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

Robert C. Feenstra, Gordon H. Hanson, and Deborah L. Swenson

3.1 Introduction

Foreign outsourcing is a prominent feature of many recent formal models of international trade.[1] By outsourcing we mean the practice in which firms divide production into stages and then locate each stage in the country where it can be performed at least cost. Anecdotal evidence suggests that outsourcing is a key aspect of the ongoing process of globalization. An important question for public policy is whether outsourcing has contributed to the rise in inequality between the wages of skilled and unskilled workers in the United States.

Recent work by Feenstra and Hanson (1996a) suggests that outsourcing can raise the skilled-unskilled wage gap. They show that if skilled and unskilled labor are used in different intensities along a product's value chain, outsourcing from a host to a recipient country reduces the relative de-

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1. The outsourcing phenomenon is referred to by a number of names; examples of such work include Antweiler and Trefler (1997), Arndt (1997, 1998a, 1998b), Feenstra and Hanson (1996a, 1996b), Hummels, Ishii, and Yi (1999), Jones and Keirzkowski (1997), Krugman (1995), and Leamer (1998).

mand for unskilled labor in both locations. Markusen and Venables (1995, 1996a, 1996b) focus on multinational firm activity and arrive at a similar conclusion. As long as multinational firms can choose their production location, they find that the presence of multinational activity implies a higher relative wage for skilled workers 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: Manufacturing agglomerates in core countries, while those in the periphery have little industry and low wages. At lower levels of transport costs, the agglomeration of manufacturing in the core disappears, leading to a fall in wage inequality across regions.[2]

Despite the theoretical interest, there are relatively few attempts to measure outsourcing empirically. Feenstra and Hanson (1996b) rely on estimates of imported manufactured inputs, as do Campa and Goldberg (1997) and Hummels, Ishii, and Yi (1999). These suffer from assuming that the import share for each input is the same across all manufacturing industries and also from excluding nonmanufactured 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 the derived result that outsourcing reduces 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 empirical verification. In addition, the underlying causes of outsourcing—such as factor endowments, transport costs, or multinational activity—deserve further investigation.

In this paper, we study outsourcing by U.S. industry conducted through the offshore assembly program (OAP). The OAP program is the only data source, to our knowledge, that provides direct observations on foreign outsourcing. Formerly called the 806/807 provision of the U.S. tariff code and later renamed the 9802 provision of the Harmonized System code, the OAP 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 percent in 1995), this program is still substantial in its effects on economic activity.

2. Matsuyama (1996) demonstrates a similar pattern of agglomeration and uneven incomes across countries. Gao (1999) 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.

For example, virtually all of the *maquiladora* plants in Mexico are engaged in the 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 on foreign value added only, the administration of the program requires a separate accounting of the value of imports resulting from assembly abroad. In particular, a key distinction is made between dutiable OAP imports, which represent the value added associated with foreign production, and nondutiable OAP imports, which represent the value embodied in U.S.-made goods originally exported from the U.S. for further processing abroad. This administrative distinction allows us 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 1980–93. We focus on five industries: apparel, leather and footwear, machinery, electrical machinery, and transportation equipment. Together these industries account for 90–93 percent of all OAP imports and 94–95 percent 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 percent during 1981–93.

Our primary hypothesis is that the goods U.S. industries export abroad for further processing are more skilled-labor intensive than other goods U.S. industries produce. In section 3.3, we describe a revenue-function approach that we use to test this idea. For the five industries of study, we treat the U.S. content of OAP imports (i.e., goods exported for further processing) and all other shipments from the industry as separate outputs. Inputs include production and nonproduction labor, capital, energy, dutiable OAP imports (i.e., value added by foreign production), and remaining intermediate inputs. For several industries, the empirical evidence supports the idea that outsourcing makes U.S. industries more intensive in skilled labor. We also use the OAP import data to search for evidence of substitution between foreign labor and domestic production and nonproduction labor.

In section 3.5, we turn to the question of which factors account for the variation in the level of OAP imports across industries and over time. A higher level of dutiable OAP imports implies a higher level of foreign outsourcing in terms of value added by foreign producers. We focus on international differences in production costs as measured by the real exchange rate between the United States 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.

3.2 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 percent to 12.2 percent and then fell somewhat to 8.5 percent 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 1980–88, and by Harmonized System categories for 1989–93. The latter years were available in electronic form, but the earlier years were available in hard copy, which were electronically scanned and then extensively checked for errors. This proved to be impossible for 1982 and 1988, due to the inadequate quality of the hard copy.[3] 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

3. For 1982, the scanned data had too many errors to make correction feasible. For 1988, the hard copy was available only by month, making scanning and correction prohibitively expensive.

these data to the four-digit Standard Industrial Classification (SIC) system, so that it matches the production data available for U.S. industries.[4]

Data on the OAP imports for the five two-digit SIC industries studied here are given in table 3.1, 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, although they have grown substantially in apparel—from 1 to 6 percent of shipments—and also in footwear and leather—from 1 to 8.5 percent of shipments.

Additional summary statistics are provided in table 3.2, where we separate the OAP imports into those attributable to U.S.-made components and those attributable to foreign value added, the latter being subject to U.S. duties. The value of these imports are shown relative to total industry shipments. It is evident that the U.S. imports versus the 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 the dutiable share). A higher U.S. share suggests that a larger fraction of components parts for a given good are produced in the United States. 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, 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 percent during 1981–93.

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

4. 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, 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.

