

**Offshore Assembly from the United States:  
Production Characteristics of the 9802 Program**

by

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Revised, May 1998

The authors thank Shelagh Matthews Mackay of the Institute of Governmental Affairs, UC Davis, for locating and acquiring the data on the 9802 program. Zeeshan Ali, Patrick Carleton, Lance Tomikawa, and Shu-Yi Tsai provided dedicated work in scanning the data. Financial support from the National Science Foundation is gratefully acknowledged, as are comments from Jim Levinsohn.

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## 1. Introduction

Outsourcing has become a prominent feature in many recent formal models of international trade.<sup>1</sup> The interesting question for public policy is whether outsourcing has contributed to the growing gap between the wages of skilled and unskilled workers. This wage gap characterizes the labor markets of many countries, and has grown over time since its emergence in the late 1970's. Recent work such as Feenstra and Hanson (1996a) demonstrates how outsourcing can augment the wage skill gap. They show that if skilled and unskilled labor are used in different intensities along the value chain of a product, outsourcing from a host to a recipient country reduces the relative demand for unskilled labor in both locations. Markusen and Venables (1995, 1996a,b) focus on multinational firm activity, and arrive at a similar conclusion. As long as multinational firms can choose their location of production, they find that the presence of multinational activity can increase the skilled-unskilled wage gap in the high-income country, and possibly in the low-income country as well. In a related vein, Krugman and Venables (1995) examine how agglomeration economies will affect cross country wage patterns. They analyze a model with trade in intermediate goods subject to transport costs. At medium levels of transport costs, a core-periphery pattern emerges: countries in the core have manufacturing agglomerated in them, while those in the periphery suffer from a lack of industry and low wages. At lower levels of transport costs, the agglomeration of manufacturing in the core areas disappears, leading to a fall in wage inequality across regions.<sup>2</sup>

In contrast to the growing theoretical work, empirical measures of outsourcing are few and far between. Feenstra and Hanson (1996b) rely on estimates of imported manufactured inputs, as do Campa and Goldberg (1997) and Hummels, Rapaport and Yi (1997). These suffer from assuming that the import share for each input is the same across all manufacturing

industries, and also from excluding non-manufactured inputs. Furthermore, these estimates do not provide any direct information on the production characteristics of the imported inputs. A common presumption of the theoretical work is that the activities being outsourced are more *unskilled-labor intensive* than those remaining in the industrial countries. This feature is essential to derive the result that outsourcing will reduce the relative demand for unskilled labor. While this presumption is theoretically justified based on factor-price differences and common technology across countries, it should be subjected to some empirical verification. In addition, the underlying causes of outsourcing – such as factor endowments, transport costs, or multinational activity – deserve to be investigated.

In this paper, we shall study outsourcing from the United States under the offshore assembly program (OAP). Formerly called the 806/807 provision of the U.S. tariff code, and now renamed the 9802 provision of the Harmonized System code, this program allows U.S. firms to export component parts and have them assembled overseas. When the finished product is imported back into the United States, duties are paid only on the *foreign value-added*. While accounting for a relatively small fraction of total U.S. imports (8.5% in 1995), this program is still substantial in its effects on economic activity. For example, virtually all of the *maquiladora* plants in Mexico are engaged in assembly of parts under the 9802 program (Feenstra and Hanson, 1997). The program leads to production in many other countries as well. Because duties are paid only on the foreign value-added, there must be a separate accounting of the value of imports resulting from assembly abroad, which are classified as dutiable OAP imports, versus the value embodied in goods originally exported from the U.S. for further processing abroad, which are classified as nondutiable OAP imports. Therefore, it is possible to estimate the production characteristics of the OAP activity.

In the next section, we provide background information on the 9802 program, and summarize features of these imports for the period 1980-1993. We shall focus on five industries: apparel, leather and footwear, machinery, electrical machinery, and transportation equipment. These industries together account for 90-93% of all OAP imports and 94-95% of the dutiable value of OAP imports during the sample period. For apparel, leather and footwear, and electrical machinery nearly all OAP imports are from developing countries, while for transportation equipment most OAP imports come from industrial countries. OAP imports in machinery come from both sources. Overall, the share of dutiable OAP imports coming from developing countries has increased from 25% to 30% during 1981-1993.

In section 3, we describe a revenue function for these five industries in the U.S., treating the U.S. content of OAP imports and all other shipments from the industry as separate outputs. Inputs include production and non-production labor, capital, energy, the foreign component of OAP imports, and remaining intermediate inputs. Of principle interest is the factor-intensity of the U.S. OAP shipments versus all other shipment from the industry: our hypothesis is that the U.S. OAP shipments should be more *skilled-labor intensive* than all other shipments. The empirical evidence presented in section 4 supports this idea for some industries. We also investigate the substitution between the foreign component of OAP imports and domestic production and non-production labor.

In section 5, we turn to the question of which factors explain the level of OAP imports. We focus on international differences in production costs, as measured by the real exchange rate between the U.S. and the principal source countries for OAP imports. To control for variation in outsourcing patterns across industries, we construct a trade-weighted real exchange rate for each two-digit industry. We expect that an appreciation of the U.S. real exchange rate, which implies

an increase in U.S. production costs relative to production costs in source countries, will be associated with higher levels of outsourcing as measured by dutiable OAP imports. Empirical results for the apparel and machinery industries are consistent with this hypothesis, while the evidence for the electrical machinery industry is mixed.

## **2. The Offshore Assembly Program**

The U.S. OAP was created through a provision of the Tariff Act of 1930. The original intent of the program was to facilitate the manufacturing practices of U.S. steel firms, many of which maintained production plants in Canada and engaged in extensive cross-border shipments of intermediate inputs. Over time, the program was expanded to include other industries and all other countries (Hanson 1997). OAP imports have become an important part of U.S. trade. Between 1980 and 1990, the share of OAP imports in total U.S. imports rose from 4.7% to 12.2%, and then fell somewhat to 8.5% in 1995 (USITC 1997).

There are two broad categories of goods that qualify for the U.S. OAP. Item 9802.00.60 of the Harmonized Tariff Schedule (HTS) of the United States (formerly item 806.30 of the Tariff Schedule of the United States, TSUSA) permits the duty-free import of metal products that are manufactured in the United States and sent abroad for further processing. Item 9802.00.80 of the HTS (formerly item 807.00 of the TSUSA) permits the duty-free entry of inputs that are manufactured in the United States and assembled abroad. To qualify for the 9802.00.80 exemption, the stated requirements are that domestic components may only be subject to assembly and assembly-related activities abroad. Since 1980, goods imported under item 9802.00.80 have accounted for over 98 percent of total OAP imports.

The data available to us consist of the value of OAP imports (i.e. imports under the 806/807 program and the 9802 program) by the disaggregate Tariff Schedule categories for 1980-1988, and by Harmonized System categories for 1989-1993. The latter years were available in electronic form, but the earlier years were available in hardcopy, which were electronically scanned and then extensively checked for errors. This proved to be impossible for 1982 and 1988, due to inadequate quality of the hardcopy.<sup>3</sup> In all remaining years, both the U.S. (i.e., nondutiable) value and the foreign (i.e., dutiable) value of the OAP imports are provided. We aggregated these data to the four-digit Standard Industrial Classification (SIC) system, so that it matches the production data available for U.S. industries.<sup>4</sup>

Data on the OAP imports for the five two-digit SIC industries studied here are given in Table 1, for selected years. Shown there are the value of OAP imports in each two-digit industry relative to total shipments in that industry, and relative to total OAP imports, separately for the developing (LDC) and industrial (OECD) countries. For apparel and leather and footwear nearly all OAP imports are from developing countries, principally Mexico and the Caribbean Basin countries. Electrical machinery, including electronic components such as semiconductors, also comes primarily from developing countries, principally those in Southeast Asia. In transportation equipment most OAP imports come from industrial countries, especially Canada but also Japan and Germany, while a smaller (but increasing) share of imports comes from Mexico. Finally, in machinery the imports come from both sources. It is evident that the OAP imports are small relative to industry shipments in all cases, though they have grown substantially in apparel – from 1% to 6% of shipments – and also in footwear and leather – from 1% to 8.5% of shipments.

Additional summary statistics are provided in Table 2, where we separate the OAP imports into those attributable to U.S. made components and those attributable to foreign value-added; only the latter are subject to duty in the United States. Shown are the value of these imports relative to total industry shipments. It is evident that the U.S. versus dutiable share of OAP imports varies substantially across industries, where the U.S. share is highest in apparel (nearly twice the dutiable share) and lowest in transportation equipment (about one-tenth of the dutiable share). In transportation equipment, the U.S. versus foreign dutiable share of OAP imports also varies substantially across source countries. For example, U.S.-made components account for over one-half of the value of automotive products and other transportation imported from Mexico; about one-quarter to one-third of the value imported from Canada; and less than 5 percent of the value imported from Japan, Korea, and Germany (USITC, 1997, p. 3-7). Overall in the five industries we investigate, the share of dutiable OAP imports originating from developing countries has increased from 25% to 30% during 1981-1993.

The cross-sectional variation in the U.S. shares of OAP imports (across four digit industries within each two-digit group), as well as its time-series variation, will be a focus of our empirical investigation. The U.S. share of OAP imports in total industry shipments – as shown in Table 2 – will serve as one dependent variable. Also shown in Table 2 are the wage-bill of production and non-production labor, measured relative to total industry shipments. These data are taken from the Bartelsman-Becker-Gray manufacturing industry database, with non-production labor used as a proxy for skilled labor and production labor used as a proxy for unskilled labor.<sup>5</sup> In all industries, there has been a marked decline in the share of production labor, by between two-tenths and four-tenths of a percentage point per year. In some industries, the share of non-production labor has also declined, but by a smaller amount. The shares of



production and non-production labor in total industry shipments will be other dependent variables in our empirical analysis.

