Outsourcing and Pass-Through: Evidence from OAP Prices.

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Abstract:

This paper studies the extent and variation in import price pass-through for U.S. outsourcing imports. Based on data from 4,676 outsourcing products imported between 1991 and 2000 an average pass-through rate of seventy-five percent is found. The data also show that outsourcing import prices are influenced by the prices chosen by competing import suppliers. Notably, both the rate of pass-through and the degree of price emulation varies substantially across country assembly locations, with larger responses appearing for outsourcing imports assembled in high-education countries.

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Introduction

The dramatic growth in international outsourcing has fueled the expansion of international trade and deepened international integration.[1] While public attention generally focuses on the implications of international production for domestic employment, developments in international outsourcing have the scope to influence many other aspects of the domestic economy. One question that has yet to be addressed is whether the pass-through of costs shocks by outsourcing firms is similar to pass-though observed in general trade prices. To address this question, this paper models and tests how cost shocks are passed through to the import prices of internationally outsourced products.

An improved understanding of pass-through to outsourcing import prices is important for a number of reasons. First, a detailed understanding of price dynamics is important, since it helps policy makers to develop and implement macro and monetary policies. Thus, as the literature on exchange rate pass-through in final goods recognizes, the formation of accurate inflation forecasts relies in part on accurate forecasts of changes in import prices.[2] For this reason, as trade in manufactured goods increasingly involves international fragmented production, it is important to learn about the nature of pass-through in outsourcing transactions. However, while Gron and Swenson (2000) study the relevance of this question for the auto industry, there is no work to date that has studied the relevance of this question for a broad range of outsourcing products.

The study of outsourcing firm price decisions is also interesting, since outsourcing import price responses provide evidence on the nature of competition in international

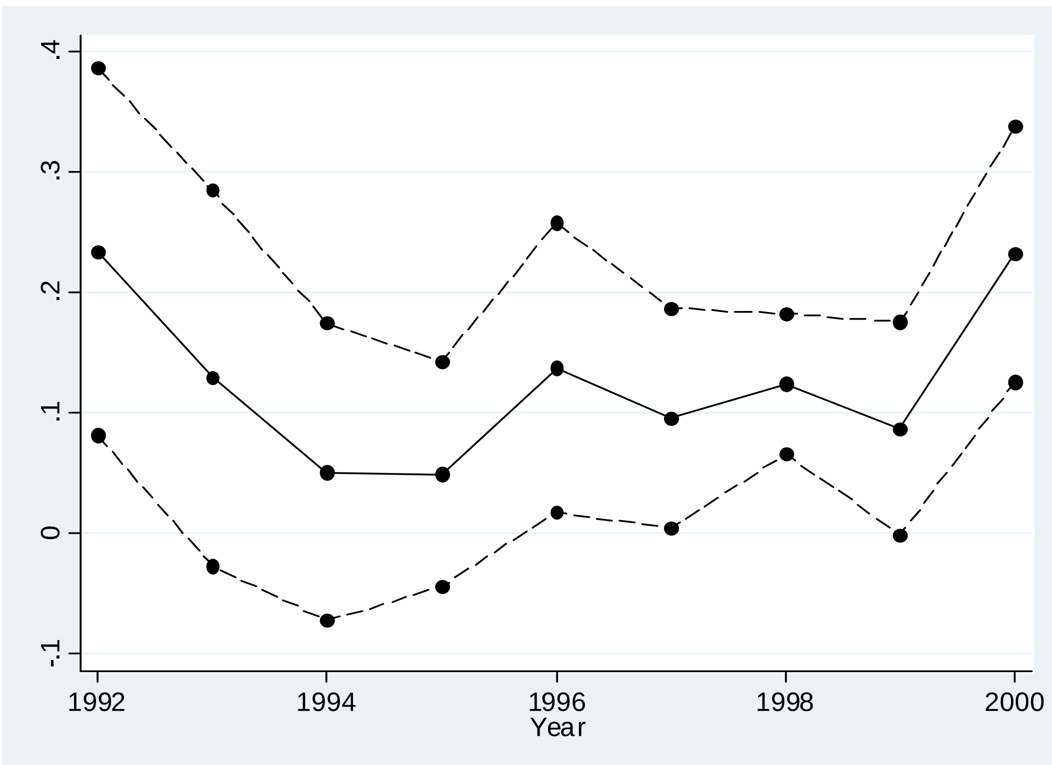
[1] Hummels, Ishii and Yi (2001) present evidence from 10 OECD and four emerging markets which indicates that increases in vertical specialization accounted for 30% of export growth between 1970 and 1990. Feenstra (1998) and Spencer (2005) provide reviews of outsourcing trends and theories. In related work Hanson, Mataloni and Slaughter (2005) document the increase in vertical activities by U.S. multinationals in the 1990's, while Gorg (2000), Egger and Egger (2005) and Swenson (2005a) study the empirical determinants of outsourcing location choices.
[2] Mishkin (2008) provides a survey on work in this area.

markets. Marazzi and Sheets (2007) argue that the decline in pass-through of foreign costs to U.S. import price indices, from fifty percent in the 1980's to twenty percent more recently, may be driven by changes in global competition, and the role of Asia in trade. To evaluate the importance of competitor responses at a micro level, this paper examines how import prices chosen by outsourcing firms respond to the prices selected by their international competitors who produced similar products. In addition, to learn more about the about factors that influence the intensity of international competition I analyze how outsourcing price responses vary with country characteristics.