Table 3.1 **OAP Imports by Two-Digit SIC Industry (percent)**

	Developing Countries (LDCs)		Industrial Countries (OECD)	
	Share of Industry Shipments	Share of OAP Shipments	Share of Industry Shipments	Share of OAP Shipments
		Apparel (SIC 23)		
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		
		Footwear and Leather (SIC 31)		
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		
		Machinery (SIC 35)		
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
		Electrical Machinery (SIC 36)		
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
		Transportation Equipment (SIC 37)		
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 3.2 Summary Statistics

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

Notes: Averages are computed over the years 1980–93, 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 average annual changes, using data for the odd-numbered years. Both averages and changes are weighted by the industry share of total manufacturing shipments.

Variable definitions are as follows:

U.S. share of OAP = 100 × (U.S. content of OAP imports)/(Value of industry shipments).

Dutiable share of OAP = 100 × (Foreign content of OAP imports)/(Value of industry shipments).

Production labor share = 100 × (Wage bill of production labor)/(Value of industry shipments).

Nonproduction labor share = 100 × (Wage bill of nonproduction labor)/(Value of industry shipments).

variation, will be a focus of our empirical investigation. The U.S. share of OAP imports in total industry shipments—as shown in table 3.2—will serve as one dependent variable. We interpret this share, quite reasonably, to be the fraction of shipments that are exported abroad for further processing. Also shown in table 3.2 are the wage bills of production and nonproduction labor, measured relative to total industry shipments. These data are taken from the NBER Manufacturing Database, with nonproduction labor used as a proxy for skilled labor and production labor used as a proxy for unskilled labor.[5] 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 nonproduction labor has also declined, but by a smaller amount. The shares of production and nonproduction labor in total industry shipments will be other dependent variables in our empirical analysis.

3.3 U.S. Revenue Function

We shall specify production in each industry in the United States as a multiple-input, multiple-output technology.[6] The outputs consist of the U.S. content of OAP imports measured relative to total industry shipments (as summarized in table 3.2), and all other shipments from the industry.[7] In some industries, we will distinguish the U.S. content of OAP imports from developing versus industrialized countries. The inputs are production and nonproduction labor, the dutiable (i.e., foreign) component of OAP imports, remaining intermediate inputs, capital, and energy.[8] 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_ℓ of the inputs. The revenue function is specified as the translog form

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

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

5. The NBER Manufacturing Database at the four-digit SIC level is available from the National Bureau of Economic Research, at http://www.nber.org/data_index.html.

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

7. That is, "all other shipments" is measured as (Total shipments − U.S. content of OAP imports)/(Total shipments).

8. 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.

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

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

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 equation (1) with respect to the log of input quantities:

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

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 equations (2) and (3), and focus on the input quantities.

The coefficients η_{ik} in equation (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 Rybzcynski derivatives for an entire economy, except that we are dealing with individual industries. Rybzcynski 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 equations (1) and (2), we obtain the output elasticity:

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

Thus, the coefficient η_{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 equation (4) is positive. In this way, the output elasticities provide us with indirect evidence on the factor intensities used in production.[9]

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 United States becomes more skill intensive as a result. In the particular industry structure we model, industries produce two types of goods, final goods and goods to be exported abroad for further processing. For the latter type,

9. Note that if the U.S. content of OAP imports versus other industry shipments are likely to be 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 about the signs of the output elasticities.

non-skill-intensive production activities have been separated off and outsourced abroad; for the former type, all production activities are still conducted in the United States. Thus, an increase in the share of dutiable OAP imports in industry shipments implies a shift toward more-skill-intensive production activities.

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 nonproduction 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 nonproduction, 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 nonproduction labor, respectively, we are interested in the sign of

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

The null hypothesis that equation (5) equals 0 is a test for the weak separability of production and nonproduction labor from dutiable OAP imports in the U.S. revenue function.

We shall estimate equations (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 nonproduction labor, where the latter is used as a proxy for skilled labor. Estimation is performed over the years 1980–93 (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.

Table 3.3 **U.S. Revenue Functions**

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content of OAP Imports	Production Labor Share	Nonproduction Labor Share
	Apparel (SIC 23), N = 385		
Production labor	−4.87 (0.52)	6.52 (0.40)	−2.14 (0.17)
Nonproduction 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^2	0.45	0.68	0.72
	Footwear and Leather (SIC 31), N = 129		
Production labor	−0.50 (0.74)	7.43 (0.56)	−3.88 (0.31)
Nonproduction 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^2	0.29	0.78	0.81

Note: Standard errors are in parentheses. Estimation is in levels for 1980–93, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

3.4 Estimation Results

In table 3.3, we report the 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 3.3, 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 nonproduction labor. These coefficient estimates are converted into output elasticities using equation (4), and the results are shown in table 3.5, below.[10] We see that an increase in production (nonproduction) 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 nonproduction (skilled) labor. Also in table 3.3, an increase in the dutiable

10. The output elasticities in table 3.5 can be computed directly from the coefficient estimates in tables 3.3 and 3.4, together with the means of the shares in table 3.2. 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 3.3 and 3.4 should also be divided by 100, before making the calculation in equation (4).

content of OAP imports decreases the share of production labor in total costs and has no impact on the share of nonproduction labor. Making the calculation in equation (5), it is clear that greater dutiable OAP imports for apparel decreases the relative demand for production labor, as reported in table 3.5.

Less interesting results are obtained for footwear and leather. In that case, both production and nonproduction labor have a negative impact on the U.S. content of OAP imports in table 3.3, and a negative output elasticity in table 3.5 (the elasticity for nonproduction 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 3.3, although 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 3.4, 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 3.5, 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 nonproduction labor. Thus, the production of U.S. components is intensive in nonproduction labor. Also from table 3.5, 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, although neither of these elasticities is significant.

