Vertical Networks and US Auto Parts Exports: Is Japan Different?

Keith Head

University of British Columbia
Vancouver, BC V6T1Z2
keith.head@ubc.ca

John Ries

University of British Columbia
Vancouver, BC V6T1Z2
john.ries@ubc.ca

Barbara J. Spencer

University of British Columbia
Vancouver, BC V6T1Z2
and
National Bureau of Economic Research
barbara.spencer@sauder.ubc.ca

In a model where upstream network insiders conduct relationship-specific investment, downstream firms have an incentive to transact within networks. Evidence from US auto parts exports to 26 auto-producing countries supports key predictions of the model. Greater production scale for assemblers lowers imported parts per car. Vertical networks matter in two ways. First, although Japan's average import levels are not unusually low, non-Japanese suppliers have relatively low market penetration for parts categories where vertical keiretsu are prominent in Japan. Second, US-owned assembly abroad and foreign-owned parts production in the US both stimulate parts exports.

1. Introduction

Despite decades of tariff reductions and infrequent use of contingent protection, many observers continue to regard the Japanese market as

We appreciate the very helpful comments of Bruce Blonigen, Jerry Hausman, Hodaka Morita, James Rauch, and two referees. We also thank Thomas Krier, Kirk Monteverde, David Teece, and Douglas Marcouiller for providing data. The paper also has benefited from presentations at the 2002 National Bureau of Economic Research (NBER) Summer Institute in International Trade and Investment, Yale School of Management, University of Toronto, Sydney University, University of Calgary, and the Claremont Colleges. Barbara Spencer is grateful for financial support from the Social Sciences and Humanities Research Council of Canada.

Journal of Economics & Management Strategy, Volume 13, Number 1, Spring 2004, 37–67

"closed" to foreigners. In support of this claim, they point to persistent trade surpluses and to a relatively low import-to-gross-domestic-product (GDP) ratio (8.5% in 2002). Since formal trade barriers seem too small to explain the alleged lack of market access, commentators point instead to special business practices. As noted by the World Trade Organization's 1998 *Trade Policy Review*, "Concern remains about the effects on foreign access to Japan of horizontally and vertically integrated groups (*kigyo-shudan* and *keiretsu*)."

Keiretsu are well known and controversial but are not the only business networks with the potential to influence international trade. Rauch's (2001) survey discusses the trade-creating activities of networks comprising members of ethnic groups and affiliates of multinational corporations. Rauch describes how such networks promote trade by disseminating information on market opportunities and the trustworthiness of potential trade partners. An additional role seems relevant for vertical networks: the facilitation of investment by upstream firms that generates benefits for downstream firms.

This paper investigates the role of business networks in trade by examining the pattern of US auto parts exports to 26 countries from 1989 to 1994. We develop the model of Spencer and Qiu (2001) that identifies vertical networks as arising from the decision of suppliers to conduct relationship-specific investment. The theory contains implications for trade by identifying the parts likely to be produced within the network and those likely to be procured at arm's length from outsiders. We find evidence consistent with the model's proposition that a larger scale of production by local automakers reduces imports by encouraging local insiders to conduct relationship-specific investment. Our results indicate that Japan's imports tend to be lower for parts where vertical *keiretsu* are prominent. On average, though, the level of Japanese imports of parts from the US is about what one would expect given observed economic characteristics. We also find higher imports by countries with a larger amount of production by US automobile affiliates—especially for parts with high engineering costs. Finally, national linkages in the form of direct investment in the United States by foreign automotive firms are associated strongly with increased exports of parts back to the investing countries.

Our study contributes to the debate on whether Japan's imports are too low and whether vertical *keiretsu* are exclusionary. Lawrence (1993) cites studies showing that Japanese manufacturing imports are lower than the levels predicted by trade models. Moreover, Lawrence (1991) finds that import penetration decreases in Japan with increases in the share of both horizontal and vertical *keiretsu* sales across industries. Fung (1991) reports a negative relationship between US exports to Japan and the combined share of horizontal and vertical *keiretsu* sales. Saxonhouse (1993) identifies problems in the papers supporting the Lawrence position and presents his own evidence showing that Japan's distinctive trade structure can be explained by its pattern of factor endowments. Using a gravity model approach, Eaton and Tamura (1994) find that Japan is more open to US exports but is less open to foreign direct investment (FDI) than most countries in Western Europe. More recently, Ueda and Sasaki (1998) find that across a number of industries, members of vertical *keiretsu* import more than nonmembers and conclude that *keiretsu* are not an important nontariff barrier to Japanese imports.

Saxonhouse (1993) also points out that any import-reducing effects of *keiretsu* may be due to efficiency rather than to collusion. The Spencer and Qiu (2001) model provides a theoretical basis for networks as a vehicle for increasing efficiency and demonstrates that relationship-specific investments by *keiretsu* suppliers can give the appearance of a trade barrier by reducing imports of intermediate goods into Japan.

Miwa and Ramseyer (2000) review the theoretical and empirical work on the economic role of relationship-specific investment and vertical *keiretsu* in the automobile industry. Countering contrary views expressed by Asanuma (1989), Aoki (1988), and Dyer (1996), they argue that relationship-specific investment and extra-contractual governance mechanisms do not appear to play important roles.[1] Further arguments downplaying the role of relationship-specific investment are provided by Casadesus-Masanell and Spulber (2000), who find that General Motor's acquisition of Fisher Body was not an effort to avoid opportunism in the presence of asset specific investment. However, other research provides empirical evidence showing that US automakers tend to internalize the production of parts for which relationship-specific investment is important. Monteverde and Teece (1982), the source of some of the data used in this study, find that the likelihood that General Motors and Ford produce parts in house is associated positively with the engineering costs of part development and with a measure of model specificity. Klier (1994) and Masten et al. (1989) also conclude that concerns about opportunism influence the vertical integration decisions of US automakers. Based on the degree to which Japanese manufacturers avoid FDI in countries imposing import restrictions and local content requirements, Hackett and Srinivasan (1998) argue that the Japanese *keiretsu* system involves stronger vertical relationships than those of firms from the United States. We extend this literature by testing the implications of our model linking the decision to conduct relationship-specific investment to international trade.

1. The vertical *keiretsu* considered in this paper should be distinguished from the horizontal *keiretsu* that Miwa and Ramseyer (2002) characterize as a myth.

The paper proceeds as follows. Section 2 models how ex-post bargaining with an assembler affects the incentive of a parts supplier to make relationship-specific investments. It predicts that network firms will produce parts only for which the marginal product of relationship-specific investment exceeds a critical level, with outsiders supplying the remaining parts. Section 3 describes our dataset on US exports of 53 different vehicle parts to 26 importing countries over the period 1989–1994. We present and interpret the econometric results in Section 4. Finally, Section 5 summarizes the implications of these results for our understanding of business networks.

2. A Model of Vertical Networks

The model used in this study is an adaptation of Spencer and Qiu (2001).[2] An automaker chooses between purchasing parts from a member of its supply network or from independent firms. We will refer to the former as *insiders* and the latter as *outsiders*.

Insider suppliers differ from outsiders in that they make relationship-specific investments (RSI) that create rent for the maker for which the part is designed and not for other makers. An important aspect of RSI is that contracts typically are imperfect and provide no guarantee of a return. Within networks, the willingness of the maker to bargain with insiders over price ameliorates the hold-up problem by ensuring that suppliers receive some of the rent created by RSI. In contrast, outsiders must sell in the competitive arm's-length market at a price equal to marginal cost.

We model the rent created by RSI as a reduction in the maker's cost of assembly, which could be due, for example, to an improvement in the fit of the part with parts produced by other suppliers or perhaps to better coordination so as to improve the efficiency of just-in-time delivery.[3] For the moment, we do not specify the physical location of insiders and outsiders, but we have in mind that there is an advantage from physical proximity, which enhances the flow of information between insiders so as to raise the effectiveness of RSI.[4] In the terminology of Williamson

2. Qiu and Spencer (2002) also use this model to examine trade policy aimed at opening the Japanese market.

3. As pointed out by a referee, the assembler also may undertake RSI through, for example, the establishment of joint design teams with the suppliers or the training of supplier engineers. For simplicity, we abstract from such investments. Assuming that suppliers and the assembler face the same ranking of parts in terms of the efficacy of RSI, the main predictions of the model would not change.

4. Branstetter (2000) finds strong empirical evidence for the importance of the flow of technological information within vertical *keiretsu* in enhancing efficiency.

(1979), relationship-specific investments create asset specificity, which could be *physical*, such as would arise with customized machinery; *site specific*, such as improvements in coordination to economize on inventory or transport costs; or *human*, which would involve gains in know-how from experience and information sharing.[5]

For simplicity, we present the analysis for a representative maker with a given level of car production or scale of operation, denoted y. The assumption that y is exogenous allows us to develop the cost minimization problem associated with sourcing components without fully specifying the downstream product market.[6] However, the effect of variations in the maker's scale of operation will play an important role in the analysis and empirical estimation.

A large number, N, of parts is required to produce an automobile, with parts and labor combined in fixed proportion in final assembly. Each assembled auto requires β_i units of part i. For each part i, there is a single insider supplier (also referred to with subscript i) that potentially makes a relationship-specific investment, denoted k_i. This investment creates a rent for the maker in the form of a reduction in the assembly cost for each auto produced using the part from supplier i. Different parts have different potential for RSI. Letting $\rho_i = \rho(i) > 0$ denote a measure of the efficacy of RSI for part i, we assume that the relationship among the rent, denoted r_i, created per part used, and the level of k_i is given by

$$r_i = \rho_i \sqrt{k_i}. \tag{1}$$

This functional form implies that higher levels of RSI create more rent for the maker, but at a decreasing rate. We exploit the fact that N is large by ordering the parts on a continuum $i \in [0, N]$, with the parts varying from low to high values of RSI efficacy, ρ_i. We assume that $\rho(i)$ is increasing strictly in i, and hence $\rho'(i) > 0$ for all $i \in [0, N]$.

