

**KEIRETSU AND RELATIONSHIP-SPECIFIC INVESTMENT:
A BARRIER TO TRADE?***

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This article develops a model of informal procurement within Japanese keiretsu so as to consider effects on intermediate-good imports, such as auto parts. Parts-suppliers make relationship-specific investments that benefit the automaker and prices are determined by bargaining after investment has been sunk. Although this investment raises efficiency, it limits the range of imports to less important parts, such as tailpipes, and it is possible that no parts are imported, despite lower foreign costs. Lack of information concerning investment rents combined with counterintuitive responses of imports to changes in output and costs could create unwarranted perceptions of a trade barrier.

1. INTRODUCTION

Persistent and large deficits in U.S. trade with Japan, reaching US \$55.7 billion in 1997, have led to significant economic tension between the two countries. Since US \$32.2 billion of this 1997 deficit, or 58 percent, involved automobile trade, with US \$10 billion attributable to trade in auto parts,² it is not surprising that a main focus of tension has been auto and auto-parts trade. Indeed, a trade dispute over autos almost resulted in a trade war between the U.S. and Japan in 1995. Since it is evident that visible and formal trade barriers, such as tariffs and import quotas, applied to manufactures are low in Japan, the central U.S. complaint is that invisible and informal barriers arising from typical Japanese business practices and regulations have substantially blocked legitimate access of American products to the Japanese market.

Particularly with respect to auto parts, the concern is that vertical relationships within Japanese corporate groups, known as *keiretsu*, could act as a structural

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² Source: U.S. Bureau of Census, unadjusted data, report FT900 (CB-98-104).

impediment to trade.³ The special nature of these relationships is perhaps one of the most distinguishing features of the Japanese auto industry. Auto producers, such as Nissan and Toyota, are involved in long-term arrangements with their keiretsu suppliers or subcontractors. As explained by Aoki (1988: pp. 216–18), in return for long-term commitment by the automaker, subcontractors make relationship-specific investments that are specifically directed toward the needs of the automaker and are of no value to firms outside the keiretsu group.⁴ Such investments would include the design costs of modifications that improve the fit or ease of assembly with other parts produced by the keiretsu, but which are not relevant to the particular production processes of other auto manufacturers. Another example might involve investment by the supplier in “just in time” delivery, such as building a plant close to the automaker’s plant or cooperating with other suppliers to coordinate delivery.⁵ “Just in time” production methods are a prominent feature of Japanese supply arrangements. A main aim of this article is then to determine the effects of these relationship-specific investments within keiretsu on the ability of foreign suppliers to export auto parts or other intermediate inputs to Japan.

To explore this issue, we develop a model of procurement with the feature that, within the keiretsu, relationship-specific investments by suppliers create rent⁶ for the automaker. In keeping with the informal nature of supply arrangements, auto-parts prices are determined through bargaining between individual suppliers and the automaker after investment has been sunk. A key aspect of the model is its consideration of a large variety or range of parts so as to define the margin at which a part is imported or produced within the keiretsu. As we show, relationship-specific investment limits access to the Japanese market by making it profitable for the keiretsu to produce a range of parts that otherwise would be imported. The rents from these investments create a net benefit to the keiretsu automaker, more than offsetting the lower U.S. production costs for parts. Generally, higher levels of investment reduce the range of imported parts, causing a fall in the U.S. share of the Japanese auto-parts’ market. Since Japanese auto production also rises, the total value of U.S. parts imports need not fall. However, for a sufficiently high level of investment, the reduction in the range of imported parts dominates and eventually imports would be reduced to zero.

³ See, for example, Levinsohn (1997). According to Church (1995), the keiretsu “do business mainly with each other, freezing out competing buyers and sellers, both foreign and domestic. This system forms the very fabric of the way the Japanese do business, and it does more than outright trade barriers or even government ‘administrative guidance’ to keep out foreign products. Especially, it seems, U.S. auto parts . . . such as shock absorbers, mufflers, tailpipes and disk-brake pads . . . sell for less than half to only a third the price of made-in-Japan parts of comparable quality. What then limits American parts to around 1.5 percent of the Japanese market? The keiretsu system, Americans conclude.”

⁴ As Aoki (1988: p. 216) states, “the prime manufacturer must maintain its reputation of commitment to the subcontractor in order to elicit the subcontractor’s commitment regarding relationship-specific investments in expertise, equipment, and research and development.” Conversely, “the subcontractor must maintain its reputation for quality, timely delivery of supplies, continual innovative effort, and so on, if it is to secure a stable and profitable position in the subcontracting group.”

⁵ See Dyer and Ouchi (1993: p. 55) for other examples.

⁶ This is a form of *relational quasi rent* as termed by Aoki (1988).

Even supposing this last worst case scenario for U.S. exports, it is not obvious that these keiretsu supply relationships create an “unfair” trade barrier, potentially justifying the use of countervailing trade remedies. A central issue is one of exclusive dealing: are U.S. and other non-Japanese suppliers unfairly excluded from long-term or other supply arrangements with keiretsu? We would argue that the simple exclusion of imports does not prove the case because the informational requirements for the effective design of relationship-specific investments could require a local presence in Japan and close communication with other keiretsu suppliers. For example, detailed information about the production processes of other suppliers may be required to improve the compatibility or fit of a particular part and close coordination with these suppliers may be required for just in time delivery.⁷ Also, if U.S. and other non-Japanese firms do locate in Japan, language and other cultural barriers may make it difficult for these firms to be effective in creating rents for the keiretsu automaker. In addition, since in our model relationship-specific investment enhances efficiency, even if exclusionary, the long-term keiretsu arrangements could be defended as a method to improve incentives for investment.⁸

Apart from these general comments, the article does not provide further insight as to whether keiretsu long-term supply arrangements are in fact exclusionary practices. Rather, having developed the basic effects of relationship-specific investment within keiretsu on the range and value of imported intermediate goods, a central theme of the article is then to argue that these relationships could create a strong impression of the existence of an “unfair” barrier to trade, even if the practices are not truly exclusionary. First, if the rents created by relationship-specific investment are not observable outside the keiretsu, then the inability to export parts that are cheaper in the U.S. could appear to be due to a trade barrier. Also, relationship-specific investment can lead to counterintuitive effects. For example, a move from a prohibitive Japanese tariff to free trade or, alternatively, a reduction in the price of U.S. parts could raise Japanese marginal cost, reducing Japanese auto output and total demand for parts. Also, to the extent Japanese auto output increases, this tends to reduce the range of parts that would be imported at free trade. We argue that these counterintuitive effects could easily be misunderstood, leading to significant perceptions of a trade barrier.

To develop these results, we take the existence of long-term supply arrangements involving relationship-specific investments within keiretsu as given.⁹ We also make

⁷ Branstetter (2000) finds strong empirical support for the importance of the flow of technological information within vertical keiretsu groups in enhancing efficiency. Also, the need to transport parts from the U.S. would complicate “just in time” delivery. Further, exchange rate fluctuations could raise the risk to U.S. firms in making investments that are specific to the Japanese buyer.

⁸ See Marvel (1982) for the general point. McMillan (1996) provides an excellent description of the sources of keiretsu efficiency and makes this argument in the context of the trade dispute over auto parts. Lawrence (1991) finds some support for the idea that vertical, as opposed to horizontal, keiretsu enhance efficiency.

⁹ Keiretsu are very stable. For instance, “member firms of Kyohokai, an association formed by Toyota parts suppliers, numbered 171 in 1984. Of these firms, 153 had been continual members of Kyohokai during the 11 years since 1973” (Asanuma, 1989: p. 5). Also subcontractors differ as to whether they are top ranked firms with technological expertise and long-term supply relationships or more marginal firms that may be used as a short-term capacity buffer so as to help maintain permanent employment in the core manufacturer (see Asanuma, 1989: pp. 16–18; Aoki, 1988; pp. 208–209). Our analysis applies to the top ranked suppliers.

the simplifying, but generally realistic, assumption that suppliers exporting from the United States are unable to make relationship-specific investments of value to the keiretsu automaker. As discussed above, we do not need to specify whether this is due to the need to overcome cultural barriers and produce locally in Japan or to some exclusionary practice. Indeed, our results concerning the implications for U.S. exports to Japan do not depend on whether keiretsu firms are domestically or foreign owned. Although not necessary for the results, an additional assumption is that U.S. parts suppliers do not make relationship-specific investments of value to the U.S. automaker.¹⁰ Since contracts made by U.S. automakers with outside suppliers are relatively short term (reducing the profitability of relationship-specific investments), whereas in Japan they are open ended, this simplifying assumption partially reflects this institutional difference.¹¹ In the absence of relationship-specific investment, parts, whether from Japan or the U.S., are priced competitively at marginal cost.¹²

While there is a large literature concerning vertical integration, contract design, and the institutional differences between Japanese and U.S. contracting arrangements,¹³ specific modelling of the informal procurement arrangements within keiretsu is relatively recent. Of particular relevance here is McLaren (1999), who argues that less formal bargaining arrangements can dominate formal contracts in encouraging cooperative investment.¹⁴ More generally, well known managerial costs arising from incentive problems within organizations can favor informal supply arrangements of the sort exemplified by the keiretsu (see Aoki, 1988). Empirical work examining the effects of keiretsu on the pattern of Japanese trade include Lawrence (1991, 1993) and Fung (1991), who argue that industries with a high

¹⁰ The model could be developed with symmetric institutions, in which U.S. and Japanese suppliers make relationship-specific investments of value to the U.S. and Japanese automakers respectively. The nature of results concerning the range and value of U.S. parts imported into Japan would not change. However, instead of simply importing those parts that can be produced more cheaply in Japan, the results developed for imports into Japan would now also apply to imports into the U.S.

¹¹ The average length of contract in the U.S. auto industry was only 2.5 years in 1989, up from 1.3 years in 1984 (Dyer and Ouchi, 1993). Some theoretical justification for asymmetry is provided by McLaren (2000), who argues that the "thickness of the market" for specialized inputs produced by unintegrated firms can lead to multiple equilibria in which countries differ as to the degree of vertical integration. Vertical integration "thins" the market, reducing the incentive for up-front production by unintegrated firms.

¹² Although U.S. auto producers tend to be more vertically integrated than their Japanese counterparts, treating U.S. suppliers as purely competitive is not unreasonable given the large number of establishments (4856 in 1992 according to the Office of Automotive Affairs) with relatively short-term contracts. However, one might want to relax this assumption to allow for a rent-shifting motive if the aim were to model the political economy aspects of lobbying by the U.S. auto industry for greater access to Japan.

¹³ See for example, Perry (1989), Aoki (1988), Asanuma (1985, 1989), and Holmstrom and Roberts (1998).

¹⁴ In McLaren (1999), the incentive for cooperative investments is increased by unintegrated buyers who raise the "threat point" of suppliers in the event that bargaining breaks down. Also see Taylor and Wiggins (1997) for the implications of U.S. and Japanese subcontracting systems for quality control.

keiretsu presence tend to have low imports.¹⁵ Also, Weinstein and Yafeh (1995) present evidence that strong relationships with their main bank can cause keiretsu expansion at the expense of imports and Cheng and Kreinin (1996) consider the preferential use of keiretsu suppliers.¹⁶

This article provides a natural basis for further work concerning the effects of trade policy in the context of the U.S./Japan trade dispute.¹⁷ However, the model's consideration of a large number of parts, with differing importance for downstream costs, could also have applications in other procurement settings. Since a higher share of downstream costs tends to make relationship-specific investment more valuable for the downstream purchasing firm, this suggests that, even with different contracting arrangements, parts with high-cost shares are more likely to be associated with long-term supply arrangements or, at the extreme, full vertical integration. In the current context, the model predicts that such parts will be produced within the keiretsu and only lower value parts will be imported. This has some real world counterpart, as shown by U.S. complaints that Japanese firms preferentially reserve high value auto parts for their own suppliers.¹⁸

In Section 2, the model is developed in an initial closed market setting, with the effects of moving to free trade presented in Section 3. Section 4 then develops the effects of relationship-specific investments within keiretsu for the ability of foreign suppliers of intermediate goods to access the Japanese market. Next, in Section 5, we explain why the use of imports could raise Japanese marginal costs and also discuss the implications of this and other counterintuitive results for perceptions of a trade barrier. Finally Section 6 contains concluding remarks.

2. THE MODEL OF RELATIONSHIP-SPECIFIC INVESTMENT

2.1. *Costs and Relationship-Specific Rents with General Numbers of Parts.* We suppose that a final good, such as an auto, is produced in both Japan and the United States based on Cournot competition between a Japanese firm, referred to as a J-maker, and a U.S. firm, referred to as an A-maker. Our results also apply to the case in which the J-maker has a world monopoly, but the extension to oligopoly seems appropriate given the institutional reality of oligopolistic competition between U.S. and Japanese auto producers. Autos are assumed homogeneous (for convenience) and are sold in a unified world market at a price $P = P(Y)$ where $Y \equiv y^J + y^A$ and y^J and y^A are the respective outputs of the J- and A-makers.

¹⁵ Saxonhouse (1991) presents an opposing view, arguing that there is little evidence that Japan's trade regime is different from other countries. Data to be explained include Japan's low share of manufactured goods imports, low share of intraindustry trade, etc. (see Lawrence, 1993: pp. 6-7).

¹⁶ Also see Feenstra et al. (1999) for estimates as to the proportion of within group purchases by Asian business groups (e.g., 31 percent for autos in Japan). Related theoretical work includes Krishna and Morgan (1998), who consider trade policy in the U.S.-Japan auto-parts dispute, and Greaney (1999), who is concerned with distortions in firm behavior due to claims of an implicit trade barrier. For vertical relations between markets and trade see Spencer and Jones (1992) and Spencer and Raubitschek (1996) among others.