### 3. U.S. Revenue Function

We shall specify production in each industry in the U.S. as a multiple-input, multiple-output technology.<sup>6</sup> The outputs consist of the U.S. content of OAP imports measured relative to total industry shipments (as summarized in Table 2), and all other shipments from the industry.<sup>7</sup> In some industries, we will distinguish the U.S. content of OAP imports from developing versus industrialized countries. The inputs are production and non-production labor, the dutiable (i.e. foreign) component of OAP imports, remaining intermediate inputs, capital, and energy.<sup>8</sup> In some industries, we will also distinguish the dutiable component of OAP imports coming from developing versus industrialized countries. The revenue function of the industry will be specified as depending on the prices  $p_i$  or  $p_j$  of the outputs, and the quantities  $x_k$  or  $x_\ell$  of the inputs. The revenue function is specified as the translog form:

$$\begin{aligned} \ln R = & \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + \sum_k \beta_k \ln x_k \\ & + \frac{1}{2} \sum_k \sum_\ell \delta_{ij} \ln x_k \ln x_\ell + \sum_i \sum_k \eta_{ij} \ln p_i \ln x_k, \end{aligned} \quad (1)$$

where  $R$  denotes total industry revenue (assumed equal to costs), and the time subscript is omitted from all variables for brevity.

The shares of each of the outputs are obtained by differentiating (1) with respect to the log of output prices, obtaining:

$$s_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \sum_k \eta_{ik} \ln x_k. \quad (2)$$

Similarly, if the inputs  $x_k$  are chosen optimally given their factor prices  $w_k$ , then the share of industry costs devoted to each input are obtained by differentiating (1) with respect to the log of input quantities:

$$s_k = \beta_k + \sum_\ell \delta_{k\ell} \ln x_\ell + \sum_i \eta_{ik} \ln p_i. \quad (3)$$

In practice, we have no information at all on the price of the U.S.-content of OAP imports versus the price of all other industry shipments. So in the estimation, we will ignore the output prices that appear in (2) and (3), and focus on the input quantities.

The coefficients  $\eta_{ik}$  in (2) measure the response of each output share to changes in the input quantities, and will be referred to as *output elasticities*. These are similar to Rybczynski derivatives for an entire economy, except that we are dealing with individual industries. Rybczynski derivatives or output elasticities are normally defined as the impact of a change in inputs on the *level* of output, rather than its share. To make this conversion, write the quantity of each output as  $\ln y_i = \ln(s_i R / p_i)$ . Differentiating this with respect to an input quantity  $\ln x_k$ , using (1) and (2), we obtain the output elasticity:

$$\frac{\partial \ln y_i}{\partial \ln x_k} = \frac{\eta_{ik}}{s_i} + s_k. \quad (4)$$

Thus, the coefficient  $\eta_{ik}$  together with the input and output shares can be used to calculate the output elasticity. As is conventional, *we will define factor  $k$  to be used intensively in output  $i$  if and only if (4) is positive*. In this way, the output elasticities provide us with indirect evidence on

the factor-intensities used in production.<sup>9</sup> *Our hypothesis is that the U.S. content OAP imports should be more skilled-labor intensive than the rest of U.S. production.* The reason for this is that the OAP program allows the less-skill intensive activities to be shifted overseas, so that the production remaining in the U.S. becomes more skill-intensive as a result.

Turning to the factor-share equation (3), the coefficient  $\delta_{k\ell}$  measures the responsiveness of each factor share to changes in the quantity of other inputs. Of particular interest is the response of production and non-production labor to changes in the amount of outsourcing, as measured by the quantity of dutiable OAP imports  $\ln x_m$ . *As this input increases, our hypothesis is that the U.S. production would shift toward more skilled, or non-production labor.* Thus, letting  $\ln x_k = \ln(s_k R / w_k)$  and  $\ln x_\ell = \ln(s_\ell R / w_\ell)$  denote the log quantities of production and non-production, respectively, we are interested in the sign of:

$$\frac{\partial \ln(x_k / x_\ell)}{\partial \ln x_m} = \frac{\delta_{km}}{s_k} - \frac{\delta_{\ell m}}{s_\ell}. \quad (5)$$

The null hypothesis that (5) equals zero is a test for the *weak separability* of production and non-production labor from dutiable OAP imports in the U.S. revenue function.

We shall estimate (2) and (3) while pooling across all four-digit industries within each two-digit group, and pooling across years. Since the output shares sum to unity, we can drop one of these share equations, and we omit the equation for the remaining value of U.S. shipments (after the U.S. content of OAP imports has been deducted). For the inputs, we estimate only the factor-shares for production and non-production labor, where the latter is used as a proxy for skilled labor. Estimation is performed over the years 1980-1993 (omitting 1982 and 1988 due to missing data), with all variables entered in levels, and *not including* any fixed effects for the

individual four-digit industries (or for the various years). We have also experimented with using first-differences of the data, thereby implicitly including industry fixed effects. Because of the missing observations (in 1982 and 1988), these differences were taken across odd-numbered years. The estimation in first-differences changes a number of coefficient estimates, and also leads to substantially higher standard errors, indicating that much of the variation in the data is cross-sectional. For this reason, we focus on the estimates without fixed effects in the next section, but report the results from estimation in first-differences in the Appendix. In order to control for some of the most important heterogeneity across industries, we also report in the Appendix estimates for the largest three-digit industries within each two-digit group.

#### **4. Estimation Results**

In Table 3, we report results for the apparel and footwear industries, for which OAP imports come almost entirely from developing countries. The results most strongly supportive of our hypotheses are obtained for the apparel industry. In Table 3, we find a negative impact of production labor on the U.S. content of OAP imports, measured as the share of total shipments, and a positive impact of non-production labor. These coefficient estimates are converted into output elasticities using (4), and the results are shown in Table 5.<sup>10</sup> We see that an increase in production (non-production) labor has a negative (positive) impact on the U.S. content of OAP imports, measured as a level, and these results are highly significant. Thus, by our definition of factor intensities, we conclude that the U.S. content of OAP imports for apparel is intensive in the use of non-production, or skilled labor. Also in Table 3, an increase in the dutiable content of OAP imports decreases the share of production labor in total costs, and has no impact on the

share of non-production labor. Making the calculation in (5), it is clear that greater dutiable OAP imports for apparel decreases the relative demand for production labor, as reported in Table 5.

Less interesting results are obtained for footwear and leather. In that case, both production and non-production labor have a negative impact on the U.S. content of OAP imports in Table 3, and a negative output elasticity in Table 5 (the elasticity for non-production labor is significant). In addition, an increase in the dutiable portion of OAP imports leads to a relative shift away from production labor in Table 3, though this estimate is not significant. These disappointing results may be due to the fact that a very large portion of OAP imports in footwear enters into a single four-digit industry: footwear, except rubber, not elsewhere classified (SIC 3149). The use of this “not elsewhere classified” category suggests that the imports are not being attributed to the industry segment responsible for their production, so that we should not expect to obtain reliable production characteristics.

In Table 4, we report the estimates for machinery, electrical machinery, and transportation equipment. For these industries we separate the OAP imports from developing (LDC) and industrial (OECD) countries. The strongest results are obtained for machinery, which has roughly equal imports from both sources. From Table 5, we find that the U.S. content of OAP imports – from either LDC or OECD countries – has a negative output elasticity for production labor and a positive elasticity for non-production labor. Thus, the production of U.S. components is intensive in non-production labor. Also from Table 5, an increase in the dutiable OAP imports from LDCs has a weakly negative effect on the relative demand for production labor, while imports from OECD countries has a weakly positive effect on relative demand for production labor, though neither of these elasticities is significant.

Turning to electrical machinery in Table 5, about 90% of these imports come from developing countries, particularly Southeast Asia. Unfortunately, neither of the output elasticities reported in Table 5 for the LDCs are significant, so we are not able to measure this production characteristic.<sup>11</sup> Just one of the output elasticities for the OECD countries is significant, though it has a surprising positive sign. The only result for this industry that is supportive of our hypotheses is that an increase in the dutiable content of OAP imports from LDCs leads to a negative and significant shift away from production labor.

Finally, in transportation equipment, the bulk of these OAP imports come from industrial countries, especially Canada, with a small but growing portion coming from Mexico. In Table 5 we find that the U.S. content of OAP imports from OECD countries has a negative output elasticity for production labor, and a positive elasticity for non-production labor. Thus, production of the U.S. components is intensive in non-production labor. In addition, an increase in dutiable OAP imports from OECD countries leads to a relative decline in the demand for production labor in the U.S. These results are all consistent with our hypotheses. But *opposite* results are obtained for the U.S. content of OAP imports from LDCs. In particular, there is a *positive* impact of production labor on the U.S. content of OAP imports from LDCs, suggesting that these U.S. components are intensive in production rather than non-production labor. This result is statistically significant, but is it economically meaningful?

