In search of substitution between foreign production and exports

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Abstract

Are foreign production and exports substitutes or complements? Standard theory of the multinational corporation (MNC) assumes substitution, while previous empirical work examining the relationship has generally found strong evidence of complementarity. This study examines product-level data, which more closely fits the assumption of a single-product firm often used in MNC theory, and finds substantial evidence for both a substitution and a complementarity effect between affiliate production and exports with Japanese automobile parts for the US market. I also test for and find evidence of substitution using product-level data on a set of Japanese-produced final consumer goods. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Trade; Multinational corporations; Foreign direct investment

JEL classification: F21; F23

1. Introduction

The continuing globalization of production makes the question of the relationship between trade and foreign direct investment ever more important. An important question that has arisen in both the theoretical and empirical literature is the extent to which exports and foreign production are substitutes or complements. More precisely, to what extent do production and affiliate sales in a foreign market

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replace or help increase exports to the same market?[1] While there are theoretical reasons to suggest both substitution and complementarity effects, surprisingly, empirical work in this area almost invariably shows a net complementarity relationship between exports and foreign production (or foreign affiliate sales) across a wide variety of data sets. Lipsey and Weiss (1981), Graham (2000), and Clausing (2000) are examples of studies that find affiliate sales positively correlated with exports at the aggregate country or industry level. Other studies have examined the relationship between affiliate sales and exports using firm-level data, including Swedenborg (1979, 2000), Lipsey and Weiss (1984), Blömstrom et al. (1988), Head and Ries (1997), and Belderbos and Sleuwaegen (1998). One might expect that the more disaggregated nature of the firm-level data would be more likely to yield net substitution, yet almost all of these studies find net complementarity as well. Thus, we are left with apparent incongruities between theory and empirical work.

This paper attempts to shed new light on the empirical relevance of substitution and complementarity effects between exports and foreign affiliate sales by examining product-level data. The advantage of using highly disaggregated product-level data is the ability to test for a substitution effect *separately* from complementarity effects, such as those arising from vertical linkages. Because of availability, I use data on Japanese production in and exports to the United States for two types of products.[2] Firstly, I examine data on automobile parts, which obviously have a strong vertical relationship with automobile production. Production of Japanese automobiles (the input-using industry) in the United States should increase Japanese exports of automobile parts to the United States (a complementarity effect), while location of Japanese automobile parts production in the United States should decrease Japanese exports of automobile parts (substitution effect). Simple plots of Japanese exports and Japanese production in the United States for 10 specific automobile parts products generally show large substitution effects, even without controlling for the potential increased demand for these products due to increased Japanese production of automobiles in the United States. Thus, product-level data shows strong *net substitution*, unlike previous studies using more aggregated data. I then test more formally for a substitution effect (from increased US automobile parts production by Japanese

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[1]The 'substitution/complementarity' terminology may be confusing because the question is not concerning how a quantity changes with respect to changes in a price in this context, as in a typical demand analysis. Rather, the question addresses how changes in one quantity affect another quantity. While the terminology may be confusing, I use the 'substitution/complementarity' terminology in this paper because it has become standard in the literature.

[2]Japanese data are used primarily because of a unique data set on Japanese production in the United States published by the Japan Economic Institute which is detailed enough to list specific products produced at the plant level, rather than a more aggregated industry designation (such as 4-digit Standard Industrial Classification), as is usually the case. Below I detail the data constraints that largely dictated the sample of products I was able to examine.

firms) and a complementarity effect (from increased US automobile production by Japanese firms) on Japanese exports of these automobile parts products, controlling for other factors. The regression results indicate substantial evidence for both effects.

While examination of automobile parts is interesting because of its vertical relationship with automobile production, it may be difficult to generalize the substitution effect results displayed by Japanese automobile parts in the United States because of US pressure for transplanted Japanese automobile firms to source more inputs domestically (see Swenson, 1997). In other words, political influences may be driving the large net substitution effects displayed by these products. This may be the case for any product subject to some form of protectionism. Therefore, I next examine substitution effects between Japanese exports and Japanese production in the United States using product-level data on 11 final consumer products which were not subject to such US government scrutiny over my sample period. The evidence from simple plots and more formal statistical analysis strongly suggests substitution of local production for exports with most of these consumer products as well. In fact, both sets of results (automobile parts and consumer products) are surprisingly strong given the limited number of observations I am able to employ. In addition, the evidence suggests that when firms locate production abroad, the substitution effects are large one-time changes, not gradual steps over time.

2. Previous literature

Theoretical models used to analyze a multinational corporation's (MNC's) decision to sell to a foreign market often assume the firm chooses between exporting or foreign production in the host country. In fact, one of the main research questions in this literature is why a MNC chooses one mode of servicing the foreign market versus the other.[3] Buckley and Casson (1981) suggest that while exports naturally incur higher costs per unit than foreign production because of greater transportation costs and possible tariffs, foreign production involves a higher fixed cost of operation (e.g. building a new plant). This implies that for lower levels of sales, firms will export to avoid the higher fixed costs associated with foreign production, whereas they will switch to foreign production for higher

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[3]In a standard Heckscher–Ohlin general equilibrium model with factor mobility, the classic paper by Mundell (1957) showed that factor flows (e.g. capital in the form of foreign direct investment) may substitute for trade flows in these general equilibrium models as well. However, Markusen (1983) and Wong (1986) show that there are numerous theoretical reasons for possible complementarity when standard Heckscher–Ohlin assumptions are relaxed. This paper will focus more on models of MNCs mentioned in the text to motivate the empirical framework, though the empirical results of this paper may have implications for both types of models.

level of sales. Markusen (1984, 1995) suggests that firm-specific assets may lead a firm to locate production abroad rather than export. Firm-specific assets have a public goods aspect to them in the sense that they can be used across multiple plants for a single firm-level investment. Thus, it may make sense for the firm to locate production in a variety of markets rather than have one production plant that exports to the many markets. Finally, the theory of internalization suggests that foreign direct investment (FDI) substitutes for exports when there are sufficient costs to external transactions such as exporting or licensing.[4] Thus, the substitution effect plays a prominent role in theory.

At the same time, there are theoretical channels by which complementarity may occur between exports and foreign production. Lipsey and Weiss (1984) and Rugman (1990) argue that a firm's production presence in a foreign market with one product may increase total demand for all of its products through a number of channels including: (1) provision of important sales and after-sale services, (2) commitment-to-market effects on consumers, and (3) more efficient and quicker deliveries and distribution. In this way, foreign production and sales of one good may create what Brainard (1993, 1997) terms 'proximity advantages' by promoting export sales of goods produced by the firm in its home country.

