Strategic Second Sourcing by Multinationals

Jay Pil Choi and Carl Davidson
Michigan State University
March 2002
Revised February 2003

Abstract: Multinationals often serve foreign markets by producing domestically and exporting as well as by investing directly in foreign production facilities. We argue that if the multinational competes in an oligopolistic market characterized by strategic complements then there are strategic reasons to use two production facilities -- committing to a second source allows the firm to keep average cost low while at the same time increasing its marginal cost. The increase in marginal cost softens product market competition resulting in higher profits. In our model, firms can sink capacity domestically, where the constant marginal cost is known, sink capacity in the foreign country, where the constant marginal cost is uncertain, or do both. In the absence of strategic considerations, the firm usually chooses to either export or use foreign direct investment -- it rarely uses both sources of production. In contrast, price competition in the product market makes it much more likely that the firm will choose to use a second source. In fact, there are cases in which the firm sinks capacity in both locations even in the absence of cost uncertainty. We argue that this theory also has implications for the "make or buy" literature in production management and the literature on second sourcing in industrial organization. Finally, we show that the practice of second sourcing has implications for the degree of exchange rate pass through when the uncertainty about foreign costs is driven by fluctuations in the exchange rate.

JEL Codes: F1, L1

Keywords: Multinationals, Second Sourcing, Foreign Direct Investment.

I. Introduction

Multinational enterprises dominate many international markets and account for a significant portion of the international trade between developed countries.[1] As a result, large literatures, both empirical and analytical, have developed aimed at explaining the behavior of such firms. While there are many stylized facts that have been uncovered, two are particularly relevant for what follows. First, there is evidence that exports and foreign direct investment (FDI) are complementary – many multinationals do both. Second, there are many industries in which two-way FDI between developed countries is prevalent.[2] While many of the analytic models of multinationals are consistent with most of the other stylized facts, they cannot provide explanations for these two phenomena. In many models, firms choose between exporting and FDI. FDI is attractive because it allows the firm to avoid transportation costs and tariffs, but it is costly because it requires the firm to build a new production facility. Thus, FDI involves a trade-off between high fixed costs and low variable costs. In such models, if the firm chooses to build a foreign production facility, it stops exporting – FDI and exports are substitutes.[3]

Kogut and Kulatilaka (1994) and Rob and Vettas (2001) have provided models in which multinationals use both exporting and FDI to serve foreign markets. In Kogut and Kulatilaka's model, the firm faces cost uncertainty and therefore setting up a foreign production facility provides it with an option value – if costs turn out to be unexpectedly

[1] In 1990 multinationals accounted for over 75% of the total U.S. trade in merchandise. Data from 1999 reveals that over 60% of multinational trade can be traced to a small set of developed countries and that 70% of their foreign direct investment is hosted by industrial countries (Caves, et al 2002, p. 164-65.)

[2] See Caves (1982) or Markusen (1995) for a survey of the stylized facts concerning multinationals. Evidence on the complementary nature of exporting and FDI can be founding Blomstrom, Lipsey and Kulchycky (1988), Blonigen (2001), and Denekamp and Farrantino (1992), and Head and Ries (2001). Evidence on two-way FDI can be found in Julius (1990) and Brainard (1997b).

[3] See, for example, Caves (1971), Buckley and Casson (1981), Smith (1987), and Horstman and Markusen (1987, 1996).

high in one plant the firm can shift production to its low cost alternative. In Rob and Vettas' model there is uncertainty about demand growth in the foreign market. The multinational begins by exporting when demand is low. Eventually demand becomes large enough to justify FDI. However, the combination of demand uncertainty and the irreversibility of investment make it optimal to continue exporting even after building a foreign production facility. The reason is simple – if the firm builds a foreign facility large enough to handle all of its expected foreign demand it runs the risk of winding up with excess capacity if demand turns out to be unexpectedly low. Producing some of its output at home and exporting it to the foreign market allows the firm to circumvent such risk. This argument, while compelling, does not provide an explanation of why multinationals would employ such a strategy in a mature market with stable demand nor does it explain why we observe two-way FDI in so many industries.

In this paper we provide a new explanation for the practice of producing output both at home and abroad. We argue that this practice, which we refer to as "second sourcing," and two-way FDI both arise naturally in oligopolistic markets characterized by strategic complements.[4] In particular, we show that if the multinationals are engaged in this type of competition there are strategic reasons to use two production facilities -- committing to a second source allows each firm to keep average cost low while at the same time increasing marginal cost. The increase in marginal cost softens product market competition resulting in higher profits.

In our model, the firm can sink capacity domestically, where the constant marginal cost is known, sink capacity in the foreign country, where the constant marginal

[4] Briefly, goods are strategic complements if the firms' best reply functions are upward sloping (as is typically the case with price competition). As explained in footnote 14, the slopes of best reply functions are determined by the cross-partials of profit functions.

cost is uncertain, or do both. Then, after the capacity decision has been made and the uncertainty has been resolved, the firm selects its price. In the absence of strategic considerations (i.e., if the firm is a monopolist), the firm usually chooses to either export or use foreign direct investment -- it rarely uses both sources of production. In contrast, if the firm faces price competition in the product market, then the conditions under which second sourcing is optimal become much weaker. By second sourcing, the firm can produce the bulk of its output in its low-cost facility (the domestic plant if foreign costs are high and the foreign plant if foreign costs are low) and the residual in the high-cost facility. This allows the firm to produce at low average cost while keeping its marginal cost high. The high marginal cost is desirable because it allows the firm to credibly commit to charging a high price; and, since best-reply functions are upward sloping in price games, this leads its competitor to also charge a high price. As a result, the firm increases its profits above the level that it would earn using a single production facility. In fact, this strategic effect is so strong that there are cases in which the firm sinks capacity in both locations even in the absence of cost uncertainty.[5]

Our theory provides an alternative explanation for the commonly observed empirical phenomenon that firms often sink production capacity for the same good in different countries. The commonly cited reasons for this behavior, such as risk management, political economy concerns, and transportation costs, may be responsible for the majority of cases. However, the strategic concerns raised in our paper could provide *additional* incentives to engage in second sourcing. In this respect, our theory

[5] Our logic is similar to that in Kreps and Scheinkman (1983) who show that capacity commitment can be used to soften price competition in oligopolistic markets. We generalize their argument to a setting in which the firm has two potential production facilities and faces cost uncertainty.

should be viewed as *complementary* to the existing theories.[6] Our model also indicates that second sourcing can have the unintended consequence of acting as a facilitating device, even if strategic concerns are not the primary motive for second sourcing.

Farrell and Gallini (1988) and Shepard (1987) also provide strategic models of second sourcing in which the role of second sourcing is to serve as a mechanism to protect buyers' interests against the monopolistic supplier's *ex post* opportunistic behavior.[7] More specifically, in their models buyers need to make relationship-specific investment in an ongoing relationship with a monopolistic supplier, which creates a dynamic consistency problem; the monopolist cannot commit to low future prices/higher qualities once the buyers have incurred the costs of investment. Second sourcing through licensing induces *ex post* competition and allows the supplying firms to make a low price/high quality commitment that would not be credible with single sourcing. Our model differs from Farrell and Gallini (1988) and Shepard (1987) in two major respects. First, the strategic considerations in our model are *horizontal* in that the motives for second sourcing stem from oligopolistic competition with a rival supplier whereas they consider the strategic motives for second sourcing in a *vertical* relationship between buyers and sellers. Second, in their model second sourcing a commitment to a *low* price whereas in our model it serves as a commitment to a *high* price to invite softer competition from the rival firm.

---

[6] In particular, our theory yields similar predictions to those of the risk management explanation. Thus, it may be difficult to validate our theory empirically by rejecting alternative explanations for FDI, especially the risk management theory.

[7] There is also an extensive literature on second sourcing in the context of procurement such as Anton and Yao (1987), Demsky, Sappington, and Spiller (1987), and Laffont and Tirole (1988). These models emphasize the role of second source to discipline an incumbent with *private* cost information. Riordan and Sappington (1989), however, argue that the benefits of second sourcing are often of limited value and in many instances sole sourcing is preferred when linkages with earlier stages of procurement (R&D activities at the development stage) are considered. In contrast to Farrell and Gallini (1988) and Shepard (1987), these models analyze second sourcing incentives for a *monopsonist*.

