

Assuming $n^{*} = 1$, from (A23), (A9) and (A13), it follows that at an internal equilibrium,

$$Z^{*}/n^{d} = -\{(p\text{-}w^{d}\text{-}c^{h})\gamma(2\text{-}E^{*}) - y^{d}p'\beta(Y^{d}/Y)E/\gamma\}/p'[n^{d}+\gamma+\beta(Y^{d}/Y)E/\gamma]. \tag{A25}$$

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