Vertical production relationship is another way that complementarity may occur. Investment by a manufacturer may increase exports of inputs to the host market. Foreign sourcing of parts by transplant firms and its effect on the US trade deficit has caused concern in recent years. For example, Swenson (1997) finds that Japanese transplanted automakers import a large amount of parts from Japan and are much less willing to substitute between US and imported inputs. Thus, there are a number of reasons why foreign production may complement exports.

As mentioned in the Introduction, empirical studies almost invariably find net complementarity. This has been true of not only country- and industry-level studies, but also firm-level studies. The strength of the complementarity effect even at less-aggregated levels of data, such as firm-level, is surprising at first glance. However, even firm-level data does not allow one to separately identify a substitution effect to the extent that the firm is multiproduct, which is quite likely given that the companies examined are large MNCs. The multi-product nature of the firm means that there may be demand complementarities across a firm's products and/or there may be vertical production relationships across the firm's products. Additionally, even firm-level data makes it more difficult to disentangle

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[4]Internalization has its roots in Williamson's (1975) transactions cost work and has become familiar to international trade economists through Dunning's (1981) ownership-location-internalization (OLI) framework. Markusen (1995) has a nice discussion of the OLI framework as it applies to models that use firm-specific assets as a motivation for MNCs.

what drives the complementarity. Is it demand complementarities or vertical relationships?[5]

There have been a number of responses in the literature to these empirical findings. Firstly, a number of studies have examined whether endogeneity bias is driving the strong complementarity results. Grubert and Mutti (1991) and Graham (2000) try to control for endogeneity bias when estimating the relationship between affiliate sales and trade using country-level data, while Head and Ries (1997) and Swedenborg (2000) control for endogeneity using samples of Japanese and Swedish firms, respectively. Graham, Head and Ries, and Swedenborg generally still find net complementarity, while Grubert and Mutti find an insignificant relationship between affiliate sales and exports after instrumenting for affiliate sales.

Secondly, a number of studies have been able to find evidence for vertical relationships leading to complementarity with firm-level data.[6] Lipsey and Weiss (1984) use information on intermediate versus finished products within the firms in their sample. They find a strong complementary relationship with respect to affiliate production and exports of intermediate goods as one would expect, but no evidence for either complementarity or substitution with respect to finished goods affiliate production and finished goods exports. Yamawaki (1991) also uses firm-level data to look at another type of vertical relationship: the effect of Japanese FDI in wholesale distribution in the United States on Japanese exports of goods to the United States for distribution. As expected, he finds a strong complementary relationship. Head and Ries (1997) are able to identify 'vertical leaders' in their data — Japanese firms that are known to source a higher share of intermediate inputs from other firms. Thus, one would expect the complementarities from vertical production to be less prevalent for these firms. Their results confirm this and, in fact, they find some evidence for a net substitution effect for vertical leader firms in their sample. In contrast, Belderbos and Sleuwaegen (1998) find evidence of substitution between foreign production and exports at the firm level by focusing on firms facing actual or threatened import protection by the destination market. They argue that one should expect a large substitution effect in

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[5]For example, Lipsey and Weiss (1981) suggest that their finding of a positive correlation at the industry level shows that manufacturing presence in another country 'tends to promote' the firm's exports to that country. This is apparently a demand complementarity argument, yet one industry for which Lipsey and Weiss (1981) find a complementary relationship is the industry classification 'automobiles and trucks'. This industry comprises production of both finished autos, as well as automobile parts, which suggests complementarity may stem from a vertical relationship.

[6]A recent paper by Swenson (1998) uses industry-level data to show that less substantial complementarity and even substitution effects are revealed as one moves from more-aggregated industry FDI data to less-aggregated data.

these circumstances since the firms facing heightened protection are likely to substitute foreign production for exports to avoid the protection. They find evidence of substitution of local production for exports with Japanese electronic firms in the European Community (EC) during the late 1980s, a period character- ized by rising EC protection against these firms.

This paper's contribution is to go one step further in the level of disaggregation to analyze product-level data. This step is taken not because it can be done, but because it makes sense. As will be shown, there are a number of advantages to this level of disaggregation. Firstly, it allows one to naturally model and test in the same equation a complementarity effect from vertical production linkages separa- tely from the substitution effect of affiliate production for exports. In this sense, the empirical model is more closely linked to the theory of a single-product firm-level decision. In addition, focus on a single product also means that demand complementarities across products are not masked by the data.

One potential disadvantage is data availability.[7] However, the recent National Bureau of Economic Research (NBER) database on US imports (see Feenstra, 1996) and other recent sources of data on Japanese investment in the United States have now made this product-level analysis possible. In the end, substitution and complementarity effects are easily identified with the product-level data I use, which stands in contrast to previous studies using more aggregated data. Additionally, I find that substitution effects are substantial and generally occur in large one-time changes for the products I investigate.

3. Empirical analyses

This section examines two complementary sets of product-level empirical analyses. In Section 3.1, I analyze whether Japanese production of automobiles and automobile parts in the United States was complementary toward and/or a substitute for Japanese exports of these automobile parts to the United States during the late 1970s through the early 1990s. The vertical production linkage between automobiles and automobile parts is of interest because theory suggests there should be a complementary relationship between Japanese automobile production in the United States and Japanese exports of automobile parts. At the same time, there should be a substitute relationship between Japanese production of automobile *parts* in the United States and Japanese exports of those same products to the United States.

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[7]A second potential disadvantage is that product-level data may be capturing behavior across multiple *firms*. An ideal data set would have product-level data *by firm*. If firms are pursuing different strategies to serve a market (exports versus local production) for a particular product over a given time period, the substitution and complementarity effects occurring at the product-level within each firm may be obscured. Unfortunately, I do not have product-level export data by firm.

In Section 3.2, I examine a separate set of consumer products exported from Japan and produced in the United States by Japanese affiliates. This is done out of a potential criticism that the automobile parts regressions (and particularly the substitution effects I find) are driven by the Japanese–US automobile voluntary export restraints (VERs) and the politically-motivated push for high local domestic content in this trade-sensitive industry. Thus, the consumer products analysis provides some evidence whether substitution effects are significant for products besides those that are subject to substantial trade protection.

3.1. Japanese automobile parts and the US market

I analyze product-level data on a specific group of Japanese automobile parts products in two ways. Firstly, I look at simple plots of exports and US production of these products over the period of my sample, 1978–1991. Since simple plots do not control for a variety of other forces that may be factors during this period, including changes in relative prices of inputs and exchange rates, I then run seemingly-unrelated regressions (SUR) for the set of products based on a model of US demand for imported Japanese automobile parts. Controlling for relative prices (and implicitly exchange rate changes), the results show strong evidence for the substitution effect exhibited by the plots, as well as the complementary effect between Japanese exports of automobile parts to the United States and Japanese production of automobiles in the United States. These simple analyses are necessary due to data limitations involved with using available product-level data, but the results are consistent and strong across these two approaches.