Turning to electrical machinery in table 3.5, about 90 percent of these imports come from developing countries, particularly Southeast Asia. Unfortunately, neither of the output elasticities reported in table 3.5 for the LDCs are significant, so we are not able to measure this production characteristic.[11] Just one of the output elasticities for the OECD countries is significant, although 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.

11. Stronger results are obtained for electronic components (SIC 367), in appendix table 3A.4, where the U.S. content of OAP imports from LDCs leads to a positive and significant shift toward nonproduction labor, indicating that the U.S. activities use nonproduction labor intensively.

Table 3.4 **U.S. Revenue Functions**

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content OAP Imports from LDCs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Machinery (SIC 35), N = 452			
Production labor	−0.11 (0.06)	−0.19 (0.05)	8.94 (0.35)	−2.85 (0.16)
Nonproduction labor	0.15 (0.05)	0.17 (0.04)	−3.32 (0.26)	7.38 (0.12)
Dutiable OAP imports from LDCs	0.07 (0.01)	0.014 (0.006)	−0.10 (0.04)	−0.04 (0.02)
Dutiable OAP imports from 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^2	0.33	0.40	0.90	0.91
	Electrical Machinery (SIC 36), N = 450			
Production labor	0.24 (0.40)	−0.05 (0.07)	8.38 (0.29)	−3.30 (0.24)
Nonproduction labor	−0.47 (0.27)	−0.04 (0.05)	−2.14 (0.19)	8.24 (0.16)
Dutiable OAP imports from LDCs	0.78 (0.06)	0.01 (0.01)	−0.33 (0.05)	−0.10 (0.04)
Dutiable OAP imports from 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^2	0.52	0.19	0.77	0.95

(*continued*)

Table 3.4 (continued)

Independent Variables (log)	Dependent Variables (share of industry shipments)			
	U.S. Content OAP Imports from LDCs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Transportation Equipment (SIC 37), N = 135			
Production labor	0.47 (0.12)	−0.42 (0.20)	7.84 (0.34)	−5.49 (0.51)
Nonproduction labor	−0.04 (0.07)	0.24 (0.10)	−0.40 (0.18)	6.49 (0.27)
Dutiable OAP imports from LDCs	0.05 (0.01)	0.01 (0.02)	0.04 (0.03)	−0.13 (0.05)
Dutiable OAP imports from 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^2	0.41	0.30	0.97	0.96

Note: Standard errors are in parentheses. Estimation is in levels for 1980–93, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

Table 3.5 Production Characteristics

	Apparel (SIC 23)	Footwear and Leather (SIC 31)
Impact of production labor on the U.S. content of OAP imports	−2.53 (0.29)	−0.32 (0.69)
Impact of nonproduction 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)

	Machinery (SIC 35)	Electrical Machinery (SIC 36)	Transportation Equipment (SIC 37)
Impact of production labor on the U.S. content of OAP imports from LDCs	−0.19 (0.18)	0.25 (0.21)	1.36 (0.33)
Impact of nonproduction labor on the U.S. content of OAP imports from LDCs	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 nonproduction 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 LDCs 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)

Note: Standard errors are in parentheses.

Finally, in transportation equipment, the bulk of OAP imports come from industrial countries, especially Canada, with a small but growing portion coming from Mexico. In table 3.5 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 nonproduction labor. Thus, production of the U.S. components is intensive in nonproduction 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 nonproduction labor. This result is statistically significant, but its economic meaning is unclear.

As noted in the section 3.3, 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, 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 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 for 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 percent of the imports) correspond to our hypotheses, but this is not the case for OAP imports from developing countries, for reasons we have suggested.

3.5 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 nonproduction 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

Table 3.6 **Summary Statistics for OAP Import Regressions**

	Dutiable OAP Imports	Real Exchange Rate	Real Output	Capital Intensity
Apparel (SIC 23)	2.14	1.94	7.93	−1.69
	(3.17)	(0.16)	(0.76)	(0.28)
Footwear and leather	6.84	2.68	7.01	−1.42
(SIC 31)	(3.27)	(1.14)	(0.76)	(0.25)
Machinery (SIC 35)				
OECD	1.19	1.38		
	(2.58)	(0.14)	9.17	−0.69
Non-OECD	0.89	1.55	(1.19)	(0.37)
	(1.83)	(0.16)		
Electrical machinery (SIC 36)				
OECD	0.59	1.62		
	(0.77)	(0.22)	9.29	−0.90
Non-OECD	4.52	1.58	(1.24)	(0.43)
	(6.58)	(0.22)		
Transport equipment (SIC 37)				
OECD	5.16	2.90		
	(6.89)	(0.17)	10.79	−1.21
Non-OECD	0.78	2.25	(1.13)	(0.43)
	(1.48)	(0.13)		

Notes: Averages are over the years 1980–93, 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.

Variable definitions are as follows:

Dutiable OAP imports = 100 × (Dutiable OAP imports)/(Non-energy material purchases).

Real exchange rate = log(Average real exchange rate), where the real exchange rate is defined as U.S. CPI/(Country *j* CPI × Country *j* nominal exchange rate), and we use country average share of dutiable OAP imports for 1980–93 as weights.

Real output = log(Industry shipments/Industry output price index).

Capital intensity = log(Industry real shipments/Industry real capital stock).