As noted in the last section, the U.S. versus dutiable share of OAP imports varies substantially across source countries: the U.S.-made components account for over one-half of the value of automotive products and other transportation imported from Mexico; about one-quarter to one-third of the value imported from Canada; and less than 5 percent of the value imported from Japan, Korea and Germany (USITC, 1997, p. 3-7). This variation may help

explain our results. Because the components sent to Mexico also require substantial U.S. manufacturing, it is quite possible that these components use more production labor in the U.S. than do other components that are sent to Canada or Japan. In this case, the U.S. content of OAP imports from LDCs could be intensive in production labor *as compared to* the U.S. content of OAP imports from OECD countries. Essentially, we are dealing with a “higher dimensional” case of more than two inputs, outputs and countries, so it is perhaps not surprising to find a slightly complex pattern of implied factor-intensities.

In summary, of the five industries we have analyzed, we obtain results quite supportive of our hypotheses in apparel and machinery. For footwear and leather, and electrical machinery, the estimates have higher standard errors so that the production characteristics are not reliably measured. In transportation equipment, the results for OAP imports from industrial countries (which account for 90% of the imports) correspond to our hypotheses, but this is not the case for OAP imports from developing countries, for reasons we have suggested.

## **5. U.S. OAP Imports**

Our results so far suggest that for a number of industries an increase in outsourcing, as measured by OAP imports, implies an increase in the skill-intensity of production. The location to which products are outsourced, developing versus industrialized countries, also appears to influence the relative demand for production and non-production labor. To understand how outsourcing contributes to changes in the structure of labor demand, we must identify the forces that determine the extent of outsourcing within an industry. In the remainder of the paper, we consider the factors that contribute to outsourcing. We examine the extent to which the variation

in dutiable OAP imports in an industry over time is associated with changes in relative cost differences between the United States and countries that are a source of OAP imports.

Trade theory attributes outsourcing to cross-country differences in relative factor endowments (Feenstra and Hanson 1996a). The existence of international factor-price differences, which result from international factor-supply differences, gives firms an incentive to spread production activities across different countries. Since we lack reliable annual data on factor endowments or factor prices for the set of countries that supply OAP imports to the United States, we use the real exchange rate to capture international differences in production costs. When the real exchange rate appreciates, the relative cost of foreign inputs declines, which we expect will lead to an increase the level of foreign inputs purchased by U.S. firms (as measured by the dutiable value of OAP imports).

Changes in the extent of outsourcing represent an increase in the demand for foreign-produced intermediate inputs relative to the demand for domestically-produced intermediate inputs. To capture this aspect of outsourcing, the dependent variable we use is dutiable OAP imports as a share of non-energy material purchases.<sup>12</sup> Table 6 reports sample means for the variables used in the analysis. Over the sample period, the mean value of dutiable OAP imports as a share of material purchases, in percentage terms, is 2.1 in apparel, and 6.8 in footwear. In the remaining sectors, a sizeable fraction of OAP imports originate from both developing and developed countries. In machinery, the percentages are 1.2 from the OECD and an additional 0.9 from developing countries. Transportation equipment is similar in that it draws a greater portion of imports from developed countries, with the percentages 5.2 and 0.8 respectively.<sup>13</sup> In contrast, electrical machinery receives 0.6 percent from OECD sources, and a much larger 5.2 percent from developing countries. The outsourcing share rises over time in apparel and



footwear and leather, fluctuates widely in transportation equipment, and is relatively stable over time in machinery and electrical machinery.

There is considerable variation across industries in the countries that supply OAP imports to the United States. In apparel and footwear, for instance, Mexico is a major source of OAP imports, but in transportation equipment the country's role is still minor. To control for such differences in outsourcing patterns, we create trade-weighted real exchange rates for each two-digit SIC industry. For each year, we use the IMF *International Financial Statistics* to compute the real exchange rate for each country responsible for OAP imports to the United States.<sup>14</sup> We then calculate an average real exchange rate for each of the five two-digit industries, using each country's share of total industry dutiable OAP imports as weights. We calculate the weights by taking each country's average share of dutiable OAP imports in an industry over the sample period. We choose average shares, rather than shares by year, since we want to avoid bias that would be introduced by changes in valuation. By our construction, a dollar appreciation represents an *increase* in the real exchange rate.

The trade-weighted exchange rates replicate the familiar pattern of U.S. exchange rate movements. Figures 1-5 show the real exchange rate series for each industry. The real value of the dollar peaked in the mid-1980's, declined sharply for a few years, and then recovered somewhat in the early 1990's. While the industry-specific real exchange rates we calculate follow a broadly similar pattern, there are cross-industry differences in the timing of exchange-rate innovations. The real exchange rate peaks for autos in 1984, while it peaks for machinery in 1986 and for apparel in 1989. Cross-industry variation in outsourcing patterns thus creates cross-industry differences in exposure to movements in international relative prices.

The machinery, electrical machinery, and transportation sectors are noticeably different from apparel and footwear in that they have non-trivial dutiable OAP imports from both the industrialized OECD and developing countries.<sup>15</sup> U.S. offshore-assembly activities in Europe or Japan may differ substantially from those in Mexico or Indonesia. In the transportation sector, for instance, U.S. and OECD labor tend to perform high-skill tasks, such as the production of autoparts, while LDC labor tends to perform low-skill tasks, such as the assembly of automotive accessories. As a result, we may see different substitution patterns towards dutiable OAP imports in LDCs than we do in OECD countries. To control for this possibility, in the machinery, electrical machinery, and transportation sectors we analyze OAP imports from LDCs and OECD countries separately. In order to do this, we refine the exchange rate variable further. For OAP imports from OECD countries, we measure the real exchange rate using country shares of OECD OAP imports as weights; for OAP imports from LDCs, we calculate the real exchange rate in an analogous manner.

The trade-weighted real exchange rates we construct vary across time, but not across four-digit industries within a two-digit sector. To control for industry-specific factors that affect outsourcing, we include real output, measured as shipments deflated by the industry output price index, and the capital-output ratio, measured as the ratio of the real capital stock to real shipments, as additional explanatory variables. Both variables are based on the Bartelsman-Becker-Gray data series for U.S. manufacturing industries. The capital intensity of production may condition the degree of substitutability between domestic and foreign-produced inputs or may capture the ease with which production may be moved offshore. Real output controls for the overall level of industry demand, which may influence the availability of domestically-

produced intermediate inputs. As with the exchange rate, we take the log values of these variables.

We estimate dutiable OAP imports separately for each of the five two-digit SIC industries over the years 1980 to 1993. The results for the apparel and footwear industries are presented in Table 7. For apparel, there is a positive and statistically significant correlation between dutiable OAP imports and the real exchange rate, which is consistent with the hypothesis that firms increase foreign outsourcing in response to an increase in U.S. production costs relative to foreign production costs. Dutiable OAP imports are negatively correlated with real output and have a positive, but statistically insignificant, correlation with the capital-output ratio. Thus, it appears that smaller industries or industries experiencing lower levels of demand are more likely to source production activities to offshore sites.

Similar to the estimation results for the input and output shares presented in the last section, the results for the footwear industry are disappointing. There is essentially a zero correlation between dutiable OAP imports and the real exchange rate. Again, we suspect that this may be attributable to the concentration of OAP footwear imports in a single four-digit industry (SIC 3149, footwear, except rubber, not elsewhere classified), which may indicate classification errors in the data for the footwear industry as a whole.

As with the production analysis, we consider dutiable OAP imports from developing and developed (OECD) countries separately in the machinery, electrical machinery and transportation industries. The results for these industry segments are presented in Table 8. In both machinery regressions the coefficient on the real exchange rate is positive, which implies that firms in the U.S. increase dutiable OAP imports when the cost of overseas activities are cheapened by a stronger dollar. In electrical machinery the exchange rate results are mixed; we find the expected

positive correlation for imports from industrial countries, while the relationship for developing countries is negative.

In contrast, the exchange rate effects for transportation equipment are negative, though the results for OAP imports from industrialized countries are not statistically different from zero. This evidence is the reverse of the finding in Swenson (1997) that U.S. and Japanese auto producers located in U.S. foreign trade zones purchase more foreign inputs when their price is reduced by appreciation of the dollar. Our data do not exclude the possibility that firm sourcing in the transportation sector responds to changes in relative costs. However, it is clear that the OAP component of sourcing in this industry segment does not correspond with our predictions.

There is no single correlation between industry factors and outsourcing in the machinery, electrical machinery and transportation equipment sectors. However, it still appears that outsourcing is generally more prevalent in the capital-intense sectors; the coefficient on capital intensity is positive in four of the six equations. The relationship between real shipments and outsourcing is also mixed, confirming that outsourcing propensities in different industries are differentially affected by industry characteristics.

Our reported regression specification relates OAP outsourcing to current values of trade-weighted exchange rates. A maintained assumption of this specification is that firms do not face prohibitive switching costs, and that firms can quickly identify and utilize cheaper sources of supply. If industries are slow to respond to exchange rate changes, it is preferable to use lagged values of the exchange rate variables. When we replace the current exchange rate measure with its value in the previous period, almost all the signs on the exchange rate coefficients remain the same, though the coefficient magnitudes are generally smaller. In the new specification the

coefficients on real output and capital intensity were almost identical to our previous results. However, the overall fit of these regressions is less good than our reported results.

As a second check on our exchange rate specification, we also worked with a regression specification that includes both current and lagged exchange-rate variables. With the exception of OAP imports of transportation equipment from developing countries, a small OAP sector, the new specification did not improve the explanatory power of our regressions. The sign of the current exchange rate coefficients remained the same as our previously reported results, and there was no systematic pattern on the lagged exchange rate coefficients, though almost all lagged exchange rate coefficients were indistinguishable from zero.