The paper divides into four additional sections. In section II, we introduce our model and solve for the firm's optimal investment strategy in the absence of strategic considerations.[8] In section III, we show that with price competition in the product market the presence of a rival weakens the conditions under which the firm will choose to second source. Moreover, in section IV, we show that in a duopoly it is often in the interest of both firms to sink capacity in both at home and abroad so that we would expect to observe two-way FDI in such industries. Finally, we close the paper in section four where we argue that this theory has implications for literature on voluntary export restraints, the "make or buy" literature in production management and the second sourcing literature in industrial organization.

II. The Monopoly Model of Second Sourcing

Consider a monopolistic supplier of a good that serves a foreign market with the demand curve of $D(p)$. We develop the monopoly model as a benchmark to highlight the importance of strategic motives of second sourcing. There are three alternative ways of serving the foreign market for the monopolist. It can choose to export, use foreign direct investment, or adopt both modes of operation which we call "second sourcing."

If the firm is engaged in domestic production and exports to the foreign country, the marginal production cost is assumed to be constant at c. If the firm is engaged in foreign direct investment, there is cost uncertainty. The constant marginal production

[8] In Appendix A we push the monopoly case further and show that the firm's choice of its production method has important implications for the degree of exchange rate pass-through when the cost uncertainty is driven by fluctuations in the exchange rate.

cost can be either at $\underline{c}$ or $\bar{c}$, with Pr ($\underline{c}$) = α, where $\underline{c} < c < \bar{c}$.[9] Let $p^m(c)$ denote the monopoly price when marginal cost is c, that is, $p^m(c) = \arg\max\,(p-c)D(p)$ and let $q^m(c)$ and $\pi^m(c)$ represent the corresponding output and profit levels.

More importantly, we assume that the firm needs to sink capacity in advance for production wherever it chooses to produce. To avoid the complex problem of optimal capacity choice and the possibility of mixed strategy equilibria with rationing, we further assume that there is some lumpiness in capacity; investment in capacity is indivisible.[10] More specifically, there are two levels of capacity to choose, large and small. The costs for installing the large capacity and small capacity are given by $\bar{F}$ and $\underline{F}$, respectively, with $\bar{F} \leq 2\underline{F}$. With the large capacity, the firm can produce up to the market demand regardless of its cost realizations. With the small capacity, the firm can supply up to k, where $D(p^m(c))/2 < k < D(p^m(\bar{c}))$. This implies that the small capacity (k) alone is not sufficient to meet the demand even at the price of $p^m(\bar{c})$ whereas the capacity with two small plants ($2k$) is sufficiently large to meet any relevant demand.

Now we can compare the firm's optimal sourcing decision. If the firm serves the market with only exports, its profit is given by:[11]

---

[9] The uncertainty associated with foreign production can be linked to a variety of factors. For example, in the management literature it has been stressed that the management of foreign operations is made difficult by differences in culture and labor relations (see, for example, Hymer 1960). As a result, the cost of managing foreign operations may be uncertain and higher than the cost of managing domestic operations. If foreign labor is cheaper, the uncertain foreign marginal cost may be either higher or lower than the certain domestic marginal cost. Other factors that may influence the uncertainty associated with foreign production include fluctuations in the exchange rate, uncertainty about government policies towards FDI and the rate at which technologies are introduced in some parts of the world.

[10] J. S. Bain's (1954, 1956) pioneering study of the structure of U.S. industry identified scale economies at the plant level that are substantial in many industries. For recent empirical evidence of the relevance of lumpy investment see Doms and Dunne (1998).

[11] With the assumption of $\bar{F} \leq 2\underline{F}$, the choice of the large capacity is always optimal when the firm exports or uses foreign direct investment.

$$\text{(1)} \qquad \Pi^{EX} = \pi^m(c) - \overline{F}$$

The firm's expected payoff from serving the market with foreign direct investment is given by:

$$\text{(2)} \qquad \Pi^{FDI}(\alpha) = [\alpha\pi^m(\underline{c}) + (1-\alpha)\pi^m(\overline{c})] - \overline{F}$$

Notice that $\Pi^{FDI}(\alpha)$ is linear in α with a slope of $\pi^m(\underline{c}) - \pi^m(\overline{c}) > 0$ (see Figure 1). Taken together with the fact that $\Pi^{FDI}(0) < \Pi^{EX}$ and $\Pi^{FDI}(1) > \Pi^{EX}$, we can establish that there is a critical value α^* such that $\Pi^{FDI}(\alpha) \geq \Pi^{EX}$ if and only if $\alpha \geq \alpha^*$, where $\alpha^* = \dfrac{\pi^m(c) - \pi^m(\overline{c})}{\pi^m(\underline{c}) - \pi^m(\overline{c})}$.

Finally, the firm can use second sourcing by sinking small capacity in both domestic and foreign countries. In this case, the division of total production between the two plants depends on the cost realization in the foreign country. If marginal cost in the foreign country is low, the whole capacity in the foreign country will be exhausted first, and the rest of the demand will be met with production in the domestic country. If marginal cost in the foreign country is high, the pattern of production is reversed; that is, the capacity in the domestic country will be exhausted and the residual demand will be met with production in the foreign country. This implies that if marginal cost in the foreign country is low, the last unit is produced domestically, the relevant marginal cost is c and the profit-maximizing price is $p^m(c)$. In contrast, if marginal cost in the foreign country is high, the last unit is produced in the plant located in the foreign country, the relevant marginal cost is $\bar{c}$ and the profit-maximizing price is $p^m(\bar{c})$. The expected payoffs from second sourcing thus can be written as:

$$\text{(3)} \qquad \Pi^{SS}(\alpha) = \alpha[\pi^m(c) + (c - \underline{c})k] + (1-\alpha)[\pi^m(\bar{c}) + (\bar{c} - c)k] - 2\underline{F}$$

Lemma 1. $\pi^m(c) + (c - \underline{c})k < \pi^m(\underline{c})$ and $\pi^m(\bar{c}) + (\bar{c} - c)k < \pi^m(c)$.

Proof. $\pi^m(\underline{c}) = [p^m(\underline{c}) - \underline{c}]D(p^m(\underline{c})) \geq [p^m(c) - \underline{c}]D(p^m(c))$

$$= [p^m(c) - c]D(p^m(c)) + (c - \underline{c})D(p^m(c)) > \pi^m(c) + (c - \underline{c})k$$

The last inequality follows due to our assumption that $k < D(p^m(\bar{c})) < D(p^m(c))$.

Similarly,

$$\pi^m(c) = [p^m(c) - c]D(p^m(c)) \geq [p^m(\bar{c}) - c]D(p^m(\bar{c}))$$

$$= [p^m(\bar{c}) - \bar{c}]D(p^m(\bar{c})) + (\bar{c} - c)D(p^m(\bar{c})) > \pi^m(\bar{c}) + (\bar{c} - c)k \qquad \#$$

Lemma 1 implies that $\Pi^{SS}(0) < \Pi^{EX}$ and $\Pi^{SS}(1) < \Pi^{FDI}(1)$; without cost uncertainty, second sourcing is always dominated by one of the two alternative mode of operation. By continuity, second sourcing is also dominated by exporting for small values of α and dominated by foreign direct investment for values of α close to 1.

We now investigate whether second sourcing can be the preferred method of operation for intermediate values of α. Intuitively, we would expect this to be the case. As we have just shown, for low values of α the firm is effectively choosing between exporting and second sourcing. Second sourcing involves risk, but may result in a lower average cost. Since the firm's profit function is convex in costs, it generally prefers the more risky production method. However, for very low values of α second sourcing entails a higher expected average cost than exporting. Thus, the firm chooses to export. As α increases, the expected average cost associated with second sourcing falls and it should eventually dominate exporting. Now, consider the case in which α is high, where the firm chooses between FDI and second sourcing. In this case, FDI is the riskier production method and will be preferred if the expected average cost from FDI and second sourcing are similar. However, as α falls, the expected average cost associated with FDI rises faster than the expected average cost from second sourcing so that second sourcing should eventually become the superior alternative.