¹⁷ Qiu and Spencer (2001) use this model to examine the effects of VIEs (voluntary import expansions) and VERs (voluntary export restraints) aimed at opening the Japanese market.

¹⁸ See, for example, Lachica (1995).

A large number N of parts is required to produce an auto, with parts and labor combined in fixed proportion. Without loss of generality, we set the units of output of each part i so that each auto is produced using just *one* part of each type. In modelling the keiretsu, a central role is played by the fact that parts differ with respect to their costs of production and hence their importance for downstream costs. The cost of production of parts also differs across the two countries. Letting c^i and c^{*i} represent the constant average (and marginal) cost of production of part i in Japan and the U.S., respectively, we arrange parts i in order of increasing average cost. This ordering is assumed to be the same in both countries. Exploiting the fact that the number N of parts is large, it is convenient to express costs c^i and c^{*i} as differentiable and increasing functions $c^i = c^*(i)$ and $c^{*i} = c(i)$ on the continuum $i \in [0, N]$. For the keiretsu parts producers, the importance of part i for downstream costs is then captured by the cost-share¹⁹

$$\sigma^i = \sigma(i) = c(i)/C(N) \quad \text{for } C(N) \equiv \int_0^N c^i di$$

(σ is Greek s for share) where the ordering of parts implies $\sigma'(i) > 0$.

As previously discussed, the U.S. parts producers act as purely competitive firms with no commitment to the J- or A-makers. Within the keiretsu, we assume for simplicity that there is just one J-supplier²⁰ of each part i . Each J-supplier i (or more simply supplier i) potentially makes a relationship-specific investment, denoted k^i , which creates rent for the J-maker (but not for the A-maker) in the form of a reduction in assembly costs.²¹ Since the J-maker gains rent only through the use of the part, the level of rent, denoted r^i , is assumed to be constant for each unit of part i purchased from supplier i . Recalling that each auto is produced with just one unit of each part, r^i also represents the J-maker's rent per auto from investment k^i . The magnitude of r^i is assumed to be proportional to the initial value, denoted w^0 , of the J-maker's assembly cost per auto in the absence of relationship-specific investments and also to the relative contribution of part i to cost, as measured by the cost-share $\sigma(i)$. This last condition reflects the idea that the greater the proportion of costs associated with the part, the greater the potential for cost reduction. For example, a given amount of investment is likely to be more effective in reducing costs when it

¹⁹ To see the correspondence between the discrete and continuous versions of the model, suppose that $c(j) = a + \rho j$ for $j = 1, 2, \dots, N$, which implies $\sigma^j \equiv c(j)/C(N)$ for $C(N) \equiv \sum_{j=1}^N c^j = N[a + (\rho/2)(N + 1)]$. If $c(i) = c^0 + \rho i$ for $i \in [0, N]$, then $C(N) = \int_0^N c(i) di = N[c^0 + (\rho/2)N]$. For $c^0 \equiv a + \rho/2$ and $j = i + 1$, we obtain $c(i + 1/2) = \int_1^{i+1} (c^0 + \rho t) dt = c^0 - \rho/2 + \rho(i + 1) = c^j$ and $\sigma^{i+1/2} = \sigma^j$. If $c(j)$ is nonlinear then $\sigma^{i+1/2} \approx \sigma^j$.

²⁰ If there is more than one long-term supplier for part i , this may weaken the bargaining power of these suppliers. However, it is in the interest of the J-maker to allow suppliers some bargaining power in order to gain the benefit from relationship-specific investments (see Proposition A.1 (ii) of the Appendix). Assuming investment takes place, most of our results are not sensitive to the level of bargaining power.

²¹ From Dyer and Ouchi (1993: Figure 2), in 1984, assembly costs were 23.1 percent of total costs for a U.S. car and only 15.7 percent for a comparable Japanese car. Relationship-specific investments can reduce assembly costs by improving the "fit" with other parts or by facilitating "just in time" delivery so as to reduce inventory costs.

applies to engines rather than to seat covers. Also, we obtain the reasonable feature that the level of rent created per auto is invariant to an inflation in the costs of all parts. Finally, letting θ denote the productivity of investment in creating rent, the rent created per auto by investment k^i is given by

$$(2.1) \quad r^i = w^o \sigma(i) \theta h(k^i) \quad \text{for } 0 < \theta \leq \theta^{\max},$$

where $\theta^{\max} \equiv \min\{1, C(N)/w^o\}$ and $h(k^i)$ satisfies

$$(2.2) \quad h(0) = 0 \quad h'(k^i) > 0 \quad h''(k^i) < 0 \quad \text{and} \quad h(k^i) < 1.$$

Two examples of functions satisfying (2.2)²² are $h(k^i) = 1 - \exp\{-k^i\}$ and $h(k^i) = 1 - 1/(1 + k^i)$.

From (2.1) and (2.2), it follows that rent, r^i , is increasing in k^i , but at a decreasing rate:

$$(2.3) \quad dr^i/dk^i = w^o \sigma(i) \theta h'(k^i) > 0 \quad \text{and} \quad d^2r^i/(dk^i)^2 = w^o \sigma(i) \theta h''(k^i) < 0.$$

Also, the conditions $\theta \leq \theta^{\max}$ and $h(k^i) < 1$ sufficiently restrict the magnitude of the rent, r^i , that there is no “free lunch” from assembly or from the production and use of keiretsu parts. Since $r^i < w^o \sigma(i)$ from $\theta^{\max} \leq 1$, $h(k^i) < 1$, and (2.1), the J-maker’s assembly cost per auto, denoted w , is strictly positive; i.e.,

$$w = w^o - \int_0^N r^i di = \int_0^N (w^o \sigma(i) - r^i) di > 0.$$

Correspondingly, since $r^i < \sigma^i C(N) = c^i$ from $\theta^{\max} \leq C(N)/w^o$, $h(k^i) < 1$, and (2.1), the marginal resource cost, $c^i - r^i$, from the production and use of keiretsu parts once investment k^i has been sunk, is also strictly positive.

Adjusting for relationship-specific investment and letting p^i represent the price paid to supplier i , the J-maker’s marginal cost for part i is given by $\gamma^i \equiv p^i - r^i$ if the part is purchased from within the keiretsu and by c^{*i} if the part is imported. The J-maker’s overall marginal cost, denoted γ^J , then equals the sum of these costs for parts plus w^0 . To focus on the question of access to the Japanese market, we assume that parts can be freely imported into the U.S. from Japan and hence that the A-maker buys part i at a price equal to the $\min\{c^{*i}, c^i\}$. Thus, given a constant assembly cost, the A-maker’s marginal cost, denoted γ^A , is a constant. The J-maker, supplier i , and the A-maker respectively earn profits:

$$(2.4) \quad \pi^J = y^J(P(Y) - \gamma^J) \quad \phi^i = y^J(p^i - c^i) - k^i \quad \text{and} \quad \pi^A = y^A(P(Y) - \gamma^A).$$

²² If $h(k^i) = 1 - \exp\{-k^i\}$, then $h(0) = 0$, $h'(k^i) = \exp\{-k^i\}$, $h''(k^i) = -h'(k^i)$, and $h(k^i) < 1$. If $h(k^i) = 1 - 1/(1 + k^i)$, then $h(0) = 0$, $h'(k^i) = 1/(1 + k^i)^2$, $h''(k^i) = -2/(1 + k^i)^3$, and $h(k^i) < 1$.

2.2. *Order of Moves and Bargaining over Price within Keiretsu.* Relationship-specific investments within keiretsu take place at arm's length. Consequently, even if such investment would be beneficial to the J-maker, payment is typically determined only after investment is sunk and there is no guarantee that the cost will be covered.²³ The model captures this idea by assuming that J-suppliers commit to their investments prior to bargaining with the J-maker as to the price they will receive for their product. Although the bargained price, p^i , can depend on the rent, r^i , created by investment, k^i , it is assumed that third party verification problems²⁴ prevent payments based on k^i directly. As outlined in Section A.1 of the Appendix, it is possible to formulate a model of incomplete contracts with the same results, but a bargaining framework would seem to best reflect the institutional arrangements within keiretsu.²⁵

We assume the following order of moves. In stage 1, each supplier i commits to its investment k^i , which becomes sunk at this stage, and simultaneously, the J-maker and A-maker both specify their respective outputs y^J and y^A . Since each firm sets its choice variable to maximize own profit taking the other choice variables as given, this gives rise to a Nash equilibrium in k^i , y^J , and y^A . If the J-maker has a monopoly, then $y^A \equiv 0$. Profits π^J and π^A (in the duopoly case) are strictly positive, but it is possible that a J-supplier would make a loss by producing in stage 2 (i.e., $\phi^i < 0$ for all $k^i \geq 0$) or that bargaining would break down and the supplier would not produce the part. In both these cases, anticipating the outcome of stage 2, supplier i sets $k^i = 0$ and exits the market at stage 1. In stage 2, the J-maker engages in simultaneous Nash bargaining²⁶ over price p^i with each supplier i remaining in the market. If an agreement is reached, the J-maker orders its desired number of parts. Otherwise the J-maker purchases part i at the lowest price available, either at a price c^i from a competitive spot market in Japan or at a price c^{*i} from U.S. suppliers if imports are not prohibited. Parts and final-good output are then produced and sold.

An alternative possibility²⁷ would be to assume that investments k^i are determined in stage 1 and y^J , y^A , and p^i in stage 2. Suppliers would then strategically choose k^i considering the effect on the Cournot equilibrium outputs in stage 2 as well as

²³ As stated by Dyer and Ouchi (1993: p. 52), "Japanese suppliers frequently give automakers a head start in development by starting work on projects even before they are assured of winning the project."

²⁴ It is possible that a judge would not be able to verify the value of k^i , even if all parties can estimate the value of k^i from knowledge of r^i , σ^i , and θ . Adding uncertainty to the model would disguise the value of k^i , but although a suitably designed model would give similar results, the model becomes rather more complex.

²⁵ The role of bargaining is supported by Asanuma (1985), who observes that parts prices are revised at regular intervals, by bilateral negotiation, incorporating both risk and incentives for innovation and effort.

²⁶ See Binmore et al. (1986) for a justification of the Nash bargaining concept as a subgame perfect equilibrium in a game where participants alternate offers until one side accepts.

²⁷ This may be the more natural order of moves for the example in which relationship-specific investment involves building a plant near the J-maker. However, if the investment involves small design changes to make the part a better fit with other keiretsu parts, then the importance of knowing exact production requirements may make the simultaneous choice of y^J with k^i a more natural assumption.

the bargained price p^i . However, since with a continuum of parts it is reasonable to assume that the effect of an individual variation in k^i on y^j is negligible, the outcome is then the same as with the assumed order of moves.

We initially develop the model in a closed market setting in which the import of parts into Japan is prevented through government regulations or a prohibitive tariff. Considering stage 2 first, the J-maker's objective in bargaining with supplier i is to minimize the total cost, $y^j \gamma^i = y^j(p^i - r^i)$, of part i for the given output y^j committed in stage 1. Since the J-maker's disagreement or "threat point" is to buy the part at a price c^i from the spot market, this implies a payoff from reaching agreement of $y^j(c^i - \gamma^i)$. Correspondingly, since k^i is sunk, supplier i maximizes variable profit $\phi^i + k^i = y^j(p^i - c^i)$ with a threat point of no production and zero variable profit. Hence, setting p^i to maximize $G^i \equiv y^j(c^i - \gamma^i)^\alpha(p^i - c^i)^{1-\alpha}$ for $\alpha \in [0, 1]$, where α represents the bargaining power of the J-maker and $1 - \alpha$ the bargaining power of each J-supplier, it follows,²⁸ using $c^i - r^i > 0$, that at the Nash bargaining equilibrium

$$(2.5) \quad p^i - c^i = (1 - \alpha)r^i \geq 0 \quad \text{and} \quad \gamma^i \equiv p^i - r^i = c^i - \alpha r^i > 0.$$

As can be seen from (2.5), supplier i gains a share, $1 - \alpha$, of the rent it creates, resulting in a reduction of αr^i in the marginal cost of part i for the J-maker. Since the respective payoffs to the J-maker and supplier i are non-negative for all $k^i \geq 0$, i.e.,

$$(2.6) \quad y^j(c^i - \gamma^i) = y^j \alpha r^i \geq 0 \quad \text{and} \quad \phi^i + k^i = y^j(1 - \alpha)r^i \geq 0,$$

agreement is always reached for supplier i to produce the part. However, if $k^i = 0$ then, since $\gamma^i = c^i$ from (2.5), the J-maker's cost is the same as if the part had been purchased on the spot market.