3.1.1. Descriptive analysis

Fig. 1 shows Japanese automobile parts exports (Standard Industrial Classification (SIC) 3714) to the United States and the exchange rate from 1978 to 1992. There is a substantial increase in the trend of imported Japanese automobile parts exports beginning in 1983, which then levels off beginning in 1989. One potential explanation for the strong surge in export growth in automobile parts is the location of automobile production by Japanese producers beginning in the early and mid-1980s. In fact, the correlation between the value of US-imported Japanese automobile parts and numbers of automobiles produced by Japanese producers from 1978 to 1990 is 0.98, suggesting a strong complementarity effect through this vertical linkage. The flattening out of exports by 1989 may be explained by the substantial FDI by Japanese automobile parts producers into the United States to substitute for exports. Table 1 shows data on Japanese investment in US automobile parts production for various years from 1980 to 1990. Clearly, there was substantial Japanese investment that began at least as early as 1986 in US automobile parts production. The last column of Table 1 shows manufacturing direct investment as a reference for gauging the size of the direct investment in automobile parts production — from 1986 to 1990, automobile parts production
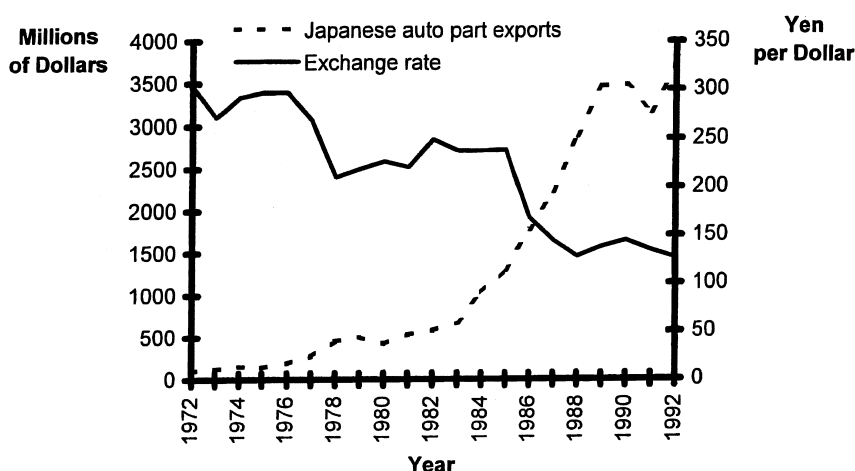
Fig. 1. Japanese automobile parts exports to the United States and the yen–dollar exchange rate, 1972–1992. Sources: export data taken from the NBER Trade Database Disk 1: US Imports, 1972–94, and yen–dollar-exchange rate taken from the appendix tables in the *Economic Report of the President*.

Table 1
Japanese foreign direct investment flows into the United States for automobile parts and manufacturing, 1980–1990, various years[a]

Year	Number of new Japanese-owned automobile parts plants in the United States	Number of employees in new Japanese-owned automobile parts plants in the United States	New US employees for all Japanese-owned manufacturing plants
1980	2	100	5232
1984	1	50	16,940
1986	23	2817	23,640
1987	47	8583	39,952
1988	54	13,697	74,801
1989	64	15,171	80,800
1990	36	6734	31,772

[a] Plant and employee numbers are for year of entry. All data include new plants, acquisitions, and joint ventures, as well as plants with various shares of ownership, though the vast majority are fully- or majority-owned. There were a handful of cases where employee numbers for certain plants were imputed because of missing data the year of entry or because employee numbers were reported for a group of plants rather than an individual plant. Source: Japan Economic Institute. *Japan's Expanding Manufacturing Presence in the United States*, various issues.

accounted for 12 to 21% of all new Japanese manufacturing investment in the United States.[8] What is difficult to assess from the information in Fig. 1 and Table 1 however, is why exports of automobile parts did not flatten out sooner or even begin to decrease from a substitution effect of US production for exports. The substitution effect may not appear as strong because of the strong demand generated by the increasing automobile production. On the other hand, the plotted US production numbers by Japanese producers may represent very small levels of substitution. The inability to disentangle these various effects is the crux of the data aggregation issue.

To control for the aggregation issue, I next analyze product-level data on 10 specific automobile part products: (1) toughened glass for automobiles, (2) laminated safety glass for autos, (3) automotive mirrors, (4) radio-cassette players for autos, (5) radio receivers for autos, (6) engine starters, (7) engine coils, (8) door locks for autos, (9) bumpers and parts, and (10) automobile seats and parts. These products satisfy a couple of crucial criteria. Firstly, it was possible to construct credible data on Japanese exports to the United States for these products. I use the NBER database on US imports (described in Feenstra (1996)) to construct time-series data at a detailed product level. However, there was a complete change in product code classification system in the United States after 1988 from the Tariff Schedules of the United States Annotated (TSUSA) to the Harmonized Tariff System (HTS). Unfortunately, there is far from a one-to-one mapping between these two systems. Often, one TSUSA line item is distributed across numerous HTS codes (or vice versa) making it impossible to construct a credible time series record of import activity. This substantially limited which products could be analyzed. Secondly, to examine the effect of foreign production, it was necessary that the automobile part product eventually was produced in the United States by Japanese firms. These 10 automobile part products chosen for study have direct mappings from the TSUSA to HTS system, so that a consistent time series for Japanese imported automobile parts could be constructed, and saw significant Japanese production in the United States in the 1980s. A data appendix, available from the author, further describes construction of the database for these automobile part regressions and accompanying data difficulties.

Fig. 2 presents simple plots of Japanese exports and US production by Japanese firms over time for four of the 10 automobile parts products that show substantial substitution effects — laminated safety glass, radio-cassette players, bumpers, and engine starters. While I do not present similar plots of the other six products for the sake of space (available from author upon request), three others, toughened glass, radio receivers, and seats and parts, show plausible evidence of substitution as well. In many ways, these plots are surprising in light of the fact that I am obviously not controlling for the complementarity effect of increased automobile