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 nonenergy material purchases.[12] This variable thus captures U.S. industry demand for value added abroad. Table 3.6 reports sample means for the variables used in the analysis. Over the sample period, the mean value of dutiable OAP imports as a percentage of material purchases is 2.1 in

12. We compute nonenergy domestic inputs as (Material cost − Energy). These data are available at the four-digit industry level in the NBER Database.

apparel and 6.8 in footwear. In the remaining sectors, a sizable 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 than from developing countries, with the percentages 5.2 and 0.8, respectively.[13] 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 in footwear and leather, fluctuates widely in transportation equipment, and is relatively stable over time in machinery and in 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.[14] 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. In our construction, an increase in the real exchange rate variable represents a dollar appreciation.

The trade-weighted exchange rates replicate the familiar pattern of U.S. exchange rate movements. Figure 3.1 shows the real exchange rate series for each industry. The real value of the dollar peaked in the mid-1980s, declined sharply for a few years, and then recovered somewhat in the early 1990s. While our constructed industry-specific real exchange rates follow a broadly similar pattern, there are notable 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.

13. The reported means are weighted by industry shares of total manufacturing shipments. Transportation equipment has six outsourcing observations that 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 3.8, their presence increases the size of the estimated regression coefficients markedly.

14. We measure the real exchange between the United States and country j as U.S. CPI/(country j CPI $\times$ country j nominal exchange rate).

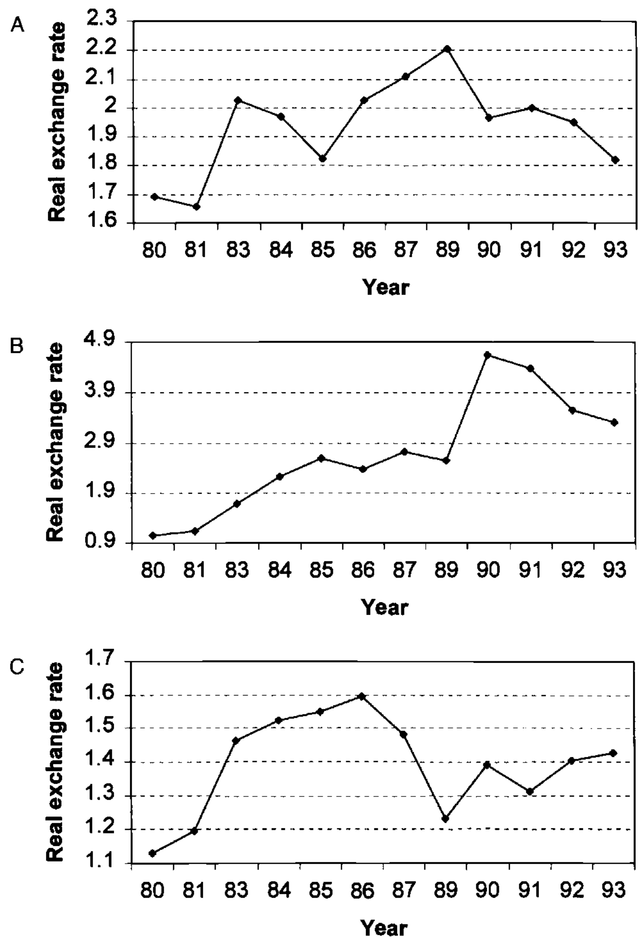

Fig. 3.1 Real exchange rate series, by industry: (*A*) Apparel, SIC 23; (*B*) Footwear, SIC 31; (*C*) Machinery, SIC 35; (*D*) Electrical machinery, SIC 36; (*E*) Transport equipment, SIC 37

The machinery, electrical machinery, and transportation equipment sectors are noticeably different from apparel and footwear in that they have nontrivial dutiable OAP imports from both the industrialized OECD and developing countries.[15] 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 tends to perform high-skill tasks, such as the production of auto parts, while LDC labor

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

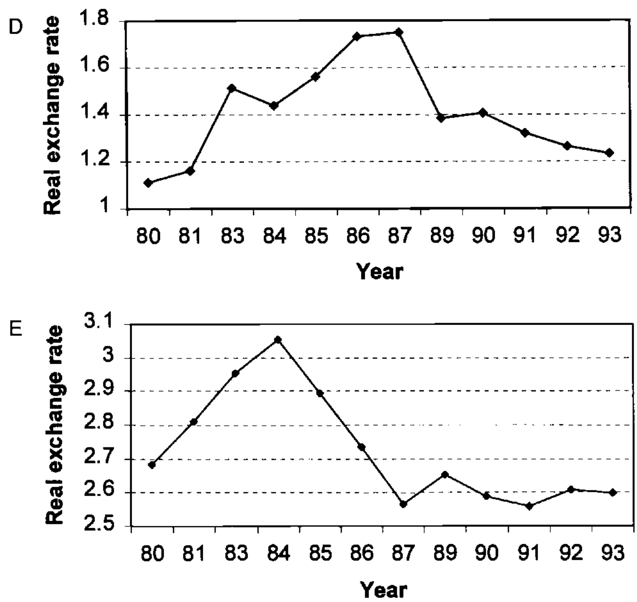

Fig. 3.1 (cont.)

tends to perform low-skill tasks, such as the assembly of automotive accessories. As a result, we may see different substitution patterns toward dutiable OAP imports in LDCs than we do in OECD countries. To control for this possibility, in the machinery, electrical machinery, and transportation equipment 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 NBER Database 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.

Table 3.7 Regression Results for Dutiable OAP Imports

Independent Variables (log)	Dependent Variable: Dutiable OAP Imports (share of nonenergy material purchases)
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^2	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^2	0.259

Notes: The sample is all four-digit industries within each two-digit sector for the years 1980–93, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See table 3.6 for variable definitions.