To test the robustness of our regression specification, in unreported results we examined how the estimated effects change if we add dummy variables for each four-digit SIC industry. For the apparel industry, there remains a strong positive correlation between dutiable OAP imports and the real exchange rate; the coefficient value is very similar to that in Table 7. There is again a negative correlation between dutiable OAP imports and real output. One change in the results is that with industry dummy variables there is a strong negative correlation between OAP imports and the capital-output ratio. For the footwear industry, the inclusion of four-digit industry dummy variables has very little impact on the results. The exchange-rate results for machinery and electrical machinery are also little changed by the alternative specification, though the inclusion of the 4-digit industry dummies causes the puzzling negative exchange rate coefficient for OAP imports of electrical machinery from LDCs to shrink to insignificance. The correlation between outsourcing and both industry factors is also reversed in this segment when the 4-digit industry controls are added. The remaining results for transportation equipment are

little changed by the inclusion of industry controls, though, here too, the puzzling negative exchange rate coefficient for imports from developing countries shrinks further in significance.

While there is a positive and statistically significant relationship between outsourcing and the real exchange rate in several industries, we still need to determine whether these effects are economically significant. As a policy experiment, we examine how dutiable OAP imports would change if the U.S. dollar were to appreciate by 10%. We calculate the implied effects and display the results in Table 9. Given that the coefficient for the real exchange is statistically insignificant for footwear (SIC 31) and transportation equipment imports (SIC 37) from the OECD, we exclude these segments from the exercise.

Our results show that the predicted change in OAP imports, relative to non-energy domestic inputs is small in all industries. For example, a 10 percent appreciation of the dollar is predicted to raise OAP imports of machinery from the industrial OECD by a mere 0.08 percent. Nonetheless, this change is equivalent to a 6.72 percent change in OAP outsourcing if one compares the change to the average level of OAP activity in this sector. Relative to their baseline averages, it appears that the predicted responsiveness of OAP activity to changes in the relative cost of production is more pronounced for OAP activities conducted in developing countries. In these terms, the largest predicted change is found for apparel.

We repeated our analysis at the 3-digit industry level for five industry sectors: Office and Computing Machines (SIC 357), TV and Radio Receiving Equipment (SIC 365), Electronic Components (SIC 367), Motor Vehicles (SIC 371) and Aircraft and Aircraft Parts (SIC 372). We had two reasons for considering these sectors at the finer industry level. First, these five industries were responsible for the greatest level of OAP outsourcing in our sample, as measured by their volume of dutiable OAP imports. As a result, we expect outsourcing changes to be

most visible in these large OAP activities. The next reason for selecting these industries relates to the counterintuitive nature of some of our results in Tables 8 and 9. Our greatest surprise perhaps, is our earlier finding that electronic machinery outsourcing from developing countries appears to fall when the dollar appreciates. However, electronic machinery is an industry in which the country composition of outsourcing varies widely. While electronic components and accessories, which includes semiconductors, was dominated by Southeast Asian outsourcing, other segments such as TV and Radio receiving equipment had outsourcing activities that were more internationally dispersed. A maintained assumption of our previous specification is that exchange rate effects are common to all firms within a 2-digit industry. While this assumption may be innocuous in many industries, it may misrepresent the true cost changes experienced in the more heterogeneous sectors such as electronics. To explore this possibility, we created a new set of exchange-rate variables that corresponded to the 3-digit industry sourcing patterns for these highly active industries. As before, these exchange rate variables are tailored to reflect the country composition of OAP outsourcing activities in each of these industries.

Table 10 contains the regression estimates for our more disaggregated sectors. We again consider OAP imports from developed and developing countries separately. A few changes are notable. For machinery overall we found a fairly low responsiveness of OAP outsourcing in developing countries. When we treat office and computing machinery separately, however, we find that the measured sensitivity of OAP outsourcing in developing countries rises markedly. As the calculations in table 11 indicate, these effects are economically large. A ten percent appreciation of the dollar would cause outsourcing in the office and computing machinery industry to rise by 0.752. Relative to baseline levels of outsourcing in this industry, this represents a 30% increase.

The move to more detailed exchange rate variables also resolves some of the paradoxical findings of our previous analysis. In both TV and Radio receiving equipment (365) and electronic components and accessories (367) all of our exchange rate cost measures now have the expected positive sign which implies that outsourcing increases when the dollar appreciates. The new coefficients are not statistically significant for the first sector, but the findings are especially strong in the electronic components segment that includes semiconductors. Economically, this effect is somewhat less powerful. While significant statistically, the implied effect of a 10 percent dollar appreciation on outsourcing of electronic components from developing countries is a 4.8 percent increase in outsourcing relative to the sector's average level of outsourcing.

The move to more detailed industry analysis does not remove all puzzles. We continue to find perverse negative coefficients on the cost variables for motor vehicle outsourcing in developing countries and aircraft and aircraft parts outsourcing from developed countries. At the same time motor vehicle outsourcing in developed countries responds strongly in the hypothesized direction. Table 11 shows that developed country outsourcing in the motor vehicle industry is predicted to rise 2.79 percent if the dollar appreciates by ten percent.

Overall, our examination of outsourcing is similar to our earlier findings for U.S. production. The best results are concentrated in apparel and machinery where we find that increases in the cost of U.S. production, as proxied by exchange-rate movements, cause the level of foreign OAP sourcing to rise. In footwear and leather, our findings are imprecisely estimated, and the import of non-OECD electrical machinery appears to exhibit cross industry differences which relate to the country composition of industry imports.



## 6. Conclusions

In recent years the U.S. and other countries have observed a growing gap between the wages paid to skilled versus unskilled workers. Though there are many possible explanations for rising wage inequality, Feenstra and Hanson (1996a) demonstrate that changes in the U.S. wage structure can be attributed at least partly to foreign outsourcing. We examine trade conducted through the United States offshore assembly program to gain insight into recent outsourcing trends and its potential consequences.

As U.S. firms disperse production across countries through the OAP program, we expect the activities that they keep at home to use more skilled labor and less unskilled labor. This implies that the U.S. content of OAP imports should be relatively intense in the use of skilled labor. We find support for this hypothesis in apparel and machinery imports through the OAP, as well as in OAP imports of transportation equipment from industrial countries.

We also examine how OAP outsourcing activities respond to changes in the relative cost of U.S. production as measured by industry-specific trade-weighted exchange rates. Here, we find that elevated costs of production in the U.S. cause firms in a number of industries to substitute toward foreign production. While cost-induced movements toward the purchase of OAP inputs are small as compared with the size of U.S. industry, the predicted response to cost changes implies a significant change in the magnitude of OAP activities.

## Endnotes

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<sup>1</sup> Although the outsourcing phenomenon is referred to by a number of names, examples of such work include Antweiler and Trefler (1997), Arndt (1997, 1998a,b) Feenstra and Hanson (1996a,b), Hummels, Rapaport and Yi (1997), Jones and Keirzkowski (1997), Krugman (1995), and Leamer (1998).

<sup>2</sup> Matsuyama (1996) demonstrates a similar pattern of agglomeration and uneven incomes across countries. Gao (1998) has extended this type of model to allow for multinational firms, and found that agglomeration breaks down more quickly (at higher levels of transport costs) due to these firms, leading to more equal incomes across countries.

<sup>3</sup> For 1982, the scanned data had too many errors to make correction feasible. For 1988, the hardcopy was available only by month, making scanning and correction prohibitively expensive.

<sup>4</sup> U.S. imports by four-digit SIC categories are available from the National Bureau of Economic Research, at [http://www.nber.org/data\\_index.html](http://www.nber.org/data_index.html), as constructed by Robert Feenstra. The same programs used to construct the four-digit SIC import data from disaggregate sources were adapted to aggregate the OAP imports to that level.

<sup>5</sup> The Bartelsman-Becker-Gray manufacturing industry database at the four-digit SIC level is available from the National Bureau of Economic Research, at [http://www.nber.org/data\\_index.html](http://www.nber.org/data_index.html).

<sup>6</sup> Rather than specifying only the U.S. production, it would be desirable to jointly model the domestic and offshore production. This would include, for example, the production and non-production labor used in the U.S. and abroad. Unfortunately, this integrated approach was not possible due to data limitations. In particular, the production and non-production labor used in the Mexican *maquiladoras* are not reported on an industry basis, but are available only for total

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manufacturing. This means that the foreign content of OAP imports, which we are using as an input into the U.S. revenue function, is essentially serving as a proxy for the foreign labor and capital inputs.

<sup>7</sup> That is, “all other shipments” is measured as  $(\text{total shipments} - \text{U.S. content of OAP imports}) / (\text{total shipments})$ .

<sup>8</sup> The quantity of dutiable OAP imports is constructed by taking the value of dutiable OAP imports for each four-digit SIC industry, and deflating it by the price index for total industry shipments.

<sup>9</sup> Note that if the U.S. content of OAP imports versus other industry shipments are likely produced in the same plants, it is impossible to *directly* measure the factor-intensities of these two outputs. In other words, we are dealing with a situation of “joint production,” so that even with two outputs, there is no *a priori* presumption on the signs of the output elasticities.

<sup>10</sup> The output elasticities in Table 5 can be computed directly from the coefficient estimates in Tables 3 and 4, together with the means of the shares in Table 2. Because the shares were expressed as percentages, they should first be converted into fractions by dividing by 100. This means that the coefficient estimates in Tables 3 and 4 should also be divided by 100, before making the calculation in (4).

<sup>11</sup> Stronger results are obtained for Electronic Components (SIC 367), in Appendix Table A4, where the U.S. content of OAP imports from LDC countries leads to a positive and significant shift towards non-production labor, indicating that the U.S. activities uses non-production labor intensively.