Let c_i represent the constant unit cost of production of part i for insiders. Outsiders supply a homogeneous version of the part in a competitive spot market at price p_i^*, which is equal to the lowest marginal cost at which the part can be supplied. Both c_i and p_i^* include all relevant transport costs to the maker's facility (as well as tariffs if the part is imported). We define δ as the cost advantage of sourcing from an

5. Based on these three forms of asset specificity, Dyer (1996) finds that Japanese automakers and suppliers are more specialized than their US counterparts but that there is considerable variation across automakers within Japan.

6. Spencer and Qiu's (2001) specification of the product market for cars as a Cournot duopoly with segmented markets reveals that the main insights of the model are robust to relaxing the single assembler assumption.

outsider: $\delta = c_i - p_i^*$. Note that δ does not include the rent generated by RSI. We assume for simplicity that δ is constant across parts.[7]

Although parts can be produced more cheaply by outsiders, the maker can gain from the purchase of part i from an insider supplier due to the effect of RSI in reducing assembly costs. Supposing that part i is purchased at price $p_i \geq c_i$, then the rent, r_i, created by RSI reduces the maker's net cost to $p_i - r_i$. Consequently, it is possible that $p_i - r_i < p_i^*$, reflecting an overall cost advantage to the maker from the use of insider-made parts. Since $\beta_i y$ represents the demand for each part (β_i units of each part are required per auto), the resulting profit for insider supplier i is given by

$$\pi_i = \beta_i y(p_i - c_i) - k_i. \tag{2}$$

We assume that the investment, k_i, is sunk prior to bargaining between each supplier and the maker as to price p_i and that an insider cannot be guaranteed a return based on a contract that is conditional on k_i. This is due to the difficulty of actually observing k_i, which would include nonobservable costs (or at least nonverifiable by courts), such as the costs of obtaining the information and of coordination with other suppliers. Consequently, the resulting price p_i can be based on r_i but not on k_i.

The order of moves is as follows: At stage 1, each supplier i commits to its investment $k_i \geq 0$ so as to maximize its own profits taking the maker's level of output, y, as given.[8] In making this decision, each supplier correctly anticipates the outcome of the stage 2 bargaining process determining the prices, p_i, for parts. We assume the maker at least will break even, but suppliers have to consider the possibility that if the agreed upon price is too low, RSI at stage 1 could result in a loss. At stage 2, the maker engages in Nash bargaining over price p_i simultaneously with each remaining supplier. If an agreement is reached with the supplier of part i, the maker orders the $\beta_i y$ parts needed to produce output y. Otherwise, the maker buys the same quantity of part i from the spot market supplied by outsider firms.

The maker's *marginal* cost due to part i is given by $p_i - r_i$ if it reaches an agreement in its bargaining with supplier i. It has a threat point of buying the part from outsiders at a price of p_i^* if bargaining breaks down. Thus, the maker's net payoff from reaching agreement is given by $[p_i^* - (p_i - r_i)]\beta_i y$, that is, the difference between the price of

7. Spencer and Qiu (2001) show that the theory can accommodate $\delta'(i) \leq 0$ and small values of $\delta'(i) > 0$. The empirical specification also could accommodate variation in δ across parts in the part-fixed effects.

8. In Spencer and Qiu (2001), the maker sets its output simultaneously with k_i, leading to a Nash equilibrium in k_i and y.

outsiders and the net cost of parts procured from insiders multiplied by the quantity of parts produced.

Correspondingly, since investment k_i is sunk by stage 2, supplier i's surplus from reaching an agreement is its variable profit, $(p_i - c_i)\beta_i y$. If bargaining breaks down, supplier i has the option of producing as an outsider for the spot market, but since $\delta > 0$, it will choose not to produce. The combined surplus from agreement is $[p_i^* - (p_i - r_i) + (p_i - c_i)]\beta_i y = (r_i - \delta)\beta_i y$.

Letting $\alpha \in [0, 1]$ represent the bargaining power of the maker, the Nash bargaining solution awards a share $1 - \alpha$ of the combined surplus from agreement to the supplier. Taking into account the cost of RSI, post-agreement supplier profit is

$$\pi_i = (1 - \alpha)(r_i - \delta)\beta_i y - k_i. \tag{3}$$

If $r_i - \delta < 0$ bargaining breaks down, the maker sources part i from outsiders, and the insider's profit would be $\pi_i = -k_i$. Note from (3) that suppliers must have at least some bargaining power (i.e., $\alpha < 1$) if they are to obtain a profit in stage 2. And since suppliers would not do RSI without an expected profit, it actually is beneficial to the maker to have less-than-complete bargaining power.

At stage 1, supplier i determines the optimal value of k_i in the event that it would produce the part by maximizing π_i as in (3), taking y as given. Using (1), this implies that

$$k_i = (\beta_i y(1 - \alpha)\rho_i)^2 / 4 \quad \text{and } r_i = \beta_i y(1 - \alpha)\rho_i^2 / 2. \tag{4}$$

As shown in (4), both k_i and r_i are increasing in the scale of maker operations y. Since parts are ordered on the basis of increasing efficacy of RSI ($\rho'(i) > 0$ for $i \in [0, N]$), k_i and r_i also are increasing strictly in i for $k_i > 0$. Even if $k_i > 0$ from (4), it is possible that revenue would not be sufficient to cover k_i, and hence supplier i would set $k_i = 0$ and not produce the part. We obtain the closed form for local supplier profits by substituting the solutions for k and r from (4) into equation (3), yielding

$$\pi_i = \beta_i y(1 - \alpha)\left[\beta_i y(1 - \alpha)\rho_i^2 / 4 - \delta\right]. \tag{5}$$

From (5), it is apparent that the greater is i, the greater is the potential insider profit:

$$d\pi_i / di = (\beta_i y(1 - \alpha))^2 \rho_i \rho'(i) / 2 > 0. \tag{6}$$

Defining part $i = T$ as the critical part for which $\pi_T = 0$, parts are produced by insiders with RSI for $i \geq T$ and by outsiders for $i < T$. In

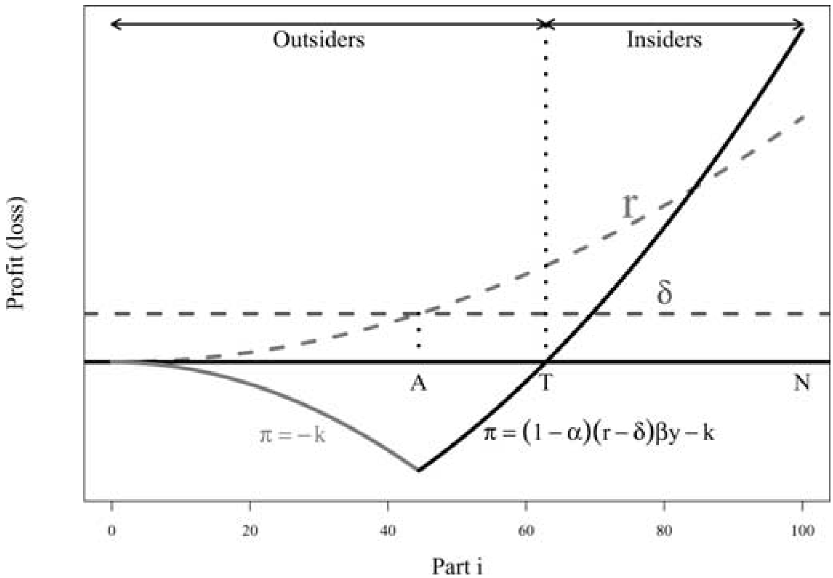

FIGURE 1. THE RANGE OF PARTS SOURCED FROM INSIDERS

terms of ρ_i, it follows that local production takes place if and only if $\rho_i \geq \rho_T$. Solving for the level of ρ that sets π equal to zero we obtain

$$\rho_T = 2\sqrt{\delta/[\beta_i y(1-\alpha)]}. \tag{7}$$

Figure 1 illustrates the model. Parts $i \in [0, N]$ are ordered along the X-axis in terms of increasing ρ_i. The upward-sloping dashed curve representing r_i corresponds to the hypothetical reduction in assembler costs if the supplier chose k_i according to equation (4). The possible profit (or loss) of supplier i if it chooses to produce is shown by the solid line, denoted π. For $r_i \geq \delta$, profit is given by equation (3), which is increasing in i. For $r_i < \delta$, the supplier anticipates that bargaining will break down and that it will suffer a loss equal to the amount of RSI (k_i). Since the lines denoting r_i and δ (the horizontal dashed line) cross at $i = A$, the maker would prefer insiders for all parts $i \geq A$. However, supplier i's share of the return for parts $i \in [A, T)$ is not sufficient to cover the cost of RSI with the outcome that these parts are sourced from outsiders. Profit is zero (the π line cuts the X-axis) at part $i = T$, which is the lowest value of RSI importance at which insiders can expect to break even. Each supplier i will commit to its RSI and will choose to produce for $i \geq T$ but will set $k_i = 0$ for $i < T$.

Since insiders make up-front relationship-specific investments, an increase in the derived demand for parts due to an increase in the maker's scale, y, raises the profitability of RSI by allowing k_i to be spread over more units. Consequently, an increase in y shifts up the insider's profit function in Figure 1, causing point T to shift to the left.[9] It follows that an increase in the scale of the maker leads to an increase in the range of parts produced by insiders and hence to a reduction in the content per auto produced by outsiders. This prediction plays an important role in our empirical analysis.