2.3. Stage 1: Relationship-Specific Investments and Output Decisions. In stage 1, there is a Nash equilibrium in which the J- and A-makers set their outputs and J-suppliers simultaneously set their investment levels. Examining the investment decisions first, if supplier i remains to produce in stage 2, it sets $k^i \geq 0$ to maximize ϕ^i as in (2.6), taking y^j , y^A , and k^j for $j \neq i$ as given.²⁹ Since ϕ^i is concave³⁰ in k^i , the Kuhn-Tucker first order conditions, given by

$$(2.7) \quad \partial \phi^i / \partial k^i = y^j(1 - \alpha)(dr^i / dk^i) - 1 \leq 0 \quad \text{and} \quad (\partial \phi^i / \partial k^i)k^i = 0,$$

define k^i as a function, $k^i = k(\sigma^i, y^j)$, where k^i satisfies $\partial \phi^i / \partial k^i = 0$ if $k^i > 0$ and $k^i = 0$ if $\partial \phi^i / \partial k^i < 0$. Taking into account stage 2, from (2.6) evaluated at $k^i = k(\sigma^i, y^j)$, supplier i earns a stage 1 profit given by

$$(2.8) \quad \phi^i = \phi(\sigma^i, y^j) = y^j(1 - \alpha)r^i - k(\sigma^i, y^j) \quad \text{for } r^i = w^o \sigma^i \theta h(k(\sigma^i, y^j)),$$

²⁸ From $d \ln G^i / dp^i = (1 - \alpha)/(p^i - c^i) - \alpha/(c^i - \gamma^i) = 0$, we obtain $\alpha(p^i - c^i) = (1 - \alpha)(c^i - \gamma^i)$ for $\gamma^i = p^i - r^i$.

²⁹ From (2.6), y^A and investments k^j for $j \neq i$ influence k^i only through their effects on y^j .

³⁰ We have from (2.6) that $\partial^2 \phi^i / (\partial k^i)^2 = y^j(1 - \alpha)w^o \sigma^i(i) \theta h''(k^i) < 0$.

where the parameters θ and α are omitted for convenience. Since, from (2.8), J-suppliers have the option of earning zero profit by setting $k^i = 0$, all J-suppliers produce in stage 2 and from (2.7), supplier i engages in relationship-specific investment, setting $k^i > 0$, if and only if $\partial\phi^i/\partial k^i > 0$ at $k^i = 0$.

Since a requirement for relationship-specific investment is that J-suppliers receive a positive share of the rent they create (see (2.7)), we assume $\alpha < 1$. Evaluating (2.7) at $k^i = 0$, using dr^i/dk^i from (2.3), the ordering of parts from lowest to highest cost-share then ensures that $d(\partial\phi^i/\partial k^i)/di = y^j(1 - \alpha)w^o\sigma'(i)\theta h'(0) > 0$ and hence that $k^i > 0$ implies $k^j > 0$ for all $j > i$. Thus, letting part $i = Z$ (Z for zero investment) satisfy

$$(2.9) \quad k^Z = 0 \quad \text{and} \quad \partial\phi^Z/\partial k^Z = y^j(1 - \alpha)w^o\sigma(Z)\theta h'(0) - 1 = 0,$$

(2.9) defines the cutoff point, $Z = Z(y^j; \theta, \alpha)$ at which $k^i = k(\sigma^i, y^j) > 0$ if $i > Z$ and $k^i = 0$ for $i \leq Z$. We assume that some suppliers set $k^i > 0$, which implies $Z < N$. An important case is $k^i > 0$ for all $i \in [0, N]$, which, for convenience, we refer to as satisfying $i > Z$. This case applies at $\theta = \theta^{\max}$, since we assume

$$(2.10) \quad \partial\phi^0/\partial k^0 = y^j(1 - \alpha)w^o\sigma^0\theta^{\max}h'(0) - 1 > 0,$$

which implies that $k^0 = k(\sigma^0, y^j; \theta^{\max}) > 0$ and hence $k(\sigma^i, y^j; \theta^{\max}) > 0$ for all $i \in [0, N]$.

The conditions under which J-suppliers make relationship-specific investments are summarized in Proposition 1(i). Also, as shown in Proposition 1(ii), the ordering of parts in terms of increasing cost shares σ^i has the useful feature that for $i > Z$, parts are also ordered in terms of increasing levels of k^i , r^i , and ϕ^i . Supposing that suppliers i and j for $i > j$ make the same level of investment, then since part i involves a higher cost-share, this generates a higher level of rent for the J-maker. Since the outcome of bargaining is that each supplier receives a share $1 - \alpha$ of the rent created, this translates into a higher return to supplier i from investment, with the result that supplier i sets $k^i > k^j$.

PROPOSITION 1. *Assume parts cannot be imported into Japan.*

- (i) *For $i > Z$, supplier i invests $k^i = k(\sigma^i, y^j) > 0$, earns profit $\phi^i = \phi(\sigma^i, y^j) > 0$, and creates rent $r^i > 0$ per unit of the J-maker's output. For $i \leq Z$, $k^i = k(\sigma^i, y^j) = 0$ and $\phi^i = \phi(\sigma^i, y^j) = 0$.*
- (ii) *For $i > Z$, higher cost-shares σ^i are associated with greater levels of k^i , r^i , and ϕ^i .*

PROOF. (i) Since $k^i > 0$ for $i > Z$ (proved in the text), it follows that $h(k^i) > 0$ from (2.2) and hence that $r^i = w^o\sigma^i\theta h(k^i) > 0$ for $i > Z$. If $k^i = 0$, then $h(0) = 0$ implies $r^i = 0$ and $\phi^i = 0$. Using $y^j(1 - \alpha)w^o\sigma^i\theta = 1/h'(k^i)$ (from (2.7) for $k^i > 0$ and (2.3)) in (2.8) and $h(k^i)/k^i > h'(k^i)$ (from $h(0) = 0$ and $h''(k^i) < 0$), we obtain

$$(2.11) \quad \phi^i = \phi(\sigma^i, y^j) = [h(k^i) - k^i h'(k^i)]/h'(k^i) > 0 \quad \text{for } i > Z$$

(ii) For the comparative statics, a useful expression is

$$(2.12) \quad \lambda^i \equiv -(h'(k^i))^2/h(k^i)h''(k^i) > 0 \quad \text{for } k^i > 0,$$

where the sign follows from (2.2). Since from (2.7) and (2.3), $\partial^2 \phi^i/(\partial k^i)(\partial \sigma^i) = y^j(1 - \alpha)w^o \theta h'(k^i)$ and $\partial^2 \phi^i/(\partial k^i)^2 = y^j(1 - \alpha)w^o \sigma(i)\theta h''(k^i)$, we obtain $dk^i/d\sigma^i = -h'(k^i)/\sigma^i h''(k^i) > 0$ for $i \geq Z$. Also, from $dr^i/d\sigma^i = w^o \theta h(k^i)[1 + \sigma^i h'(k^i)(dk^i/d\sigma^i)/h(k^i)]$ using (2.12) and from (2.8) using $\partial \phi^i/\partial k^i = 0$ we have that for $i > Z$,

$$(2.13) \quad dr^i/d\sigma^i = r^i(1 + \lambda^i)/\sigma^i > 0 \quad \text{and} \quad d\phi^i/d\sigma^i = y^j(1 - \alpha)r^i/\sigma^i > 0.$$

Q.E.D.

From Proposition 1 and (2.5), we can express the J-maker's marginal cost as

$$(2.14) \quad \gamma^j = \int_0^Z c^i di + \int_Z^N (c^i - \alpha r^i) di + w^o.$$

Since from (2.14), $\gamma^j = C(N) + w^o - \int_Z^N \alpha r^i di$, it follows that for $0 < \alpha < 1$, the rent created by $k^i > 0$ reduces the J-maker's marginal cost below the level $\gamma^j = C(N) + w^o$ achieved either at $\alpha = 0$, where J-suppliers capture all the rent created by $k^i > 0$, or at $\alpha = 1$, where J-suppliers have no incentive to invest ($r^i = 0$).

Now considering the stage 1 determination of output, at the Nash equilibrium in y^j , y^A , and k^i , the J-maker treats k^i and hence γ^j as fixed. Thus, there is no strategic role for output in influencing the prices paid for parts at the second stage bargaining game. From (2.4), using subscripts J and A to represent partial derivatives with respect to y^j and y^A , respectively, it follows that y^j and y^A satisfy the standard Cournot first order conditions

$$(2.15) \quad \pi_J^j = P + y^j P' - \gamma^j = 0 \quad \pi_A^A = P + y^A P' - \gamma^A = 0.$$

Assuming that the following second order and stability conditions,

$$(2.16) \quad \begin{aligned} \pi_{JJ}^j &= 2P' + y^j p'' < 0 & \pi_{AA}^A &= 2P' + y^A P'' < 0 & \text{and} \\ H^o &\equiv \pi_{JJ}^j \pi_{AA}^A - \pi_{JA}^j \pi_{AJ}^A = p'(3p' + Yp'') > 0, \end{aligned}$$

hold globally, conditions (2.15) define the equilibrium output levels $y^j = y^j(\gamma^j)$ and $y^A = y^A(\gamma^j)$ as functions of the J-maker's marginal cost, where the constant γ^A is omitted for convenience.

However, the dependence of $k^i = k(\sigma^i, y^j)$ on y^j means that $\gamma^j = \gamma^j(y^j)$ is also dependent on y^j and hence, for the comparative statics, we require the additional stability conditions:

$$(2.17) \quad \pi_{JJ}^j - d\gamma^j/dy^j < 0 \quad \text{and} \quad H \equiv H^o - \pi_{AA}^A (d\gamma^j/dy^j) > 0.$$

From (2.15), holding γ^j fixed with respect to variations in y^j , we first obtain the standard result that an increase in γ^j reduces y^j and we then use (2.17) to take account of the effect of y^j on γ^j ; i.e., we obtain

$$(2.18) \quad dy^j/d\gamma^j = \pi_{AA}^A/H^o < 0 \quad \text{and} \quad 1 - (dy^j/d\gamma^j)(d\gamma^j/dy^j) = H/H^o > 0.$$

If the J-maker has a monopoly, (2.18) reduces to

$$(2.19) \quad dy^J/d\gamma^J = 1/\pi_{JJ}^J < 0 \quad \text{and} \\ 1 - (dy^J/d\gamma^J)(d\gamma^J/dy^J) = (\pi_{JJ}^J - d\gamma^J/dy^J)/\pi_{JJ}^J > 0.$$

3. OPENING THE JAPANESE MARKET

With the removal of the government imposed trade restriction, there is free trade in the sense that there are no laws restricting trade, but the extent to which parts are imported is affected by the long-term supply arrangements within the keiretsu. This section develops the implications of free trade for the bargaining model, relationship-specific investment, and imports.

The potential for Japanese imports arises from the assumption that at least some range of parts can be produced more cheaply in the U.S. Letting $\delta^i = \delta(i) \equiv c(i) - c^*(i)$ represent the efficiency gap between U.S. and Japanese production costs for part i , the simplest assumption is that $c(i)$ and $c^*(i)$ are linear in i with equal slopes leading to a constant efficiency gap across all parts; i.e., for all $i \in [0, N]$,

$$(3.1) \quad \delta^i = \delta = c(0) - c^*(0) \geq 0 \quad c'(i) = c^{*'}(i) \quad \text{and} \quad c''(i) = c^{*''}(i) = 0.$$

The case $\delta = 0$ is retained as a benchmark. However, for greater generality and to better specify the range of parts for which relationship-specific investment causes keiretsu production to displace imports, we focus on the possibility that δ^i differs across parts, with part $i = 0$ potentially imported due to $\delta^0 > 0$ and part $i = E$, satisfying $\delta^E = 0$ (E for equal costs), produced within the keiretsu. To help ensure that there is only one region of imports (namely, parts with low cost-shares), we make the simplifying assumption³¹ that the efficiency gap is decreasing or constant as the cost-share rises, and hence that

$$(3.2) \quad \delta(0) > 0, \delta(E) = 0 \quad \text{and} \quad \delta'(i) \leq 0 \quad \text{for all } i \in [0, N].$$

If $\delta(N) < 0$, then $E < N$ and Japan has an actual cost advantage for parts with the highest cost-shares.³² Finally, we focus on the case in which keiretsu investment is potentially relevant for imports by assuming that $Z \leq E$. If $Z \geq E$, then all parts for which the U.S. has a cost advantage are imported.

With respect to bargaining at stage 2, free trade gives the J-maker the additional option of importing parts at prices c^{*i} from U.S. producers. Using a superscript F to

³¹ For a unique region of imports, it is sufficient that J-supplier profits be strictly increasing in i for $i \in [Z, N]$. This tends to be an endogenous outcome of the model since profits increase due to rising levels of σ^i and k^i . This ordering is reinforced by $\delta'(i) \leq 0$, but our results also apply if $\delta'(i) > 0$ and not too large.