We estimate dutiable OAP imports separately for each of the five two-digit SIC industries during the years 1980–93. The results for the apparel and footwear industries are presented in table 3.7. 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 when U.S. production costs rise 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 section 3.4, 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 (LDC) and developed (OECD) countries separately in the machinery, electrical machinery, and transportation equipment industries. The results for these industry segments are presented in table 3.8. In both machinery regressions, the coefficient on the real exchange rate is positive, which implies that firms in the United States increase their use of

Table 3.8 Regression Results for Dutiable OAP Imports

Independent Variables (log)	Dependent Variables (shares of nonenergy material purchases): Dutiable OAP Imports from OECD	Dutiable OAP Imports from LDCs
	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^2	.029	.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^2	.041	.19
	Transportation Equipment (SIC 37), N = 172, 136	
Real exchange rate	−.0077 (.0311)	−.0101 (.0056)
Capital intensity	−.0514 (.0130)	.0013 (.0017)
Real output	.0079 (.0046)	.0005 (.0006)
Constant	−.0737 (.1036)	.0259 (.0139)
R^2	.15	.025

Notes: The sample is all four-digit industries within each two-digit sector for the years 1980–93, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See table 3.6 for variable definitions.

dutiable OAP imports when a stronger dollar reduces the relative cost of overseas activities. 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, although the results for OAP imports from industrialized countries are not statistically different from 0. This evidence contrasts with Swenson's (1997) finding that U.S. and Japanese auto producers located in U.S. foreign trade zones purchase more foreign inputs when their relative price is reduced by dollar appreciation. Our data do not exclude the possibility that outsourcing in the transportation sector responds to changes in relative costs. However, it is clear that the OAP component of outsourcing in this industry segment does not correspond with our predictions.

There is no common pattern of 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-intensive sectors; the coefficient for 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 use 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, although 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, although almost all lagged exchange rate coefficients were indistinguishable from 0.

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 3.7. 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, although the inclusion of the four-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 four-digit industry controls are added. The remaining results for transportation equipment are little changed by the inclusion of industry controls, although here, too, the puzzling negative exchange rate coefficient for imports from developing countries shrinks further in significance.

Table 3.9 **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

Note: NA, not applicable.

Variable definitions are as follows:

Dutiable OAP imports = 100 × (Dutiable OAP imports)/(Non-energy material purchases).

Maximum dutiable OAP imports = Maximum value of share in two-digit industry for sample period.

Change in OAP imports = 100(Real exchange rate coefficient × log(1.1)).

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 percent. We calculate the implied effects and display the results in table 3.9. Given that the coefficient for the real exchange rate is statistically insignificant for footwear (SIC 31) and transportation equipment (SIC 37) imports from the OECD, we exclude these segments from the exercise.

Our results show that the predicted change in OAP imports, relative to nonenergy 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 three-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 3.8 and 3.9. 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 the sector for electronic components and accessories, which includes semiconductors, was dominated by Southeast Asian outsourcing, other sectors 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 two-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 three-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 3.10 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 3.11 indicate, these effects are economically large. A 10 percent appreciation of the dollar would cause outsourcing in the office and computing machinery industry to rise by 0.752 percent. Relative to baseline levels of outsourcing in this industry, this represents a 30 percent 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 (SIC 365) and electronic components and accessories (SIC 376), 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, which includes semiconductors. Economically, this effect is somewhat less powerful. While significant statistically, the implied effect

Table 3.10 **Regression Results for Dutiable OAP Imports**

Independent Variables (log)	Dependent Variables (shares of nonenergy material purchases): Dutiable OAP Imports from OECD	Dutiable OAP Imports from LDCs
Office and Computing Machines (SIC 357), N = 48, 47		
Real exchange rate	−0.0005 (0.0089)	0.0789 (0.0343)
Capital intensity	−0.0484 (0.0186)	−0.0112 (0.0144)
Real output	−0.0292 (0.0068)	−0.0161 (0.0048)
Constant	0.2803 (0.0634)	0.1195 (0.0480)
R^2	0.251	0.230
TV and Radio Receiving Equipment (SIC 365), N = 22, 21		
Real exchange rate	0.00057 (0.00047)	0.0025 (0.0133)
Capital intensity	0.0307 (0.0102)	0.0241 (0.0826)
Real output	0.0103 (0.0028)	0.0737 (0.0246)
Constant	−0.0525 (0.0237)	−0.5464 (0.2119)
R^2	0.411	0.24
Electronic Components (SIC 367), N = 107, 108		
Real exchange rate	0.00048 (0.00008)	0.0535 (0.0113)
Capital intensity	−0.0039 (0.0025)	0.0124 (0.0286)
Real output	−0.0027 (0.0008)	−0.0059 (0.0104)
Constant	0.0257 (0.0059)	0.1231 (0.0775)
R^2	0.388	0.431
Motor Vehicles (SIC 371), N = 48, 48		
Real exchange rate	0.2936 (0.2634)	−0.0004 (0.0003)
Capital intensity	−0.3827 (0.1913)	0.0020 (0.0058)
Real output	−0.2723 (0.1017)	−0.0067 (0.0031)
Constant	2.065 (1.315)	0.1031 (0.0373)
R^2	0.119	0.075
Aircraft and Aircraft Parts (SIC 372), N = 35		
Real exchange rate	−0.0263 (0.0119)	
Capital intensity	0.0043 (0.0186)	
Real output	−0.0063 (0.0093)	
Constant	0.1050 (0.0807)	
R^2	0.077	

Notes: The sample is all four-digit industries within each two-digit sector for the years 1980–93, excluding 1982 and 1988. Regressions are weighted by the industry share of total manufacturing shipments. Standard errors are in parentheses. See table 3.6 for variable definitions.