The implications of this model for trade depend on the locations of insiders and outsiders. The basic hypothesis used to develop the empirical specification is that insiders include local parts suppliers producing in the same country as the automaker. In particular, members of vertical *keiretsu* in Japan are viewed as insiders with respect to the production of auto parts for makers in Japan, but there also may be local vertical networks in other countries. This insider categorization is based on the logic that the information needed to design a part for a particular car model requires geographic proximity between upstream and downstream firms. However, we also consider the possibility that the coordination required for RSI can occur over longer distances if mediated by a multinational enterprise. Thus, a US supplier located in the United States might be an insider when it transacts with a US multinational firm operating in a foreign market. Correspondingly, an affiliate of a Japanese supplier located in the United States could be an insider when exporting parts to Japan. The empirical section will provide a test of the validity of these views of the boundaries of networks.

Since as currently specified the model predicts either zero sourcing of part i from outsiders or exactly $\beta_i y$ units, for the empirical specification, we adapt the model to reflect the greater continuity in export levels that we observe in the trade data. This involves relaxing our assumption of a representative maker so as to introduce heterogeneity across makers within each country as to the use of a local insider or outsider as a source for each part. Thus, due to differences in characteristics, one maker might be using local insiders for a given part i, while another uses outsiders for the same part. Consequently, each part will have a probability of being sourced from a local insider, leading to non-zero import probabilities for all parts.

We introduce this heterogeneity by assuming that the cost advantage for outsiders, $\delta = c_i - p_i^*$, varies randomly across the makers in each country, where c_i is the cost of insiders and p_i^* is the delivered price

9. More formally, from (5) and (6) obtain $dT/dy = -\rho_T/2y\rho'(T)$.

charged by outsiders. To account for variation in parameters such as costs, output per maker, and the efficacy of RSI across countries, we also add j subscripts to identify the country of production. From our model, the probability, denoted Λ_{ij}, that a maker in country j sources part i from a local insider then is given by the probability that δ_j is small enough to make $\pi_{ij} \geq 0$. Using π_{ij} from (5), we obtain

$$\Lambda_{ij} = \Pr[\pi_{ij} \geq 0] = \Pr\left[\delta_j \leq \beta_i y_j (1-\alpha)\rho_{ij}^2/4\right]. \tag{8}$$

The next step is to assume that δ_j is drawn from the Pareto distribution with scale parameter ϕ_j and shape parameter $\lambda > 1$. Thus, the expected value of δ_j, given by $\phi_j\lambda/(\lambda - 1)$, varies across countries but not across parts. The cumulative density function for a Pareto random variable is given by $F[x] = 1 - (\phi/x)^\lambda$, where ϕ is the scale parameter. The use of the Pareto distribution allows us to express the probability of selecting a local insider in the following multiplicative form:

$$\Lambda_{ij} = F\left[\beta_i y_j (1-\alpha)\rho_{ij}^2/4\right] = 1 - \left[4\phi_j/\beta_i y_j (1-\alpha)\rho_{ij}^2\right]^\lambda. \tag{9}$$

Under this formulation, the probability of using a local insider for part i is a continuous function of the parameters ρ_{ij} and y_j.

Even if a maker from country j does purchase part i from an outsider, the United States is not necessarily the cheapest source. Since our empirical analysis concerns the value of US exports of auto parts, we let Υ_{ij} represent the probability that a maker in country j imports part i from the United States conditional on not purchasing the part from a local insider. The overall probability that country j imports part i from the United States then is given by $(1 - \Lambda_{ij})\Upsilon_{ij}$. Thus, evaluating US exports at their free-on-board (fob) prices, denoted p_i^{fob}, and letting Y_j represent total car production in country j, the value of US exports of part i to country j is

$$V_{ij} = p_i^{\text{fob}} \beta_i Y_j (1 - \Lambda_{ij})\Upsilon_{ij}. \tag{10}$$

Dividing V_{ij} by Y_j and taking natural logs, it can be shown that[10]

$$\ln(V_{ij}/Y_j) = F_i - \lambda \ln y_j - 2\lambda \ln \rho_{ij} + \ln \Upsilon_{ij} + \lambda \ln(4\phi_j), \tag{11}$$

where $F_i \equiv \lambda(\ln 4 - \ln(1-\alpha)) - (\lambda - 1)\ln(\beta_i) + \ln p_i^{\text{fob}}$. We present the data and motivate the choice of variables in the next section. We develop the final regression specification in Section 4.

10. The result follows since $\ln(V_{ij}/Y_j) = \ln(p_i^{\text{fob}}\beta_i) + \ln(1 - \Lambda_{ij}) + \ln\Upsilon_{ij}$ from (10) and $\ln(1 - \Lambda_{ij}) = \lambda[\ln(4\phi_j) - \ln\beta_i - \ln y_j - \ln(1-\alpha) - 2\ln\rho_{ij}]$ from (9).

3. Data

We group the data into five categories: (1) US parts exports; (2) scale of car production; (3) direct investment and trade costs; (4) the efficacy of RSI; and (5) concordance and description of parts.

3.1 Exports of US Car Parts

Disaggregated US export data come from the Center for International Data (2001), maintained by Robert Feenstra at the University of California–Davis. These data, classified according to the harmonized system (HS), measure the fob *value* of parts exports from 1989 to 1994. We searched the HS descriptions to locate every 10-digit HS commodity category that involves automobile parts to obtain a complete set of export data to 26 countries producing motor vehicles. When possible, we confined the sample to parts specifically intended for passenger cars. In some cases even the most disaggregated HS codes do not distinguish among types of motor vehicles. A complete list of the HS codes that comprise our sample and their descriptions is available from the authors.

3.2 Scale of Car Production

Car production, Y_j, and average scale, y_j, are calculated from annual passenger car production data provided by the Motor Vehicle Manufacturers Association of the United States (1991–96) at the country and at the automaker level for 26 auto producing countries. We estimate M_j, the number of makers in country j, as the number of equal-sized makers in each country based on the inverse of a Herfindahl index, H_j, calculated with 1992 data. Thus, we set $y_j \equiv Y_j/M_j = Y_jH_j$.

3.3 Direct Investment and Trade Costs

Direct investment and trade cost data are used to control for factors that may influence the probability that a maker in country j would import part i from the United States conditional on not purchasing the part from a local insider [Υ_{ij} in equation (11)]. Under the hypothesis that US suppliers are insiders with respect to transactions with the "Big 3"—US-based automakers General Motors, Ford, and Chrysler—our theory suggests that the presence of the Big 3 in a country will promote the use of US suppliers and hence will raise US content per auto through increased imports from the United States. We identify production by majority-owned affiliates of the Big 3 for 26 countries using data from the Motor Vehicle Manufacturers Association of the United States (1991–96). Dividing by total car production in each host country, we define BIG3 as the share of annual production in each country accounted for by affiliates of the Big 3.

Direct investment into and out of the United States has implications for the pattern of trade in auto parts. In particular, overseas investment of multinationals can generate *reverse imports*—that is, sales from the host-country affiliates back to the home country. For example, the presence of Japanese auto parts companies in the United States may increase US auto parts exports to Japan. Building on a model by Baldwin and Ottaviano (2001), Greaney (2003) argues that asymmetric network effects, which she models as a foreign firm cost disadvantage in selling to home buyers, can amplify such reverse imports.[11] To capture these influences on US exports (seen as reverse imports by the investing countries), we control for the level of foreign direct investment in the US automotive sector.

It also is important to control for the direct investment of US suppliers abroad. If US suppliers follow US assemblers into foreign markets, failure to control for supplier investment will lead to estimates of the coefficient on BIG3 that reflect the influence of these investments. Supposing that supplier direct investment abroad substitutes for supplier exports, a negative bias would result.

To obtain measures for these controls, we collect data from the Bureau of Economic Analysis listing the number of employees of majority-owned, US affiliates in foreign countries (USDIA) and the number of employees of all foreign affiliates operating in the United States (USFDI) for the Motor Vehicles and Parts Industry.[12] Data based on majority ownership are preferable to maintain compatibility with our BIG3 measure but are not available for USFDI, which lists all affiliates with more than a 10% equity stake. Since parts exports are expressed

11. Baldwin and Ottaviano (2001) and Greaney (2003) consider an equilibrium in which multiproduct Coumot duopolists place one variety abroad and a substitute variety at home in order to reduce cross-variety cannibalization. In our empirical work, we treat FDI decisions as being determined outside the model. However, if our vertical network model were extended to allow for FDI, it would differ considerably from Greaney's model. First, different auto parts categories (e.g., wheels and windshields) are complements—not substitutes. Second, the bargaining relationships central to our model are not equivalent to a cost disadvantage in an arm's length market.

12. This data is not available at the level of auto parts. Also, data for the Motor Vehicles and Parts Industry is missing for some countries in our study. In these cases, we estimate data by multiplying the country's level of USDIA or USFDI in a more aggregated industry (Transportation Equipment or Other Manufactiring) by the relevant region's (e.g., Europe or Asia) share of Motor Vehicles and Parts in the more aggregated industry. In some cases a range is given or data are suppressed for confidentiality. When a range is given rather than actual levels, we use the midpoint of the range. When data are suppressed, we interpolate or extrapolate to fill in missing values.

relative to host country output in our regression specification [see (11)], we divide the USDIA and USFDI data by Y_j and multiply by 1,000 to obtain our direct investment measures, DIA and FDI, in units of number of employees per 1,000 cars produced in country *j*. This choice of units is convenient to avoid fractional values. Because DIA reflects employees in the Motor Vehicles and Parts Industry, DIA includes employees of the Big 3. However, since BIG3 will control for assembler investment, the coefficient on DIA may be interpreted as the effect of direct investment abroad by US suppliers.

Our final direct investment variable is a part-specific measure based on the employment of affiliates of Japanese auto parts producers in the United States. Using information from Dodwell Marketing Consultants (1997), we determine the level of employment by these Japanese affiliates for each of our parts categories and divide by the total employment across Japanese firms to compute JDI_i.[13] We expect this variable to have a positive affect on the probability that a part is exported from the United States.