³² For example, if there are three parts, with $c(1) = \$230$, $c(2) = \$310$, and $c(3) = \$390$ in Japan, but $c^*(1) = \$200$, $c^*(2) = \$300$, and $c^*(3) = \$400$ in the U.S., then $\delta(1) = \$30$, $\delta(2) = \$10$, and $\delta(3) = -\$10$. Since c^i is the total cost of part i required per auto, parts at the high end of the scale $i \in [0, N]$ could involve both high cost parts produced in average volume or average cost parts produced in high volume.

distinguish values at free trade, for parts $i \geq E$ where Japan has a cost advantage, the payoffs from agreement at the Nash bargaining equilibrium are unchanged from (2.6). Hence, as in Proposition 1, supplier i sets $k^{iF} = k(\sigma^i, y^J) > 0$ and earns profits

$$(3.3) \quad \phi^{iF} = \phi(\sigma^i, y^J) = y^J(1 - \alpha)r^i - k(\sigma^i, y^J) > 0 \quad \text{for } i \geq E > Z,$$

with $k^{EF} = k(\sigma^E, y^J) = 0$ and $\phi^{EF} = 0$ for $Z = E$. By contrast, in bargaining with supplier i for $i < E$, the availability of lower cost imports changes the J-maker's "threat point," with the consequence that³³

$$(3.4) \quad p^{iF} - c^i = (1 - \alpha)(r^i - \delta^i) \quad \text{and} \quad \gamma^{iF} = c^{*i} - \alpha(r^i - \delta^i) \quad \text{for } i \leq E.$$

Comparing (3.4) with (2.5), since $\delta^i = c^i - c^{*i} > 0$ for $i < E$, competition from imports reduces the price paid to the J-supplier by $(1 - \alpha)\delta^i$, while the J-maker absorbs the amount, $\alpha\delta^i$, of the efficiency gap.³⁴ Analogously to (2.6), the respective payoffs of the J-maker and supplier i (relative to the disagreement point) become

$$(3.5) \quad y^J(c^{*i} - \gamma^{iF}) = y^J\alpha(r^i - \delta^i) \quad \text{and} \\ \phi^{iF} + k^{iF} = y^J(1 - \alpha)(r^i - \delta^i) \quad \text{for } i \leq E.$$

Agreement is then reached for supplier i to produce the part if and only the rent created is sufficiently large to make $r^i - \delta^i \geq 0$. If $r^i - \delta^i < 0$, then part i is imported. Hence, supplier i 's profit at stage 2 is

$$(3.6) \quad \phi^{iF} = y^J(1 - \alpha)(r^i - \delta^i) - k^i \quad \text{if } r^i - \delta^i \geq 0 \quad \text{and} \\ \phi^{iF} = -k^i \quad \text{if } r^i - \delta^i < 0.$$

Turning to stage 1, profit maximization by supplier i involves, first, the optimal choice of k^i conditional on remaining to bargain with the J-maker and, second, the decision whether to remain in the market. With respect to the first choice, supplier i sets $k^i \geq 0$ to maximize ϕ^{iF} as in (3.6), taking y^J and y^A as given. Since the potential for imports reduces the revenue to supplier i by an amount $(1 - \alpha)y^J\delta^i$, which is independent of the level of investment, this gives rise to the same first order conditions for the choice of k^i as before (see (2.7)). This is convenient, since the opening of trade then has no effect on the investment function, $k^i = k(\sigma^i, y^J)$, for firms that remain as producers. As for the decision whether to remain in the market, if supplier i produces the part, from (3.6) and (2.8), it earns a stage 1 equilibrium profit given by

$$(3.7) \quad \phi^{iF} = \phi^F(i, y^J) \equiv \phi(\sigma^i, y^J) - y^J(1 - \alpha)\delta^i \quad \text{for } i \leq E.$$

Alternatively, if bargaining would break down (i.e., if $r^i - \delta^i < 0$) or if revenues from production are positive (due to $r^i - \delta^i \geq 0$) but are not sufficient to cover the

³³ Maximizing $G^{iF} \equiv y^J(c^{*i} - \gamma^{iF})^\alpha (p^{iF} - c^i)^{1-\alpha}$, this follows from $(1 - \alpha)(c^{*i} - \gamma^{iF}) - \alpha(p^{iF} - c^i) = 0$ for $\gamma^{iF} = p^{iF} - r^i$.

³⁴ Although γ^{iF} is reduced by $(1 - \alpha)\delta^i$, $c^i - r^i > 0$ implies $\gamma^{iF} = (1 - \alpha)c^{*i} + \alpha(c^i - r^i) > 0$.

sunk cost of investment, then supplier i chooses not to invest, exiting the market at stage 1. Thus, noting that $\phi^{iF} \geq 0$ implies $r^i - \delta^i \geq 0$, supplier i remains to produce part i if and only if $\phi^{iF} = \phi^F(i, y^J) \geq 0$. Also, since $r^i - \delta^i \geq 0$ for $\delta^i > 0$ implies $k^i > 0$, it follows that all J-suppliers remaining to produce parts $i < E$ must engage in relationship-specific investment.

To specify the range of imported parts, letting $i = T$ (T for trade) denote the marginal part just produced by the keiretsu, then $T \leq E$ satisfies

$$(3.8) \quad \phi^F(T, y^J; \theta, \alpha) = y^J(1 - \alpha)(r^T - \delta(T)) - k(\sigma^T, y^J; \theta) = 0,$$

which defines³⁵ $T = T(y^J; \theta, \alpha)$ for $y^J = y^J(\gamma^{JF})$. Proposition 2 describes the pattern of trade and investment.

PROPOSITION 2. *Assume $\delta(i)$ satisfies (3.2). If $Z = E$, then $T = E$. If $Z < E$, then T satisfies $Z < T < E$ and supplier i produces part i , investing $k^i = k(\sigma^i, y^J) > 0$ for $i \geq T$, including parts i for $T \leq i < E$ with $\delta(i) > 0$. Parts i for $i < T$ are imported, but no parts are imported if $\phi^F(0, y^J) \geq 0$.*

PROOF. Since $\phi(\sigma^i, y^J) = 0$ at $k^i = 0$, we obtain $\phi^{iF} = -y^J(1 - \alpha)\delta(i) < 0$ for $i \leq Z$ and $i < E$ from (3.7). This implies that if $Z = E$, part i is imported for $i < E$ and hence $Z = T = E$. If $Z < E$, then part i is imported for $i \leq Z$ and hence $T > Z$. Also, since $d\phi^{iF}/di = y^J(1 - \alpha)[r^i\sigma'(i)/\sigma(i) - \delta'(i)]$ from (3.7) and (2.13), we obtain

$$(3.9) \quad d\phi^F(i, y^J)/di = y^J(1 - \alpha)\sigma'(i)r^i(1 + \chi^i)/\sigma(i) > 0 \quad \text{for } Z < i \leq E,$$

where $\chi^i \equiv -\sigma(i)\delta'(i)/\sigma'(i)r^i > 0$ if $\delta'(i) < 0$ and $\chi^i = 0$ if $\delta'(i) = 0$. Since $T > Z$ for $Z < E$, it follows, using (3.9), that $k^{iF} = k(\sigma^i, y^J) > 0$ for $i \geq T$ and parts are imported for $i < T$. Since $\phi^F(E, y^J) > 0$ for $k^{EF} > 0$, we also obtain $T < E$. If $\phi^F(0, y^J) \geq 0$, then no parts are imported, since $\phi^{iF} > 0$ for all i from (3.9). Q.E.D.

As illustrated in Figure 1, parts i with equal or higher cost-shares (i.e., for $i \geq T$) are produced within the keiretsu and parts i with lower cost-shares (i.e., for $i < T$) are imported. Consequently, imported parts represent the lowest value parts in the sense that they make the least contribution to the cost of an auto. Since from Proposition 2, T satisfies $Z < T < E$, all keiretsu suppliers remaining at free trade invest, setting $k^i > 0$, including the producer of the marginal part T . Also, production by keiretsu suppliers covers a range of parts $i \in [T, E]$ for which the U.S. has lower production costs.³⁶ However, this production takes place only if the investment by each supplier raises efficiency relative to importing.³⁷ Thus, for $i \geq T$, the rent from investment k^i ,

³⁵ This follows since ϕ^F is increasing in i (see (3.9) below). Although y^J is determined endogenously, expressing $T = T(y^J)$ helps separate out the important relationship between imports and keiretsu output.

³⁶ The assumption that $\delta(i)$ satisfies (3.2) ensures that part $i = E$ exists and that $i \in [T, E]$ is not empty.

³⁷ For $T \leq i < E$, it follows from $\phi^{iF} \geq 0$ and $k^i > 0$ (see Proposition 2) that $r^i - \delta^i = c^{ni} - (c^i - r^i) > 0$. Thus the import cost, c^{ni} , exceeds the marginal resource cost, $c^i - r^i$, of keiretsu production. The cost, k^i , is also covered since supplier i produces only if $\phi^i \geq 0$.

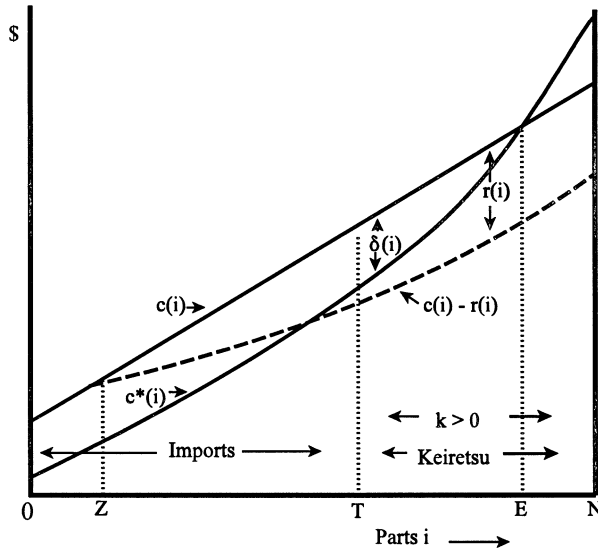


FIGURE 1

COSTS AND THE RANGE OF IMPORTED PARTS

shown as the difference between $c(i)$ and the dashed line, $c(i) - r(i)$, more than offsets the efficiency gap, δ^i . For $i < T$, the difference between these lines is the rent that would have been created if the part had been produced in the keiretsu. Nevertheless, as we will subsequently argue, this failure to import the cheaper U.S. parts can be significant if the rents are unobservable outside the keiretsu.

From Proposition 2, using (2.5) and (3.4), the J-maker's marginal cost at free trade becomes

$$(3.10) \quad \gamma^{JF} = \int_0^T c^{*i} di + \int_T^E (c^{*i} - \alpha(r^i - \delta^i)) di + \int_E^N (c^i - \alpha r^i) di + w^0.$$

Consequently, at the stage 1 Nash equilibrium in y^J, y^A , and k^i , the outputs $y^J = y^J(\gamma^{JF})$ and $y^A = y^A(\gamma^{JF})$ satisfy the same first order and stability conditions (2.15), (2.16), and (2.17) as before. Since the opening of trade affects the J-maker's marginal cost, comparisons with the pretrade outcome are complicated by endogenous changes in output. However, since the investment function $k^i = k(\sigma^i, y^J)$ is unchanged (see above), holding output y^J fixed, the opening of trade has no effect on the level of k^i for parts that continue to be produced in the keiretsu. Nevertheless the range of parts produced with $k^i > 0$ is reduced by the import of parts $i \in (Z, T)$.

Although both output and relationship-specific investment are endogenously determined in the full model, it is useful to first explore the partial effects of an exogenous increase in the J-maker's output. As shown in Proposition 3, since an increase in y^J increases the incentives for relationship-specific investment, leading more J-suppliers to stay in business, it also tends to reduce the range of imported parts. This requires that some parts be imported (i.e., that $T(y^J) \geq 0$ is defined³⁸ from (3.8)) and that

³⁸ If $\phi^F(0, y^J) > 0$ then all J-suppliers make strictly positive profits from (3.9) and T is not defined.

J-suppliers produce some parts for which the U.S. has a cost advantage (i.e., that $Z < E$ and hence $T < E$ from Proposition 2). For the case (3.1) in which the U.S. cost advantage is constant, we assume that $T \leq N$. The endogenous choice of relationship-specific investment also creates economies of scale for the J-maker. This last result requires that $0 < \alpha < 1$, since if $\alpha = 0$ or if $\alpha = 1$, then $\gamma^i = \min\{c^{*i}, c^i\}$ and marginal cost remains constant.³⁹

PROPOSITION 3. *An exogenous increase in the J-maker's output: (i) narrows the range of imported parts for $Z < E$, (ii) increases rents from relationship-specific investment, and (iii) reduces the J-maker's marginal cost γ^{JF} for $0 < \alpha < 1$.*

PROOF. (i) From (3.8), using $\partial\phi^{TF}/\partial k^T = 0$, and $r^T - \delta^T > 0$ for $Z < E$ (since $k^T > 0$ from Proposition 2), we obtain $d\phi^{TF}/dy^J = (1 - \alpha)(r^T - \delta^T) > 0$. Using (3.9), we then obtain

$$(3.11) \quad dT/dy^J = -\sigma(T)(r^T - \delta^T)/y^J \sigma'(T)r^T(1 + \chi^T) < 0.$$

(ii) From $\partial\phi^i/\partial k^i = 0$ as in (2.7), we obtain $dk^i/dy^J = -h'(k^i)/y^J h''(k^i) > 0$ (see (2.2)) and hence

$$(3.12) \quad dr^i/dy^J = (dr^i/dk^i)(dk^i/dy^J) = r^i \lambda^i / y^J > 0 \quad \text{for } i \geq T,$$

where $\lambda^i > 0$ from (2.12). From part (i) and $k^i > 0$ for $i \geq T$, the range of parts with $k^i > 0$ is increased for $Z < E$. For $Z = E$, then $T = Z = E$ is unchanged. (iii) From (3.10), (3.12), and (3.11) we obtain

$$(3.13) \quad d\gamma^{JF}/dy^J = -\alpha \left[\int_T^N (dr^i/dy^J) di - (r^T - \delta^T)(dT/dy^J) \right] \leq 0,$$

where $d\gamma^{JF}/dy^J < 0$ for $\alpha > 0$ and $d\gamma^{JF}/dy^J = 0$ for $\alpha = 0$. Q.E.D.

4. ACCESS TO THE JAPANESE MARKET

This section concerns the implications of keiretsu relationship-specific investment for the ability of foreign suppliers of intermediate goods to access the Japanese market.