of a 10 percent dollar appreciation on the 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 a 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

Table 3.11 OAP Imports and Changes in Exchange Rates

	Dutiable OAP Imports	Change in OAP Imports (from 10% dollar appreciation)
Office and computing machines (SIC 357)		
OECD	1.61	NA
Non-OECD	2.50	0.752
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	0.0047
Non-OECD	10.6	0.510
Motor vehicles (SIC 371)		
OECD	11.6	2.79
Non-OECD	0.93	−0.038
Aircraft and parts (SIC 372)		
OECD	1.79	−0.251

Note: NA, not applicable.
Variable definitions are as follows:
Dutiable OAP imports = 100 × (Dutiable OAP imports)/(Non-energy material purchases).
Change in OAP imports = 100(Real exchange rate coefficient × log(1.1)).

time, motor vehicle outsourcing in developed countries responds strongly in the hypothesized direction. Table 3.11 shows that developed country outsourcing in the motor vehicle industry is predicted to rise 2.79 percent if the dollar appreciates by 10 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, are associated with higher levels of foreign OAP sourcing. In footwear and leather, our findings are imprecisely estimated, and the import of non-OECD electrical machinery appears to exhibit cross-industry differences that relate to the country composition of industry imports.

3.6 Conclusion

In recent years the United States and other countries have observed a growing gap between the wages paid to skilled versus unskilled workers. Although there are many possible explanations for this rising wage inequality, Feenstra and Hanson (1996a) suggest 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 their 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 (i.e., goods exported abroad for further processing) should be characterized by a relatively intensive 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 U.S. costs of production in a number of industries are associated with substitution toward foreign production. While cost-induced movements toward the purchase of OAP inputs are small compared to the size of U.S. industry, the predicted response to cost changes implies a significant change in the magnitude of OAP activities.

Appendix

The estimates shown in tables 3.3 and 3.4 are obtained for the years 1980–93 (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 3A.1 and 3A.2. Because of missing data (in 1982 and 1988), these differences were taken across odd-numbered years.

In order to control for some of the most important heterogeneity across industries, in tables 3A.3, 3A.4, and 3A.5 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 3A.1 **U.S. Revenue Functions**

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content of OAP Imports	Production Labor Share	Nonproduction Labor Share
Apparel (SIC 23), N = 191			
Production labor	1.37 (1.22)	9.48 (0.90)	−0.98 (0.48)
Nonproduction 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^2	0.07	0.45	0.43
Footwear and Leather (SIC 31), N = 62			
Production labor	−3.93 (2.84)	7.73 (1.46)	−1.13 (1.13)
Nonproduction 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^2	0.14	0.39	0.17

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.

Table 3A.2 **U.S. Revenue Functions**

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content OAP Imports from LCDs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Machinery (SIC 35), N = 214			
Production labor	0.09 (0.24)	0.73 (0.24)	4.36 (0.46)	−2.45 (0.59)
Nonproduction labor	−0.52 (0.30)	−0.66 (0.29)	−2.12 (0.57)	5.18 (0.74)
Dutiable OAP imports from LDCs	0.04 (0.01)	−0.01 (0.01)	0.04 (0.03)	0.002 (0.03)
Dutiable OAP imports from 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^2	0.07	0.18	0.43	0.62
	Electrical Machinery (SIC 36), N = 223			
Production labor	2.44 (1.61)	−0.05 (0.18)	6.29 (0.76)	−1.68 (0.82)
Nonproduction labor	2.67 (1.45)	0.09 (0.16)	−1.37 (0.69)	5.42 (0.74)

Dutiable OAP imports from LDCs	0.79 (0.12)	0.03 (0.01)	−0.19 (0.06)	−0.11 (0.06)
Dutiable OAP imports from 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^2	0.42	0.36	0.29	0.43
Transportation Equipment (SIC 37), N = 62				
Production labor	−0.39 (0.19)	0.72 (0.75)	7.71 (1.61)	0.96 (2.08)
Nonproduction labor	0.20 (0.11)	0.29 (0.44)	−0.59 (0.93)	1.82 (1.21)
Dutiable OAP imports from LDCs	0.03 (0.01)	0.01 (0.03)	0.08 (0.07)	0.10 (0.09)
Dutiable OAP imports from 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^2	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.

Table 3A.3 U.S. Revenue Functions: Machinery

Independent Variables (log)	U.S. Content OAP Imports from LDCs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Dependent Variables (share of industry shipments)			
	Machinery (SIC 35), N = 452			
Production labor	−0.11 (0.06)	−0.19 (0.05)	8.94 (0.35)	−2.85 (0.16)
Nonproduction labor	0.15 (0.05)	0.17 (0.04)	−3.32 (0.26)	7.38 (0.12)
Dutiable OAP imports from LDCs	0.07 (0.01)	0.014 (0.006)	−0.10 (0.04)	−0.04 (0.02)
Dutiable OAP imports from 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^2	0.33	0.40	0.90	0.91
	Office and Computing Machines (SIC 357), N = 47			
Production labor	−0.21 (0.71)	0.007 (0.61)	2.97 (0.57)	−4.18 (1.51)
Nonproduction labor	0.12 (0.95)	0.13 (0.82)	−1.71 (0.77)	7.12 (2.04)
Dutiable OAP imports from LDCs	0.37 (0.08)	0.17 (0.07)	−0.06 (0.06)	−0.04 (0.17)
Dutiable OAP imports from 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^2	0.71	0.71	0.96	0.82

Note: Standard errors are in parentheses. Estimation is in levels for 1980–93, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