A number of variables are used to capture trade costs, which we denote by the vector $\underline{\tau}_j$. Following standard practice in gravity equations, we calculate the log of great-circle distance in miles between country *j*'s major city and the population centroid of the United States (Kansas City: latitude 40N, longitude 95W). We also include indicator variables for countries that are English-speaking (Australia, Canada, and the United Kingdom) and that were communist in 1989 (China, Czechoslovakia, Hungary, Poland, USSR/CIS, and Yugoslavia). We also add indicators for Canada and Mexico to capture unique aspects such as trade arrangements (the 1965 Canada–United States Auto Pact and *maquiladora* program launched by Mexico in the same year) and for adjacency to the United States. Finally, we include the log of per-capita GDP (1989–94 World Bank data), another standard variable in gravity equations.

It is likely that cars exported to the United States can meet US safety and environmental standards more easily if they are equipped with relevant components imported from the United States. Consequently, we allow for the possibility that the propensity of country *j* to import parts from the United States is increasing in the share of country *j*'s car output exported to the United States, denoted by X-US.[14] We obtain

13. We confine the sample to the 136 manufacturing firms that were operating in the 1989 to 1994 period. All but 14 were operating in 1989. Rather than computing a time-varying measure that allows these 14 companies to be added to the sample over the six years, we instead use a time-invariant measure that reflects the employment of these 136 companies in the year 1996 that the data was reported.

14. We thank Jerry Hausman for this suggestion.

Table I.
Exports of US Parts to Auto-Producing Countries

Country (ISO code)	(1) Exp. % V_j/V	(2) Cars % Y_j/Y	(3) Scale y_j	(4) Big3 %	(5) DIA	(6) FDI
Canada (ca)	63.84	3.84	290	80.6	84.0	4.6
Mexico (mx)	21.80	2.40	146	57.1	119.1	0.2
Japan (jp)	4.22	30.85	1734	0.0	0.1	3.5
United Kingdom (uk)	1.84	4.51	299	42.9	59.6	5.1
Germany (de)	1.70	15.11	907	34.7	29.3	1.3
Australia (au)	1.24	1.07	87	60.8	50.5	0.1
Korea, S. (kr)	0.88	4.38	475	0.0	0.3	0.2
Belgium (be)	0.83	1.05	308	100.0	56.1	1.5
France (fr)	0.64	10.90	1162	0.0	4.5	1.7
Brazil (br)	0.57	2.98	242	37.0	54.9	0.0
The Netherlands (nl)	0.56	0.34	101	0.0	15.5	9.9
Taiwan (tw)	0.42	0.97	57	30.4	10.7	1.1
Italy (it)	0.32	5.34	907	0.0	10.7	0.5
Sweden (se)	0.23	1.09	188	0.0	0.7	3.3
China (cn)	0.16	0.45	68	0.0	0.0	0.1
Spain (es)	0.15	6.14	373	38.4	16.1	0.0
Austria (at)	0.15	0.08	24	0.0	202.9	6.3
Argentina (ar)	0.14	0.65	71	12.6	11.7	0.0
Turkey (tr)	0.12	0.74	101	2.4	3.1	0.0
Russia (ru)	0.06	3.97	386	0.0	0.0	0.0
India (in)	0.05	0.64	114	0.0	0.0	0.0
Malaysia (my)	0.04	0.39	114	0.0	0.0	1.0
Yugoslavia (yu)	0.02	0.48	52	0.0	0.0	0.0
Hungary (hu)	0.01	0.10	30	0.0	0.0	0.0
Poland (pl)	0.01	0.89	143	0.0	0.0	0.0
Czech R. (cz)	0.00	0.65	188	0.0	0.0	0.0

the value of US car imports by country of origin from the Center for International Data (2001).

Table I lists the 26 countries with passenger-car production together with an isocode used to identify each country. Column 1 lists each country's share of US exports (to the 26 countries), and column 2 provides each country's share of world car production outside the United States. Dividing by 1,000, we present the local scale, y_j, in column 3 in units of 1,000s of cars per maker. Column 4 reports BIG3 and shows that General Motors, Ford, and Chrysler produce cars in ten of the countries according to our data. Finally, columns 5 and 6 show the values of DIA and FDI, respectively.

The relationship between each country's share of car parts exports from the United States and its share of non-US car production (from

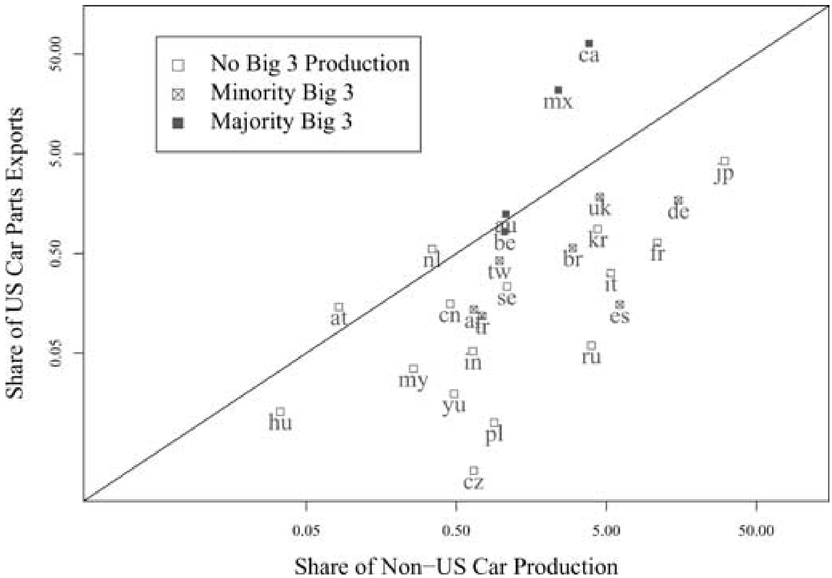

FIGURE 2. CAR PRODUCTION SHARES AND SHARES OF US PARTS EXPORTS

columns 2 and 3, respectively, in Table I) is shown in Figure 2. If each country imported US parts in the same fixed proportion to output, then the points would line up on the 45-degree line. We code each country into three categories: BIG3, namely "No Big 3 Production;" "Minority Big 3," less that 50% of output produced by Ford, General Motors, and Chrysler affiliates; and "Majority Big 3." Canada and Mexico are well above the 45-degree line and therefore have import shares much greater than production shares. On the other hand, the former communist nations, the CIS (ru), Czech Republic (cz), China (cn), Hungary (hu), and Yugoslavia (yu), import less than their car production share of US parts. Japan also lies below the 45-degree line.

3.4 Efficacy of RSI

Our formal theory does not specify the criteria determining which parts have high efficacy of RSI and hence involve strong vertical networks. One hypothesis is that vertical networks form to produce parts that have certain technical characteristics associated with a greater need for RSI. This group would include parts, such as engines, that involve costly investments in engineering and design that are relevant mainly to a particular automaker. Using information provided by a design engineer, Monteverde and Teece (1982) rate the engineering costs of developing each of the parts involved in a new car model on a 1–10 scale, with 10 being the highest. Supposing that these engineering costs are specific mostly to a maker, we use the engineering cost rating for part *i*, denoted by ECR_i, as a proxy for the efficacy of RSI. There are no doubt other technical characteristics that enhance the potential for RSI. For example, RSI could be important for achieving just-in-time delivery, with the nature of these investments varying over parts due to differing requirements for packaging and transport. We do not consider this possibility due to lack of data. Spencer and Qiu (2001) propose a further possibility (also not considered) that a higher efficacy of RSI is associated with parts that are more important part in the sense that they represent a greater share of the cost of an auto.

A second hypothesis is that a greater strength of network involvement in the production of a part may itself raise the efficacy of RSI for that part. Two features of vertical networks could be significant here. First, to the extent that membership in a vertical network reduces the hold-up problem, it will raise the incentive for suppliers to engage in RSI. This is reflected in our model by the ability of insiders to bargain so as to obtain a share of the rent from RSI. Second, information flows within vertical networks generally could improve the efficiency of RSI. This incorporates the possibility that the range of parts produced with RSI in a particular vertical network is determined at least partly by historical accident or cultural factors associated with the formation and operation of the network and not just by the technical characteristics of parts. Thus a vertical network, such as *keiretsu*, potentially could raise the efficacy of RSI for a particular group of parts, but these parts need not be the same as those with prominence in other vertical networks, such as in the United States. However, our data will not be able to distinguish this explanation for differences in the efficacy of RSI across networks from an alternative possibility, namely that the vertical network is based on cronyism and does not generate RSI. In this case, the preferential sourcing of parts from insiders would reduce rather than would raise the efficiency of production.

We develop three measures of the degree to which producers of particular parts participate in vertical networks in Japan and the United States. Two of these measures, INH-U_i and INH-J_i, measure the extent to which part *i* is produced in house in the United States and Japan, respectively, and the third, KEI_i, measures *keiretsu* involvement in the production of part *i* in Japan. Monteverde and Teece (1982) provide estimates of the share of in-house sourcing for each part by General Motors and Ford. INH-U_i is then a single measure (by part) of in-house production shares in the United States, generated by taking a weighted average of the Monteverde and Teece (1982) measures in which General

Motors has two-thirds weight in order to reflect roughly its production volume.

Our measures, INH-J$_i$ and KEI$_i$, are derived using data from Dodwell Marketing Consultants (1990), which lists the major Japanese suppliers of individual auto parts for each automobile manufacturer in Japan. It identifies whether the part is produced in house and provides information as to the grouping of each supplier. A supplier is considered to be in a particular maker's group based on the equity holdings of the maker, supplier reliance on the maker for 50% of its sales, or other factors such as historical relationships or personnel ties. Following standard terminology in the literature cited in the introduction, we refer to Dodwell's groupings as vertical *keiretsu*.