Recalling that θ represents the productivity of relationship-specific investment, an initial step is to show in Proposition 4 that an increase in θ expands both keiretsu output (i.e., $dy^J/d\theta > 0$) and the range of parts for which keiretsu firms potentially make investments (i.e., $dZ/d\theta < 0$). Thus for θ sufficiently large, we move into the region $Z < E$ in which some J-suppliers produce parts for which the U.S. has a cost

³⁹ Although it is not obvious what mechanism would ensure the credibility of a commitment to a particular value of α , there is no presumption that it is best to set $\alpha = 0$ so as to fully internalize the returns from investment to the J-suppliers. As shown in Proposition A.1 of the Appendix, holding output fixed, total keiretsu profit is maximized at $\alpha = 0$. However, if output is allowed to vary, both the J-maker's profit and aggregate keiretsu profit are maximized at strictly positive values of α .

advantage. In this region, further increases in θ restrict access to the Japanese market by reducing the range of imported parts (i.e., $dT/d\theta < 0$). More J-suppliers stay in business because the increased rent from investment raises both the price and volume of each part sold to the J-maker. At the extreme, no parts are imported. Letting $\theta = \theta^{Z=E}$ denote⁴⁰ the value of θ at which $Z = E$, the range of imported parts falls as θ is increased above $\theta^{Z=E}$. If θ increases to $\theta^{T=0}$, defined by $\phi^F(0, y^J; \theta^{T=0}) = 0$, the keiretsu supplier of part 0 just breaks even and imports are reduced to zero.⁴¹ Assuming that supplier 0 would earn strictly positive profits⁴² at $\theta = \theta^{\max}$, then $\theta^{T=0} < \theta^{\max}$ and no parts are imported for $\theta \in [\theta^{T=0}, \theta^{\max}]$.

PROPOSITION 4. (i) $dy^J/d\theta > 0$ for $\alpha > 0$ ($= 0$ for $\alpha = 0$), (ii) $dZ/d\theta < 0$ for $Z \geq 0$, and (iii) $dT/d\theta < 0$ for $\theta \in (\theta^{Z=E}, \theta^{T=0}]$. No parts are imported for $\theta \in [\theta^{T=0}, \theta^{\max}]$.

PROOF. See the Appendix.

The effect of relationship-specific investment in reducing the range of imported parts has significant consequences for a number of measures of access to the Japanese market. As shown in Proposition 5, with fewer parts imported, the level of U.S. content per Japanese auto, denoted $v^{AJ} = \int_0^T c^{*i} di$, is reduced. Since the prices, p^{iF} , paid to keiretsu firms also increase, this implies a reduction in the U.S. share, $S^{AJ} \equiv v^{AJ}/v^J$ for $v^J \equiv v^{AJ} + \int_T^N p^{iF} di$, of the Japanese parts market. A further and perhaps more direct indicator of the possible presence of a trade restriction is $S^c = \int_T^E c^{*i} di / \int_0^E c^{*i} di$, which represents the proportion of parts that are not imported, despite an efficiency gap favoring the U.S. Since S^c is increased, this measure also suggests that relationship-specific investment limits access to the Japanese market.

PROPOSITION 5. For $\theta \in (\theta^{Z=E}, \theta^{T=0}]$, an increase in θ :

- (i) reduces U.S. content, v^{AJ} , per Japanese auto,
- (ii) reduces the U.S. share, S^{AJ} , of the Japanese market for parts, and
- (iii) increases the proportion, S^c , of parts that are not exported to Japan, despite a U.S. cost advantage.

PROOF. (i) Using $dT/d\theta < 0$ from Proposition 4(iii), we obtain $dv^{AJ}/d\theta = c^{*T}(dT/d\theta) < 0$. (ii) Since $dp^{iF}/d\theta = (1 - \alpha)(dr^i/d\theta) > 0$ from (3.4) and (A.11) and $dT/d\theta < 0$, we obtain

$$dS^{AJ}/d\theta = \left[((v^J - v^{AJ})c^{*T} + v^{AJ}p^{TF})(dT/d\theta) - v^{AJ} \int_T^N (dp^{iF}/d\theta) di \right] / (v^J)^2 < 0$$

(iii) Using $dT/d\theta < 0$, we obtain $dS^c/d\theta = -c^{*T}(dT/d\theta) / \int_0^E c^{*i} di > 0$. Q.E.D.

⁴⁰ From (2.9), we obtain $\theta^{Z=E} \equiv 1/y^J(1 - \alpha)w^0\sigma(E)h'(0) > 0$.

⁴¹ Since $d\phi^F/di > 0$, all J-suppliers produce at $\theta^{T=0}$. From (3.7), using $\theta = 1/y^J(1 - \alpha)w^0 \times \sigma(i)h'(k^i)$ from (2.7) and (2.3) and $\phi(\sigma^0, y^J) > 0$ for $k^0 > 0$ (see (2.11)), we obtain $\theta^{T=0} = \delta(0)/w^0\sigma^0\phi(\sigma^0, y^J)h'(k^0) > 0$.

⁴² We assume $\phi^F(0, y^J; \theta^{\max}) > 0$, which, since $d\phi^F(0, y^J, \theta)/d\theta > 0$, holds for θ^{\max} sufficiently large.

The results in Proposition 5 all suggest that relationship-specific investment limits access to the Japanese market. However, since this investment also increases the J-maker's output, there is an opposing effect due to an increase in the volume of imports for those parts that continue to be imported. This opens the possibility that aggregate imports might rise. Summing over the range of imported parts, since one of each part is required per auto, we can express the total volume, Q^{AJ} , and value, V^{AJ} , of parts imports as

$$(4.1) \quad Q^{AJ} \equiv T(y^J; \theta)y^J \quad \text{and} \quad V^{AJ} \equiv v^{AJ}y^J \quad \text{where} \quad v^{AJ} = \int_0^T c^{*i} di.$$

However, for the case (3.1) in which the efficiency gap, $\delta^i = \delta$, is constant, Proposition 6 shows that there exists a value of θ , denoted $\theta = \theta^L$ (L for large), such that if $\theta > \theta^L$, then the reduction in the range of imported parts from an increase in y^J dominates, causing both the volume, Q^{AJ} , and value, V^{AJ} , of Japanese imports to fall. Eventually, at $\theta = \theta^{T=0}$, imports are reduced to zero. In addition, since an increase in θ preferentially reduces the imports of higher value parts, the value of U.S. exports falls more than in proportion to the fall in the volume of U.S. exports. Nevertheless, since it is possible that for low values of θ , an increase in θ would raise both Q^{AJ} and V^{AJ} , this undermines any general claim that relationship-specific investment within the keiretsu is an impediment to trade. Letting $\theta = \theta^{T=N}$ denote⁴³ the value of θ at which $T = N$, the condition $\theta \geq \theta^{T=N}$ ensures that at least one part is produced by a J-supplier.

PROPOSITION 6. *Assume $\delta^i = \delta$ as in (3.1). There exists some $\theta^L \in [\theta^{T=N}, \theta^{T=0}]$ such that for all $\theta \in (\theta^L, \theta^{T=0}]$, the total volume Q^{AJ} and value V^{AJ} of U.S. exports are reduced by (i) a small increase in output, y^J , OR (ii) an increase in θ . An increase in θ reduces V^{AJ} more than in proportion to Q^{AJ} .*

PROOF. See the Appendix.

Figure 2 illustrates the effect of θ on both the value, V^{AJ} , and share, S^{AJ} , of U.S. parts exports to the Japanese market assuming that $\delta^i > 0$ for every part. All parts are imported for $\theta < \theta^{T=N}$, but for $\theta \geq \theta^{T=N}$, the range of imported parts falls (from Proposition 5(i)), reducing S^{AJ} below one (as measured on the right hand axis). The figure illustrates the case in which V^{AJ} initially rises (due to the increase in the J-maker's output). However, as Proposition 6 shows, V^{AJ} eventually falls for $\theta \geq \theta^L$ and imports cease for $\theta \geq \theta^{T=0}$.

5. PERCEPTIONS OF A TRADE BARRIER

As previously mentioned, our result in Proposition 2 that a range of parts is produced by the keiretsu when U.S. costs are lower can be explained by the presence of rents from relationship-specific investment. Thus one might be tempted to dismiss

⁴³ Analogously to $\theta^{T=0}$ (see footnote 41), we obtain $\theta^{T=N} \equiv \delta^N / w^o \sigma(N) \phi(\sigma^N, y^J) h'(k^N) > 0$.

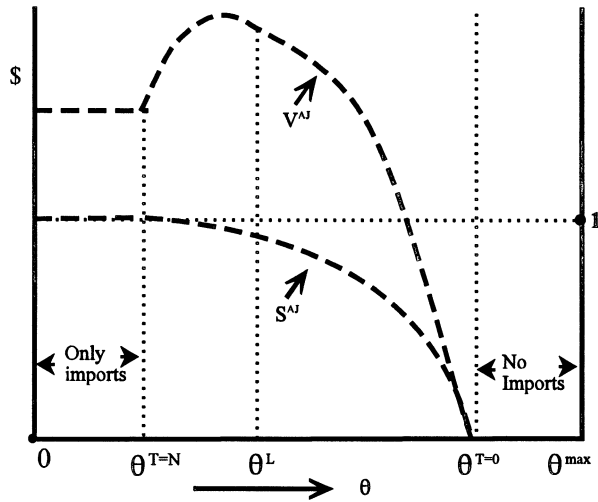


FIGURE 2

PRODUCTIVITY, θ , AND THE VALUE OF U.S. PARTS EXPORTS

it as simply due to incomplete accounting. We would argue, however, that the result has considerable relevance when considering the perceptions of a trade barrier that lie behind the U.S./Japan trade dispute concerning access to the Japanese market. Since it seems reasonable to suppose that the rents created by relationship-specific investments are, in fact, not observable outside the keiretsu, U.S. market participants and other interested parties could easily fall into this accounting trap. For example, by complaining that U.S. parts are not exported, despite prices that are less than half of made-in-Japan parts (see the quote, footnote 3), Church (1995) may well be suffering from this misperception. In the remainder of this section, we further develop the argument that relationship-specific investment can create perceptions of a trade barrier, by first examining the behavior of the J-maker's marginal cost and then considering effects arising from the size of the efficiency gap between the U.S. and Japan. As we will show, some of these effects of investment can mimic a government imposed trade barrier or simply create suspicion because they are counterintuitive and hard to understand.

Comparing (3.10) with (2.14), for a given output y^J , the effect of the opening of trade on the J-maker's marginal cost is given by

$$(5.1) \quad \gamma^{JF} - \gamma^J = - \left[\int_0^Z \delta^i di + \int_Z^T (\delta^i - \alpha r^i) di + \int_T^E (1 - \alpha) \delta^i di \right].$$

Since parts i for $i \leq Z$ involve no relationship-specific investment, they are all imported with the opening of trade and, as can be seen from (5.1), the J-maker's marginal cost for each part i falls by δ^i . However, it is not necessary that parts be imported for marginal cost to fall. Parts i for $i \in [T, E)$ continue to be produced by keiretsu suppliers, but marginal cost is reduced by $\gamma^{iF} - \gamma^i = -(1 - \alpha)\delta^i$ due to potential competition from imports. Indeed, since there is no change in marginal cost

for parts $i \geq E$ where Japan has a cost advantage, the J-maker's overall marginal cost falls if imports remain at zero with the removal of the trade restriction.

However, for parts i for $i \in (Z, T)$, which are produced with relationship-specific investment prior to trade and are imported subsequently, it is possible that the J-maker's marginal cost is increased. The problem is that if the J-maker's bargaining power, α , is large, it can be unprofitable for J-suppliers to invest, even though the rent created would exceed the efficiency gap by more than the cost of the investment.⁴⁴ It is even possible that the opening of trade would raise the J-maker's overall marginal cost.⁴⁵ Recalling that, prior to trade, marginal cost is $\gamma^i = c^i - \alpha r^i$, the opening of trade raises the marginal cost of part $i \in (Z, T)$ if and only if⁴⁶ $c^{*i} - \gamma^i = -(\delta^i - \alpha r^i) > 0$. If all J-suppliers set $k^i > 0$ prior to the opening of trade, but subsequently all parts are imported (which requires $\delta^i > 0$ for all i), then the first and third terms of (5.1) vanish and since $\delta^i - \alpha r^i$ is decreasing⁴⁷ in i , it follows that

$$(5.2) \quad \gamma^{JF} - \gamma^J = - \int_0^N (\delta^i - \alpha r^i) di > 0 \quad \text{if } \delta^0 - \alpha r^0 < 0.$$

This increase in cost requires that the J-maker's bargaining power be relatively large. Greater bargaining power has two opposing effects. It tends to reduce the J-maker's marginal cost, by lowering the bargained prices, p^{iF} , of parts for given levels of investment, but it also causes J-suppliers to reduce their relationship-specific investments, which reduces rents, making the suppliers more vulnerable to being replaced by imports. Thus as α is increased, the opening of trade causes a greater shift toward the use of imports, making it more likely that the loss of relationship-specific investment will cause the J-maker's marginal cost to rise. As Proposition A.2 of the Appendix shows, even if α is set at the J-maker's preferred level, satisfying $\partial \gamma^{JF} / \partial \alpha = 0$, we may have $\gamma^{JF} - \gamma^J > 0$ under some parameter values. Nevertheless, the possibility that $\gamma^{JF} - \gamma^J > 0$ remains a special case.