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<sup>12</sup> We compute non-energy domestic inputs as (material cost-energy). This data is available at the four-digit industry level in the Bartelsman-Becker-Gray data.

<sup>13</sup> The reported means are weighted by industry shares of total manufacturing shipments. Transportation equipment has six outsourcing observations which are large outliers. If they are included, the mean of the outsourcing variable is 9.1. These observations have been dropped from the sample. While their inclusion does not affect the qualitative outcome of the outsourcing regressions in Table 8, their presence increases the size of the estimated regression coefficients markedly.

<sup>14</sup> We measure the real exchange between the United States and country  $j$  as  $\text{U.S. CPI}/(\text{country } j \text{ CPI} * \text{country } j \text{ nominal exchange rate})$ .

<sup>15</sup> South Korea and Mexico joined the OECD during the sample period. We classify them with the developing countries in our analysis.

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**Table 1: OAP Imports by Two-digit SIC Industry (in Percent)**

	<i>Developing Countries (LDC)</i>		<i>Industrial Countries (OECD)</i>	
	Share of Industry Shipments	Share of OAP Shipments	Share of Industry Shipments	Share of OAP Shipments
	<i>Apparel (SIC 23)</i>			
1981	1.1	3.2		
1983	1.1	2.7		
1985	1.6	2.9		
1987	2.1	2.0		less than 0.1
1989	3.2	4.3		
1991	4.8	9.6		
1993	6.4	9.6		
	<i>Footwear and Leather (SIC 31)</i>			
1981	1.0	0.5		
1983	1.0	0.3		
1985	1.9	0.4		
1987	2.8	0.4		less than 0.1
1989	5.7	0.9		
1991	8.0	2.3		
1993	8.5	1.7		
	<i>Machinery (SIC 35)</i>			
1981	0.3	3.1	0.7	7.8
1983	0.6	4.5	0.5	4.2
1985	0.7	4.8	0.7	5.0
1987	1.0	3.2	1.1	3.4
1989	0.7	4.1	0.7	3.6
1991	0.6	4.6	0.7	5.5
1993	0.7	4.2	0.5	2.9
	<i>Electrical Machinery (SIC 36)</i>			
1981	3.7	30.2	0.3	2.8
1983	3.9	28.1	0.3	2.5
1985	2.4	14.9	0.4	2.7
1987	3.7	11.4	0.5	1.7
1989	2.4	12.1	0.4	1.9
1991	4.0	29.7	0.2	1.8
1993	3.9	22.1	0.2	1.4
	<i>Transportation Equipment (SIC 37)</i>			
1981	0.1	1.0	4.0	44.0
1983	0.3	3.2	4.7	47.6
1985	0.6	5.3	6.5	58.0
1987	1.6	7.3	14.1	66.4
1989	0.7	5.3	8.4	60.7
1991	0.6	5.7	2.9	29.5
1993	0.5	3.7	5.7	45.0



**Table 2: Summary Statistics**

	Average (Percent)	Annual Change	Average (Percent)	Annual Change
	<i>Apparel (SIC 23)</i>		<i>Footwear and Leather (SIC 31)</i>	
U.S. share of OAP	1.8	0.27	1.1	0.17
Dutiable share of OAP	1.0	0.14	2.3	0.69
Production labor share	16.1	-0.21	15.5	-0.28
Non-prod. labor share	6.2	-0.002	6.2	0.02
	<i>Machinery (SIC 35)</i>		<i>Electrical Machinery (SIC 36)</i>	
U.S. share of OAP	0.3	0.02	1.8	-0.03
Dutiable share of OAP	1.0	0.03	2.0	-0.01
Production labor share	12.2	-0.20	11.4	-0.39
Non-prod. labor share	10.7	-0.12	12.7	-0.13
	<i>Transportation Equipment (SIC 37)</i>			
U.S. share of OAP	0.4	-0.003		
Dutiable share of OAP	4.3	0.28		
Production labor share	10.1	-0.30		
Non-prod. labor share	5.2	-0.16		

*Variable Definitions:*

U.S. share of OAP =  $100 \times (\text{U.S. content of OAP imports}) / (\text{Value of industry shipments})$

Dutiable share of OAP =  $100 \times (\text{Foreign content of OAP imports}) / (\text{Value of industry shipments})$

Production labor Share =  $100 \times (\text{Wage bill of production labor}) / (\text{Value of industry shipments})$

Non-prod. labor Share =  $100 \times (\text{Wage bill of non-production labor}) / (\text{Value of industry shipments})$

Notes: Averages are computed over the years 1980-1993, excluding 1982 and 1988 (due to missing data in those years), and over the four-digit industries within each two-digit group. Changes are measured as an average annual changes, using data for the odd-numbered years. Both averages and changes are weighted by the industry share of total manufacturing shipments.

**Table 3: U.S. Revenue functions**

<i>Dependent Variables: (share of industry shipments)</i>	U.S. Content of OAP Imports	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>			
<i>Apparel (SIC 23), N=385</i>			
Production labor	-4.87 (0.52)	6.52 (0.40)	-2.14 (0.17)
Non-production labor	2.05 (0.58)	-0.47 (0.45)	4.98 (0.19)
Dutiable OAP imports	1.04 (0.07)	-0.52 (0.05)	-0.02 (0.02)
Other Intermediate inputs	-1.70 (0.53)	-8.78 (0.41)	-2.84 (0.17)
Capital	3.22 (0.49)	1.62 (0.37)	-0.46 (0.16)
Energy	-0.20 (0.40)	1.54 (0.31)	0.27 (0.13)
R <sup>2</sup>	0.45	0.68	0.72
<i>Footwear and Leather (SIC 31), N=129</i>			
Production labor	-0.50 (0.74)	7.43 (0.56)	-3.88 (0.31)
Non-production labor	-1.78 (0.82)	-2.50 (0.62)	5.65 (0.35)
Dutiable OAP imports	0.35 (0.09)	-0.20 (0.07)	0.01 (0.04)
Other Intermediate inputs	0.35 (0.42)	-2.71 (0.32)	-0.73 (0.18)
Capital	-0.87 (0.80)	-0.55 (0.61)	-0.23 (0.34)
Energy	0.88 (0.71)	-1.33 (0.54)	-1.13 (0.30)
R <sup>2</sup>	0.29	0.78	0.81

Note: Standard errors are in parentheses. Estimation is in levels for 1980-1993, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

**Table 4: U.S. Revenue functions**

<i>Dependent Variables:</i> <i>(share of industry shipments)</i>	U.S. Content OAP Imports from LDC	U.S. Content OAP Imports from OECD	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>				
<i>Machinery (SIC 35), N=452</i>				
Production labor	-0.11 (0.06)	-0.19 (0.05)	8.94 (0.35)	-2.85 (0.16)
Non-production labor	0.15 (0.05)	0.17 (0.04)	-3.32 (0.26)	7.38 (0.12)
Dutiable OAP imports LDC	0.07 (0.01)	0.014 (0.006)	-0.10 (0.04)	-0.04 (0.02)
Dutiable OAP imports OECD	0.04 (0.01)	0.11 (0.01)	0.18 (0.07)	0.01 (0.03)
Other Intermediate inputs	-0.27 (0.05)	-0.31 (0.53)	-7.33 (0.29)	-4.72 (0.13)
Capital	0.03 (0.08)	0.10 (0.06)	3.80 (0.46)	-0.26 (0.21)
Energy	-0.04 (0.11)	0.04 (0.09)	-1.20 (0.65)	0.45 (0.29)
R <sup>2</sup>	0.33	0.40	0.90	0.91
<i>Electrical Machinery (SIC 36), N=450</i>				
Production labor	0.24 (0.40)	-0.05 (0.07)	8.38 (0.29)	-3.30 (0.24)
Non-production labor	-0.47 (0.27)	-0.04 (0.05)	-2.14 (0.19)	8.24 (0.16)
Dutiable OAP imports LDC	0.78 (0.06)	0.01 (0.01)	-0.33 (0.05)	-0.10 (0.04)
Dutiable OAP imports OECD	0.10 (0.08)	0.09 (0.01)	-0.04 (0.06)	-0.06 (0.05)
Other Intermediate inputs	-3.32 (0.27)	-0.22 (0.05)	-4.63 (0.20)	-3.31 (0.17)
Capital	2.06 (0.33)	-0.05 (0.06)	-0.45 (0.24)	-0.75 (0.21)
Energy	0.06 (0.32)	0.28 (0.06)	-0.19 (0.23)	0.23 (0.20)
R <sup>2</sup>	0.52	0.19	0.77	0.95
<i>Transportation Equipment (SIC 37), N=135</i>				
Production labor	0.47 (0.12)	-0.42 (0.20)	7.84 (0.34)	-5.49 (0.51)
Non-production labor	-0.04 (0.07)	0.24 (0.10)	-0.40 (0.18)	6.49 (0.27)
Dutiable OAP imports LDC	0.05 (0.01)	0.01 (0.02)	0.04 (0.03)	-0.13 (0.05)
Dutiable OAP imports OECD	-0.01 (0.02)	0.15 (0.03)	-0.06 (0.05)	0.36 (0.07)
Other Intermediate inputs	-0.22 (0.06)	-0.31 (0.09)	-6.16 (0.16)	-2.51 (0.24)
Capital	0.03 (0.08)	0.17 (0.12)	0.08 (0.20)	0.18 (0.31)
Energy	0.06 (0.11)	-0.01 (0.17)	0.05 (0.30)	0.77 (0.43)
R <sup>2</sup>	0.41	0.30	0.97	0.96

Note: Standard errors are in parentheses. Estimation is in levels for 1980-1993, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