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[8]Using the same database, Blonigen and Tomlin (2000) also provide evidence that Japanese automobile parts plants grew much more rapidly during this period than other Japanese manufacturing plants in the United States.
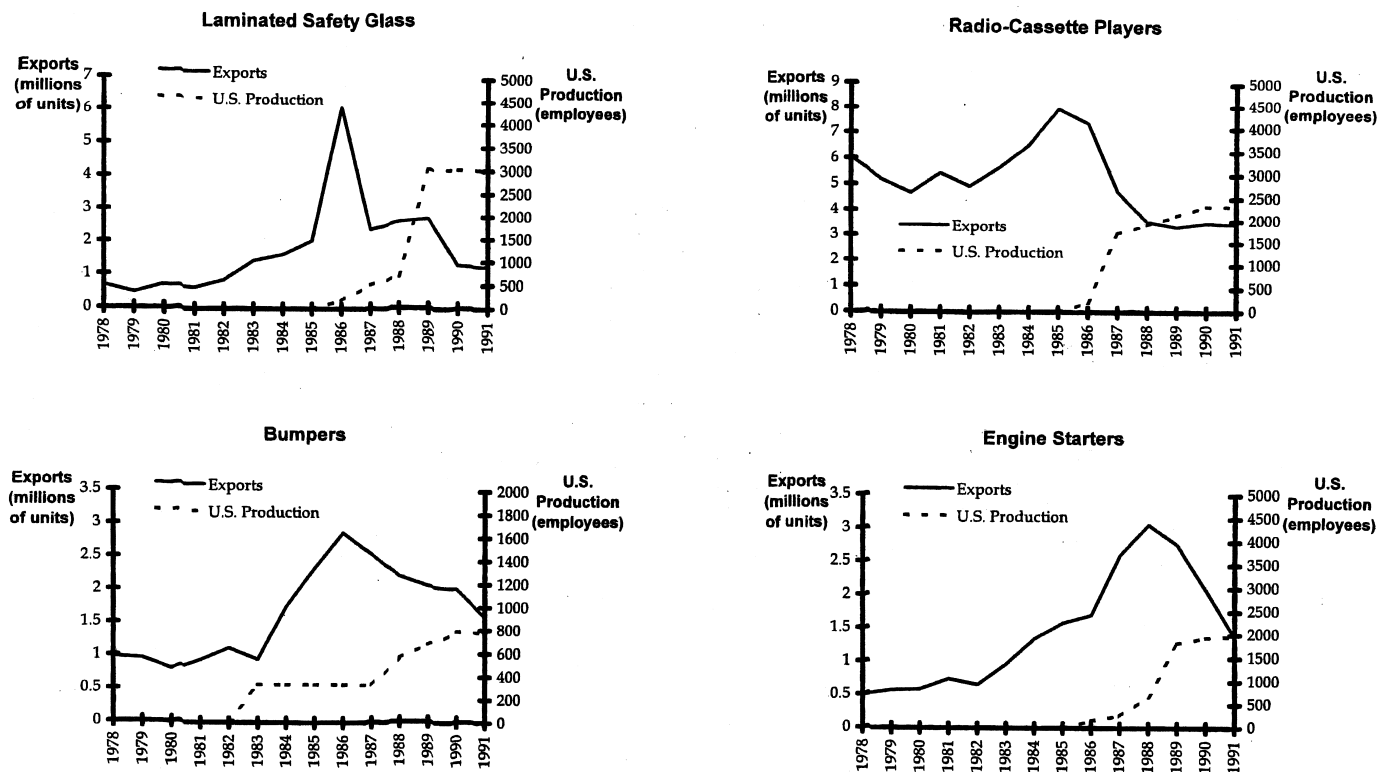
Fig. 2. Japanese exports to the United States and production in the United States for laminated safety glass, radio-cassette players, bumpers, and engine starters. Sources: export data taken from the NBER Trade Database Disk 1: US Imports, 1972–94, and US production data from Japan Economic Institute, *Japan's expanding US manufacturing presence*, various issues.

production, nor for other factors such as relative input prices and exchange rate changes.

3.1.2. Regression analysis

To more formally test for both substitution and complementary effects of foreign production on exports in the case of Japanese automobile parts in the United States, I assume there are two representative US demanders of automobile parts: Japanese automobile subsidiaries located in the United States and US-owned automobile plants located in the United States.[9] Thus, derived demand for Japanese-produced automobile parts will be a function of automobile production by each type of producer, the price of the automobile parts, and prices of other inputs into the production process. This can be obtained by setting up a standard cost minimization problem for each type of automobile producer, solving for demand for the automobile part input and aggregating. Thus we have the following derived demand function in the United States for Japanese produced automobile parts:

$$X_J^D = X_J^D(P, Y_J, Y_U) \tag{1}$$

where P is a vector of input prices, and Y_J and Y_U are production by Japanese-owned and US-owned automobile producers in the United States, respectively. Supply of Japanese-produced automobile parts comes either from Japan as exports or from local production in the United States. I assume these parts are identical across the two locations and necessarily sell for the same price. If I assume that the local production facilities always operate at capacity,[10] then I can express net export demand as:

$$X_{JIMP}^D = X_J^D(P, Y_J, Y_U) - X_{JLP} \tag{2}$$

where X_{JLP} is the amount of local production supplied by the market. Eq. (2) implies that imports of Japanese automobile parts will be positively related to production of automobiles by both Japanese- and US-owned producers and perfectly replaced or substituted by local production, controlling for relative price changes.

I use this simple model because of the data limitations I face. A richer model would specify the supply side in more detail with attention to cost side factors, as well as the supplying industry's specific trade-off between local production and exports. Eq. (2) implies that a firm always operates local production at capacity

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[9]Okamoto (1998) finds evidence that US firms purchase Japanese-produced automobile parts.

[10]The assumption of production at capacity seems more reasonable for these data than for most because of the rapid growth of Japanese auto-related plants in the United States during this time period. Blonigen and Tomlin (2000) find employee levels of Japanese auto-related plants in the United States more than doubled on average from 1987 to 1990.

and any changes in demand conditions will be reflected in how much is exported to the market. To the extent that the firm would alter both local production and exports in the same direction in response to demand changes (e.g. reduce production in both locales in response to lower demand) there is an endogeneity bias toward finding complementarity, not substitution as hypothesized.

To test, I assume there are three types of inputs into automobile production: automobile parts produced by Japanese-owned establishments, automobile parts produced by US-owned establishments, and capital. The associated factor prices are w_J, w_{US}, and r, respectively. If factor demands are homogeneous of degree zero in factor prices, I can rewrite Eq. (2) as

$$X^D_{JIMP} = X^D_J \left(\frac{w_J}{w_{US}}, \frac{r}{w_{US}}, Y_J, Y_U \right) - X_{JLP}. \qquad (3)$$

Because of the small number of observations (14 annual for each automobile part), I specify a linear version of Eq. (3) for testing each of the 10 automobile parts equations:

$$[x_{JIMP}]_t = \gamma_0 + \gamma_1 \left[\frac{w_J}{w_{US}} \right]_t + \gamma_2 \left[\frac{r}{w_{US}} \right]_t + \gamma_3 [Y_J]_t + \gamma_4 [Y_{US}]_t + \gamma_5 [X_{JLP}]_t + \epsilon_t$$

$$(4)$$

where the variables are defined as above, ϵ_t is a normally distributed error term and the γs are parameters to be estimated. If data on Japanese local production of automobile parts were available, the estimated coefficient on γ_5 is hypothesized to equal -1; i.e. a pure substitution effect. Instead, I only know employment levels of Japanese-owned affiliate automobile parts plants in the United States and necessarily use these employment data (measured in hundreds of employees) to proxy for production data.[11] These data come from the Japan Economic Institute publication *Japan's Expanding US Manufacturing Presence*, various issues through 1990. Because I use employment data, rather than production data, there is no reason to expect γ_5 to equal -1 in the estimation below, though clearly it is hypothesized to be negative in sign. Japanese import quantities (x_{JIMP}) and prices (w_J — measured as unit values) are taken from the NBER import database. Because w_J is expressed in US dollars, it implicitly takes into account not only exchange rate changes, but also firms' 'pass through' of those changes to the US market. US automobile part prices (w_{US}) and the price of capital (r) come from Bureau of Labor Statistics producer price indexes and the Economic Report of the