Defining a *link* as a unique pairing of a maker and a major supplier, we count the respective numbers of links involving in-house production and *keiretsu* for a given maker and part. Dividing by the total links for each maker, we then obtain the share of in-house links and *keiretsu* links per maker. Finally, to generate INH-J$_i$ and KEI$_i$ as single measures per part, we calculate the weighted average across makers of the shares of in-house links and *keiretsu*, respectively, using car production in 1996 as the weight. It is important to understand that a high value of KEI$_i$ or INH-J$_i$ for a particular part does not imply in itself that the value of imports of that part must be low. First, since the links that form the basis of our measures involve only suppliers located in Japan, the measures say nothing about the existence or otherwise of suppliers from the United States. Second, since the links provide no information on the value of sales and since the measures themselves are based on the proportion of links of a particular type (and not on the number of suppliers), the measures do not constrain in any way the value of production in Japan or the value of imports. The question as to whether a high value of KEI$_i$ or INH-J$_i$ actually is associated with a high proportion of production in Japan and hence with a low proportion of imports is addressed in our empirical analysis.

Using the example of mufflers, which has a large *keiretsu* presence, Table II illustrates the derivation of the INH-J$_i$ and KEI$_i$ variables. The table sets out the main suppliers of mufflers [as defined by Dodwell (1990)] for the makers in Japan. We illustrate supply links by in-house production with $\oplus$, supply by a *keiretsu* member with $\otimes$, and supply by an outsider with $\odot$. The first section lists the makers to show production in house. For the case of mufflers, Suzuki is the only maker to produce in house. Since for Suzuki there are two other suppliers (Futaba and Sankei GK), its ratio of in-house links to total links is 1 to 3. Weighting by the fraction of output (8%) produced by Suzuki, INH-J$_i$ (not shown) for mufflers is 2.67%. The next group of suppliers, Sango to Hoei, represents firms that

Table II.
Major Suppliers of Mufflers to the Six Largest Automakers

Maker	Toyota	Nissan	Honda	Mazda	Mitsubishi	Suzuki
Toyota						
Nissan						
Honda						
Mazda						
Mitsubishi						
Suzuki						$\oplus$
Sango	$\otimes$					
Futaba	$\otimes$		$\odot$		$\odot$	$\odot$
Calsonic		$\otimes$				
Sankei GK			$\otimes$			$\odot$
Niho				$\otimes$		
Sankei K				$\odot$	$\otimes$	
Hoei					$\otimes$	
Comex				$\odot$		
Miyoshi				$\odot$		
Fraction In House	0	0	0	0	0	1/3
Fraction *keiretsu*	2/2	1/1	1/2	1/4	2/3	0/3
Weight	36%	18%	12%	8%	10%	8%

are part of one of the makers' *keiretsu*. However, it is interesting to note that some of these suppliers also produce for makers outside their own *keiretsu*. Thus, Futaba is part of the Toyota *keiretsu* but also produces for Honda, Mitsubishi, and Suzuki. The final two suppliers, Comex and Miyoshi, are outsiders that supply only Mazda. As can be seen from Table II, there are only two suppliers for Toyota (Sango and Futaba), and since they are both member of the Toyota *keiretsu*, the number of *keiretsu* links relative to total links is $2/2 = 1$. Weighting this fraction by the share of output across the makers listed in the table (covering 92% of auto output), we obtain $\text{KEI}_i = 68.67/0.92 = 74.6\%$.[15]

In all, we have four proxies for the strength or intensity of vertical networks disaggregated by auto parts, which we use to capture the efficacy of relationship-specific investment. None of these variables contain time-series variation. Table III defines the variables and displays their correlations. We also report correlations with JDI_i, our measure of

15. Accounting for links with the makers (Daihatsu, Fuji, Hino, and Isuzu) not shown in the table, we obtain $\text{KEI}_i = 72.4\%$ for mufflers. For concordance with the trade data, we combine mufflers with exhaust pipes. Since $\text{KEI}_i = 73.4\%$ for exhaust pipes, we obtain $\text{KEI}_i = 72.9\%$ for the combined category.

TABLE III.
CORRELATIONS BETWEEN PARTS-LEVEL PROXIES FOR NETWORK STRENGTH

	$INH\text{-}J_i$	KEI_i	$INH\text{-}U_i$	ECR_i	JDI_i
$INH\text{-}J_i$: Japan In-House Links (%)	1.000				
	(50)				
KEI_i: *Keiretsu* Links (%)	−0.059	1.000			
	(50)	(50)			
$INH\text{-}U_i$: GM/Ford In-House Sourcing (%)	0.294	−0.144	1.000		
	(39)	(39)	(41)		
ECR_i: Engineering Cost Rating (1–10)	0.601*	0.019	0.333*	1.000	
	(40)	(40)	(41)	(42)	
JDI_i: Japanese Employment in US (%)	−0.144	−0.290*	0.055	−0.040	1.000
	(50)	(50)	(41)	(42)	(53)

Note: An * denotes significance at the 5% level. The number of observations used in the pairwise correlations are shown in parentheses.

the share of part *i* in FDI by affiliates of Japanese auto parts producers in the United States. Monteverde and Teece (1982) establish that the technical measure, ECR_i, is related positively to General Motors's and Ford's decision to produce in house. We also observe this positive association in our correlations, since $INH\text{-}U_i$ has a significant and positive correlation with ECR_i. Interestingly, Japanese in-house production as measured by $INH\text{-}J_i$ has an even stronger positive relationship with ECR_i. These correlations indicate that parts with high engineering cost ratings tend to be produced in house. In contrast, Table III shows that our other measure of the strength of network participation, KEI_i, has virtually no correlation with ECR_i and has a negative but insignificant correlation with $INH\text{-}J_i$ and $INH\text{-}U_i$. If all four proxies are driven by the same underlying reason for RSI, then they all should be correlated positively. Leaving aside measurement problems, this suggests that parts produced with high *keiretsu* involvement are not associated with high costs of engineering. *Keiretsu*-produced parts may be associated with some other technical characteristics, such as those involved with just-in-time delivery, but it also is possible that they mainly reflect historical relationships specific to Japan. Finally, KEI_i has a negative correlation (5% significance level) with our Japanese FDI measure, JDI_i, indicating that parts categories with a high proportion of *keiretsu* links tend to be associated with a low share of employment by Japanese affiliates in the United States.[16]

16. This negative correlation does not imply that *keiretsu* suppliers have a lower propensity for FDI in the United States than other suppliers of the same part. Instead, it suggests that parts classifications offering the greatest benefits of direct investment in the United States generally were not the parts for which *keiretsu* members represent a high proportion of Japanese-parts producers.

3.5 Concordance and Description of Parts

The different sources have unique ways of categorizing parts. The export data is identified according to the HS, whereas the data from Dodwell Marketing Consultants (1990) and Monteverde and Teece (1982) reflects the categorization of the authors. We created a concordance to combine the information from the difference sources. Based on an examination of the data, we formed the 53 parts classifications shown in Table IV. These categories reflect a level of aggregation equaling or exceeding the aggregation level in the various sources. Thus, each of the parts categories used in the different sources of data is mapped to one of the categories we devised. In cases where multiple parts categories are combined in a single category of ours, we summed the HS-level exports and averaged the RSI proxies.

The 26 auto-producing countries in this sample imported an average of 39.6 of the 53 different parts, with only six countries importing fewer than 30 parts. All parts (except brake hose) were shipped to at least 11 countries.[17] In column 1 of Table IV, parts are ordered by their share of the value of US parts exports. Engines top the list at 15.4%, followed by transmissions (8.1%) and then by body stampings (8.0%). Column 2 displays Japan's share of US parts exports for each part. This column reveals high Japanese imports of catalytic converters (26.2%), tires (22.7%), and starter motors (16.1%). In contrast, Japanese purchases account for less than 1.3% of engines, transmissions, and body stampings exports from the United States. The last four columns of Table IV specify the share of in-house links in Japan (INH-J_i), *keiretsu* links in Japan (KEI_i), engineering cost ratings (ECR_i), and the share of Japanese parts investment in the United States (JDI_i) for each part. Column 6 shows that the largest share of FDI, 25.8%, is in the Tires category, largely reflecting Bridgestone's acquisition of Firestone. Blanks in the table indicate incomplete data for measures of engineering cost and network participation.

4. Regression Analysis

Recall that (11) expresses the value of US exports of part i to country j relative to total production of cars in country j, V_{ij}/Y_j, as a function of the number of vehicles produced per maker in country j, Y_j, the efficacy of RSI for part i in country j, ρ_{ij}, and the probability that country j imports part i from the United States conditional on the part not being purchased from a local insider, γ_{ij}.

17. See Head et al. (2002) for details.

TABLE IV.