**Table 5: Production Characteristics**

	<i>Apparel (SIC 23)</i>	<i>Footwear and Leather (SIC 31)</i>	
Impact of production labor on the U.S. content of OAP imports	-2.53 (0.29)	-0.32 (0.69)	
Impact of non-production labor on the U.S. content of OAP imports	1.19 (0.32)	-1.61 (0.77)	
Impact of dutiable OAP imports on the relative demand for production labor	-0.030 (0.007)	-0.015 (0.011)	
	<i>Machinery (SIC 35)</i>	<i>Electrical Machinery (SIC 36)</i>	<i>Transportation Equipment (SIC 37)</i>
Impact of production labor on the U.S. content of OAP imports from LDC	-0.19 (0.18)	0.25 (0.21)	1.36 (0.33)
Impact of non-production labor on the U.S. content of OAP imports from LDC	0.53 (0.13)	-0.13 (0.14)	-0.05 (0.17)
Impact of production labor on the U.S. content of OAP imports from OECD	-0.42 (0.14)	0.087 (0.036)	-1.01 (0.52)
Impact of non-production labor on the U.S. content of OAP imports from OECD	0.61 (0.10)	0.11 (0.024)	0.70 (0.28)
Impact of dutiable OAP imports from LDC on the relative demand for production labor	-0.004 (0.005)	-0.021 (0.007)	0.029 (0.013)
Impact of dutiable OAP imports from OECD on the relative demand for production labor	0.014 (0.009)	0.001 (0.009)	-0.074 (0.018)

Notes: Standard errors are in parentheses.

**Table 6: Summary Statistics for OAP Import Regressions**

	Dutiable OAP Imports	Real Exchange Rate	Real Output	Capital Intensity
Apparel (SIC 23)	2.14 (3.17)	2.13 (0.12)	7.93 (0.76)	-1.69 (0.28)
Footwear and Leather (SIC 31)	6.84 (3.27)	3.42 (0.24)	7.01 (0.76)	-1.42 (0.25)
Machinery (SIC 35)				
OECD	1.19 (2.58)	1.38 (0.14)	9.17 (1.19)	-0.69 (0.37)
Non-OECD	0.89 (1.83)	1.55 (0.16)		
Electrical Machinery (SIC 36)				
OECD	0.59 (0.77)	1.62 (0.22)	9.29 (1.24)	-0.90 (0.43)
Non-OECD	4.52 (6.58)	1.58 (0.22)		
Transport Equipment (SIC 37)				
OECD	5.16 (6.89)	2.90 (0.17)	10.79 (1.13)	-1.21 (0.43)
Non-OECD	0.78 (1.48)	2.25 (0.13)		

*Variable Definitions:*

Dutiable OAP Imports = 100x(Dutiable OAP imports/non-energy material purchases)

Real Exchange Rate = Log average real exchange rate (U.S. CPI/(nominal exchange rate\*country j's CPI)), using country average share of dutiable OAP imports for 1980-1993 as weights.

Real Output = Log(industry shipments/industry output price index)

Capital Intensity = Log(industry real shipments/industry real capital stock)

Notes: Averages are over the years 1980-1993, excluding 1982 and 1988, and over the four-digit industries within each two-digit sector. They are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses.

**Table 7: Regression Results for Dutiable OAP Imports**

*Dependent Variable: Dutiable OAP Imports  
(share of non-energy material purchases)*

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*Independent Variables (in logs):*

*Apparel (SIC 23), N=386*

Real Exchange Rate	0.073 (0.013)
Capital Intensity	0.004 (0.006)
Real Output	-0.005 (0.002)
Constant	-0.089 (0.031)
R <sup>2</sup>	0.082

*Footwear and Leather (SIC 31), N=121*

Real Exchange Rate	-0.009 (0.108)
Capital Intensity	0.616 (0.106)
Real Output	-0.102 (0.034)
Constant	1.692 (0.498)
R <sup>2</sup>	0.259

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Notes: The sample is all four-digit industries within each two-digit sector for the years 1980-1993, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See Table 6 for variable definitions.

**Table 8: Regression Results for Dutiable OAP Imports**

*Dependent Variables: (shares of non-energy material purchases)*      Dutiable OAP Imports from OECD      Dutiable OAP Imports from LDCs

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*Independent Variables (in logs):*

*Machinery (SIC 35), N= 518, 455*

Real Exchange Rate	.0082(.0077)	.0126(.0053)
Capital Intensity	.0041(.0032)	-.0028(.0025)
Real Output	-.0028(.0010)	.0023(.0008)
Constant	.0297(.0135)	-.0344(.0103)
R <sup>2</sup>	0.029	0.046

*Electrical Machinery (SIC 36), N=463, 453*

Real Exchange Rate	.0041(.0016)	-.0301(.0129)
Capital Intensity	.0020(.0011)	.0831(.0085)
Real Output	-.0008(.0003)	.0096(.0023)
Constant	.0084(.0038)	.0780(.0301)
R <sup>2</sup>	0.041	0.19

*Transportation Equipment (SIC 37), N=172, 136*

Real Exchange Rate	-.0077(.0311)	-.0101(.0056)
Capital	-.0514(.0130)	.0013(.0017)
Real Output	.0079(.0046)	.0005(.0006)
Constant	-.0737(.1036)	.0259(.0139)
R <sup>2</sup>	0.15	0.025

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Notes: The sample is all four-digit industries within each two-digit sector for the years 1980-1993, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See Table 6 for variable definitions.

**Table 9: OAP Imports and Changes in Exchange Rates**

	Dutiable OAP Imports	Maximum Dutiable OAP Imports	Change in OAP Imports from 10% dollar appreciation
Apparel (SIC 23)	2.14	40.68	0.70
Footwear and Leather (SIC 31)	6.84	333.67	na
Machinery (SIC 35)			
OECD	1.19	39.2	0.08
Non-OECD	0.89	18.1	0.12
Electrical Machinery (SIC 36)			
OECD	0.59	16.2	0.04
Non-OECD	4.52	58.9	-0.29
Transportation Equipment (SIC 37)			
OECD	5.16	1.08	na
Non-OECD	0.78	13.7	-0.10

*Variable Definitions:*

Dutiable OAP Imports =  $100 \times (\text{Dutiable OAP imports}) / (\text{non-energy material purchases})$

Maximum Dutiable OAP Imports = maximum value of share in two-digit industry for sample period

Change in OAP Imports =  $100 \times (\text{Real Exchange Rate Coefficient} \times \log(1.1))$



**Table 10: Regression Results for Dutiable OAP Imports**

*Dependent Variables: (shares of non-energy material purchases)*      Dutiable OAP Imports from OECD      Dutiable OAP Imports from LDCs

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*Independent Variables (in logs):*

*Office and Computing Machines (SIC 357), N= 48,47*

Real Exchange Rate	-0.0005(.0089)	.0789(.0343)
Capital Intensity	-.0484(.0186)	-.0112(.0144)
Real Output	-.0292(.0068)	-.0161(.0048)
Constant	.2803(.0634)	.1195(.0480)
R <sup>2</sup>	0.251	0.230

*TV and Radio Receiving Equipment (SIC 365), N=22, 21*

Real Exchange Rate	.00057(.00047)	.0025(.0133)
Capital Intensity	.0307(.0102)	.0241(.0826)
Real Output	.0103(.0028)	.0737(.0246)
Constant	-.0525(.0237)	-.5464(.2119)
R <sup>2</sup>	0.411	0.24

*Electronic Components (SIC 367), N=107,108*

Real Exchange Rate	.00048(.00008)	.0535(.0113)
Capital	-.0039(.0025)	.0124(.0286)
Real Output	-.0027(.0008)	-.0059(.0104)
Constant	.0257(.0059)	.1231(.0775)
R <sup>2</sup>	0.388	0.431

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Notes: The sample is all four-digit industries within each two-digit sector for the years 1980-1993, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See Table 6 for variable definitions.

**Table 10 (Continued): Regression Results for Dutiable OAP Imports**

*Dependent Variables: (shares of non-energy material purchases)*      Dutiable OAP Imports from OECD      Dutiable OAP Imports from LDCs

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*Independent Variables (in logs):*

*Motor Vehicles (SIC 371), N= 48,48*

Real Exchange Rate	.2936(.2634)	-.0004(.0003)
Capital Intensity	-.3827(.1913)	.0020(.0058)
Real Output	-.2723(.1017)	-.0067(.0031)
Constant	2.065(1.315)	.1031(.0373)
R <sup>2</sup>	0.119	0.075

*Aircraft and Aircraft Parts (SIC 372), N=35*

Real Exchange Rate	-.0263(.0119)
Capital Intensity	.0043(.0186)
Real Output	-.0063(.0093)
Constant	.1050(.0807)
R <sup>2</sup>	0.077

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Notes: The sample is all four-digit industries within each two-digit sector for the years 1980-1993, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See Table 6 for variable definitions.