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[11]Clearly, some proportion of employees in any manufacturing plant are not directly involved in production, but to the extent that this proportion is similar across plants in a product, this implies only a scaling issue with this variable. In addition, I directly contacted the Japanese-owned US plants in both sets of regressions (automobile parts and consumer products) to verify that they indeed were manufacturing plants, and not distribution or retail operations.

President, respectively. Automobile production data in the United States measured in millions of vehicles (Y_J and Y_{US}) come from *Ward's Auto World*.

Table 2 reports estimation results using Zellner's iterative SUR technique on the 10 automobile part equations. SUR methodology is justified by the distinct possibility that there were economy-wide or industry shocks that would affect the disturbance terms of all automobile part regressions, so that they are contemporaneously correlated. While OLS gave qualitatively similar results, SUR generally improved the precision of the coefficient estimates.

All 10 equations have F-statistics significant at the 95% confidence level and reasonable adjusted R-squares. For sake of space, the constant and coefficients on the relative prices are not reported in Table 2, but were generally estimated with precision and correct signs. Both hypothesized relationships between trade and foreign production by the Japanese find strong support. Japanese automobile parts production in the United States has a statistically significant negative relationship on US imports of Japanese automobile parts at the 95% confidence level in nine of the 10 equations, with correct signs in all of them. The strength of the estimated

Table 2
SUR regressions of import demand for Japanese automobile parts, 1978–1991[a]

Regressors: Dependent variable	Japanese auto part production in the US	Japanese automobile production in the US	US domestic automobile production	Adjusted R^2	F test
Toughened glass	−0.199***	8.609***	0.419**	0.92	23.15***
	(0.000)	(0.000)	(0.017)		(0.000)
Laminated safety glass	−0.194***	7.133***	0.348**	0.69	6.86***
	(0.000)	(0.000)	(0.019)		(0.009)
Automotive mirrors	−2.048***	6.949***	−0.392**	0.91	28.74***
	(0.000)	(0.000)	(0.036)		(0.000)
Radio-cassette players	−0.363***	2.053***	0.260*	0.75	8.87***
	(0.000)	(0.000)	(0.054)		(0.004)
Radio receivers	−0.030***	0.215	−0.019	0.79	10.81***
	(0.000)	(0.257)	(0.616)		(0.002)
Engine starters	−0.283***	7.039***	0.091	0.65	5.91**
	(0.000)	(0.000)	(0.315)		(0.014)
Engine coils	−0.117***	4.806***	0.121*	0.89	21.34***
	(0.000)	(0.000)	(0.055)		(0.000)
Door locks	−0.116***	1.013***	−0.031	0.92	29.12***
	(0.000)	(0.000)	(0.128)		(0.000)
Bumpers and parts	−0.021**	0.589**	0.335***	0.67	6.21**
	(0.039)	(0.019)	(0.000)		(0.012)
Seats and parts	−0.068	1.760***	−0.080	0.91	26.71***
	(0.152)	(0.000)	(0.459)		(0.000)

[a] *P*-values are in parentheses. ***, ** and * denote a *t*-statistic at the 1, 5 and 10% significance levels, respectively. All equations are estimated from 14 annual observations (1978–1991) using Zellner's iterative Seemingly Unrelated Regressions (SUR) technique.

substitution between trade and foreign production in these product-level regressions is in sharp contrast to previous empirical work.

The results also show a strong positive relationship between Japanese automobile production in the United States and imported Japanese automobile parts: nine of the 10 have *t*-statistics at the 95% confidence level. Thus, as expected, vertical industrial relationships are associated with strong complementary relationships between exports and foreign production at the product level. The relationship between automobile production by US-owned automobile manufacturers and imports of Japanese automobile parts is less strong in general, as one might expect, but does show a strong positive relationship in automotive glass products, radio cassette players, engine coils, and bumpers and parts.

The coefficients relating foreign production and exports are economically significant as well. For example, estimated coefficients in laminated safety glass imply that an extra 100 employees in US production by Japanese firms means 194,000 square feet less annual exported laminated safety glass, while an extra 100,000 Japanese autos produced in the United States translates into an increase of 713,300 square feet in annual exports from Japan. An extra 100 employees in US production of door locks leads to 116,000 less exported door locks from Japan, while an additional 100,000 Japanese autos produced in the United States increases exports by 101,300 door locks.[12]

Of course, there is the possibility of specification bias with these estimates. One source of concern is the time-series properties of the data. However, the Durbin–Watson statistics generally do not indicate autocorrelation across the equations, and when the system was reestimated allowing for an AR1 process, results are qualitatively unchanged. A second concern is endogeneity of the Japanese automobile production in the United States variable. It is not clear which way this bias may affect the estimates. On one hand, there may be a third factor, such as growth in demand that may increase both exports and foreign affiliate production. In this case, as previous literature has argued and found (Grubert and Mutti, 1991), endogeneity is likely to bias the estimates toward finding complementarity, not substitution. On the other hand, there may be a third factor such as exchange rate or tariff changes that would simultaneously move the exports and foreign affiliate production in opposite fashion, which would bias toward finding substitution. Unfortunately, the small number of observations here makes correction techniques for endogeneity inappropriate in the sense that they rely on asymptotic properties

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[12]The estimated coefficients on Japanese automobile production in the United States seem higher than they should be for a number of products. However, for these products the coefficient may be capturing the effect of exports being used as replacement parts in the United States, rather than for construction of new autos. Because of degrees of freedom and collinearity problems it is difficult to control for this in the estimation.

for consistency and efficiency, with unknown small-sample properties.[13] Specification bias could also come from measurement error in my variables, including reliance on import unit values for price data (e.g. see Feenstra and Shiells, 1994). Despite these various issues, none necessarily suggest that the estimates should be systematically biased toward finding substitution.