To check our intuition, we first simplify our analysis by placing a restriction on $\overline{F}$ and $\underline{F}$. Since the relative size of $2\underline{F}$ and $\overline{F}$ affects the relative merit of second sourcing in a predictable way, we assume $\overline{F} = 2\underline{F}$.[12] This implies that there is no intrinsic advantage of having one plant of the large capacity vis-à-vis two plants of the small capacity if the marginal costs are the same regardless of the capacity choice.

We first compare the option of second sourcing vis-à-vis the option of exporting. As in the comparison of foreign direct investment and exporting, once again we can define a unique value $\hat{\alpha}$ such that such that $\Pi^{SS}(\alpha) \geq \Pi^{EX}$ if and only if $\alpha \geq \hat{\alpha}$ because

[12] None of our qualitative results depend on this assumption. While it is clear that second sourcing becomes less attractive as $\underline{F}$ increases, this is true under monopoly and oligopoly as well. In fact, the only implication of relaxing this assumption and allowing for $\overline{F} < 2\underline{F}$ is that in this latter case the set of parameter values for which second sourcing is optimal is smaller than the case in which $\overline{F} = 2\underline{F}$. The strategic advantages from second sourcing that arise under oligopoly do not disappear.

$\Pi^{SS}(\alpha)$ is a strictly increasing function of α and $\Pi^{SS}(0) < \Pi^{EX}$ and $\Pi^{SS}(1) > \Pi^{EX}$. The critical value $\hat{\alpha}$ can be expressed as

(4) $$\hat{\alpha} = \frac{\pi^m(c) - \pi^m(\bar{c}) - (\bar{c} - c)k}{\pi^m(c) - \pi^m(\bar{c}) + (2c - \bar{c} - \underline{c})k}$$

Let Σ be the set of α in which second sourcing is the preferred mode of operation. Proposition 1 tells us that the existence of such a set depends on the relative magnitude of $\hat{\alpha}$ and α*. Proposition 1 is illustrated in Figure 1.

Proposition 1. If $\hat{\alpha} < \alpha^*$, we can find a range of α such that second sourcing is the preferred mode of operation. In this case, let E, Σ, and Φ be the sets of α in which exporting, second sourcing and foreign direct investment are optimal, respectively. Then, the optimal sourcing decision can be characterized by two critical cut-off points $\underline{\alpha}$ and $\bar{\alpha}$ such that $0 < \underline{\alpha} < \bar{\alpha} < 1$ and E = $[0, \underline{\alpha}]$, Σ = $[\underline{\alpha}, \bar{\alpha}]$, Φ = $[\bar{\alpha}, 1]$. If $\hat{\alpha} > \alpha^*$, second sourcing is always dominated by one of the other two, i.e., Σ =ϕ.

Proof. Let us define $\hat{\hat{\alpha}} \in (0,1)$ as the unique value of α such that $\Pi^{FDI}(\alpha) \geq \Pi^{SS}(\alpha)$ if and only if $\alpha \geq \hat{\hat{\alpha}}$. We can find such a value because $d\Pi^{FDI}(\alpha)/d\alpha = \pi^m(\underline{c}) - \pi^m(\bar{c}) >$ $[\pi^m(c) + (c - \underline{c})k] - [\pi^m(\bar{c}) + (\bar{c} - c)k] = d\Pi^{SS}(\alpha)/d\alpha$ (where the inequality follows from Lemma 1) and $\Pi^{SS}(0) > \Pi^{FDI}(0)$ and $\Pi^{SS}(1) < \Pi^{FDI}(1)$. The critical value $\hat{\hat{\alpha}}$ can be expressed as

$$\hat{\hat{\alpha}} = \frac{(\bar{c} - c)k}{\pi^m(\underline{c}) - \pi^m(c) - (2c - \bar{c} - \underline{c})k}$$

By comparing $\hat{\alpha}$, $\hat{\hat{\alpha}}$, and α^*, it can be easily verified that $\hat{\alpha} < \alpha^*$ if and only if $\hat{\hat{\alpha}} > \alpha^*$. Now, since $d\Pi^{FDI}(\alpha)/d\alpha > d\Pi^{SS}(\alpha)/d\alpha > d\Pi^{EX}/d\alpha = 0$, $\Pi^{EX} > \Pi^{SS}(0) > \Pi^{FDI}(0)$ and $\Pi^{SS}(1) < \Pi^{FDI}(1) < \Pi^{EX}$, the sets E, Σ, and Φ can be characterized by two critical cut-off points $\underline{\alpha}$ and $\bar{\alpha}$ where $\underline{\alpha}$ = min [$\hat{\alpha}$, α^*] and $\bar{\alpha}$ = max [α^*, $\hat{\hat{\alpha}}$]. such that $0 < \underline{\alpha} < \bar{\alpha} < 1$ and E = [0, $\underline{\alpha}$], Σ = [$\underline{\alpha}$, $\bar{\alpha}$], Φ = [$\bar{\alpha}$, 1].

If $\hat{\alpha} < \alpha^*$, $\underline{\alpha} = \hat{\alpha}$ and $\bar{\alpha} = \hat{\hat{\alpha}}$. Since $\underline{\alpha} < \alpha^* < \bar{\alpha}$, we have E = [0, $\underline{\alpha}$], Σ = [$\underline{\alpha}$, $\bar{\alpha}$], Φ = [$\bar{\alpha}$, 1]. If $\hat{\alpha} > \alpha^*$, we have $\underline{\alpha} = \bar{\alpha} = \alpha^*$. This implies that E = [0, α^*], $\Sigma = \phi$, Φ = [α^*, 1]. #

The relative magnitude of $\hat{\alpha}$ and α^* is in general ambiguous. The following lemma, however, helps us understand the likelihood of second sourcing.

Lemma 2. $\dfrac{\partial \underline{\alpha}}{\partial k} < 0$.

Proof. $\dfrac{\partial \underline{\alpha}}{\partial k} = -\dfrac{[\pi^m(c) - \pi^m(\bar{c})](c - \underline{c})k}{[\pi^m(c) - \pi^m(\bar{c}) + (2c - \bar{c} - \underline{c})k]^2} < 0.$

This comparative statics result indicates that second sourcing is more likely to occur as the lumpy capacity level of the small plant, *k*, becomes larger since a larger proportion of the total output can be produced in a lower cost plant.[13] This result is also consistent with the fact $\Pi^{SS}(\alpha)$ is an increasing function of *k* whereas the capacity size of the small plant is irrelevant for the other two alternative modes of production.

To summarize, if there is a high probability that foreign costs will be low (i.e., if α is high), it is in the interest of the monopolist to produce all of its output using FDI. If there is a high probability that foreign costs will be high (i.e., if α is low), then it is in the interest of the monopolist to produce all of its output domestically and export it. Finally, there are some cases in which for intermediate values of α the firm finds it optimal to second source, producing the bulk of its output in its low cost plant and the residual in its high cost plant. The rationale for second sourcing is provided by Kogut and Kulatilaka (1994) – it provides the firm with an option that allows them to produce the bulk of their output in their low cost facility in the presence of cost uncertainty.

In Appendix A we push our monopoly analysis further and argue that the practice of second sourcing has important implications for the degree of exchange rate pass through in the presence of exchange rate uncertainty. In the next section we extend our model to allow for strategic interaction with a rival and show that strategic considerations expands the set of α under which second sourcing is the preferred mode of operation.

III. Strategic Second Sourcing

Now, suppose that there are two firms that produce differentiated products competing in prices in this market. We begin by assuming that the second firm has a

---

[13] It should be noted, however, that it is more likely that the capacity cost of a small plant $\underline{F}$ will increase with the level of *k*. Then, this increase in $\underline{F}$ should be taken into account in the calculation of the relative merit of alternative sourcing decisions.

constant marginal cost of c with unlimited capacity. In this section we show that the presence of this rival makes it more likely that the firm will choose to use second sourcing as its production mode (in the sense that the conditions under which second sourcing is optimal become weaker when strategic interaction takes place). In the next section we extend the model so that both firms may use second sourcing and show that two-way second sourcing can be supported as a sub-game perfect Nash equilibrium.

In our initial strategic model, firm 1 makes its investment decision in the first stage of the game, before the uncertainty about marginal cost in its foreign facility has been resolved. In stage 2, after the uncertainty is resolved, the firms compete in prices. Thus, when firm 2 sets its price, it has complete information about firm 1's investment decision and firm 1's marginal cost.