AUTO PARTS CATEGORIES USED IN THIS STUDY (ORDERED BY EXPORT SHARE)

Part	(1) % of Total V_i/V	(2) % to Japan V_{iJ}/V_i	(3) INH-J	(4) KEI	(5) ECR	(6) JDI
Engines	15.3	1.3	53.4	25.0	9.0	0.0
Transmissions	8.0	0.4	24.0	54.6	10.0	1.6
Body Stampings	8.0	0.2			8.0	3.5
Engine Parts	7.3	3.3	14.7	23.6	7.3	4.1
Wiring Sets	6.7	0.8	0.0	0.8	4.0	7.1
Tires	5.4	22.6	0.0	0.0		25.8
Brakes	5.2	1.6	5.2	34.8	5.7	1.7
Axles	4.9	0.6	49.2	31.3	10.0	0.0
Seat Parts	3.9	3.8	0.0	48.5	4.0	10.4
Bumpers	2.8	12.3	31.0	17.6	7.0	0.0
Wheels	2.6	9.7	7.3	29.2	5.7	1.8
Steering	2.5	0.5	13.8	38.5	7.1	4.6
Catalytic Converters	2.3	26.1	22.3	20.5	9.0	0.3
Mufflers and Exhaust Pipes	2.0	13.9	1.3	72.9	3.0	0.8
Safety Belts	1.7	0.4	0.0	17.8	3.0	0.0
Radios	1.7	4.5	0.0	4.5	5.7	3.3
Windshield Wipers	1.4	0.8	0.0	16.0	7.0	0.4
Baskets	1.3	1.9	0.0	13.4		5.5
Radiators	1.2	1.2	0.0	27.0	8.0	1.8
Windows	1.2	5.9	0.0	6.0	1.0	2.8
Lighting	1.2	0.5	0.0	33.1	3.5	3.9
Fuel Pumps	1.1	0.8	1.3	49.9	6.0	0.3
Climate Control	1.1	7.2	6.6	47.5	5.7	4.1
Shock Absorbers	1.1	1.9	11.9	12.0	2.0	1.3
Starter Motors	1.0	16.1	0.0	35.8	7.0	0.0
Alternators	0.8	1.0	0.0	35.8	7.0	0.1
Oil/Fuel Filters	0.7	2.1	0.0	51.6	1.0	0.3
Flasher Units	0.6	3.5	0.0	59.5		0.0
Diesel Fuel Injectors	0.6	4.4	0.0	35.6		0.0
Intake Air Filters	0.5	12.2	0.0	34.0	4.3	0.2
Batteries	0.5	0.7	0.0	0.0	2.0	3.2
Seats	0.5	2.8	10.4	48.3		2.8
Clutches	0.5	4.1	9.7	44.4		0.3
Mirrors	0.5	1.1	0.0	26.2	5.0	0.5
Meters	0.4	2.8	0.0	23.8	8.0	2.6
Brake Linings	0.4	0.9	0.0	11.9		0.0
Driveshafts	0.4	0.8	20.4	32.6	3.0	0.0
Cam/Crankshafts	0.4	0.7	39.7	16.9	9.0	0.0
Hinges	0.3	0.5	0.0	60.5	5.0	0.6
Locks	0.3	0.2	0.0	58.5	5.5	0.2
Spark Plugs	0.3	5.0	0.0	17.8	1.0	0.4

Continued

Table IV.
Continued

Part	(1) % of Total V_i/V	(2) % to Japan V_{iJ}/V_i	(3) INH-J	(4) KEI	(5) ECR	(6) JDI
Ignition Coils	0.3	0.7	0.0	47.6	2.0	0.1
Distributors	0.2	0.4	0.0	41.6	6.0	0.0
Coil Springs	0.2	0.2	0.0	11.9	3.0	0.5
Fans	0.2	0.4	0.0	53.2	4.0	0.0
Body Shells	0.2	7.9				0.0
Horns	0.1	0.8	0.0	47.8	2.0	0.0
Furniture Parts	0.1	2.5	4.9	44.5	4.7	2.8
Flywheels and Pulleys	0.1	0.6	6.8	64.4		0.0
Rubber Mechanical Articles	0.0	6.3	0.0	0.0		0.0
Clocks	0.0	1.7	0.0	32.3	2.0	0.0
Chassis	0.0	1.8			6.8	0.0
Brake Hose	0.0	0.3	0.0	40.5		0.3

For the empirical implementation, we assume that the log of ρ_{ij} takes the form

$$\ln \rho_{ij} = E_i + \theta_i \text{JPN}_j, \tag{12}$$

where JPN_j equals one for Japan and zero otherwise. The constant term E_i will be combined with F_i from (11) and will be absorbed into a fixed effect for each part. We initially assume that θ_i is given by a constant, θ_0, that does not vary over parts. If unique Japanese institutions raise the efficacy of RSI for all parts, then θ_0 is positive, which when substituted back into (11) would imply a lower level of imports by Japan. Subsequent specification will assume that θ_i varies over parts by interacting the relevant strength of network proxies from Table III with JPN. Since our strength of network proxies are included in E_i, the use of fixed effects precludes direct estimation of the effects of these proxies on the average level of imports across countries.

Next, to specify the probability that parts not purchased from local insiders are sourced from the United States, we assume that

$$\ln \Upsilon_{ij} = \nu_i - \underline{\psi} \cdot \underline{\tau}_j + \omega_i \text{BIG3}_j + \varphi_1 \text{DIA}_j + \varphi_2 \text{FDI}_j + \varphi_3 \, \text{JDI}_i \cdot \text{JPN}_j, \tag{13}$$

where ν_i is a term reflecting US efficiency in part i relative to other countries. For economy of notation, we include the share of country j's car output exported to the United States (X-US) in our (column) vector $\underline{\tau}_j$ of trade costs of US shipments to country.

If US parts exporters are insiders in business relations with the foreign subsidiaries of US makers, we would expect that the coefficient

ω_i of BIG3 in (13) is positive. Initially, we assume that $\omega_i = \omega_0$ and hence that it does not vary over parts. However, our theory also suggests that subsidiaries of the Big 3 would import relatively more RSI-intensive parts from the United States, which we test by interacting the relevant strength of network proxies from Table III with BIG3. As explained in section 3, combined with BIG3, we expect DIA to enter negatively in (13) if foreign direct investment by US parts suppliers substitutes for US exports.[18] The term FDI controls for the possibility that foreign direct investment by country j's firms in auto part production in the United States raises country j's imports. Since our part-specific measure JDI_i concerning the share of each auto part in direct investment into the United States is limited to Japanese investments, this term is included as an interaction variable with Japan.

Substituting (13) and (12) into (11) and adding an error term ε_{ij}, our full specification is

$$\ln(V_{ij}/Y_j) = \text{FE}_i - \underline{\psi} \cdot \underline{\tau}_j - \lambda \ln y_j + \gamma_i \text{JPN}_j + \omega_i \text{BIG}3_j + \varphi_1 \text{DIA}_j + \varphi_2 \text{FDI}_j + \varepsilon_{ij}, \tag{14}$$

where $\gamma_i \equiv \varphi_3 \, \text{jdi}_i - 2\lambda\theta_i$ and where $\text{FE}_i \equiv F_i - 2\lambda E_i + \nu_i$ is the fixed effect for each part. The term $\lambda \ln(4\phi_j)$ from (11) is included in ε_{ij}, which is assumed to be distributed normally. We note that the part-fixed effect FE_i will absorb additional part-specific influences on trade such as the number of suppliers for each part (affecting the ability of insiders to obtain part of the surplus from RSI) and the weight/value of each part (affecting the likelihood of importing the part).

Table V reports the coefficients from (14) estimated using our panel of parts exports from 1989 to 1994. All regressions include year-specific intercepts and standards errors that are robust to correlation across time for country-part combinations.[19] Most of the coefficients of the variables included in the trade cost vector ($\underline{\tau}_j$) are sensible and significant. Canada and Mexico import significantly more than average. This reflects both geography and trade policy.[20] The one perverse result is a positive estimated effect of distance. In regressions without the Canada and Mexico indicator variables, the estimated coefficient on distance is negative and significant. Higher per capita income leads to higher parts imports,

18. With the inclusion of DIA, we need to clarify that Λ_{ij} and Υ_{ij}, respectively, represent the probability that a maker will use a local supplier with origin in country j and the probability that a maker in country j would import part i from the United States conditional on not purchasing part i from a local insider with origin in country j.

19. We use Stata's "robust cluster" command.

20. Note that our sample predates the North American Free Trade Agreement (NAFTA) and that Canada and the United States essentially had integrated markets in autos and their parts due to the 1965 Canada in United States Auto Pact.

Table V.
The Impact of Destination-Country Attributes on the Value of Car Parts Exports from the US

	Dependent Variable: ln US Exports per Car $\ln(V_{ij}/Y_j)$					
	(1)	(2)	(3)	(4)	(5)	(6)
Canada	5.54[a]	2.96[a]	2.95[a]	2.95[a]	3.94[a]	3.94[a]
	(0.58)	(0.57)	(0.55)	(0.55)	(0.55)	(0.55)
Mexico	6.32[a]	4.11[a]	3.90[a]	3.90[a]	5.04[a]	5.04[a]
	(0.36)	(0.37)	(0.37)	(0.37)	(0.38)	(0.38)
ln Distance from US	1.59[a]	0.19	0.22	0.23	0.97[a]	0.97[a]
	(0.20)	(0.21)	(0.21)	(0.22)	(0.23)	(0.23)
ln GDP/Pop	0.27[a]	0.28[a]	0.26[a]	0.26[a]	0.22[a]	0.22[a]
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
English Speaking	0.98[a]	0.94[a]	0.72[a]	0.71[a]	0.50[a]	0.50[a]
	(0.11)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)
Communist	−0.26	−0.84[a]	−0.76[a]	−0.75[a]	−0.51[a]	−0.51[a]
	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)
X-US (Car Exports to US/Y_j)	0.90[a]	1.05[a]	0.97[a]	0.97[a]	1.07[a]	1.07[a]
	(0.34)	(0.32)	(0.31)	(0.32)	(0.30)	(0.30)
JPN (Japan Dummy)	−1.44[a]	0.22	0.39[c]	0.39[c]	−0.06	−0.29
	(0.19)	(0.21)	(0.21)	(0.21)	(0.22)	(0.22)
ln y (ln Cars per Maker)		−0.74[a]	−0.74[a]	−0.74[a]	−0.63[a]	−0.63[a]
		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
BIG3 (Big 3 Output/Y_j)			0.69[a]	0.68[a]	1.09[a]	1.09[a]
			(0.17)	(0.17)	(0.17)	(0.17)
DIA (US Employment in j/Y_j)				0.13	−1.77[b]	−1.77[b]
				(0.82)	(0.78)	(0.78)
FDI (j Employment in US/Y_j)					115.19[a]	115.16[a]
					(8.44)	(8.44)
$\text{JDI}_i \cdot \text{JPN}$ (Share of i in Japanese employment in US)						11.73[a]
						(2.78)
N	6177	6177	6177	6177	6177	6177
R^2	0.560	0.631	0.634	0.634	0.649	0.65
RMSE	1.73	1.586	1.578	1.578	1.547	1.544

Notes: Sample period runs from 1989 to 1994. Part-specific and year-specific dummy variables are included but are not reported.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
[c]Significant at the 10% level.

perhaps due to association with better transportation infrastructure. English-speaking countries import more US parts, whereas communist countries import fewer parts. Also, a higher proportion of car exports to the United States (X-US) is associated with a greater proportion of imports of US auto parts. This suggests that nations import US auto parts partly in order to comply with US technical regulations for motor vehicles.