Further insight into the effects of trade on the J-maker's marginal cost is obtained by varying the size of the efficiency gap. For simplicity, we assume $\delta^i = \delta \equiv c^0 - c^{*0} \geq 0$ as in (3.1) and, to abstract from changes in γ^A , we assume that the J-maker is a monopolist. Variation in δ is achieved by varying c^{*0} holding c^0 fixed. Letting $\theta = \theta^{Z=0}$ denote the value of θ at which $Z = 0$, we assume for Proposition 7 that $\theta > \theta^{Z=0}$, and hence that all J-suppliers would set $k^i > 0$ at $\delta = 0$ or, equivalently, that all J-suppliers would invest in the presence of a prohibitive trade barrier. Letting $\delta = \delta^{T=0}$ represent the value of δ at which $T = 0$, we demonstrate that $\delta^{T=0} > 0$ and hence that no parts are imported for $\delta \in [0, \delta^{T=0}]$. Imports take place for $\delta > \delta^{T=0}$, but, as

⁴⁴ If $\alpha > 0$, it is possible that $\phi^{iF} < 0$, but that $\gamma^J(r^i - \delta^i) - k^i > 0$ (see (3.6)).

⁴⁵ This is an extreme example of the well-known inefficiencies in ex ante investment incentives associated with incomplete contracts (see for example, Laffont and Tirole, 1993).

⁴⁶ If $c^{*i} - \gamma^i > 0$, then since $\gamma^{iF} = \gamma^i - (1 - \alpha)\delta^i$ due to the threat of imports, keiretsu production of part i would lower the J-maker's marginal cost with or without trade (i.e., $\gamma^{iF} < \gamma^i < c^{*i}$). However, even if $c^{*i} - \gamma^i < 0$, it is possible that $\gamma^{iF} < c^{*i} < \gamma^i$ and hence that keiretsu production of part i at free trade would lower J-maker costs. From (3.5), this requires $c^{*i} - \gamma^{iF} = \alpha(r^i - \delta^i) > 0$ which holds for $i \geq T$, but which may also hold for some parts $i \in (Z, T)$, which would be imported at free trade.

⁴⁷ This follows since $d(\delta^i - \alpha r^i)/di = \delta'(i) - \alpha(dr^i/di) < 0$ for $i > Z$.

we show, this could increase the J-maker's marginal cost. All parts are imported if δ becomes sufficiently large.

PROPOSITION 7. *Assume $\theta > \theta^{Z=0}$, the J-maker is a monopolist, and $\delta^i = \delta = c^0 - c^{*0}$ as in (3.1). In response to the removal of the Japanese trade barrier or alternatively a reduction in U.S. costs at free trade:*

- (i) *no parts are imported for $\delta \in [0, \delta^{T=0}]$ where $\delta^{T=0} > 0$, but the J-maker's output y^J increases, and*
- (ii) *parts are imported for $\delta > \delta^{T=0}$, but it is possible that $d\gamma^{JF}/dc^{*0} < 0$ and hence that $\gamma^{JF} - \gamma^J > 0$.*

PROOF. See the Appendix.

From standard models, one would expect that the removal of protection or a reduction in import prices for intermediate goods would reduce domestic costs and that the associated increase in domestic final-good production would raise intermediate-good imports. By contrast, we have shown that relationship-specific investment can cause this line of reasoning to break down at two places. First, it is possible that the J-maker's cost is increased by the opening of trade (i.e., $\gamma^{JF} - \gamma^J > 0$ and $\partial\gamma^{JF}/dc^{*0} < 0$). Second, an increase in the J-maker's output causes the range of intermediate-good imports to fall, reducing the total value of these imports if θ is sufficiently large. In addition, given that the rents from relationship-specific investment are unobservable to potential U.S. exporters, they might expect that parts for which the U.S. has a cost advantage would all be imported at free trade. However, from Proposition 7(i), it is possible that no parts are imported. More generally, recalling the results of Propositions 2 and 6, a proportion S^C of lower cost U.S. parts would not be imported and the parts that are not imported are the "more important" parts involving a larger share of production costs. The fact that these responses go against the conventional wisdom and are not readily understandable from standard trade models could easily give rise to negative perceptions of a continuing trade barrier.

Supposing that U.S. suppliers form expectations of the J-maker's demand for their products based on Japanese pretrade production levels and on conventional responses to the opening of trade, under the first possibility of an increase in marginal cost, Japanese auto output and volume of demand for imports would be lower than expected. However, since this first possibility occurs only if the range of imported parts is "large," driving out investment that would otherwise lower the J-maker's marginal cost, this makes significant perceptions of a trade barrier less likely.⁴⁸ By contrast, in the more likely case that the opening of trade lowers the J-maker's marginal cost, the response of imports could create a particularly negative impression. Import levels are likely to be low relative to keiretsu production, and for a small efficiency gap, i.e., for $0 < \delta < \delta^{T=0}$, imports would remain at zero. This mimics a government imposed trade barrier since a reduction in import prices for parts or a move from protection to free trade in this region would not result in any imports.

⁴⁸ However, since y^J falls, if θ is not too high (see Proposition 6), U.S. suppliers might be suspicious that the volume and value of their exports is somehow restricted.

Also, the fact that there are no imports despite an increase in the J-maker's output (γ^{JF} falls in this region) could further strengthen the impression that the market is not really open. More generally, it would seem highly suspicious if in response to a fall in U.S. costs, the J-maker's output increases, but the range of imported parts falls.

Finally, some analysis of welfare effects seems worthwhile. World welfare, denoted W , is represented by the additively separable utility function, $W = u(Y) + Z$, where $u(Y)$ is the utility from final-good output, Y , and Z is the output of a tradable numeraire good produced under pure competition by labor alone. Imposing the budget constraint that all income is spent, we obtain $W \equiv u(Y) - PY + \pi^A + \pi^J + \Phi^F$ where, from (3.3) and (3.6), the total profit, Φ^F , of J-suppliers is given by

$$(5.3) \quad \Phi^F \equiv \int_T^N \phi^{iF} di = y^J(1 - \alpha) \left[\int_T^E (r^i - \delta^i) di + \int_E^N r^i di \right] - \int_T^N k^i di.$$

From (5.3), using $\partial \phi^i / \partial k^i = 0$ for $i \geq T$, $\phi^T = 0$, and $dy^J / d\theta \geq 0$, we obtain

$$d\Phi^F / d\theta = (1 - \alpha) \left[y^J \left(\int_T^N (r^i / \theta) di + \int_T^E (r^i - \delta^i) di + \int_E^N r^i di \right) (dy^J / d\theta) \right] > 0.$$

For $\alpha = 0$, since output y^J and hence y^A , Y , π^J , and π^A are unchanged (see Proposition 4), this effect of θ in raising Φ^F implies that relationship-specific investment raises Japanese and world welfare. For $\alpha > 0$, it follows using (B.4) and $dy^A / dy^J = -\pi_{AJ}^A / \pi_{AA}^A$ from (2.15) that

$$(5.4) \quad dy^J / d\theta > 0 \quad dy^A / d\theta = -\pi_{AJ}^A (\partial \gamma^{JF} / \partial \theta) / H \quad \text{and} \\ dY / d\theta = (p' / H) (\partial \gamma^{JF} / \partial \theta) > 0.$$

As can be seen from (5.4), both y^J and Y increase, but if $\pi_{AJ}^A < 0$ (the strategic substitutes case), then the A-maker's output, y^A , falls. This can reduce world welfare, since if the A-maker is the lower cost producer (i.e., if $\gamma^{JF} > \gamma^A$), the average cost of world production rises to the extent that J-maker's market share, y^J / Y , is increased. Nevertheless, if the J-maker is the lower cost producer (i.e., if $\gamma^{JF} \leq \gamma^A$), we show in Proposition 8 that an increase in θ increases both y^J / Y and world welfare.⁴⁹ This result applies independently of whether y^A and y^J are strategic substitutes or strategic complements.

PROPOSITION 8. *Assume $\theta > \theta^{Z=E}$. If $\gamma^{JF} \leq \gamma^A$ and $\alpha > 0$, then $d(y^J / Y) / d\theta > 0$ and $dW / d\theta > 0$.*

PROOF. See the Appendix.

With respect to Japanese welfare for $\alpha > 0$, there is some ambiguity as to the sign of $d\pi^J / d\theta$, but since π^J rises if y^A falls and Φ^F and Y both increase, Japan is

⁴⁹ This result is related to Fung (1998), who argues that although U.S. exports may be hurt by the activities of main banks in Japan, this can raise efficiency and world welfare.

certainly better off in the strategic substitutes case. For the U.S., since $d\pi^A/d\theta = y^A p'(dy^J/d\theta) < 0$ for $\alpha > 0$, it is a matter of weighing a consumer gain against a loss by the A-maker. Examining this trade-off, we let $W^A = u(Y^{AC}) - PY^{AC} + \pi^A$ denote U.S. welfare, where Y^{AC} is U.S. consumption. Since $dW^A/d\theta = -Y^{AC} p'(dY/d\theta) + y^A p'(dy^J/d\theta)$ (using (2.15)), this implies

$$dW^A/d\theta = -Y^{AC} p'(dy^A/d\theta) + (y^A - Y^{AC}) p'(dy^J/d\theta).$$

It follows that if U.S. production exceeds U.S. consumption (i.e., if $y^A > Y^{AC}$) and if y^A falls, then the reduction in U.S. profits dominates, causing W^A to fall. However, W^A rises for strategic complements and $y^A \leq Y^{AC}$.

6. CONCLUDING REMARKS

We have shown that the links between the J-maker and its suppliers due to relationship-specific investment within the keiretsu reduce the range of imported parts, making it harder for U.S. suppliers to access the Japanese market. Also, despite the associated increase in Japanese auto production and demand for parts, a sufficiently high level of relationship-specific investment will reduce the total value of parts imports from the U.S. and it is possible that no parts will be imported. Although we do not address the issue of whether membership in the keiretsu is “unfairly” exclusionary, since imports are driven out by the effect of relationship-specific investment in raising keiretsu efficiency, our analysis suggests that long-term supply arrangements within keiretsu could be defended on the basis that they are efficiency enhancing.

However, even if imports are not “unfairly” restricted, keiretsu supply relationships are likely to give rise to a perception of an “unfair” trade barrier. This is because the endogenous choice of investment within keiretsu can lead to counterintuitive responses in the levels of keiretsu production and imports, making it hard for outside observers to understand what is really happening. In particular, the removal of a government ban on imported parts can actually raise Japanese production costs, reducing Japanese auto output and total demand for parts. Also, if relationship-specific investment is sufficiently productive, then imports will remain at zero with the opening of trade or in response to a small reduction in U.S. costs at free trade, giving the appearance of a continuing “unfair” trade barrier. Strengthening this likely misperception is the fact that Japanese marginal costs fall in this case, raising Japanese production of both autos and parts. As a final point, we hope that recognition of these effects in the context of the policy debate concerning U.S./Japan trade issues would create a better understanding by the parties involved, helping to ease trade tensions.

APPENDIX

A.1. *Formal Contracts as an Alternative to Bargaining.* The payment scheme for keiretsu suppliers obtained in our bargaining framework could also be implemented through the use of contracts, signed in stage 0 before investment takes place. Assuming relationship-specific investment k^i is not verifiable by a third party and hence not

contractible, but the rent r^i is contractible, the contract price can be represented as a linear sharing rule (see Laffont and Tirole, 1993),

$$(A.1) \quad p^i = c^i + (1 - \alpha^c)(r^i - \delta^i) \text{ for } i \leq E \quad \text{and} \quad p^i = c^i + (1 - \alpha^c)r^i \text{ for } i \geq E$$

where α^c and $1 - \alpha^c$ for $\alpha^c \in [0, 1]$ respectively represent the shares of the J-maker and supplier i in the net cost reduction achieved by investment k^i . By signing the contract, supplier i agrees to supply any quantity of parts demanded at the price determined by (A.1). As previously mentioned, uncertainty could be added so as to disguise the value of k^i , but this is not necessary and the model becomes rather more complex.

Although the same outcome is achieved under the contract and bargaining models if the same sharing rule $\alpha^c = \alpha$ is used, the difference in the institutional settings could affect which sharing rule is chosen. The tradition in the procurement literature has been to choose the optimal contract from the viewpoint of the firm issuing the contracts or, alternately, based on considerations of efficiency and consumer welfare in a regulatory environment. Since the J-maker is responsible for purchasing inputs from a large number of suppliers, this suggests that the choice of α^c in a contracting framework might involve maximization of the J-maker's profit. However, in our keiretsu bargaining context, a more natural objective might be to maximize the aggregate profit of all keiretsu firms, including the J-suppliers. Despite these comments, it is not obvious what mechanism that would ensure the credibility of a commitment to a specific value of α , particularly in the bargaining framework. Fortunately, apart from the possibility that the opening of trade would raise the J-maker's marginal cost, our results are generally robust to the value of α .