Table 3A.4 **U.S. Revenue Functions: Electrical Machinery**

Independent Variables (log)	Dependent Variables (share of industry shipments)			
	U.S. Content OAP Imports from LDCs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Electrical Machinery (SIC 36), N = 450			
Production labor	0.24 (0.40)	−0.05 (0.07)	8.38 (0.29)	−3.30 (0.24)
Nonproduction labor	−0.47 (0.27)	−0.04 (0.05)	−2.14 (0.19)	8.24 (0.16)
Dutiable OAP imports from LDCs	0.78 (0.06)	0.01 (0.01)	−0.33 (0.05)	−0.10 (0.04)
Dutiable OAP imports from 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^2	0.52	0.19	0.77	0.95
	TV and Radio Receiving Equipment (SIC 365), N = 21			
Production labor	−1.70 (4.18)	0.50 (0.32)	10.18 (2.38)	0.16 (0.94)
Nonproduction labor	0.03 (4.26)	−0.39 (0.32)	−5.07 (2.42)	1.61 (0.96)
Dutiable OAP imports from LDCs	0.17 (0.26)	0.006 (0.02)	−0.10 (0.15)	0.07 (0.06)
Dutiable OAP imports from 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^2	0.77	0.60	0.90	0.93

(*continued*)

Table 3A.5 (continued)

Independent Variables (log)	Dependent Variables (share of industry shipments)			
	U.S. Content OAP Imports from LDCs	U.S. Content OAP Imports from OECD	Production Labor Share	Nonproduction Labor Share
	Electronic Components (SIC 367), N = 107			
Production labor	−1.34 (1.94)	0.47 (0.50)	7.25 (0.74)	−3.36 (0.89)
Nonproduction labor	6.08 (2.08)	−0.32 (0.54)	−3.58 (0.79)	9.05 (0.94)
Dutiable OAP imports from LDCs	1.33 (0.24)	−0.05 (0.06)	−0.72 (0.09)	−0.57 (0.11)
Dutiable OAP imports from 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^2	0.76	0.39	0.94	0.90

Note: Standard errors are in parentheses. Estimation is in levels for 1980–93, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

Table 3A.5 U.S. Revenue Functions: Transportation Equipment

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content OAP Imports from LDCs		U.S. Content OAP Imports from OECD		Production Labor Share		Nonproduction Labor Share	
Transportation Equipment (SIC 37), N = 135								
Production labor	0.47	(0.12)	−0.42	(0.20)	7.84	(0.34)	−5.49	(0.51)
Nonproduction labor	−0.04	(0.07)	0.24	(0.10)	−0.40	(0.18)	6.49	(0.27)
Dutiable OAP imports from LDCs	0.05	(0.01)	0.01	(0.02)	0.04	(0.03)	−0.13	(0.05)
Dutiable OAP imports from 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^2	0.41		0.30		0.97		0.9	
Motor Vehicles (SIC 371), N = 43								
Production labor	0.56	(0.94)	0.19	(0.17)	5.29	(1.71)	0.44	(0.67)
Nonproduction labor	0.42	(0.65)	−0.13	(0.12)	−0.510	(1.18)	1.57	(0.46)
Dutiable OAP imports from LDCs	0.11	(0.05)	0.0003	(0.01)	−0.09	(0.10)	−0.03	(0.04)
Dutiable OAP imports from 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^2	0.49		0.63		0.99		0.99	

(*continued*)

Table 3A.5 (continued)

Independent Variables (log)	Dependent Variables (share of industry shipments): U.S. Content OAP Imports from LDCs		U.S. Content OAP Imports from OECD		Production Labor Share		Nonproduction Labor Share	
Aircraft and Aircraft Parts (SIC 372), N = 24								
Production labor	−0.06	(0.09)	0.94	(0.85)	11.36	(2.48)	1.20	(3.36)
Nonproduction labor	0.05	(0.06)	−0.61	(0.57)	−0.32	(1.65)	8.05	(2.24)
Dutiable OAP imports from LDCs	0.006	(0.002)	0.02	(0.02)	0.09	(0.05)	0.13	(0.07)
Dutiable OAP imports from 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^2	0.53		0.78		0.98		0.92	

Note: Standard errors are in parentheses. Estimation is in levels for 1980–93, excluding 1982 and 1988. All regressions are weighted by the industry share of total manufacturing shipments.

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Comment James A. Levinsohn

In international trade, economists often speak of goods as embodying factors. In that vein, this paper embodies a huge amount of labor—skilled labor I might add, for the work involved in using the data the authors collected was tremendous. This was not an example of coming up with a clever use of data pulled off of the StatCan CDs or OECD diskettes. Rather, the authors tracked down a novel and hitherto unexploited source of data, and they use this data to investigate an old problem in a new and very creative way. It is a very nice paper and a super example of what we can learn when we take time to step back from the abstract notion of international trade and look closely at the actual institutions and programs by which trade is conducted.

The problem the authors address is a long-standing one, and it will be helpful to keep the goal of the paper in mind. There is a significant amount of outsourcing going on today. It is natural to suspect that outsourcing might decrease the demand for unskilled labor relative to skilled labor. The question that the authors ask is key to addressing this suspicion. They ask: Is outsourcing relatively unskilled-labor intensive (compared to the same activity when it is not outsourced)?

There is a natural way to answer this question. Why not just get the data on input use for plants that produce a good offshore and compare that with input use for plants that produce the good domestically? If the plant that is offshore uses twice as much unskilled labor per unit of output and one-third less skilled labor compared to a plant located in the United States, then we have our answer (for that plant, anyway). Do this exercise for thousands of plants and we are there.