Column 1 in Table V shows a "naive" specification that omits the effect of local scale $\ln y_j$ (output per maker), which is implied by the model. In this specification, the log of the ratio of country j's parts imports to its output of cars, $\ln(V_{ij}/Y_j)$, depends only on the variables in $\underline{\tau}_j$, which is consistent with the proposition that after correcting for trade costs, each country imports parts from the United States in proportion to its production. Since the coefficient of the Japan dummy, JPN, is negative and is significant at the 1% level in column 1, this specification suggests that Japanese imports are too low. Column 2, portraying results when we add $\ln y_j$, reveals that the negative Japan effect is a consequence of failing to control for local scale effects that enter negatively and significantly. Japan's imports do not differ significantly from those of other countries. The R^2 also improves from 0.56 to 0.63.

Column 3 shows results when we add BIG3 measuring the share of a county's car production accounted for by the Big 3 US automakers. This has a positive effect on US parts exports at the 1% significance level. Since Japan has no majority-owned Big 3 affiliates, its level of auto parts imports cannot be explained by a US assembler presence, and therefore Japan appears to import more parts than other countries (10% significance level).

Japan's relative trade performance, however, partly may be a consequence of a failure to correct for the direct investment activity of parts suppliers. If FDI substitutes for imports, then higher levels of FDI by US suppliers in countries other than Japan would tend to reduce US exports to these countries. Also, a higher-than-average level of investment by Japanese automotive firms in the United States could lead to a higher-than-average level of reverse imports of parts back to Japan due to network ties among national firms.[21] Adding DIA and FDI to control for US direct investment abroad and for FDI into the United States, the results are reported in the last three columns of Table V. Column 4 shows that DIA entered alone has an insignificant positive effect on parts exports. However, also having included FDI in columns 5 and 6, the coefficient of DIA becomes negative at the 5% significance level, providing support for the idea that direct investment by US suppliers abroad substitutes for US parts exports. Also, we find that FDI in the United States strongly promotes trade to the home country. Once both these direct investment variables are included, the Japan dummy variable becomes insignificant. Finally in column 6, the notion that the

21. We thank a referee for alerting us to the potential influence of FDI patterns on Japan's import levels.

US affiliates of Japanese parts producers are highly active in shipping parts to Japan is reinforced by the fact that JDI_i, our measure of the share of part *i* in employment by Japanese parts suppliers in the US, is positive and highly significant.

The results in Table V indicate that countries with US assemblers on average import more US parts and that Japan imports roughly the amount of parts one would expect given its economic characteristics and the effects of foreign direct investment in promoting or in substituting for trade. A full analysis of whether Japan is a high or low importer also would require consideration of the effects of trade barriers such as tariffs and domestic content requirements. Since Japan is viewed as having low formal trade barriers, correcting for trade barriers may make Japan's imports look low. Also, pressure from the United States may have increased Japan's imports of auto parts during our sample period.[22]

The results reported in Table VI focus on the factors that influence the type of part exported to Japan as well as the type of part exported to countries with a large Big 3 presence. This involves testing various hypotheses by interacting JPN and BIG3 with the relevant strength of network proxies from Table III. We also further explore the effect of our part-specific measure JDI_i, which we already have shown is significant in explaining the pattern of exports to Japan.

The specifications in Table VI include all variables employed in column 6 of Table V, but we only report the coefficients on JPN, BIG3, $\text{JDI}_i \cdot \text{JPN}$, and further interactions to economize on space. The unreported variables do not vary over parts, and the signs of the coefficient estimates and their significance are unaffected by the addition of the interaction variables. Column 1 displays results when we add $\text{KEI}_i \cdot \text{JPN}$ and $\text{KEI}_i \cdot \text{JDI}_i \cdot \text{JPN}$. The latter variable allows for the effect of Japanese FDI in the United States on exports of parts to be influenced systematically by the levels of *keiretsu* participation in part production. The negative coefficient on $\text{KEI}_i \cdot \text{JPN}$ indicates that parts for which *keiretsu* are prominent tend not to be exported to Japan but that the effect is not statistically significant. However, the positive and significant coefficient on $\text{KEI}_i \cdot \text{JDI}_i \cdot \text{JPN}$ reveals that Japanese FDI in the United States particularly promotes exports of *keiretsu*-intensive parts. Column 2 reflects a similar specification, except that ECR_i replaces KEI_i in the interactions. The insignificant estimates suggest that variation in the engineering cost rating does not influence the pattern of Japanese imports across parts or the trade-promoting effect of Japanese FDI.[23]

22. In response to President George Bush's trip to Japan in January 1992, Japanese automakers announced a "voluntary" plan to double their 1990 imports of US auto parts by 1994. Actual imports rose 30% in 1993 [see McMillan (1996)].

23. At a referee's suggestion, we also tested for an interaction between KEI and ECR. The estimated effect was insignificant.

TABLE VI.
THE IMPACT OF PROXIES FOR NETWORK STRENGTH ON THE PATTERN OF US AUTO PARTS EXPORTS

	Dependent Variable: ln US Exports per Car, $\ln(V_{ij}/Y_j)$					
Model	(1)	(2)	(3)	(4)	(5)	(6)
JPN (Japan Dummy)	0.05	−0.84[c]	−0.27	−0.31	0.06	0.36
	(0.41)	(0.50)	(0.28)	(0.23)	(0.41)	(0.37)
BIG3 (Big 3 Output/Y_j)	1.09[a]	1.16[a]	0.66[c]	0.98[a]	0.98[a]	1.01[a]
	(0.17)	(0.19)	(0.35)	(0.17)	(0.17)	(0.18)
JDI$_i$ · JPN	7.50[a]	44.73[b]	19.03[a]	11.37[a]	7.28[a]	6.04[a]
(Share Japanese employment in US)	(2.32)	(18.65)	(6.25)	(2.70)	(2.36)	(2.29)
KEI$_i$ · JPN	−1.29				−1.32	−2.33[b]
(*Keiretsu* Links)	(1.19)				(1.19)	(0.92)
KEI$_i$ · JDI$_i$ · JPN	32.94[b]				33.08[b]	39.00[a]
	(14.98)				(14.92)	(14.38)
ECR$_i$ · JPN		1.14				
(Engineering Cost Rating)		(0.88)				
ECR$_i$ · JDI$_i$ · JPN		−54.06				
		(38.93)				
ECR$_i$ · BIG3			0.95[c]			
			(0.56)			
INH-J$_i$ · BIG3				1.63	1.65	1.64
(Japan In-House Links)				(1.04)	(1.04)	(1.04)
N	5895	4951	4951	5895	5895	5791
R^2	0.653	0.651	0.652	0.653	0.654	0.66
RMSE	1.522	1.568	1.567	1.522	1.521	1.507

Notes: Sample period runs from 1989 to 1994. Year effects are included but are not reported.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
[c]Significant at the 10% level.

Column 3 provides information on whether countries with a greater presence of the Big 3 tend to import parts with higher engineering cost ratings. This would be the case if ECR$_i$ measures the efficacy of RSI and if US suppliers are insiders when transacting with the Big 3 abroad. The positive and significant estimate on ECR$_i$ · BIG3 (10% significance level) is consistent with this hypothesis. In the next column, we replace ECR$_i$ with INH-J$_i$ as the interaction with BIG3. This allows us to increase the sample size (ECR$_i$ data are only available for 40 of our parts categories) by using a variable we found to be correlated strongly with the engineering cost rating (see Table III). The effect is still positive but is slightly less significant.[24] The column 5 results combine the interactions used in

24. We do not report the result for an interaction between BIG3 and INH-U$_i$, which enters insignificantly.

columns 1 and 4 and yield almost identical results to those found when they were estimated separately.

Column 6 shows results utilizing the previous specification but estimated without the parts category Mufflers and Exhaust Pipes. From Table IV, this category represents only 2% of the parts exported from the United States but 13.9% of the parts imported by Japan. This high level of Japanese imports may reflect the importance of US-made exhaust systems in ensuring that cars destined for the United States comply with US emission standards. Any such effect would not be captured fully by X-US, since it corrects only for the average relationship between imports of parts and exports of cars to the United States. When Mufflers and Exhaust Pipes is excluded, we find that the base *keiretsu* effect is negative and significant at the 5% level. Thus, for parts categories with low levels of US investment, the effect of *keiretsu* is to deter exports to Japan. However, as in columns 1 and 5, the interaction of a high level of *keiretsu* participation and a high level of Japanese FDI in the United States promotes exports. Nevertheless, for all but the three parts categories with values of JDI_i above 6% (see Table IV), we find that the net effect of *keiretsu* is to reduce exports. This suggests that the effect of *keiretsu* typically is negative. Indeed, when we drop $\text{KEI}_i \cdot \text{JPN} \cdot \text{JDI}_i$ from the regression shown in column 6, the coefficient on KEI_i is negative and significant at the 10% level.

The specification used in Table VI has the advantage that information from 40 to 50 parts is combined to obtain the estimates of the responsiveness of US exports to import-country characteristics. It imposes the restriction that the only differences in coefficients across parts lie in the fixed effect and the interactions with JPN and BIG3. This leads to efficient estimation if the assumption holds. However, there are plausible reasons to believe that coefficients on other variables might vary also across parts. For instance, as mentioned above, the import sensitivity to X-US may vary across parts. In addition, differences in transportability in all likelihood should lead to differences in distance and adjacency (Canada and Mexico) effects. This could change our results of interest if there were a correlation, for instance, between transportability and the proxies for the efficacy of RSI.