We use $p(c_1, c_2)$ to denote the vector of Nash equilibrium prices when firm j's marginal cost is c_j and $\pi(c_1, c_2)$ represents the vector of corresponding profit levels for the two firms. Then, if firm 1 produces domestically and exports, the equilibrium price vector is $p(c,c)$ and firm 1's profits are

$$(5) \qquad \Pi_S^{EX} = \pi_1(c,c) - \overline{F}$$

where the sub-script S refers to the fact that these profits are earned in a strategic setting. If firm 1 chooses to use FDI instead, the equilibrium prices vector is $p(\underline{c},c)$ if firm 1's foreign marginal cost is $\underline{c}$; otherwise the equilibrium price vector is $p(\overline{c},c)$. It follows that firm 1's expected profit from using FDI in this strategic setting are

(6) $$\Pi_S^{FDI}(\alpha) = \alpha\pi_1(\underline{c}, c) + (1-\alpha)\pi_1(\overline{c}, c) - \overline{F}.$$

The profit functions in (5) and (6) have the same properties as their corresponding functions for the monopolist examined in section II. In particular, for values of α close to zero, exporting dominates FDI (since $\Pi_S^{EX} = \pi_1(c,c) - \overline{F} > \pi_1(\overline{c},c) - \overline{F} = \Pi_S^{FDI}(0)$), while FDI dominates exporting for values of α close to one (since $\Pi_S^{EX} = \pi_1(c,c) - \overline{F} < \pi_1(\underline{c},c) - \overline{F} = \Pi_S^{FDI}(1)$). In addition, $\Pi_S^{FDI}(\alpha)$ is linear in α with slope $\pi_1(\underline{c},c) - \pi_1(\overline{c},c) > 0$, so that there exists a unique value of α, call it α_S^*, such that $\Pi_S^{FDI}(\alpha) \geq \Pi_S^{EX}$ if and only if $\alpha \geq \alpha_S^*$, where $\alpha_S^* = \dfrac{\pi_1(c,c) - \pi_1(\overline{c},c)}{\pi_1(\underline{c},c) - \pi_1(\overline{c},c)}$.

Now, suppose that firm 1 decides to second-source by sinking capacity in both locations. Then its marginal cost depends on the realization of its foreign marginal cost and on the size of its capacity. As in the case of monopoly, we want to assume that the small plant is not large enough to allow firm 1 to meet all of its demand even when the equilibrium price vector is $p(\overline{c},c)$, but that with two small plants the firm has enough capacity to meet any relevant demand for its product. This will be the case if $D_1(p(c,c))/2 < k < D_1(p(\overline{c},c))$ where $D_1(p)$ denotes firm 1's demand curve. The fact that $k < D_1(p(\overline{c},c))$ implies that regardless of the realization of the foreign marginal cost, firm 1 will have to use both plants to meet demand. This means that if firm 1's foreign marginal cost is low, it will produce at capacity in its foreign plant, produce the residual in its domestic plant, and the Nash equilibrium price vector will be $p(c,c)$. In contrast, if firm 1's foreign marginal cost is high, it will produce at capacity in its domestic plant, produce the residual in its foreign plant, and the Nash equilibrium price vector will be $p(\bar{c}, c)$. It follows that firm 1's expected profit from second sourcing is given by

$$\text{(7)} \qquad \Pi_S^{SS}(\alpha) = \alpha[\pi_1(c,c) + (c - \underline{c})k] + (1-\alpha)[\pi_1(\bar{c},c) + (\bar{c} - c)k] - 2\underline{F}$$

So far our analysis in this section has closely paralleled the monopoly case examined in section II. Here is where the analysis begins to diverge. In the monopoly case, Lemma 1 allowed us to show that exporting dominates second sourcing for low values of α while FDI dominates second sourcing for high values of α. There is no counter-part to Lemma 1 when firm 1 operates in a strategic setting. To see this, suppose that $\alpha = 0$. Then firm 1 earns $\pi_1(c,c) - \bar{F}$ by exporting while its profit from second sourcing is $\pi_1(\bar{c},c) + (\bar{c} - c)k - 2\underline{F}$. It is not clear which of these values is larger. Exporting allows firm 1 to produce at lower average cost. However, by second sourcing firm 1 is able to produce the bulk of its output domestically (so that average cost may be very close to its average cost from exporting) and produce the residual in its foreign plant where marginal cost is high. This high marginal cost allows firm 1 to credibly commit to charging a higher price than it would if it exported; and, since the goods are strategic complements, this leads its rival to charge a higher price as well.[14] The increase in firm2's price that is triggered by second-sourcing may increase firm 1's profits enough to offset the higher average cost. As a result, second sourcing may dominate exporting even in the case in which $\alpha = 0$. A similar argument allows us to conclude that second

[14] In order to ensure that the firms' prices are strategic complements we must place a restriction on our profit functions. Following Bulow, Geanakoplos, and Klemperer (1985), if we use $\pi^i(p_i, p_j)$ to denote the profits earned by firm i in the price game, then the actions of the two firms will be strategic complements if the cross-partials of π^i and π^j are both positive.

sourcing may also dominate FDI even when $\alpha = 1$ and that second sourcing may be the optimal mode of production for all α!

Our goal is to show that strategic considerations make second sourcing more likely. To do so, we need to compare firm 1's investment decision in this strategic setting with the investment decision that it would make in the absence of strategic considerations. This can be accomplished solving firm 1's problem under the assumption that firm 2's price is fixed at $p_2(c,c)$. We refer to this as the "non-strategic case." With firm 2's price held fixed at this value, firm 1 earns the same profit from exporting in the strategic and non-strategic cases. Moreover, the value of α which equates the profit earned by exporting with the expected payoff from FDI (α_S^*) is the same in both settings.

In the non-strategic case, firm 1 behaves in the same manner as the monopolist examined in section II. Its profit functions have the same properties as those introduced in (1)-(3) and its investment decision is completely characterized by Proposition 1. There are cases in which second sourcing is never optimal (when $\hat{\alpha} > \alpha^*$) and there are cases in which it is the preferred production method. In the latter case, Proposition 1 informs us that second sourcing is optimal if $\alpha \in [\underline{\alpha}, \overline{\alpha}]$. If we use Σ_S (Σ_N) denote the set of α such that second-sourcing is the preferred mode of operation in the strategic (non-strategic) setting, then Proposition 2 tells us that strategic considerations widen the set of α under which second sourcing is optimal.

Proposition 2: The presence of a rival expands the set of α for which second sourcing is the preferred mode of operation – that is, $\Sigma_N \subset \Sigma_S$.

Proof: It is sufficient to show that the presence of a rival reduces $\underline{\alpha}$ and increases $\overline{\alpha}$. Define $\overline{\alpha}_S$ to be the value of α such that $\Pi_S^{FDI}(\alpha) = \Pi_S^{SS}(\alpha)$ and define $\overline{\alpha}_N$ to be the value of α such that $\Pi_N^{FDI}(\alpha) = \Pi_N^{SS}(\alpha)$ where the sub-script N refers to the non-strategic case. Then, from (6) and (7), $\overline{\alpha}_S$ solves

(8) $$f(\alpha) = \frac{k}{\pi_1(\underline{c}, c) - \pi_1(c, c)}$$

where $f(\alpha) \equiv \dfrac{\alpha}{\alpha(c - \underline{c}) + (1-\alpha)(\overline{c} - c)}$. From (2) and (3), $\overline{\alpha}_N$ solves

(9) $$f(\alpha) = \frac{k}{\pi^m(\underline{c}) - \pi^m(c)}.$$

Since firm 2's price is held fixed at $p_2(c,c)$ in the non-strategic case, it follows that $\pi^m(c) = \pi_1(c,c)$. In addition, since the goods are strategic complements, $\pi^m(\underline{c}) > \pi_1(\underline{c}, c)$ (since in the strategic case firm 2 charges a price lower than $p_2(c,c)$ when firm 1's foreign marginal cost is $\underline{c}$). This implies that the right-hand-side (9) is lower than the right-hand-side of (8). Since $f'(\alpha) > 0$, it follows immediately that $\overline{\alpha}_S > \overline{\alpha}_N$.