3.2. Testing for substitution with final consumer products

While the above results on automobile parts cleanly separates out significant complementarity and substitution effects, it may be of interest to see if product-level data works well at identifying a substitution effect of affiliate production for other types of products as well. In particular, Japanese automobile manufacturers in the United States were under political pressure to increase domestic content, and in response, investment by Japanese-owned automobile parts suppliers into the United States was quite substantial in the last half of the 1980s. This may have intensified substitution effects of foreign production for exports in the case of these goods and calls into question the generality of the results. Therefore, this section tests for substitution between Japanese exports and affiliate production in the United States using product-level, time-series data on 11 final consumer products which were not subject to such US government scrutiny over this time period.

3.2.1. Descriptive analysis
I look for substitution of local production for exports using separate time-series data on 11 final consumer products: (1) hand-held vacuum cleaners, (2) other vacuum cleaners, (3) microwave ovens, (4) grand pianos, (5) other pianos, (6) music synthesizers, (7) sake, (8) soy sauce, (9) ballpoint pens, (10) golf balls, and (11) golf clubs. This list of products is the result of a number of considerations. Firstly, the focus is on products not involved in significant US trade protection, because one could argue that substitution effects will be unnaturally large with these products as firms 'tariff jump' the trade protection. Secondly, I was concerned about using intermediate goods, because it is often difficult to control for the derived demand coming from various downstream industries. With automobile parts this vertical relationship is clear and the mapping is fairly clean

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[13]Despite these concerns, I estimated the system using three-stage least squares, instrumenting for both the local production variable and the price term. I tried a number of possible instrument matrices which included the yen–dollar exchange rate, contemporaneous and lagged levels of total Japanese manufacturing employees in the United States, and the discount rate in Japan. Results from the three-stage least squares regression were qualitatively similar to those reported in Table 2. Most estimates on local production increased, which supports the notion that the substitution coefficients are biased downward in those instances. These results are available upon request from the author.

from automobile parts to automobiles. But for intermediate goods like steel, semiconductors, engines, chemicals, etc., the vertical relationship is far from clean. Thus, I focus specifically on consumer products for final consumption. Final additional constraints were finding products with some FDI in the United States and being able to map the product-level export data over time, especially the switch in 1989 from the TSUSA to HTS import classification schemes, as discussed above. This issue of mapping proved especially difficult for certain products, such as consumer electronics, as there were often a number of changes in how these products were classified over time.

The data for these 11 consumer products come from the same sources as for the automobile parts regressions. Import data come from the NBER US import database described in Feenstra (1996), while data on local production by Japanese firms in the United States come from the Japan Economic Institute publications, *Japan's Expanding US Manufacturing Presence*. Unlike the automobile parts data, the import data for the consumer products often remained consistent further back in time (with the exception of data for golf clubs and music synthesizers). Additionally, there were substantially less FDI occurrences of which to keep track for these products, so it was feasible to update local employee numbers beyond 1990, the ending date of my primary source. Thus, most of the time series run from 1972 to 1994, which are all the years covered by the NBER US import database. Again, a data appendix available from the author provides more details on data sources and construction.

Fig. 3 plots Japanese exports and US production by Japanese firms over time for four of the 11 final consumer products. Once again, for the sake of space I only present four products where the substitution effects appear substantial, but plots of the remaining products are available from the author upon request. In addition, a number of the products not shown display plausible negative correlation between exports and level of US affiliate employees. Thus, as with many of the automobile part products, the data often reveal not just substitution effects for these final consumer products, but *large* substitution effects. However, these plots do not control for other factors that may affect the level of exports into the United States, so I next turn to regression analysis.

3.2.2. Regression analysis

As noted above, examination of final consumer products means that there is no vertical production relationship for which to control. Thus, the derived demand model used in Section 3 to indicate an empirical framework for automobile parts is not applicable here. Instead, I begin simply with the following reduced form demand equation for each Japanese product:

$$EX_t + LP_t = \alpha + \beta_1 P_t + \beta_2 INC_t + \epsilon_t, \tag{5}$$

where EX is Japanese exports to the United States, LP is local production by

Hand Vacuum Cleaners
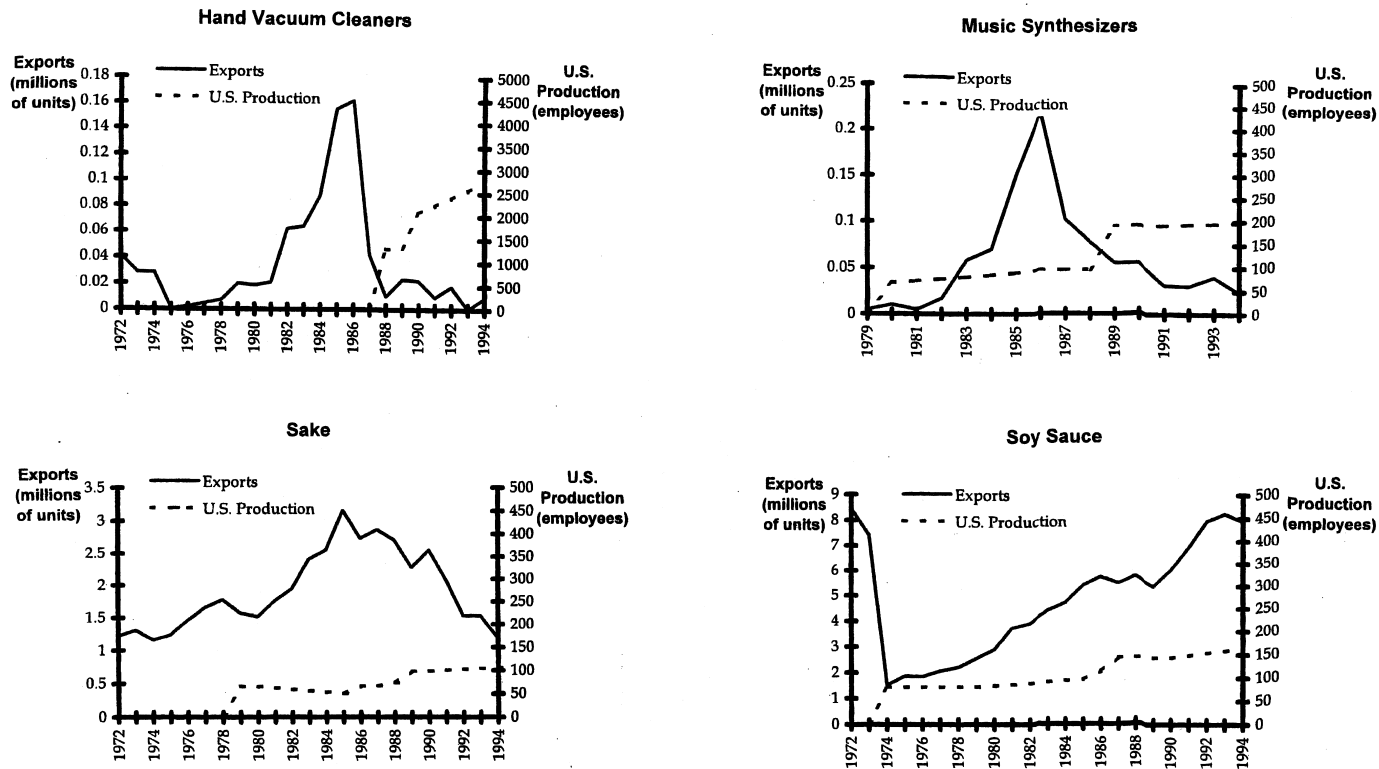
Music Synthesizers

Sake

Soy Sauce

Fig. 3. Japanese exports to the United States and production in the United States for hand vacuum cleaners, music synthesizers, sake, and soy sauce. Sources: export data taken from the NBER Trade Database Disk 1: US Imports, 1972–94, and US production data from Japan Economic Institute, *Japan's expanding US manufacturing presence*, various issues.