We investigate the robustness of our results by using the following two-step method that relaxes the restrictions on the estimated coefficients. In the first step, instead of stacking the parts and estimating fixed effects, we estimate (14) for each part. Thus, all coefficients (not just the intercept) are allowed to vary from part to part. Since there is no variation in the RSI proxies and JDI_i for a given part, the interactions employing these variables are omitted in the first step. We are interested specifically in recovering $\hat{\gamma}_i$ and $\hat{\omega}_i$, the estimated coefficients on JPN and

BIG3, in order to investigate the part-specific information that explains variation in their magnitudes. In the second step, we regress $\hat{\gamma}_i$ on JDI_i, KEI_i, and $\text{KEI}_i \cdot \text{JDI}_i$. A second regression fits $\hat{\omega}_i$ to INH-J_i. These second-step regressions have only one observation per part. The coefficients $\hat{\gamma}_i$ and $\hat{\omega}_i$ have different standard errors that we use as (inverse) weights to correct for heteroskedasticity.[25] The intercepts of the second-step regressions correspond to the coefficients on JPN and BIG3 shown in Table V.

In the step-one regressions for each part (not shown for brevity), the mean value for each explanatory variable corresponds very closely to the estimates shown in Table V. Interestingly, the relationship between exports of Mufflers and Exhaust Pipes and the explanatory variables differs dramatically from the rest of the sample. Specifically, the estimates for every coefficient for this part (including the coefficient of X-US) fall outside the 95% confidence interval surrounding the mean of the estimates of the other part categories.

The second-step regressions yield the following results:

$$\hat{\gamma}_i = \underset{(.38)}{0.52} + \underset{(4.38)}{0.76}\ \text{JDI}_i - \underset{(1.02)}{2.79}\ \text{KEI}_i + \underset{(25.03)}{70.48}\ \text{JDI}_i \cdot \text{KEI}_i$$

$$\hat{\omega}_i = \underset{(.20)}{0.97} + \underset{(1.51)}{1.45}\ \text{INH-J}_i.$$

The numbers in parentheses below the coefficients are standard errors. Despite using information on the full set of parts, the results demonstrate *keiretsu* effects that are significant (1% level) and larger than those shown in the last column in Table VI when we excluded Mufflers and Exhaust Pipes. Note that JDI_i enters insignificantly on its own, although it has a positive effect when interacted with KEI_i. This means that parts with a high level of employment by Japanese affiliates in the United States are associated with a high level of exports only in conjunction with a strong *keiretsu* presence. This specification is able to explain 26% of the cross-part variance in the Japan coefficient. The second regression shows that, as before, INH-J_i is related positively to the coefficient on BIG3, ω_i but that it is not significant.

5. Conclusion

The pattern of US auto parts exports exhibits significant relationships that support our theory emphasizing the role of vertical networks in trade. Greater scale of host-country auto production lowers import

25. See Saxonhouse (1976) for this method. We use Stata's robust cluster command to obtain the first-step standard errors.

penetration, a result supporting the model's prediction that local scale increases the returns to relationship-specific investment. After controlling for production scale and other country characteristics, we find that Japan's import levels are not outliers. However, variation in the strength of *keiretsu* influences the composition of Japanese parts imports. In general, US exports to Japan are reduced for parts where *keiretsu* sourcing is more important. This trade-reducing effect dominates the trade-creating effect of the combination of a high *keiretsu* presence and a high level of Japanese parts production in the United States. In addition to the *keiretsu* effects, other results underscore the importance of vertical networks in trade. Countries where US automakers account for large shares of car production tend to import more parts from the United States. Moreover, countries whose firms employ more automotive sector workers in the United States tend to import more US auto parts.

A preference for insiders over outsiders results in our model from endogenous decisions by insiders to conduct relationship-specific investment. Insider networks may reflect technical characteristics of parts that give rise to a high efficacy of RSI or themselves may generate greater efficacy of RSI. In this context, rather than being exclusionary, networks can be a source of greater efficiency in production. Our results are consistent with this view of networks, but further evidence would be required to reject the hypothesis that particular networks, such as *keiretsu* in Japan, reflect cronyism. Since vertical *keiretsu* links are not correlated with engineering cost ratings, they do not appear to reflect technical efficiency, at least as far as we can measure it. Thus, the economic basis for cross-part variation in the prominence of *keiretsu* remains a puzzle that merits further investigation.

References

Aoki, M., 1988, *Information, Incentives, and Bargaining in the Japanese Economy*, Cambridge, UK: Cambridge University Press.

Asanuma, B., 1989, "Manufacture-Supplier Relationships in Japan and the Concept of Relation-Specific Skill," *Journal of the Japanese and International Economies*, 3, 1–30.

Baldwin, R.E. and G.I.P. Ottaviano, 2001, "Multiproduct Multinationals and Reciprocal FDI Dumping," *Journal of International Economics*, 54, 429–448.

Branstetter, L., 2000, "Vertical Keiretsu and Knowledge Spillovers in Japanese Manufacturing: An Empirical Assessment," *Journal of the Japanese and International Economies*, 14, 73–104.

Casadesus-Masanell, R. and D.F. Spulber, 2000, "The Fable of Fisher Body," *Journal of Law and Economics*, 43, 67–103.

Center for International Data, 2001, http://data.econ.ucdavis.edu/international/index.html, University of California–Davis (accessed 21 March 2001).

Dodwell Marketing Consultants, 1990, *The Structure of the Japanese Auto Parts Industry*, Tokyo, Japan: Dodwell Marketing Consultants.

——, 1997, *The Structure of the Japanese Auto Parts Industry*, Tokyo, Japan: Dodwell Marketing Consultants.

Dyer, J.H., 1996, "Specialized Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry," *Strategic Management Journal*, 17, 271–291.

Eaton, J. and A. Tamura, 1994, "Bilateralism and Regionalism in Japanese and US Trade and Direct Foreign Investment Patterns," *Journal of the Japanese and International Economies*, 8, 478–510.

Fung, K.C., 1991, "Characteristics of Japanese Industrial Groups and Their Potential Impact on US–Japan Trade," in R. Baldwin, R., ed., *Empirical Studies of Commercial Policy*, Chicago, IL: University of Chicago Press, 137–168.

Greaney, T.M., 2003, "Reverse Importing and Asymmetric Trade and FDI: A Networks Explanation," *Journal of International Economics*, 61(2), 453–465.

Hackett, S.C. and K. Srinivasan, (1998), "Do Supplier Switching Costs Differ across Japanese and US Multinational Firms?" *Japan and the World Economy*, 10, 13–32.

Head, K., J. Ries and B.J. Spencer, 2002, "Vertical Networks and US Auto Parts Exports: Is Japan Different?" NBER Working Paper, No. 9162.

Klier, T., 1994, "Lean Manufacturing and the Decision to Vertically Integrate: Some Empirical Evidence from the US Automobile Industry," Federal Reserve Bank of Chicago Working Paper (wp-1994-1).

Lawrence, R.Z., 1991, "Efficient or Exclusionist? The Import Behavior of Japanese Corporate Groups," *Brookings Papers on Economic Activity*, 1, 311–330.

——, 1993, "Japan's Different Trade Regime: An Analysis with Particular Reference to *Keiretsu*," *Journal of Economic Perspectives*, 7, 3–19.

Masten, S.E., J.W. Meehan and E.A. Snyder, 1989, "Vertical Integration in the US Auto Industry," *Journal of Economic Behavior and Organization*, 12, 265–273.

McMillan, J., 1996, "Why Does Japan Resist Foreign Market-Opening Pressure?" in J. Bhagwati and R. Hudec, eds., *Harmonization and Fair Trade*, Cambridge, MA: MIT Press, 515–541.

Miwa, Y. and J.M. Ramseyer, 2000, "Rethinking Relationship-Specific Investments: Contracting in the Japanese Automobile Industry," *Michigan Law Review*, 98, 2636–2667.

—— and ——, 2002, "The Fable of the *Keiretsu*," *Journal of Economics & Management Strategy*, 11, 169–224.

Monteverde, K. and D.J. Teece, 1982, "Supplier Switching Costs and Vertical Integration in the Automobile Industry," *Bell Journal of Economics*, 13, 206–213.

Motor Vehicle Manufacturers Association (MVMA) of the United States, 1991–1996, *World Motor Vehicle Data*, Detroit, MI: MVMA.

Qiu, L.D. and B.J. Spencer, 2002, "*Keiretsu* and Relationship-Specific Investments: Implications for Market-Opening Policy," *Journal of International Economics*, 58, 49–79.

Rauch, J.E., 2001, "Business and Social Networks in International Trade," *Journal of Economic Literature*, 39, 1177–1203.

Saxonhouse, G.C., 1976, "Estimated Parameters as Dependent Variables," *American Economic Review*, 66(1), 178–183.

——, 1993, "What Does Japanese Trade Structure Tell Us about Japanese Trade Policy?" *Journal of Economic Perspectives*, 7, 21–43.

Spencer, B.J. and L.D. Qiu, 2001, "*Keiretsu* and Relationship-Specific Investment: A Barrier to Trade?" *International Economic Review*, 42, 871–901.

Ueda, K. and Y.N. Sasaki, 1998, "The Import Behavior of Japanese Corporate Groups: Evidence from Micro-Survey Data," *Japan and the World Economy*, 10, 1–11.

Williamson, O.E., 1979, "Transaction-Cost Economics: The Governance of Contractual Relations," *Journal of Law and Economics*, 22, 233–261.

World Trade Organization, 1998, *Trade Policy Review: Japan*, Geneva, Switzerland: WTO, xxviii.