Now, define $\underline{\alpha}_S$ to be the value of α such that $\Pi_S^{EX} = \Pi_S^{SS}(\alpha)$ and define $\underline{\alpha}_N$ to be the value of α such that $\Pi_N^{EX} = \Pi_N^{SS}(\alpha)$. Then, from (5) and (7), $\underline{\alpha}_S$ solves

(10) $$\alpha[\pi_1(c,c) + (c - \underline{c})k] + (1-\alpha)[\pi_1(\overline{c}, c) + (\overline{c} - c)k] = \pi_1(c,c).$$

From (1) and (3), $\underline{\alpha}_N$ solves

(11) $$\alpha[\pi^m(c) + (c - \underline{c})k] + (1-\alpha)[\pi^m(\overline{c}) + (\overline{c} - c)k] = \pi^m(c).$$

By construction, the right-hand-sides of (10) and (11) are equal. In addition, the left-hand-sides of (10) and (11) are increasing in α and $\pi_1(\bar{c}, c) > \pi^m(\bar{c})$ (since in the strategic case firm 2 charges a price higher than $p_2(c, c)$ when firm 1's foreign marginal cost is $\bar{c}$). It follows that $\underline{\alpha}_S < \underline{\alpha}_N$. #

An example with symmetric linear demand and symmetric cost uncertainty can be used to illustrate our basic results. Suppose that the demand for firm *i's* product is given by $D_i(p_i, p_j) = q_i = 1 - p_i + \delta p_j$ with $0 < \delta < 1$ and that $\underline{c} = c - \Delta$ and $\bar{c} = c + \Delta$. Then, if we define $x \equiv \sqrt{\pi(c, c)} = \dfrac{1 - c(1-\delta)}{2-\delta}$ and $z \equiv \dfrac{2-\delta^2}{4-\delta^2} < \dfrac{1}{2}$, it is straightforward to show that (details are provided in Appendix B)

$$\text{(12)} \qquad \bar{\alpha}_S = \frac{k}{z[2x + \Delta z]} \qquad 1 - \underline{\alpha}_S = \frac{k}{z[2x - \Delta z]}$$

and

$$\text{(13)} \qquad \bar{\alpha}_N = \frac{4k}{4x + \Delta} \qquad 1 - \underline{\alpha}_N = \frac{4k}{4x - \Delta}.$$

If we compare these values we find that, as expected, $sign(\bar{\alpha}_S - \bar{\alpha}_N) = sign[4x + \Delta(1+2z)] > 0$ and $sign(\underline{\alpha}_N - \underline{\alpha}_S) = sign[4x - (1+2z)\Delta] > 0$, where the last inequality follows from the fact that $z < ½$ and $2x > \Delta$. This confirms that rivalry expands the set of the parameter values under which second sourcing is optimal. Moreover, from (12), if $k \geq z(2x + \Delta z)$, then in the presence of a rival second sourcing is the preferred mode of operation for all α.[15] Lemma 1 guarantees that this cannot be the case when the firm is a monopolist. Thus, there are cases in which the strategic advantages from second sourcing are so great that it is the optimal production method even in the absence of cost uncertainty!

We can also use this example to examine how an increase in the spread of the distribution governing the foreign marginal cost affects the likelihood of second sourcing. From above, it is clear that an increase in Δ reduces both $\underline{\alpha}_S$ and $\overline{\alpha}_S$. Thus, an increase in Δ makes it more likely that we will observe second sourcing for low levels of α and less likely that we will observe second sourcing for high levels of α. There are two reasons for this. First, if α is low the firm is effectively choosing between exporting and second sourcing while if α is high, the choice is between FDI and second sourcing. In the former case, second sourcing is the riskier alternative while in the latter case it is the safer alternative. Due to the fact that the profit function is convex, an increase in the spread of the distribution causes leads the firm to rely more heavily on the riskier production method. Second, if α < ½ then an increase in Δ causes the expected foreign marginal cost to fall. In this case, second sourcing becomes relatively more attractive than exporting since under second sourcing part of the firm's output is produced in the foreign country. On the other hand, if α > ½, then an increase in Δ causes the expected foreign marginal cost to rise. This makes FDI relatively more attractive than second sourcing, since *all* of the output is produced in the foreign country under FDI.

---

[15] As shown in Appendix B, our analysis holds for $k \in [\frac{x}{2}, x - \Delta z]$. Thus, second sourcing is optimal for all α if $k \in [z(2x + \Delta z), x - \Delta z]$. This region is non-empty if $x(1-2z) > \Delta z(1+z)$.

To derive the net affect on the likelihood of second sourcing note that with this demand curve $\overline{\alpha}_S - \underline{\alpha}_S = \frac{k}{z}\left[\frac{1}{2x+z\Delta} + \frac{1}{2x-z\Delta} - \frac{z}{k}\right]$. It follows that

$$sign\left[\frac{\partial(\overline{\alpha}_S - \underline{\alpha}_S)}{\partial\Delta}\right] = sign\left[\frac{1}{(2x-z\Delta)^2} - \frac{1}{(2x+z\Delta)^2}\right] > 0,$$

so that the set of α for which second sourcing is optimal widens as Δ increases.

IV. "Two-Way" Direct Foreign Investment

We noted in the introduction that many industries are characterized by two-way FDI. We can provide a strategy-based explanation for this phenomenon by expanding our model to allow both firms to make an initial investment decision. To do so, we assume that the two firms are based in different countries. Each firm can produce at home at a known marginal cost of *c*. Alternatively, they can build a foreign facility where the unknown marginal cost will be either $\underline{c} = c - \Delta$ (with probability α) or $\overline{c} = c + \Delta$ (with probability 1-α). As in our previous models, the cost of building a domestic or foreign plant with unlimited capacity is given by $\overline{F}$ while the cost of building a small plant in either location is given by $\underline{F}$ with $2\underline{F} = \overline{F}$. To be consistent with our previous models, we assume that one small plant is always too small to meet market demand, but that two small plants are sufficient to meet any demand. In this setting, this will be the case if $\frac{D_i(p(c,\overline{c}))}{2} < k < D_i(p(c,\underline{c}))$ for *i = 1,2*. Under this assumption, a firm that second sources always has to use both plants to meet demand but it is never fully capacity constrained.

For simplicity, we illustrate our point using linear demand. We assume that the product markets in the two countries are not segmented and that the aggregate demand for firm i's product is given by $D_i(p_i, p_j) = q_i = 1 - p_i + \delta p_j$ with $0 < \delta < 1$. It is straightforward to show that with this demand curve and cost structure our restriction on k is equivalent to $\frac{x + \Delta y}{2} < k < x - \Delta y$, where $x \equiv \sqrt{\pi(c,c)}$ and $y \equiv \frac{\delta}{4 - \delta^2}$.

Our goal is to show that there exists a sub-game prefect Nash equilibrium in which both firms use second sourcing to produce their output. Since the model is symmetric, all that we need to show is that it is in firm 1's interest to second source given that its rival is doing so. We begin with the case in which firm 1 produces its output domestically so that its marginal cost is c. With firm 2 second sourcing, it produces the bulk of its output in its low cost plant and the residual in its high-cost facility. This implies that in equilibrium firm 2's marginal cost is equal to its marginal cost in its high-cost plant. Thus, if we use $\hat{\Pi}^{EX}(\alpha)$ to denote firm 1's expected payoff from producing all of its output domestically while its rival is second sourcing, then we have

(14) $$\hat{\Pi}^{EX}(\alpha) = \alpha\pi(c,c) + (1-\alpha)\pi(c,\bar{c}) - \overline{F}$$

Now, suppose instead that firm 1 uses FDI to produce all of its output. Then if we use $\hat{\Pi}^{FDI}(\alpha)$ to denote the expected profit earned by firm 1 when it uses FDI while its rival second sources, we have

(15) $$\hat{\Pi}^{FDI}(\alpha) = \alpha^2\pi(\underline{c},c) + \alpha(1-\alpha)[\pi(\bar{c},c) + \pi(\underline{c},\bar{c})] + (1-\alpha)^2\pi(\bar{c},\bar{c}) - \overline{F}$$