**Table 11 OAP Imports and Changes in Exchange Rates**

	Dutiable OAP Imports	Change in OAP Imports from 10% dollar appreciation
<hr/>		
Office and Computing Machines (SIC 357)		
OECD	1.61	na
Non-OECD	2.50	.752
TV and Radio Receiving Equipment (SIC 365)		
OECD	1.18	na
Non-OECD	7.93	na
Electrical Components and Accessories (SIC 367)		
OECD	0.69	.0047
Non-OECD	10.6	.510
Motor Vehicles (SIC 371)		
OECD	11.6	2.79
Non-OECD	0.93	-.038
Aircraft and Parts (SIC 372)		
OECD	1.79	-.251
<hr/>		

*Variable Definitions:*

Dutiable OAP Imports =  $100 \times (\text{Dutiable OAP imports}) / (\text{non-energy material purchases})$

Change in OAP Imports =  $100 \times (\text{Real Exchange Rate Coefficient} \times \log(1.1))$

## Appendix

The estimates shown in Tables 3 and 4 are obtained for the years 1980-1993 (omitting 1982 and 1988 due to missing data), with all variables entered in *levels*, and not including any fixed effects for the individual four-digit industries. The estimation results for *first-differences* are reported in Tables A1 and A2. Because of missing data (in 1982 and 1988), these differences were taken across odd-numbered years.

<b>Table A1: U.S. Revenue Functions</b>			
<i>Dependent Variables:</i> (share of industry shipments)	U.S. Content of OAP Imports	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>			
<i>Apparel (SIC 23), N=191</i>			
Production labor	1.37 (1.22)	9.48 (0.90)	-0.98 (0.48)
Non-production labor	0.57 (0.73)	-0.99 (0.54)	3.21 (0.29)
Dutiable OAP imports	0.22 (0.09)	-0.01 (0.06)	-0.04 (0.04)
Other Intermediate inputs	-1.81 (1.02)	-7.30 (0.75)	-2.45 (0.41)
Capital	-3.09 (2.42)	0.84 (1.78)	1.13 (0.96)
Energy	-0.07 (0.42)	0.28 (0.31)	-0.15 (0.17)
R <sup>2</sup>	0.07	0.45	0.43
<i>Footwear and Leather (SIC 31), N=62</i>			
Production labor	-3.93 (2.84)	7.73 (1.46)	-1.13 (1.13)
Non-production labor	2.28 (1.98)	-3.47 (1.02)	2.16 (0.79)
Dutiable OAP imports	0.55 (0.29)	0.17 (0.15)	-0.19 (0.12)
Other Intermediate inputs	-0.09 (0.69)	-0.30 (0.36)	-0.33 (0.27)
Capital	-10.68 (9.15)	-0.77 (4.74)	-2.27 (3.66)
Energy	-1.00 (1.52)	-1.24 (0.79)	-0.40 (0.61)
R <sup>2</sup>	0.14	0.39	0.17

Note: Standard errors are in parentheses. Estimation is in first-differences, taken across odd-numbered year. All regressions are weighted by the industry share of total manufacturing shipments.

**Table A2: U.S. Revenue Functions**

<i>Dependent Variables: (share of industry shipments)</i>	U.S. Content OAP Imports from LDC	U.S. Content OAP Imports from OECD	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>				
<i>Machinery (SIC 35), N=214</i>				
Production labor	0.09 (0.24)	0.73 (0.24)	4.36 (0.46)	-2.45 (0.59)
Non-production labor	-0.52 (0.30)	-0.66 (0.29)	-2.12 (0.57)	5.18 (0.74)
Dutiable OAP imports LDC	0.04 (0.01)	-0.01 (0.01)	0.04 (0.03)	0.002 (0.03)
Dutiable OAP imports OECD	-0.02 (0.02)	0.08 (0.02)	0.01 (0.04)	-0.14 (0.05)
Other Intermediate inputs	0.08 (0.15)	-0.57 (0.14)	-3.09 (0.28)	-3.45 (0.36)
Capital	0.21 (0.39)	0.91 (0.38)	3.26 (0.73)	0.27 (0.95)
Energy	-0.04 (0.20)	-0.06 (0.20)	-0.15 (0.37)	0.46 (0.49)
R <sup>2</sup>	0.07	0.18	0.43	0.62
<i>Electrical Machinery (SIC 36), N=223</i>				
Production labor	2.44 (1.61)	-0.05 (0.18)	6.29 (0.76)	-1.68 (0.82)
Non-production labor	2.67 (1.45)	0.09 (0.16)	-1.37 (0.69)	5.42 (0.74)
Dutiable OAP imports LDC	0.79 (0.12)	0.03 (0.01)	-0.19 (0.06)	-0.11 (0.06)
Dutiable OAP imports OECD	0.19 (0.10)	0.09 (0.01)	-0.02 (0.05)	-0.12 (0.05)
Other Intermediate inputs	-6.62 (0.99)	-0.43 (0.11)	-2.72 (0.47)	-4.62 (0.51)
Capital	-4.12 (1.51)	0.00 (0.17)	0.56 (0.72)	1.05 (0.78)
Energy	0.26 (1.24)	0.33 (0.14)	-0.16 (0.59)	1.47 (0.64)
R <sup>2</sup>	0.42	0.36	0.29	0.43
<i>Transportation Equipment (SIC 37), N=62</i>				
Production labor	-0.39 (0.19)	0.72 (0.75)	7.71 (1.61)	0.96 (2.08)
Non-production labor	0.20 (0.11)	0.29 (0.44)	-0.59 (0.93)	1.82 (1.21)
Dutiable OAP imports LDC	0.03 (0.01)	0.01 (0.03)	0.08 (0.07)	0.10 (0.09)
Dutiable OAP imports OECD	0.03 (0.01)	0.06 (0.04)	-0.22 (0.09)	-0.06 (0.11)
Other Intermediate inputs	0.23 (0.11)	-0.98 (0.44)	-5.64 (0.94)	-2.88 (1.22)
Capital	0.09 (0.10)	-0.06 (0.39)	-0.12 (0.20)	-0.63 (0.31)
Energy	0.01 (0.12)	-0.18 (0.47)	-2.15 (0.99)	-0.64 (1.28)
R <sup>2</sup>	0.34	0.29	0.36	0.47

Note: Standard errors are in parentheses. Estimation is in first-differences, taken across odd-numbered years. All regressions are weighted by the industry share of total manufacturing shipments.

In order to control for some of the most important heterogeneity across industries, in Table A3-A5 we show additional estimates for machinery, electrical machinery, and transportation equipment, that separate the most important three-digit industries within these two-digit groups. Fixed effects are *not* used in these regressions.

**Table A3: U.S. Revenue Functions: Machinery**

<i>Dependent Variables:</i> <i>(share of industry shipments)</i>	U.S. Content OAP Imports from LDC	U.S. Content OAP Imports from OECD	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>				
<i>Machinery (SIC 35), N=452</i>				
Production labor	-0.11 (0.06)	-0.19 (0.05)	8.94 (0.35)	-2.85 (0.16)
Non-production labor	0.15 (0.05)	0.17 (0.04)	-3.32 (0.26)	7.38 (0.12)
Dutiable OAP imports LDC	0.07 (0.01)	0.014 (0.006)	-0.10 (0.04)	-0.04 (0.02)
Dutiable OAP imports OECD	0.04 (0.01)	0.11 (0.01)	0.18 (0.07)	0.01 (0.03)
Other Intermediate inputs	-0.27 (0.05)	-0.31 (0.53)	-7.33 (0.29)	-4.72 (0.13)
Capital	0.03 (0.08)	0.10 (0.06)	3.80 (0.46)	-0.26 (0.21)
Energy	-0.04 (0.11)	0.04 (0.09)	-1.20 (0.65)	0.45 (0.29)
R <sup>2</sup>	0.33	0.40	0.90	0.91
<i>Office and Computing Machines (SIC 357), N=47</i>				
Production labor	-0.21 (0.71)	0.007 (0.61)	2.97 (0.57)	-4.18 (1.51)
Non-production labor	0.12 (0.95)	0.13 (0.82)	-1.71 (0.77)	7.12 (2.04)
Dutiable OAP imports LDC	0.37 (0.08)	0.17 (0.07)	-0.06 (0.06)	-0.04 (0.17)
Dutiable OAP imports OECD	0.07 (0.07)	0.20 (0.06)	0.19 (0.05)	-0.21 (0.14)
Other Intermediate inputs	-1.06 (0.32)	-0.86 (0.28)	-1.00 (0.26)	-3.26 (0.69)
Capital	-0.06 (0.77)	-0.34 (0.66)	-1.83 (0.63)	-0.78 (1.66)
Energy	0.52 (0.66)	0.61 (0.56)	0.99 (0.53)	0.76 (1.41)
R <sup>2</sup>	0.71	0.71	0.96	0.82

Note: Standard errors are in parentheses. Estimation is in levels for 1980-1993, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