Japanese affiliates in the United States, P is the price of the Japanese product, INC is income of US consumers measured by real US GDP, and ϵ is an assumed normally distributed error term. To test the relationship between EX and LP, I can simply move LP_t to the right side of (5) and expect a coefficient of -1 if there is only a pure substitution effect. However, as with the automobile parts regressions above, I do not have data on local production, but only employees used for local production. If we assume there is a linear time-invariant relationship between local production and local employees (LE) of the form, $LP_t = \beta_3 \, LE_t$, Eq. (5) becomes

$$EX_t = \alpha + \beta_1 P_t + \beta_2 INC_t + \beta_3 LE_t + \epsilon_t. \tag{6}$$

The expected sign on β_2 is positive, while I expect negative signs for β_1 and β_3.

The above specification is admittedly parsimonious — I have assumed a linear reduced form demand model with local production as a perfect substitute for the exported good. However, this approach is justified by the small number of observations I can employ for estimating each product's demand. While misspecification bias may cause inefficient estimates (i.e. higher standard errors), if it systematically biases the coefficient estimate on LE, it should be toward *not* finding substitution. This is because, first, any demand-increasing effect from locating production in the United States (such as proximity advantages) is not separately modeled or identified from the substitution effect. Secondly, there is the same endogeneity concern with respect to local production as encountered with the automobile parts equations.[14]

Table 3 reports SUR regression results for the 11 consumer products using Eq. (6) as the testing specification. Because the data for golf clubs and music synthesizers do not begin until 1979, all product equations in Table 3 are estimated with 16 annual observations running from 1979 to 1994. Below I report results from estimating the other nine products as a SUR system with annual data that goes back to 1972. Overall, the regressions reported in Table 3 perform well. Ten of the 11 equations have *F*-tests that reject the null hypothesis of zero coefficients at the 95% confidence level or higher. In addition, all coefficients on the price and income terms are as expected (except for income in the microwave ovens equation) with many statistically significant. This suggests that these are decently identified demand equations.

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[14]There is also the concern of endogeneity with the price term and properly identifying a demand equation. However, all price terms have correct signs in the regressions reported in Table 3 using OLS. I also estimated the system of equations using three-stage least squares estimation and using the same instruments as those used for the automobile parts three-stage least squares regression discussed in footnote 13. These results were qualitatively similar to those reported in Table 3 and are available from the author upon request. I also tried specifying and testing a Japanese export supply equation in place of Eq. (6). While the variables used to explain demand in (6) almost always had correct signs and explained the data nicely without instrumenting for price, this was rarely true for various supply equation specifications I tried.

Table 3
SUR regressions of import demand for Japanese final consumer products, 1979–1994[a]

Regressors: Dependent variable	Price	Income	Japanese production in the US	Adjusted R^2	F-test
Hand vacuum cleaners	−0.001***	0.055***	−0.005***	0.50	5.96**
	(0.001)	(0.008)	(0.000)		(0.010)
Other vacuum cleaners	−0.005***	0.419***	−0.021***	0.73	14.32***
	(0.000)	(0.000)	(0.000)		(0.000)
Microwave ovens	−0.039***	−1.870*	−0.856	0.56	7.37***
	(0.000)	(0.100)	(0.110)		(0.005)
Grand pianos	−0.004***	0.010***	−0.002**	0.81	16.76***
	(0.000)	(0.000)	(0.023)		(0.000)
Other pianos	−0.001	0.001	−0.001	−0.21	0.12
	(0.374)	(0.307)	(0.254)		(0.949)
Music synthesizers	−0.245***	0.081***	−0.035*	0.45	5.10**
	(0.000)	(0.004)	(0.074)		(0.016)
Sake	−0.332***	0.492***	−0.681***	0.92	56.90***
	(0.000)	(0.000)	(0.000)		(0.000)
Soy sauce	−0.796	4.348***	1.850	0.90	44.75***
	(0.489)	(0.000)	(0.139)		(0.000)
Ballpoint pens	−381.58***	142.18***	13.733***	0.97	144.02***
	(0.001)	(0.000)	(0.000)		(0.000)
Golf balls	−0.011	1.581***	−1.757***	0.90	45.25***
	(0.489)	(0.000)	(0.000)		(0.000)
Golf clubs	−0.002***	0.256***	−0.069**	0.73	14.22***
	(0.007)	(0.000)	(0.026)		(0.000)

[a] P-values are in parentheses. ***, ** and * denote a t-statistic at the 1, 5 and 10% significance levels, respectively. All equations are estimated from 16 annual observations (1979–1994) using Zellner's iterative Seemingly Unrelated Regressions (SUR) technique and an AR1 correction. Equations are estimated with a constant, but its coefficient is not reported here.

There is support for substitution effects across these products as well. Nine of the 11 regressions show a negative relationship between US production by Japanese firms and Japanese exports of these products to the United States, with seven of these statistically significant at standard confidence levels. Only ballpoint pens display a statistically significant positive effect of local production on the exported good. As with the automobile parts regressions, the coefficients can be used to gauge the magnitude of the substitution effect. For example, an additional 100 employees involved in US production of golf balls reduces US imports by 1.757 million dozen, whereas 100 additional US employees lowers US sake imports by 681,000 gallons. While caution should be taken in interpreting these coefficients because of specification and sample size, these magnitudes seem plausible.

As mentioned earlier, there may be a number of sources of specification bias. Again, a source of concern that may be correctable with the limited number of

observations is the time-series properties of the data. With these regressions, the majority of the Durbin–Watson statistics indicate possible serial correlation. Thus, the coefficients in Table 3 are estimated with an AR1 correction. The majority of equations yield a statistically significant correlation between periods, yet qualitatively, results are quite similar across the equations regardless of whether there is an AR1 correction or not.[15]

While the effect of exchange rate movements (and firms' pass through decisions) are controlled for through the import price term in these regressions, there may be concern that other macroeconomic (besides US GDP) or industry trends may be driving these estimates. Table 4 reports how sensitive the effect of Japanese production in the United States on Japanese exports to the United States is for a few alternative specifications that control for other general economic effects. Column 1 of Table 4 reports the coefficient on Japanese production in the United States obtained from the base specification used in Table 3. This is reported in order to compare results across alternative specifications. Column 2 of Table 4 reports the coefficient on Japanese production in the United States when I include a linear time trend to the base specification. The time trend is statistically significant for a number of equations, but it has little impact on our coefficient of interest for most products. The exception is soy sauce, which changes signs from positive to negative, but is still estimated imprecisely.