The problem is that the authors do not have the data necessary to conduct this exercise. Actually, for myriad reasons, it is unclear whether any-

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one has this data. So the authors are forced to be more creative and their solution is really very clever and very original.

The authors use the OAP (offshore assembly program) as the "experiment" with which to answer the question of whether outsourcing reduces the demand for skilled labor. The OAP lets firms outsource production and then only pay duties on the foreign value added. The idea is that through this program, firms have to report the value of the goods as they cross the Rio Grande into Mexico and the value when those same, but now finished, goods recross into Texas. What we would really like to know is whether the extra steps of production that take place abroad use relatively more unskilled labor than the production that takes place entirely in the United States. In other words, we would like to know whether the stuff that goes into the OAP program is "finished" with more unskilled labor than is the case for the same product that doesn't go into the OAP program.

The problem is that, even with this program, the authors do not have any data on the actual input use divided into production in the United States and production abroad. Again, the authors have to be creative.

They assume the industry produces two outputs. One of these outputs is OAP production, while the other is the rest of output. That is, apparel produces stuff that gets reimported and stuff that never leaves the country. In their framework, these are different products. Their hypothesis is that the stuff that is going to be reimported is more skilled-labor intensive (when it leaves the United States) than the stuff that never leaves the United States. The key idea is that if the unskilled-intensive work takes place abroad, the stuff is relatively skilled-labor intensive when it first leaves the United States.

Their methodology is to estimate what they called production functions. This was one place that I found the paper a little confusing, and it is an issue of semantics. I do not think they estimate production functions at all, but rather they estimate something very akin to a Rybczynski derivative. Clarifying the difference is important. A production function is a relationship between the output of a plant, firm, or industry, and the inputs it actually uses. The Rybczynski derivative is a relationship between the output of a plant, firm, or industry, and the total endowments it has at its disposal. The authors do not have separate data on inputs used by local plants and on inputs used by the outsourcing plants. I found this a little confusing in the paper since the section where this material is presented is called "U.S. production functions." What the authors want to do, then, is regress output shares (where the shares are the share going into the OAP program and the share produced entirely domestically) on inputs and prices. The Rybczynski derivative they want to estimate addresses the following question: Holding output prices constant, as an industry gets more of a factor, does the share of output going to offshore production increase or decrease? The Rybczynski theorem tells us that holding prices constant, as you get more of a factor, the output of the good that uses that factor intensively goes up, and the output of the other factor goes down. The authors use this insight to back out implied intensities of outsourcing relative to purely domestic production. It is actually pretty straightforward, but I have to admit that the constant references to production functions confused me. It took a while for me to figure out what was going on. Once I figured it out, I realized that this is a very clever way of using trade theory to infer factor intensities without ever having any data on the actual factors used in outsourcing and domestic production.

There is one potential problem with how this all gets pulled off. The Rybczynski approach is one in which output prices are held constant while factor endowments shift. Fine. The problem is that the authors don't actually have any price data, so they estimate their equation, in which they acknowledge that price should be a regressor, without actually including price in the regression. I'd like to stress that the authors are entirely upfront about this, but it might lead some to question just what is being estimated. In many cases, this omission would be quite serious, since in the background, prices are also moving around and we might wonder just what we are measuring when we infer factor intensities. I think this is one problem that could use a little more discussion in the paper.

Two econometric issues might warrant further discussion. The dependent variable in these regressions is a share (varying between 0 and 1), so ordinary least squares (OLS) is appropriate. A simple logistic transformation of the dependent variable will solve this and this hardly ever makes a difference in the results. The second issue is less easily addressed, but perhaps deserves acknowledgment. In the typical estimation of Rybczynski derivatives, the independent variables are country endowments. It is, in this context, quite reasonable to consider these country endowments to be exogenous variables. In this paper, "endowments" are the factors used as inputs in a particular industry, and in this case the exogeneity assumption is less obviously correct. Inputs are quite possibly choice variables suggesting that OLS is inappropriate.

The authors then look at five key industries: apparel, leather and footwear, machinery, electrical machinery, and transportation equipment. Their results are mixed. If they had stopped with apparel, the results would accord with most of our priors. Since this conference was in Monterey, I'll use a fishing analogy. If you go fishing and come back and say that you didn't catch anything, that doesn't make you a bad fisherman. Maybe there was nothing to catch. It does, however, make you an honest fisherman. These authors are honest fisherman.

Rather than having detailed factor use data for plants in the United States that produce finished products as well as factor use data for plants in the United States that outsource and the same data for the plants that do the outsource work, the authors essentially have no factor use data broken down by whether the output is outsourced and no price data. They had to put a lot of structure on the problem in order to get their data to talk. It is a creative attempt, using an original data source, but in some cases, the data just would not talk.

The authors then switch gears and address a very different question that has little to do (on the surface, anyway) with the trade and labor issue, but which is well suited to their data. They ask whether firms do more outsourcing when costs are relatively higher at home. They manage to do this without ever using any firm-level data and without observing costs. This part of the paper is perhaps a little less convincing just because, all else being equal, I think we know firms do not do less production abroad when offshore assembly gets cheaper. The empirical question is one of magnitudes, but so much is changing that might impact costs, that their exchange rate approach has some trouble extracting the signal from the noise. Many cost shifters other than exchange rates are probably moving over their sample, so it is a little hard to interpret the results from an empirical framework that does not control for any cost shifters other than the real exchange rate. If the exchange rate is highly correlated with these other excluded cost shifters, the authors are in good shape. One interpretation of the results in this section of the paper is that the empirical approach is asking whether the exchange rate is a good proxy for otherwise unobserved cost shifters, and the answer is sometimes.