A.2. The Sharing Rule and Profits within the Keiretsu. Now considering the incentives for the choice of α , we simplify the presentation by assuming the J-maker is a monopolist and that all parts can be produced more cheaply in the U.S. (i.e., $\delta^i > 0$ for all i). For purposes of comparison, we first set out the conditions determining the optimal choice of output and investment if the keiretsu were fully vertically integrated and if investment k^i were observable. From (2.4) and (5.3), the aggregate profit, denoted $\Pi \equiv \pi^J + \Phi^F$, of the keiretsu can be expressed as

$$(A.2) \quad \Pi = y^J(P(y^J) - \gamma) - \int_T^N k^i \, di \quad \text{where}$$

$$\gamma \equiv \gamma^{JF} - \int_T^N (1 - \alpha)(r^i - \delta^i) \, di = \int_0^T c^{*i} \, di + \int_T^N (c^i - r^i) \, di + w^0,$$

represents the marginal cost of the integrated firm. Hence, maximizing Π from (A.2), y^J and k^i satisfy

$$(A.3) \quad \begin{aligned} d\Pi/dy^J &= P + y^J P' - \gamma = 0 \quad \text{and} \\ d\Pi/dk^i &= y^J(dr^i/dk^i) - 1 = 0 \quad \text{if } i \geq T, \quad \text{where} \\ y^J(r^i - \delta^i) - k^i &\geq 0 \quad \text{for } i \geq T \quad \text{and} \quad y^J(r^i - \delta^i) - k^i < 0 \quad \text{for } i < T. \end{aligned}$$

Returning to the setting in which J-suppliers are independent and k^i is not contractible, if y^J is chosen to maximize aggregate keiretsu profit, Π , taking k^i as given, or if the objective is to minimize total keiretsu costs of production for a given level of output, then as shown in Proposition A.1(i), we obtain the standard result that returns to J-suppliers from investment should be fully internalized by setting $\alpha = 0$. Investments k^i and output y^J are then at the same joint profit maximizing levels as in (A.3). However, the inability to pay suppliers in the form of fixed costs, based on actual levels of investment, means that the markups paid to J-suppliers raise the J-maker's marginal cost. Thus, from (A.2) and (3.4), γ^{JF} exceeds γ by $\int_T^N (p^i - c^i) di$, creating a distortion from double marginalization. Consequently, output, y^J , is reduced below the joint profit maximizing level when the J-maker maximizes π^J as in our model. Since at $\alpha = 0$ and at $\alpha = 1$, γ^{JF} is at the maximum determined by the cost of importing all parts, this distortion can be partially offset by setting $\alpha > 0$ so as to reduce the J-maker's marginal cost. The effect on J-supplier profit is ambiguous, but, from Proposition A.1(ii), a small increase in α above zero raises both π^J and aggregate keiretsu profit, Π . More specifically, letting α^J and α^K represent the values of α that maximize π^J and Π , respectively, we obtain $0 < \alpha^K < \alpha^J < 1$, where γ^{JF} is minimized at α^J .

PROPOSITION A.1. Assume the J-maker has a monopoly of the final-good, $\delta^i > 0$ for all i and $T \leq N$. If J-suppliers choose k^i to maximize ϕ^i for a given level of y^J ,

- (i) then, holding y^J fixed, or, if y^J maximizes Π for given k^i , keiretsu profit Π is maximized at $\alpha = 0$, and
- (ii) if y^J maximizes π^J for given k^i , we obtain $0 < \alpha^K < \alpha^J < 1$, where α^J satisfies $\partial\gamma^{JF}/\partial\alpha = 0$.

PROOF. Assuming that $\phi^F(T, y^J; \theta, \alpha) = 0$ for some part T (as in (3.8)), then holding y^J fixed, we obtain $\partial T(y^J; \alpha)/\partial\alpha = -(\partial\phi^{FT}/\partial\alpha)/(\partial\phi^{FT}/\partial T)$ and hence, from (3.8), (3.9), and (2.7),

$$(A.4) \quad \partial T/\partial\alpha = \sigma(T)(r^T - \delta^T)/(1 - \alpha)\sigma'(T)r^T(1 + \chi^T) > 0.$$

For $i \geq T$, from $\partial\phi^i/\partial k^i = 0$ as in (2.7) we obtain $\partial k^i/\partial\alpha = h'(k^i)/(1 - \alpha)h''(k^i) < 0$ (see (2.2)) and hence

$$(A.5) \quad \partial r^i/\partial\alpha = (dr^i/dk^i)(\partial k^i/\partial\alpha) = -r^i\lambda^i/(1 - \alpha) < 0,$$

where $\lambda^i \equiv -(h'(k^i))^2/h(k^i)h''(k^i) > 0$ from (2.12). Also, we can show from (3.10) and (A.2) that

$$(A.6) \quad \partial\gamma^{JF}/\partial\alpha = -\int_T^N (r^i - \delta^i) di + \alpha(\partial\gamma/\partial\alpha),$$

where $\partial\gamma/\partial\alpha = -[\int_T^N (\partial r^i/\partial\alpha) di - (r^T - \delta^T)(\partial T/\partial\alpha)] > 0$ from (A.4) and (A.5). Next, from (5.3), $d\phi^{iF}/dk^i = 0$ for $i \geq T$ and $\phi^{TF} = 0$ and, also, from (2.4), we

obtain

$$(A.7) \quad d\Phi^F/d\alpha = -[y^J - (1 - \alpha)(dy^J/d\alpha)] \left(\int_T^N (r^i - \delta^i) di \right)$$

$$d\pi^J/d\alpha = (P + y^J P' - \gamma^{JF})(dy^J/d\alpha) - y^J(d\gamma^{JF}/d\alpha)$$

It then follows from $\Pi \equiv \pi^J + \Phi^F$, using (A.7), (A.2), and (A.6), that

$$(A.8) \quad d\Pi/d\alpha = (P + y^J P' - \gamma)(dy^J/d\alpha) - y^J[d\gamma^{JF}/d\alpha - \partial\gamma^{JF}/\partial\alpha + \alpha(\partial\gamma/\partial\alpha)]$$

- (i) If $d\Pi/dy^J = P + y^J P' - \gamma = 0$, then $y^J = y^J(\gamma)$ and $d\gamma^{JF}/d\alpha - \partial\gamma^{JF}/\partial\alpha = (d\gamma^{JF}/dy^J)(dy^J/d\gamma)(d\gamma/d\alpha)$ where $d\gamma/d\alpha = (\partial\gamma/\partial\alpha)/[1 - (d\gamma/dy^J)(dy^J/d\gamma)] > 0$. Since $dy^J/d\gamma < 0$ and $d\gamma^{JF}/dy^J \leq 0$ ($= 0$ at $\alpha = 0$) from (3.13), we obtain $d\gamma^{JF}/d\alpha - \partial\gamma^{JF}/\partial\alpha \geq 0$ ($= 0$ for $\alpha = 0$) and hence from (A.8), $d\Pi/d\alpha \leq 0$ ($= 0$ at $\alpha = 0$) and also $\partial\Pi/\partial\alpha = -\alpha y^J(\partial\gamma/\partial\alpha) \leq 0$ ($= 0$ at $\alpha = 0$), proving the result.
- (ii) If $\pi_J^J = P + y^J P' - \gamma^{JF} = 0$, then, using $d\gamma^{JF}/dy^J = 0$ at $\alpha = 0$ (see (3.13)), we obtain $d\gamma^{JF}/d\alpha - \partial\gamma^{JF}/\partial\alpha = (d\gamma^{JF}/dy^J)(dy^J/d\alpha) = 0$ at $\alpha = 0$. However, since $d\gamma^{JF}/d\alpha = \partial\gamma^{JF}/\partial\alpha < 0$ at $\alpha = 0$ (see (A.6)), it also follows that $dy^J/d\alpha = (dy^J/d\gamma^{JF})(d\gamma^{JF}/d\alpha) > 0$ at $\alpha = 0$ and hence from (A.8), using $\gamma^{JF} - \gamma > 0$ from (A.2), that $d\Pi/d\alpha = (\gamma^{JF} - \gamma)(dy^J/d\alpha) > 0$ at $\alpha = 0$. This proves $\alpha^K > 0$. Next, from (A.7), using (A.2) and (2.19), we obtain $d\pi^J/d\alpha = -y^J(d\gamma^{JF}/d\alpha) = -y^J \pi_{JJ}^J (\partial\gamma^{JF}/\partial\alpha)/(\pi_{JJ}^J - d\gamma^{JF}/dy^J)$. Since $\partial\gamma^{JF}/\partial\alpha < 0$ at $\alpha = 0$ and since γ^{JF} is continuous with the same value at $\alpha = 0$ as at $\alpha = 1$, it follows that $0 < \alpha^J < 1$ and that α^J satisfies $d\pi^J/d\alpha = d\gamma^{JF}/d\alpha = \partial\gamma^{JF}/\partial\alpha = 0$. Finally, using (A.7) and $dy^J/d\alpha = 0$ at $\alpha = \alpha^J$, we obtain $\alpha^K < \alpha^J$ since $d\Pi/d\alpha = d\Phi/d\alpha = -\int_T^N y^J(r^i - \delta^i) di < 0$ at $\alpha = \alpha^J$. Q.E.D.

Next, we show in Proposition A.2 that if $\partial\gamma^{JF}/\partial\alpha = 0$ and hence $\alpha = \alpha^J$ is at the level preferred by the J-maker, then it is possible that marginal cost is increased (i.e., $\gamma^{JF} - \gamma^J > 0$) by the opening of trade.

PROPOSITION A.2. *Assume $\delta^i > 0$ for all i and $T \leq N$. If $\delta^0 - \alpha r^0 \leq 0$ where α satisfies $\partial\gamma^{JF}/\partial\alpha = 0$, then there exists some $\ddot{\alpha} \in (0, 1)$ such that $\gamma^{JF} - \gamma^F > 0$ if $\alpha > \ddot{\alpha}$.*

PROOF. Since $\delta^1 - \alpha r^1 \leq 0$ implies $k^1 > 0$, it follows from (5.1) that

$$(A.9) \quad \gamma^{JF} - \gamma^J = -\int_0^T (\delta^i - \alpha r^i) di - (1 - \alpha) \int_T^N \delta^i di.$$

Since $\int_T^N (r^i - \delta^i) di = \alpha(\partial\gamma/\partial\alpha) > 0$ from $\partial\gamma^{JF}/\partial\alpha = 0$ and (A.6), rearranging (A.9), we obtain

$$(A.10) \quad \gamma^{JF} - \gamma^J = -\left(\int_T^N r^i di + \int_0^T \delta^i di \right) + \alpha \left[\int_0^N r^i di + (1 - \alpha)(\partial\gamma/\partial\alpha) \right].$$

Letting $\ddot{a} \equiv \Omega/(\Omega + \xi)$ where $\Omega \equiv \int_T^N r^i di + \int_0^T \delta^i di$ and $\xi \equiv \int_0^T (r^i - \delta^i) di + (1 - \alpha)(d\gamma/d\alpha)$, it follows from $\Omega > 0$ and $\xi > 0$ that $\ddot{a} \in (0, 1)$ and hence, from (A.10), that $\gamma^{JF} - \gamma^J > 0$ iff $\alpha \in (\ddot{a}, 1)$. Q.E.D.

A.3. *Proofs of Propositions 4, 6, 7, and 8.*

PROPOSITION 4. (i) $dy^J/d\theta > 0$ for $\alpha > 0$ ($= 0$ for $\alpha = 0$), (ii) $dZ/d\theta < 0$ for $Z \geq 0$, and (iii) $dT/d\theta < 0$ for $\theta \in (\theta^{Z=E}, \theta^{T=0})$. No parts are imported for $\theta \in [\theta^{T=0}, \theta^{\max}]$.

PROOF. (i) For $i \geq Z$, from $\partial\phi^i/\partial k^i = 0$ as in (2.7), we obtain $\partial k^i/\partial\theta = -h'(k^i)/\theta h''(k^i) > 0$ for a given y^J (see (2.2)). Since $\partial r^i/\partial\theta = w^o \sigma^i h(k^i)[1 + \theta h'(k^i)(\partial k^i/\partial\theta)/h(k^i)]$ using λ^i from (2.12), we obtain

$$(A.11) \quad \partial r^i/\partial\theta = r^i(1 + \lambda^i)/\theta > 0 \quad \text{for } k^i > 0.$$

Also, from (3.9) and $\partial\phi^{TF}/\partial\theta = y^J(1 - \alpha)r^T/\theta$ (from (3.8) using $\partial\phi^{TF}/\partial k^T = 0$ and $\partial r^i/\partial\theta = r^i/\theta$), we obtain

$$(A.12) \quad \partial T/\partial\theta = -\sigma(T)/\theta\sigma'(T)(1 + \chi^T) < 0 \quad \text{for } Z < E,$$

where $\chi^i > 0$ if $\delta'(i) < 0$ and $\chi^i = 0$ if $\delta'(i) = 0$. For $Z = E$, then $T = Z = E$ is constant. Next, from (3.10), using (A.11), (A.12), and $r^T - \delta^T \geq 0$ ($= 0$ for $T = Z = E$), we obtain

$$(A.13) \quad \partial\gamma^{JF}/\partial\theta = -\alpha \left[\int_T^N (\partial r^i/\partial\theta) di - (r^T - \delta^T)(\partial T/\partial\theta) \right] < 0 \quad \text{for } \alpha > 0.$$

and $\partial\gamma^{JF}/\partial\theta = 0$ at $\alpha = 0$. Finally, from $\gamma^{JF} = \gamma^J(y^{JF}; \theta)$, $y^{JF} = y^J(\gamma^{JF})$ and (2.18), it follows that $d\gamma^{JF}/d\theta = (\partial\gamma^{JF}/\partial\theta)/[1 - (d\gamma^{JF}/dy^J)(dy^J/d\gamma^{JF})] = (H^o/H)(\partial\gamma^{JF}/\partial\theta)$ and hence, from (2.18) and (A.13), that

$$(A.14) \quad dy^J/d\theta = (\pi_{AA}^A/H)(\partial\gamma^{JF}/\partial\theta) > 0 \quad \text{for } \alpha > 0 \text{ (} = 0 \text{ for } \alpha = 0 \text{)}.$$

(ii) Assuming $k^0 = 0$ and hence $Z \geq 0$, it follows from (2.9) that $dZ/dy^J = -\sigma(Z)/y^J\sigma'(Z) < 0$ and $\partial Z/\partial\theta = -\sigma(Z)/\theta\sigma'(Z) < 0$. Hence, using part (i), we obtain $dZ/d\theta = (\partial Z/\partial y^J)(dy^J/d\theta) + \partial Z/\partial\theta < 0$.