Perhaps the exports of these final consumer products are behaving in a similar manner to other products in their associated industry. Or in other words, if one plotted Japanese exports of other products in the same industry for which there is US-based Japanese production, would one get similar plots to the products estimated in Table 3? To control for this, column 3 of Table 4 reports the coefficient on Japanese production in the United States when I include both a linear time trend and a variable capturing the quantity of Japanese exports to the United States in the product's 4-digit SIC industry.[16] This industry variable is constructed by taking the export value of the associated 4-digit industry minus the product's export value, converting this to yen and deflating by a Japanese export price index. In this manner, one can construct a measure of the associated industry's 'quantity' movements. Because of data availability on the industry quantity variable, the data now span the period 1979 to 1992 (see data appendix for more details). For most of the products, this specification yields almost

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[15]A number of the estimated AR1 correlations are quite large and cannot reject a correlation of one, which would suggest a unit root. I estimated all 11 equations in first differences. For the majority of equations an *F*-test rejects the first-differences specification. For the two equations where the first-differences specification is accepted, results are qualitatively identical to the levels regressions.

[16]An alternative analysis would be to gather data on other products in these industries for which there was no US-based Japanese production and create plots similar to Fig. 3. This would be an immensely time consuming process and many products would have TSUSA to HTS mapping problems.

Table 4
Coefficient on Japanese production in the US for various SUR regressions of import demand for Japanese final consumer products, 1979–1994[a]

Dependent variable	Table 3 specification	Table 3 specification with trend	Table 3 specification with trend and industry quantity controls
Hand vacuum cleaners	−0.005***	−0.007***	−0.009***
	(0.000)	(0.000)	(0.000)
Other vacuum cleaners	−0.021***	−0.021***	−0.025***
	(0.000)	(0.000)	(0.000)
Microwave ovens	−0.856	−0.472	−0.968***
	(0.110)	(0.329)	(0.000)
Grand pianos	−0.002**	−0.003***	−0.001
	(0.023)	(0.001)	(0.448)
Other pianos	−0.001	−0.002***	−0.001
	(0.254)	(0.000)	(0.110)
Music synthesizers	−0.035*	−0.008	−0.027
	(0.074)	(0.688)	(0.110)
Sake	−0.681***	−0.723***	−0.750***
	(0.000)	(0.000)	(0.000)
Soy sauce	1.850	−1.861	−7.921***
	(0.139)	(0.280)	(0.000)
Ballpoint pens	13.733***	16.580***	−0.376
	(0.000)	(0.000)	(0.926)
Golf balls	−1.757***	−1.539***	−2.967***
	(0.000)	(0.000)	(0.000)
Golf clubs	−0.069**	−0.073**	−0.082***
	(0.026)	(0.022)	(0.007)

[a] P-values are in parentheses. ***, ** and * denote a t-statistic at the 1, 5 and 10% significance levels, respectively. All equations are estimated from 16 annual observations (1979–1994) using Zellner's iterative Seemingly Unrelated Regressions (SUR) technique and an AR1 correction. Equations are estimated with a constant, but its coefficient is not reported here.

identical results to the base specification.[17] The exceptions are soy sauce and ball point pens which now yield results more consistent with a substitution effect. Soy sauce now displays a statistically significant negative correlation between production in the United States and exports as hypothesized, and ballpoint pens no longer have a statistically significant positive correlation. In summary, Table 4 shows the relative insensitivity of the estimates on Japanese production in the United States to these alternative specifications.

A final sensitivity test is to eliminate the music synthesizer and golf club equations from the SUR so that the number of observations for each equation can be expanded to start from 1972 rather than 1979. Given the limited number of

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[17]While I do not report the coefficients on the industry quantity controls because of space limitations, many of them are statistically significant. Interestingly, there were nearly as many with a negative sign, as with a positive sign.

observations for each equation in the base specification, this is obviously a large percentage increase in observations. However, when I estimate the remaining nine products using SUR on 21 annual observations from 1972 to 1992, results do not change significantly from estimates in Tables 3 and 4. The estimates include an AR1 correction, a time trend and industry quantity control for each equation, and are not reported in the interest of space. Eight of the nine coefficients relating Japanese exports and Japanese production in the United States have a significant negative sign, with four statistically significant.[18]

4. Conclusion

This paper was motivated by the many empirical studies showing complementarity between exports and foreign production. Why is it so difficult to find substitution effects? Previous papers had explored statistical concerns, including endogeneity and aggregation bias. This paper provides evidence that aggregation bias may be playing a large role. I show substitution effects are relatively easy to identify in product-level data. In fact, product-level data allows one to separately identify substitution from complementarity effects (here from vertical production relationships), rather than try to infer them from estimates using more aggregate data. In this sense, the paper highlights the importance of matching the level of data aggregation with the hypotheses being tested. This is particularly true at a time when there is an increasing proliferation of available microeconomic data in the field of international economics.

There are a number of extensions that can follow from this paper. Firstly, while I was able to separately test for complementarity from vertical production relationships, my data do not allow a test of complementarity from other channels mentioned in the literature, such as demand complementarities across a firm's related products. Secondly, there is more work to be done to interpret the large shifts in local production versus exports this paper finds for many products. This paper's analyses (particularly the simple plots) shows that substitution of foreign production for exports often are large one-time shifts, not gradual changes over time. However, it is also apparent that there is not complete replacement of exports by local production for the products I analyze. Thus, firms may be choosing to have some combination of both to serve a market. One possible reason for this

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[18]Another concern raised by a referee is that Japanese firms may have began substantial production of these products in other countries, using these countries as export platforms to the United States. Since my dependent variable only measures exports from Japan, this could bias the substitution effects I find. Upon the referee's suggestion I examined the behavior of US imports from other Asian countries in the 11 consumer products during this time period, but found no systematic trends indicating increased exports to the United States from these other Asian countries as Japanese exports to the United States fell.

would be to hedge against exchange rate risk, as suggested by Goldberg and Kolstad (1995). On the other hand, if there are multiple firms represented by my product level data, there may be both positive exports and local production at the product level, because some firms in the product line are serving the market with solely local production, while other firms in the product line are solely exporting. This suggests there is a need for future work with product-level data by firm to resolve some of these important questions.

Acknowledgements

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