Finally, firm 1's expected payoff from second sourcing when its rival also second sources is given by $\hat{\Pi}^{SS}(\alpha)$ where

$$\text{(16)} \qquad \hat{\Pi}^{SS}(\alpha) = \alpha^2[\pi(c,c) + (c - \underline{c})k] + (1-\alpha)^2[\pi(\bar{c},\bar{c}) + (\bar{c} - c)k] + \alpha(1-\alpha)[\pi(c,\bar{c}) + (c-\underline{c})k + \pi(\bar{c},c) + (\bar{c}-c)k] - 2\underline{F}$$

The profit functions in (14)-(16) have many of the same properties as those depicted in Figure 1. In particular, $\hat{\Pi}^{EX}(0) > \hat{\Pi}^{FDI}(0)$, $\hat{\Pi}^{EX}(1) < \hat{\Pi}^{FDI}(1)$ and the expected payoffs from FDI and second sourcing are both increasing in α with $\hat{\Pi}^{FDI}(\alpha)$ steeper than $\hat{\Pi}^{SS}(\alpha)$. The only new wrinkle is that the expected profit from exporting is now decreasing in α since an increase in α implies that the firm's rival is more likely to have a low marginal cost in its foreign plant. This new feature does not alter the qualitative nature of the equilibrium. It is still the case that for low values of α the firm chooses between exporting and second sourcing while for high values of α it chooses between FDI and second sourcing. It follows that if $\hat{\Pi}^{SS}(0) > \hat{\Pi}^{EX}(0)$ and $\hat{\Pi}^{SS}(1) > \hat{\Pi}^{FDI}(1)$, then the Nash equilibrium is characterized by both firms second sourcing for all α. Proposition 3 provides such a condition for the linear demand case.

Proposition 3. With linear demand curve ($q_i = 1 - p_i + \delta p_j$ with $0 < \delta < 1$) and symmetric cost uncertainty ($\underline{c} = c - \Delta$ and $\bar{c} = c + \Delta$), both firms second source for all α if $k \in [z(2x + \Delta z), x - \Delta y]$. This set is non-empty if $x > \dfrac{\Delta(y + z^2)}{1 - 2z}$.

Proof. With the linear demand curve, it can be easily verified that $\hat{\Pi}^{SS}(0) > \hat{\Pi}^{EX}(0)$ if $k > z[2x - \Delta z + 2\Delta y]$ and $\hat{\Pi}^{SS}(1) > \hat{\Pi}^{FDI}(1)$ if $k > z[2x + \Delta z]$.[16] Since δ < 1, the latter condition is more restrictive. Combining this with our earlier restriction on *k*, we find that both firms second source for all α if $k \in [z(2x + \Delta z), x - \Delta y]$. The condition for this set to be non-empty is that $x - \Delta y > z(2x + \Delta z)$, or $x > \dfrac{\Delta(y + z^2)}{1 - 2z}$. #

V. Discussion

In this paper, we developed a strategic model of second sourcing in which the use of multiple production facilities meets the dual purpose of keeping *average cost low* while at the same time *increasing marginal cost*. The practice serves as a collusive device because the increase in marginal cost softens product market competition and results in higher profits. We couched this theory in the context of a multinational's decision to sink production capacity in both domestic and foreign countries. The main reason for developing our theory in the context of international trade was that the cost uncertainty associated with producing in a foreign country provided a natural setting in which to analyze such an issue. In addition, we were able to explain two-way FDI flows between pairs of developed countries, a phenomenon that has been considered a

[16] The Nash equilibrium profits for this case are provided in (B.5) in Appendix B.

theoretical puzzle[17] in the literature despite its empirical importance (see Markusen 1995).[18]

We conclude with a discussion on how the theory developed in this paper can be applied to other contexts.

Voluntary Export Restraints

We are not the first to point out that in the presence of strategic complements firms have an incentive to make strategic moves to soften competition. In a two-stage game in which firms first select capacity and then compete in prices, Kreps and Scheinkman (1983) showed that limiting capacity allows firms to support higher equilibrium prices. In the trade literature, Harris (1985) and Krishna (1989) have shown that voluntary export restraints (VERs) can help firms soften competition in manner similar to the capacity constraints in Kreps and Scheinkman's model. In particular, they show that a VER set at the free trade level of imports can increase the profits of all firms within the industry. Our model provides a similar prediction because the limit on the level of exports plays the same role as a capacity constraint. Thus, our results can be viewed as a natural extension of Kreps and Scheinkman to a setting in which firms can use multiple production facilities or as an extension of Harris and Krishna in which second sourcing plays the role of the VER. One advantage of our model is that we can

[17] Brainard (1997a) and Horstmann and Markusen (1992) have also provided models in which equilibrium may be characterized by two-way FDI. In their models, this phenomenon arises if countries are large and have similar factor endowments and is generated by scale economies, firm level activities that are joint inputs across plants and transport costs (or tariffs).

[18] According to Julius (1990), the share of all direct investment generated by G-5 countries flowing into other G-5 countries has been rising and was estimated to be 70 percent by 1988. Our model is also consistent with the empirical evidence that the nature of most direct foreign investment in production facilities is *horizontal* in that most of the output of foreign production affiliates is sold in the foreign country (Markusen 1995).

derive the collusive role of VERs *even in the presence of foreign direct investment* as long as the capacity in the host country is not sufficient enough to meet all the demand in that country. The most prominent example of a VER is the one applied to Japanese imports in the North American automobile industry in the 1980s. However, after the imposition of the VER major Japanese automobile manufacturers set up production facilities in the US. The models of Harris and Krishna are unable to generate the collusive effects of a VER once foreign direct investment is taken into consideration. Thus, it is hard to explain the major Japanese auto manufacturers' decision to engage in foreign direct investment in the US in their models.

Second Sourcing and the Make or Buy Decision

Second sourcing is a common practice in the semiconductor industry.[19] For example, in this industry it is common for an innovating firm to license its technology to one or more competing firms in an effort to create multiple sources of supply (e.g., Intel allowed IBM to produce Intel's microprocessors internally provided that IBM agreed not to sell to a third party). In addition, firms in this industry often enter into agreements to purchase inputs from multiple suppliers. Shepard (1987) attributes the former practice to the innovating firm's desire to enhance demand for new technologies by making the product more attractive to potential buyers. Others have argued that the latter practice reduces the risk of being unable to obtain a key input when a supplier runs out of its stock. Our model provides an alternative strategic rationale for such practices. Provided that the firm can credibly commit to obtaining a fixed amount from the low-cost source

[19] See, for example, Shepard (1987).

(which can be accomplished through contracting), second sourcing softens product market competition.

Another common feature of many industries is that firms often *both* make and buy many of the components used to produce their final product. For example, in a recent study of a high-tech engineering firm Knez and Simester (2002) found that the firm obtained eighteen of its components from both an internal and an external supplier.[20] The production management literature has emphasized efficiency considerations and bargaining costs as key factors in determining whether a firm should make its parts or buy them – the presumption is that there is rarely any incentive to do both. Knez and Simester interviewed managers at this firm and asked why they relied on both internal and external suppliers. The standard response was that since external suppliers tend to provide the parts at lower cost, the firm obtains most of its supply externally. However, since there are instances in which parts are needed faster than the external supplier can deliver them, the firm obtains the residual parts internally. Eccles and White (1988) also suggest that some companies make it a policy to source a certain percentage of their needs externally on internally transferred products as a way of getting realistic market prices. Our theory suggests that if a firm has market power and competes in prices in an oligopolistic market then this practice of simultaneously making and buying parts may have unintended positive consequences. By relying on a relatively inefficient internal supplier for its residual parts, the firm may be effectively softening product market competition with its rivals.

[20] See also Monteverde and Teece's (1982) study of the auto industry. In investigating Ford and GM's decisions of whether to make or buy components, they labeled a component as "made" if over 80% of its supply was produced internally. The use of this criterion suggests that a significant number of components were provided by both an internal and external supplier.

The idea that a firm can gain strategically by manipulating its sourcing decision also appears in a recent paper by Chen (2001). This paper provides a model of vertical merger in which one upstream firm is more efficient than others. In equilibrium, one of the downstream firms merges with the more efficient firm and the remaining downstream rival chooses the integrated firm as its supplier even when the latter's input price is *higher* than prices of alternative sources. The reason for this paradoxical result is that vertical integration creates multi-market interaction between the integrated firm and its downstream rivals; when the unintegrated firm selects the integrated firm as its supplier, the vertically integrated firm behaves less aggressively in the downstream market since its aggressive pricing can cut into its profits in the upstream market. This model is similar in flavor to ours in that the sourcing decision is motivated not only by cost minimization but also by strategic considerations in the output market.