(iii) Since $Z = E$ at $\theta = \theta^{Z=E}$, it follows from part (ii) that $Z < E$ for $\theta > \theta^{Z=E}$. Hence, using (A.12), (A.14), and $dT/dy^J < 0$ from (3.11), we obtain $dT/d\theta = \partial T/\partial\theta + (dT/dy^J)(dy^J/d\theta) < 0$ for $\theta \in (\theta^{Z=E}, \theta^{T=0})$. Since imports are zero at $T = 0$, no parts are imported for $\theta \in [\theta^{T=0}, \theta^{\max}]$. Q.E.D.

PROPOSITION 6. Assume $\delta^i = \delta$ as in (3.1). There exists some $\theta^L \in [\theta^{T=N}, \theta^{T=0})$ such that for all $\theta \in (\theta^L, \theta^{T=0}]$, the total volume, Q^{AJ} , and value, V^{AJ} , of U.S. exports are reduced by (i) a small increase in output, y^J OR (ii) an increase in θ . An increase in θ reduces V^{AJ} more than in proportion to Q^{AJ} .

PROOF. (i) For $\theta \in [\theta^{T=N}, \theta^{T=0}]$, we obtain $dQ^{AJ}/dy^J = T + y^J(dT/dy^J)$ where $T = T(y^J, \theta)$. Thus, using $dT/dy^J < 0$ from (3.11), we have $dQ^{AJ}/dy^J < 0$ at $\theta = \theta^{T=0}$ (i.e., at $T = 0$). Since $d(dQ^{AJ}/dy^J)/d\theta < 0$ (see (A.16) below), it follows that if $dQ^{AJ}/dy^J > 0$ at $\theta = \theta^{T=N}$, then there exists some $\theta^L \in (\theta^{T=N}, \theta^{T=0})$ for which $dQ^{AJ}/dy^J = 0$ at $T = T(y^J, \theta^L)$ and hence $dQ^{AJ}/dy^J < 0$ for all $\theta \in (\theta^L, \theta^{T=0})$. If $dQ^{AJ}/dy^J \leq 0$ at $\theta = \theta^{T=N}$, then the result follows for $\theta^L = \theta^{T=N}$. Next, since $dV^{AJ}/dy^J = v^{AJ} + y^J c^{*T}(dT/dy^J)$ from (4.1), we obtain

$$(A.15) \quad dV^{AJ}/dy^J = c^{*T}(dQ^{AJ}/dy^J) + v^{AJ} - Tc^{*T}$$

where $v^{AJ} - Tc^{*T} \leq 0$ (< 0 for $T > 0$) from $dv^{AJ}/dT = c^{*T} > 0$ and $d^2v^{AJ}/(dT)^2 = c^{*'}(T) > 0$. Hence from (A.15), using $dQ^{AJ}/dy^J < 0$, we obtain $dV^{AJ}/dy^J < 0$ at $T = T(y^J, \theta)$ for all $\theta \in (\theta^L, \theta^{T=0})$.

To show $d(dQ^{AJ}/dy^J)/d\theta < 0$, we first expand it into the form $d(dQ^{AJ}/dy^J)/d\theta = \partial(dQ^{AJ}/dy^J)/\partial\theta + (d^2Q^{AJ}/(dy^J)^2)(dy^J/d\theta)$. Since $\partial(dQ^{AJ}/dy^J)/\partial\theta = \partial T/\partial\theta + y^J(\partial^2T/(\partial y^J)(\partial\theta))$, using $\delta^i(i) = 0$ and $\sigma^i(i) = 0$ from $\delta^i = \delta$ we next obtain $\partial T/\partial\theta = -\sigma(T)/\sigma'(T)\theta$ from (A.12) and $\partial^2T/(\partial\theta)(\partial y^J) = -(dT/dy^J)/\theta$ where $dT/dy^J = -(\sigma^T/\sigma'(T))(1 - (\delta/r^T))/y^J$ from (3.11). It then follows that $\partial(dQ^{AJ}/dy^J)/\partial\theta = -(\delta/r^T)(\sigma^T/\sigma'(T))/\theta < 0$. Also, from $d^2Q^{AJ}/(dy^J)^2 = 2(dT/dy^J) + y^J(d^2T/(dy^J)^2) = (\delta/r^T)[(dT/dy^J) - (\sigma^T/\sigma'(T))(dr^T/dy^J)/r^T]$ and $dr^T/dy^J = r^T\lambda^T/y^T + r^T(1 + \lambda^T)(\sigma'(T)/\sigma^T)(dT/dy^J)$ (see (3.12) and (2.13)), gathering terms in dT/dy^J , we can show $d^2Q^{AJ}/(dy^J)^2 = -(\delta/r^T)\lambda^T[\sigma^T/\sigma'(T)y^J + dT/dy^J] = -(\delta/r^T)^2(\sigma^T/\sigma'(T))\lambda^T/y^J < 0$. Hence, we obtain

$$(A.16) \quad d(dQ^{AJ}/dy^J)/d\theta = -(\delta/r^T)(\sigma^T/\sigma'(T))[(1/\theta) + (\delta/r^T)\lambda^T(dy^J/d\theta)/y^J] < 0.$$

(ii) Since $dQ^{AJ}/d\theta = (dQ^{AJ}/dy^J)(dy^J/d\theta) + y^J(\partial T/\partial\theta)$, using $\partial T/\partial\theta < 0$ from (A.12), $dy^J/d\theta \geq 0$ from (A.14), and $dQ^{AJ}/dy^J \leq 0$ from part (i), we obtain $dQ^{AJ}/d\theta < 0$ for $\theta \in [\theta^L, \theta^{T=0}]$. Similarly, since $dV^{AJ}/d\theta = (dV^{AJ}/dy^J)(dy^J/d\theta) + y^J(\partial v^{AJ}/\partial\theta)$, it follows using (A.15), $\partial v^{AJ}/\partial\theta = c^{*T}(\partial T/\partial\theta)$, and $v^{AJ} - Tc^{*T} \leq 0$ that $dV^{AJ}/d\theta = c^{*T}(dQ^{AJ}/d\theta) + (v^{AJ} - Tc^{*T})(dy^J/d\theta) < 0$ for $\theta \in [\theta^L, \theta^{T=0}]$. Dividing by V^{AJ} , we then obtain

$$(dV^{AJ}/d\theta)/V^{AJ} = T(c^{*T}/v^{AJ})(dQ^{AJ}/d\theta)/Q^{AJ} + (v^{AJ} - Tc^{*T})(dy^J/d\theta)/V^{AJ}$$

Since $Tc^{*T}/v^{AJ} > 1$ for $T > 0$, this implies $(dV^{AJ}/d\theta)/V^{AJ} < (dQ^{AJ}/d\theta)/Q^{AJ} < 0$ for all $\theta \in [\theta^L, \theta^{T=0}]$. Q.E.D.

PROPOSITION 7. Assume $\theta > \theta^{Z=0}$, the J-maker is a monopolist, and $\delta^i = \delta = c^0 - c^{*0}$ as in (3.1). In response to the removal of the Japanese trade barrier or alternatively a reduction in U.S. costs at free trade:

- (i) no parts are imported for $\delta \in [0, \delta^{T=0}]$ where $\delta^{T=0} > 0$, but the J-maker's output y^J increases, and
- (ii) parts are imported for $\delta > \delta^{T=0}$, but it is possible $d\gamma^{JF}/dc^{*0} < 0$ and hence that $\gamma^{JF} - \gamma^J > 0$.

PROOF. (i) Since $dy^J/dc^{*0} = (dy^J/d\gamma^{JF})(d\gamma^{JF}/dc^{*0})$ where $dy^J/d\gamma^{JF} = 1/\pi_{JJ}^J < 0$ from (2.19) and $d\gamma^{JF}/dc^{*0} = (\partial\gamma^{JF}/\partial c^{*0})\pi_{JJ}^J/(\pi_{JJ}^J - (d\gamma^J/dy^J))$ from $\gamma^{JF} = \gamma^F(y^J; c^{*0})$ and (2.19), it follows that

$$(A.17) \quad dy^J/dc^{*0} = (\partial\gamma^{JF}/dc^{*0})/(\pi_{JJ}^J - (d\gamma^J/dy^J)) < 0 \quad \text{iff } \partial\gamma^{JF}/\partial c^{*0} > 0.$$

Since $\theta > \theta^{Z=0}$, we have $k(\sigma^0, y^J) > 0$ as defined by (2.7) and hence $\phi^0 = \phi(\sigma^0, y^J) > 0$ from (2.11). For $\delta \equiv \delta^{T=0}$, since $\phi^{0F} = \phi^0 - y^J(1 - \alpha)\delta^{T=0} = 0$ (from (3.7) and (3.8)), $\phi^0 > 0$ implies $\delta^{T=0} = \phi^0/y^J(1 - \alpha) > 0$. If $\delta^{T=0}$ is unique,⁵⁰ or alternatively, letting $\delta^{T=0}$ represent the smallest value of δ at which $T = 0$, it follows that $\phi^{0F} \geq 0$ and hence that no parts are imported for $\delta \leq \delta^{T=0}$. Setting $T = 0$ in (3.10), we obtain $\partial\gamma^{JF}/\partial c^{*0} = (1 - \alpha)N > 0$ for $\delta \leq \delta^{T=0}$ and hence $dy^J/dc^{*0} < 0$ from (A.17). Also, since from (5.1), $\gamma^{JF} - \gamma^J = -(1 - \alpha)N\delta < 0$ for $\delta \leq \delta^{T=0}$, y^J increases with the opening of trade.

(ii) Expressing $T = T(y^J, c^{*0})$ from (3.8), it follows from (3.10), holding y^J fixed, that

$$(A.18) \quad \partial\gamma^{JF}/\partial c^{*0} = T + (1 - \alpha)(N - T) + \alpha(r^T - \delta)(\partial T/\partial c^{*0}),$$

where $\partial T/\partial c^{*0} = -\sigma(T)/\sigma'(T)r^T < 0$ for $\delta \geq \delta^{T=0}$ (from (3.8), (3.9), and $\chi^i = 0$). Noting that $\partial\gamma^{JF}/\partial c^{*0}$ is discontinuous at $\delta = \delta^{T=0}$, it then follows from (5.1), using the mean value theorem, that

$$\gamma^{JF} - \gamma^J = -(1 - \alpha)N\delta^{T=0} - (\partial\gamma^{JF}/\partial c^{*0})(\delta - \delta^{T=0}) \quad \text{for } \delta \geq \delta^{T=0},$$

where $\partial\gamma^{JF}/\partial c^{*0}$ represents $\partial\gamma^{JF}/\partial c^{*0}$ evaluated at some $c^{*0} \in [c^{*0}, c^0 - \delta^{T=0}]$. Hence $\partial\gamma^{JF}/\partial c^{*0} < 0$ is necessary, but not sufficient for $\gamma^{JF} - \gamma^J > 0$. Rearranging (A.18) using $\sigma(T) = \sigma(0) + T\sigma'(T)$ where $\sigma''(i) \equiv c''(i)/C(N) = 0$ from (3.1), it follows, letting $\psi \equiv r^T\sigma(0) - \delta\sigma(T)$ and $\hat{\alpha} \equiv N/(N + \psi)$, that for $\psi > 0$ and $\alpha > \hat{\alpha}$,

$$\partial\gamma^{JF}/\partial c^{*0} = N - \alpha[N + \psi/r^T\sigma'(T)] < 0.$$

Q.E.D.

PROPOSITION 8. Assume $\theta > \theta^{Z=E}$. If $\gamma^{JF} \leq \gamma^A$ and $\alpha > 0$, then $d(y^J/Y)/d\theta > 0$ and $dW/d\theta > 0$.

PROOF. (i) From $d(y^J/Y)/d\theta = [y^A(dy^J/d\theta) - y^{JF}(dy^A/d\theta)]/(Y)^2$, using (5.4), (A.14), (A.13), and (2.16) it then follows, independently of the sign of π_{AJ}^A , that for $\alpha > 0$ and $y^J \geq y^A$ (which holds for $\gamma^{JF} \leq \gamma^A$) that

$$(A.19) \quad d(y^J/Y)/d\theta = [y^A(3p' + Yp'') + (y^J - y^A)p'](\partial\gamma^{JF}/d\theta)/(Y)^2H > 0.$$

⁵⁰ Although $\partial\phi^{iF}/\partial c^{*0} > 0$ holding y^J fixed, if an increase in c^{*0} (fall in δ) reduces y^J , ϕ^{iF} may fall, causing more parts to be imported (T increases). Hence there may be more than one value of δ at which $T = 0$.

Next, we express W in the form $W = u(Y) - \bar{\gamma}Y + \Phi^F$ where $\bar{\gamma} \equiv \gamma^A(y^A/Y) + \gamma^{JF}(y^J/Y)$ represents the average world cost of production of Y . For $\alpha > 0$ and $\gamma^{JF} \leq \gamma^A$, it then follows that $d\bar{\gamma}/d\theta = (\gamma^{JF} - \gamma^A)(d(y^J/Y)/d\theta) + (y^J/Y)(d\gamma^{JF}/d\theta) < 0$ from $\gamma^{JF} - \gamma^A \leq 0$, (A.19), and (A.13) and hence, using $u'(Y) = P$, that

$$dW/d\theta = (P - \bar{\gamma})(dY/d\theta) - Y(d\bar{\gamma}/d\theta) + d\Phi/d\theta > 0.$$

Q.E.D.

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