**Table A4: U.S. Revenue Functions: Electrical Machinery**

<i>Dependent Variables: (share of industry shipments)</i>	U.S. Content OAP Imports from LDC	U.S. Content OAP Imports from OECD	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>				
<i>Electrical Machinery (SIC 36), N=450</i>				
Production labor	0.24 (0.40)	-0.05 (0.07)	8.38 (0.29)	-3.30 (0.24)
Non-production labor	-0.47 (0.27)	-0.04 (0.05)	-2.14 (0.19)	8.24 (0.16)
Dutiable OAP imports LDC	0.78 (0.06)	0.01 (0.01)	-0.33 (0.05)	-0.10 (0.04)
Dutiable OAP imports OECD	0.10 (0.08)	0.09 (0.01)	-0.04 (0.06)	-0.06 (0.05)
Other Intermediate inputs	-3.32 (0.27)	-0.22 (0.05)	-4.63 (0.20)	-3.31 (0.17)
Capital	2.06 (0.33)	-0.05 (0.06)	-0.45 (0.24)	-0.75 (0.21)
Energy	0.06 (0.32)	0.28 (0.06)	-0.19 (0.23)	0.23 (0.20)
R <sup>2</sup>	0.52	0.19	0.77	0.95
<i>TV and Radio Receiving Equipment (SIC 365), N=21</i>				
Production labor	-1.70 (4.18)	0.50 (0.32)	10.18 (2.38)	0.16 (0.94)
Non-production labor	0.03 (4.26)	-0.39 (0.32)	-5.07 (2.42)	1.61 (0.96)
Dutiable OAP imports LDC	0.17 (0.26)	0.006 (0.02)	-0.10 (0.15)	0.07 (0.06)
Dutiable OAP imports OECD	-1.18 (0.47)	0.02 (0.04)	-0.25 (0.27)	0.01 (0.11)
Other Intermediate inputs	-1.64 (2.15)	0.23 (0.16)	-4.36 (1.22)	-2.24 (0.48)
Capital	12.96 (3.68)	-0.48 (0.28)	1.94 (2.10)	-0.48 (0.83)
Energy	-3.33 (2.94)	0.02 (0.22)	3.68 (1.67)	1.81 (0.66)
R <sup>2</sup>	0.77	0.60	0.90	0.93
<i>Electronic Components (SIC 367), N=107</i>				
Production labor	-1.34 (1.94)	0.47 (0.50)	7.25 (0.74)	-3.36 (0.89)
Non-production labor	6.08 (2.08)	-0.32 (0.54)	-3.58 (0.79)	9.05 (0.94)
Dutiable OAP imports LDC	1.33 (0.24)	-0.05 (0.06)	-0.72 (0.09)	-0.57 (0.11)
Dutiable OAP imports OECD	0.41 (0.22)	0.29 (0.06)	0.07 (0.09)	0.13 (0.10)
Other Intermediate inputs	-7.66 (1.15)	-1.08 (0.30)	-3.78 (0.44)	-4.42 (0.52)
Capital	-4.38 (1.22)	-1.00 (0.31)	-0.91 (0.46)	-1.73 (0.55)
Energy	4.00 (1.67)	1.83 (0.43)	1.20 (0.63)	1.21 (0.76)
R <sup>2</sup>	0.76	0.39	0.94	0.90

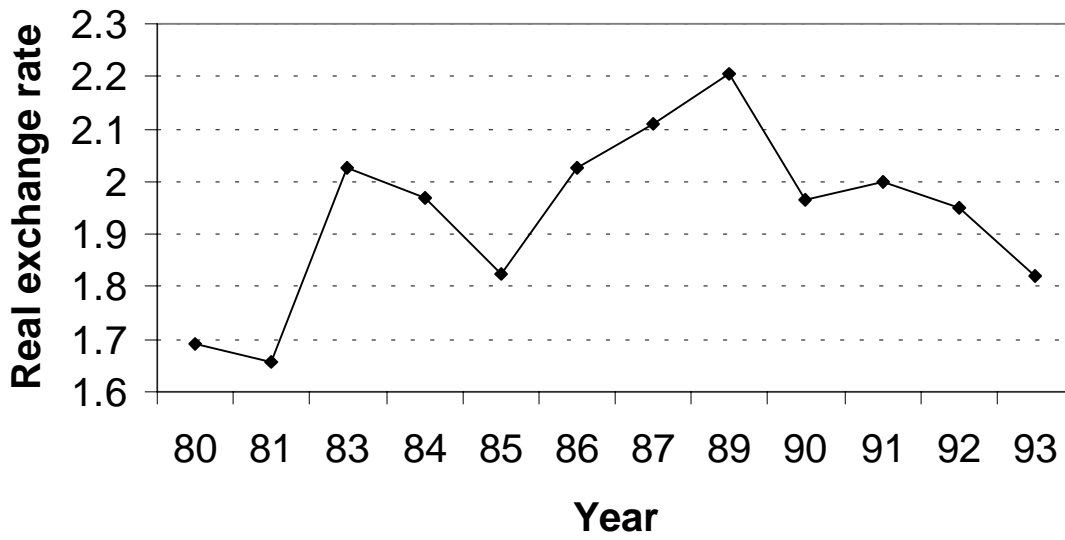
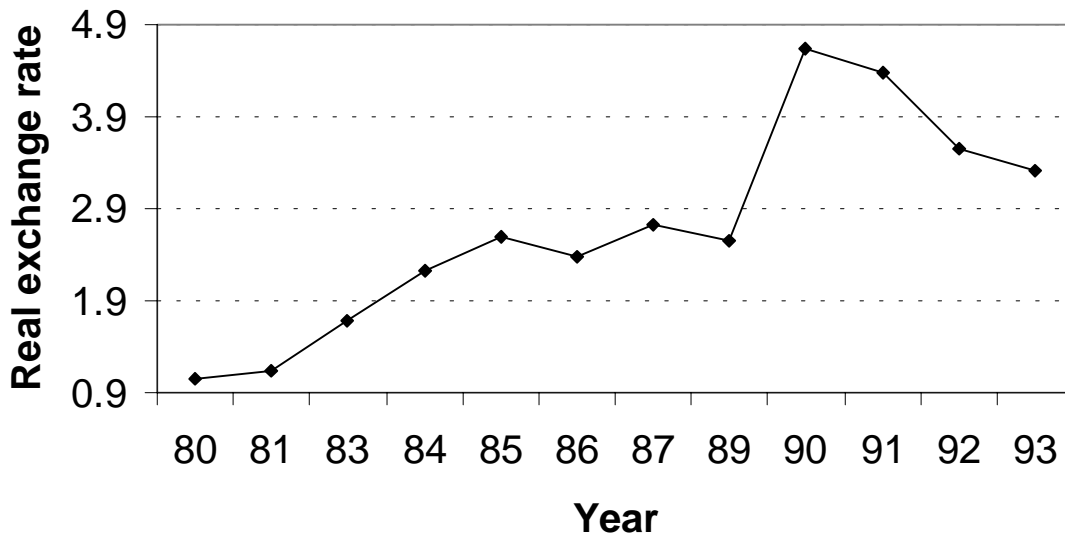
Note: Standard errors are in parentheses. Estimation is in levels for 1980-1993, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

**Table A5: U.S. Revenue Functions: Transportation Equipment**

<i>Dependent Variables: (share of industry shipments)</i>	U.S. Content OAP Imports from LDC	U.S. Content OAP Imports from OECD	Production Labor Share	Non-Prod. Labor Share
<i>Independent Variables (in logs):</i>				
<i>Transportation Equipment (SIC 37), N=135</i>				
Production labor	0.47 (0.12)	-0.42 (0.20)	7.84 (0.34)	-5.49 (0.51)
Non-production labor	-0.04 (0.07)	0.24 (0.10)	-0.40 (0.18)	6.49 (0.27)
Dutiable OAP imports LDC	0.05 (0.01)	0.01 (0.02)	0.04 (0.03)	-0.13 (0.05)
Dutiable OAP imports OECD	-0.01 (0.02)	0.15 (0.03)	-0.06 (0.05)	0.36 (0.07)
Other Intermediate inputs	-0.22 (0.06)	-0.31 (0.09)	-6.16 (0.16)	-2.51 (0.24)
Capital	0.03 (0.08)	0.17 (0.12)	0.08 (0.20)	0.18 (0.31)
Energy	0.06 (0.11)	-0.01 (0.17)	0.05 (0.30)	0.77 (0.43)
R <sup>2</sup>	0.41	0.30	0.97	0.9
<i>Motor Vehicles (SIC 371), N=43</i>				
Production labor	0.56 (0.94)	0.19 (0.17)	5.29 (1.71)	0.44 (0.67)
Non-production labor	0.42 (0.65)	-0.13 (0.12)	-0.510 (1.18)	1.57 (0.46)
Dutiable OAP imports LDC	0.11 (0.05)	0.0003 (0.01)	-0.09 (0.10)	-0.03 (0.04)
Dutiable OAP imports OECD	0.03 (0.05)	0.06 (0.01)	-0.35 (0.09)	-0.12 (0.04)
Other Intermediate inputs	-0.20 (0.21)	-0.15 (0.04)	-5.88 (0.38)	-1.85 (0.15)
Capital	-0.22 (0.20)	-0.01 (0.04)	0.35 (0.36)	-0.38 (0.14)
Energy	-0.43 (0.42)	0.02 (0.08)	1.90 (0.76)	0.38 (0.30)
R <sup>2</sup>	0.49	0.63	0.99	0.99
<i>Aircraft and Aircraft Parts (SIC 372), N=24</i>				
Production labor	-0.06 (0.09)	0.94 (0.85)	11.36 (2.48)	1.20 (3.36)
Non-production labor	0.05 (0.06)	-0.61 (0.57)	-0.32 (1.65)	8.05 (2.24)
Dutiable OAP imports LDC	0.006 (0.002)	0.02 (0.02)	0.09 (0.05)	0.13 (0.07)
Dutiable OAP imports OECD	0.0004 (0.005)	0.11 (0.05)	-0.06 (0.14)	-0.12 (0.19)
Other Intermediate inputs	-0.0006 (0.02)	-0.15 (0.19)	-6.34 (0.55)	-5.05 (0.75)
Capital	-0.06 (0.05)	0.73 (0.50)	0.16 (1.44)	-3.05 (1.95)
Energy	0.08 (0.07)	-0.45 (0.64)	-3.63 (1.85)	0.73 (2.50)
R <sup>2</sup>	0.53	0.78	0.98	0.92

Note: Standard errors are in parentheses. Estimation is in levels for 1980-1993, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.



**Figure 1: Apparel, SIC 23****Figure 2: Footwear, SIC 31**

**Figure 3: Machinery, SIC 35****Figure 4: Electrical Machinery, SIC 36**