Chen's (2001) model, however, rules out the possibility of second sourcing by assuming either switching costs due to relationship-specific investment or the use of requirement contracts in the input market, under which a downstream firm is required to purchase *all* inputs from a certain supplier at some unit price. If second sourcing is allowed in his model, a better strategy for the unintegrated downstream firm would be to arrange a dual sourcing agreement to "buy some *fixed* amount from an independent supplier" who offers the lowest price and the residual (variable amount) from the integrated firm at a higher price. In this way, the unintegrated firm can save on input costs while keeping the integrated firm's strategic incentives intact.[21] The welfare effects of multiple sourcing would be unambiguously negative in this model. First, the integrated

[21] The dual sourcing strategy could have an added advantage of mitigating the potential hold-up problem emphasized in the incomplete contract/transactions cost literature of vertical integration.

firm would be able to charge a higher price and sustain a more collusive outcome since the effects of a higher acquisition price from the integrated firm on the unintegrated downstream firm's total input costs would be lessened. Second, the integrated firm is a more efficient producer even though its price is higher than those of alternative producers. Thus, any shift of input production from the integrated firm to alternative sources is inefficient.

Appendix A

A number of authors have examined the implications of market structure and other factors on the extent of exchange rate pass through.[22] If we assume that the cost uncertainty associated with foreign production is the result of exchange rate uncertainty, then our monopoly model provides the ideal setting in which to examine the link between the firm's production method and exchange rate pass-through. To analyze this, we assume that each unit of foreign currency is worth e units of the multinational's domestic currency units and we choose units such that the firm's marginal production cost is the same in both countries if $e = 1$. Then, we can write the firm's foreign marginal cost as ec in its domestic currency. The exchange rate is assumed to fluctuate between two values $\bar{e}$ and $\underline{e}$ with $\bar{e} > 1 > \underline{e}$. This implies that marginal cost is lower in the domestic plant when $e = \bar{e}$ while it is lower in the foreign plant when $e = \underline{e}$.

For each realization of the exchange rate e, the firm's maximization problem with exports only (in domestic currency units) can be written as:

[22] See, for example, Mann (1986), Dornbusch (1987), Froot and Klemperer (1989), Fisher (1989) and Krupp and Davidson (1996).

$$\Pi^{EX} = max\ epD(p) - cD(p) = e[(p - \frac{c}{e})D(p)],$$

where p is the price in foreign currency and c is the marginal cost of production in domestic currency. Thus, the effects of an appreciation of the foreign currency (i.e., an increase in e) on the export price are equivalent to those of a decrease in the firm's marginal cost. This implies that the import price for the foreign country would fall with an appreciation of the foreign currency. In a similar way, in terms of its price effects, a depreciation of the foreign currency is equivalent to an increase in the firm's marginal cost with the import price for the foreign country increasing with a depreciation of the foreign currency.

Next we investigate the behavior of exchange rate pass-through to import prices with second sourcing. Suppose that the firm is second sourcing and that the exchange rate appreciates. Then, the multinational will fully utilize its capacity in the domestic country and then produce the residual in its foreign facility. This implies that its relevant marginal cost is $\bar{e}c$. In this case, the multinational's profit function can be written as:

$$\bar{e}pD(p) - [ck + \bar{e}c(D(p) - k)] = \bar{e}(p - c)D(p) + (\bar{e} - 1)k\ ,$$

where p is the price in the foreign currency. It follows that the multinational's profit maximizing price is the same regardless of the realization of e, when $e > 1$. This implies that once the capacity of the domestic plant has been exhausted, there will be no further exchange rate pass-through when there is an appreciation of the foreign currency.

Now consider the case where the exchange rate depreciates with second sourcing. Then, the multinational first fully utilizes its capacity in the foreign country and produces the residual in its domestic plant. This implies that the firm's relevant marginal cost is c. In this case, the multinational's profit function can be written as:

$$\underline{e}pD(p)-[\underline{e}ck+c(D(p)-k)]=\underline{e}\left[p-\frac{c}{\underline{e}}\right]D(p)+(1-\underline{e})ck,$$

where $\frac{c}{\underline{e}}>1,$ so that the price is sensitive to changes in *e*. Our conclusion is that prices are sensitive to changes in the *e* when the exchanges rate depreciates but prices are invariant to changes in *e* when the exchange rate appreciates. As a result, exchange rate pass-through is sensitive not only to the production method but also to the direction of fluctuations with second sourcing characterized by asymmetric exchange rate pass-through. We summarize the result above in the following proposition.

Proposition 4: With second sourcing, the behavior of exchange rate pass-through to import prices is asymmetric. When the importing country's currency appreciates vis-à-vis the multinational's domestic currency (i.e., increase in *e*), there is *no* exchange rate pass through with second sourcing. In contrast, when the former depreciates against the latter, the import price is sensitive to the exchange rate with the rate of pass-through being the same as the one observed without second sourcing.

Appendix B

The purpose of this appendix is to provide some of the details for the example with linear demand and symmetric cost uncertainty introduced on page 18. We start with the case of duopoly in which straightforward calculations yield the following Nash equilibrium prices and profits:

$$(B.1)\qquad p_1(c,c)=\frac{1+c}{2-\delta};\quad p_1(\underline{c},c)=p_1(c,c)-\frac{2\Delta}{4-\delta^2};\quad p_1(c,\overline{c})=p_1(c,c)+\frac{2\Delta}{4-\delta^2}$$

$$(B.2) \qquad \pi_1(c,c) = x^2; \;\; \pi_1(\underline{c},c) = [x + \Delta z]^2; \;\; \pi_1(\bar{c},c) = [x - \Delta z]^2$$

Combining (B.2) with (5)-(7) allows us to solve for $\bar{\alpha}_S$ (which equates Π_S^{FDI} and Π_S^{SS}) and $\underline{\alpha}_S$ (which equates Π_S^{EX} and Π_S^{SS}). The solution is provided in (12) in the text. Substituting the prices back into demand, we find that our assumption about capacity (that is, $D_1(p(c,c))/2 < k < D_1(p(\bar{c},c))$) is satisfied if $k \in [\frac{x}{2}, x - \Delta z]$.

For the non-strategic case, we set p_2 at $p_1(c,c)$, as given in (B.1), and solve for firm 1's optimal price. We obtain

$$(B.3) \qquad p^m(c) = p(c,c); \;\; p^m(\underline{c}) = p^m(c) - \frac{\Delta}{2}; \;\; p^m(\bar{c}) = p^m(c) + \frac{\Delta}{2}$$

$$(B.4) \qquad \pi^m(c) = x^2; \;\; \pi^m(\underline{c}) = [x + \frac{\Delta}{2}]^2; \;\; \pi^m(\bar{c}) = [x - \frac{\Delta}{2}]^2$$

Combining (B.4) with (1)-(3) allows us to solve for $\bar{\alpha}_N$ and $\underline{\alpha}_N$, which are given in (13) in the text.

Turn finally to the case in which both firms make an initial investment decision. Depending on the capacity choices of the firms and the resolution of the uncertainty, there are nine possible Nash equilibria to solve for (since each firm may end up with a marginal cost of either c, $\underline{c}$, or $\bar{c}$). Solving for the Nash equilibrium in each case, we find that firm 1's Nash equilibrium profits are given by

$$(B.5) \qquad \pi_1(c_1, c_2) = [x + \frac{c(1-\delta)}{2-\delta} + c_2 y - c_1 z]^2$$

References

Anton, James and Dennis Yao (1987). "Second Sourcing and the Experience Curve: Price Competition in Defense Procurement." *Rand Journal of Economics* (18): 57-75.

Bain, Joe (1954). "Economies of Scale, Concentration, and the Condition of Entry in Twenty Manufacturing Industries." *American Economic Review* (44): 15-39.

Bain, Joe (1956). *Barriers to New Competition*. Cambridge: Harvard University Press.

Blomstrom, Magnus, Robert Lipsey, and Ksenia Kulchycky (1988). "U.S. and Sweedish Direct Investment and Exports." In Baldwin, Robert (ed.) *Trade Policy and Empirical Analysis*. Chicago: University of Chicago Press: 259-97.

Blonigen, Bruce (2001). "In Search of Substitution Between Foreign Production and Exports." *Journal of International Economics* (53): 81-104.

Brainard, S. Lael (1997a). "A Simple Theory of Multinational Corporations and Trade with a Trade-off Between Proximity and Concentration." *American Economic Review* (87): 447-465.

Brainard, S. Lael (1997b). "An Empirical Assessment of the Proximity-Concentration Trade-Off Between Multinational Sales and Trade." *American Economic Review* (87): 520-544.

Buckley, Peter and Mark Casson (1981). "The Optimal Timing of Foreign Direct Investment." *Economic Journal* (91): 75-87.

Bulow, Jeremy, John Geanakoplos, and Paul Klemperer (1985). "Multimarket Oligopoly: Strategic Substitutes and Complements." *Journal of Political Economy* (93): 488-511.

Caves, Richard (1971). "International Corporations: The Industrial Economics of Foreign Investment." *Economica* (38): 1-27.

Caves, Richard (1982). *Multinational Enterprise and Economic Analysis*. London: Cambridge University Press.

Caves, Richard, Jeffrey Frankel, and Ronald Jones (2002). *World Trade and Payments: An Introduction* (9th edition). Addison Wesley.

Chen, Yongmin (2001). "On Vertical Mergers and Their Competitive Effects." *Rand Journal of Economics* (32): 667-685.

Demski, Joel, David Sappington, and Pablo Spiller (1987). "Managing Supplier Switching." *Rand Journal of Economics* (18): 77-97.

Denekamp, Johannes and Michael Farrantino (1992). "Substitution and Complementarity of U.S. Exports and Foreign Based Affiliate Sales in a Demand Based Gravity System." Southern Methodist University Working Paper.

Doms, Mark and Timothy Dunne (1998). "Capital Adjustment Patterns in Manufacturing Plants." *Review of Economic Dynamics* (1): 409-429.

Dornbusch, Rudiger (1987). "Exchange Rates and Prices." *American Economic Review* (77): 93-106.

Eccles, Robert and Harrison White (1988). "Price and Authority in Inter-Profit Center Transactions." *American Journal of Sociology* (94): S17-S51.

Farrell, Joseph and Nancy Gallini (1987). "Second-Sourcing as a Commitment: Monopoly Incentives to Attract Competition." *Quarterly Journal of Economics*, 103: 673-694.

Fisher, Eric (1989). "A Model of Exchange Rate Pass-through." *Journal of International Economics* (26): 119-138.

Froot, Kenneth and Paul Klemperer (1989). "Exchange Rate Pass-through when Market Share Matters." *American Economic Review* (79): 637-654.

Harris, Richard (1985). "Why Voluntary Export Restraints are 'Voluntary'." *Canadian Journal of Economics* (18): 799-809.

Head, Keith and John Ries (2001). "Overseas Investment and Firm Exports." *Review of International Economics* (9): 108-122.

Horstmann, Ignatius and James Markusen (1987). "Strategic Investments and the Development of Multinationals." *International Economic Review* (28): 109-121.

Horstmann, Ignatius and James Markusen (1992). "Endogenous Market Structures in International Trade." *Journal of International Economics* (32): 109-129.

Horstmann, Ignatius and James Markusen (1996). "Exploring New Markets: Direct Investments, Contractual Relations and the Multinational Enterprise." *International Economic Review* (37): 1-19.

Hymer, Stephen (1960). "The International Operations of National Firms." Ph.D. Thesis, Massachusetts Institute of Technology. Cambridge, MA.

Julius, DeAnne (1990). *Global Companies and Public Policy.* London: Royal Institute of International Affairs.

Knez, Marc and Duncan Simester (2002). "Direct and Indirect Bargaining Costs and the Scope of the Firm." *Journal of Business*, forthcoming.

Kogut, Bruce and Nalin Kulatilaka (1994). "Operating Flexibility, Global Manufacturing, and the Option Value of a Multinational Network." *Management Science* (40): 123-139.

Kreps, David and Jose Scheinkman (1983). "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes." *Bell Journal of Economics* (14): 326-337.

Krishna, Kala (1989). "Trade Restrictions as Facilitating Practices," *Journal of International Economics* (26): 251-270.

Krupp, Corinne and Carl Davidson (1996). "Strategic Flexibility and Exchange Rate Uncertainty." *Canadian Journal of Economics* (29): 436-456.

Laffont, Jean-Jacques and Jean Tirole (1988). "Repeated Auctions of Incentive Contracts, Investment, and Bidding Parity with an Application to Takeovers." *Rand Journal of Economics* (19): 516-537.

Mann, Catherine (1986). "Prices, Profit Margins, and Exchange Rates." *Federal Reserve Bulletin,* (June): 366-79

Markusen, James (1995). "The Boundaries of Multinational Enterprises and the Theory of International Trade." *Journal of Economic Perspectives* (9): 169-189.

Monteverde, Kirk and David Teece (1982). "Supplier Switching Costs and Vertical Integration in the Automoblie Industry." *Bell Journal of Economics* (13): 206-213.

Riordan, Michael H. and David E. M. Sappington (1989). "Second Sourcing." *Rand Journal of Economics* (20): 41-58.

Rob, Rafael and Nikolaos Vettas (2001). "Foreign Direct Investment and Exports with Growing Demand." CARESS Working Paper 01-04, University of Pennsylvania.

Shepard, Andrea (1987). "Licensing to Enhance Demand for New Technologies," *Rand Journal of Economics* (18): 360-368.

Smith, Alasdair (1987). "Strategic Investment, Multinational Corporations and Trade Policy." *European Economic Review* (31): 89-96.

Figure 1, Case A: $\hat{\alpha} < \alpha^*$ with second sourcing for $\alpha \in \Sigma$

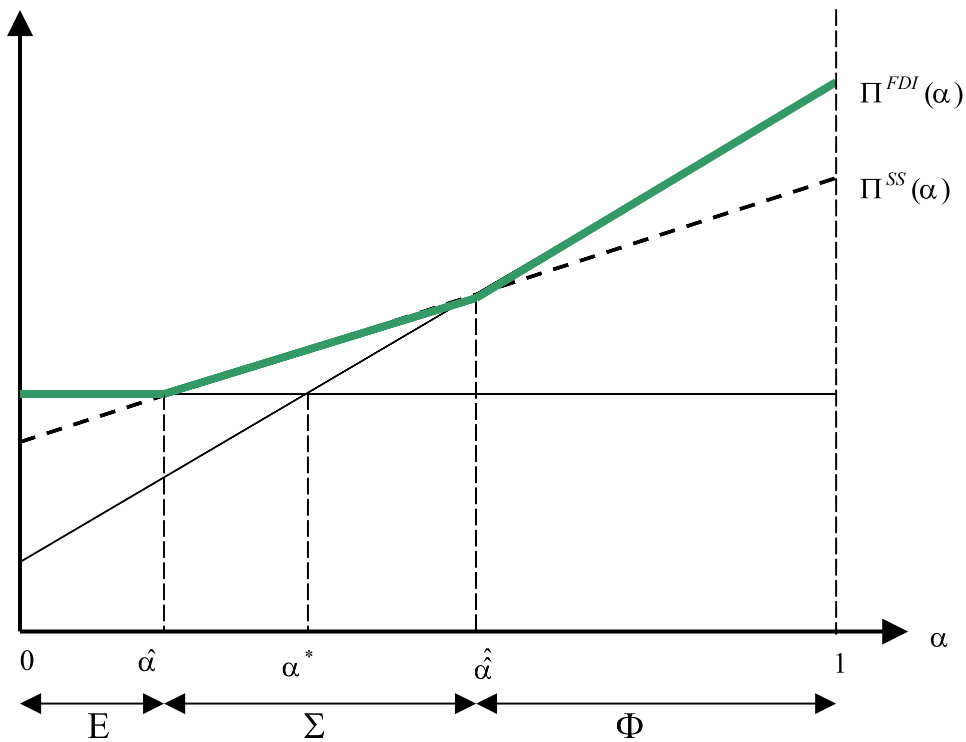

Figure 1, Case B: $\hat{\alpha} > \alpha^*$ without second sourcing (i.e., $\Sigma = \phi$)