To provide information on outsourcing price decisions, this paper studies the prices of U.S. outsourcing products imported under the auspices of the overseas assembly program, or OAP. The data set for U.S. OAP imports between 1991 and 2000 includes observations on 4,676 different products, most of which were imported from a number of assembly countries. Thus, even though some forms of U.S. outsourcing fall outside of the OAP program, the OAP provides insight into a wide swath of U.S. outsourcing activities which represented a full 8.5 percent of U.S. import value during the sample period.

Since administration of the OAP involves the collection of detailed information on outsourcing transactions at the product and country level, data from OAP import transactions facilitate measurement of cost shocks and trade frictions at the country-product level. For this reason, the heterogeneity in producer input choices both across countries and products can be exploited to identify pass-through and general price responses for outsourcing imports. For example, year by year pass-through rates can be estimated by regressing yearly changes in OAP prices at the product-country level against yearly changes in costs at the product-country level. When the coefficients from such year by year regressions are plotted in Figure 1, they show that the raw rate of pass-through for OAP imports ranged from six to twenty-three percent.[3] This rate of pass-through is a bit lower than that observed in many studies which similarly rely on individual product prices. However, to accurately estimate cost pass-through in outsourcing relationships, it is necessary to turn to a theory-based estimating framework which accounts for other economic factors that also influence price decisions.

Figure 1: OAP Outsourcing Pass-Through, based on year to year changes.



Notes: The points on the solid line are the coefficients from year by year regressions of country-product outsourcing price changes on the change in country-product total cost. The dashed lines represent the 95% confidence interval.

This paper adopts Feenstra's (1989) pass-though estimation framework, which is modified to account for the cost structure and tariff treatment facing outsourcing firms who produced products for import under the OAP. This framework, which is based on a Bertrand

[3] The cost measure is the cost measure described as "total cost" in the regression analysis that follows.

model of competition in internationally differentiated goods, focuses its attention on the pass-through of costs and on the degree to which producers emulate the price changes of their competitors.

Estimation of the model reveals a number of regularities in the pricing U.S. OAP outsourcing imports. First, roughly seventy-five percent of production and trade cost changes are passed-through to product prices. Since this rate of pass-through is consistent with pass-through rates observed in previous studies based on product-level data, it suggests that pricing decisions for outsourcing imports are indeed similar to those of final goods imports more generally.[4] More notable, the degree of cost pass-through differs across country suppliers, as pass-through to outsourcing import prices is highest for products assembled in countries that have more highly educated workforces.

The prices chosen by producers of U.S. OAP imports also respond to the prices selected by competing assemblers in other countries. The general response observed in the full sample suggests that producers of outsourcing products increase their prices by 1.4 percent when their competitors in other locations increase their prices by ten percent. However, the responsiveness to competitor prices also differs across countries, as the responsiveness to competitor prices is fifty percent larger for outsourcing producers located in more highly educated countries.

The correlation between outsourcing import price responses and assembly country education levels provides empirical support to the growing body of literature that suggests that country integration in the international economy is influenced by country characteristics.[5] If more educated countries produce products that are more differentiated from

[4] Goldberg and Knetter (1997) provides a comprehensive review of work in the area.

[5] For example, Levchenko (forthcoming) shows that countries with better institutions produce more complex goods, while that countries with better contract protections are found to 1) specialize in goods that require more relationship-specific investment Nunn (2007), and to 2) product more complex goods Costinot (2007).

their competitors, or of higher quality, one possible interpretation of this result is that outsourcing assemblers face differential trade elasticities.

The rest of this paper is structured as follows. Section two describes outsourcing under the OAP program, and highlights the variation in production decisions across products and countries that is used to provide identification in the empirical estimates of pass-through. Section 3 provides a model of pricing and the associated regression framework, which is modified to account for the procedural features of the OAP program. It also develops cost measures which account for heterogeneity across products and assembly countries that influence cost shock magnitudes. The empirical analysis in section four studies how cost changes and competitor prices affected OAP outsourcing import prices. It also examines the importance of country characteristics for these responses and discusses the economic implications in light of economic theory. The paper ends with a brief conclusion.

2. Outsourcing in the Overseas Assembly Program

This paper utilizes data from the US Overseas Assembly Program (OAP) as a means of gaining insight into the nature of pricing decisions in outsourcing transactions.[6] A key benefit of examining OAP outsourcing is that OAP import data provide detailed information on outsourcing relationships which are reported country by country at the product level. During the sample period, 1991 to 2000, the U.S. imported 4,676 distinct 8-digit HS (HS8) products through the OAP.[7]

[6] The OAP, which is codified under section 9802 of the current tariff code, grants tariff privileges to U.S. import products for their use of U.S.-origin parts, components or materials.

[7] Examples of products at the HS8 level of aggregation include: Instrument panel clocks for vehicles, spacecraft or vessels (9104000), Microwave ovens (85165000), Food grinders, processors and mixers (85094000), or footwear with outer soles of leather covering the ankle, on a base or platform of wood, not having an inner sole or protective metal toe-cap (64035111).

Table 1 displays information on the composition of OAP import transactions by country. OAP outsourcing transactions most commonly involve the assembly of U.S. parts in a developing country location. For example, if country development is defined by OECD membership, 81 percent of the HS8-year transactions in the data set involve developing country assembly. Alternatively, if countries are classified as developed if country educational attainment averaged six or more years, 63 percent of the HS8-year import observations in the data set involve developing country assembly.

The data in Table 1 suggest that geographical proximity plays an important role in determining OAP participation. Canada and Mexico are particularly prominent as the most frequent participants, registering 3,518 and 7,940 unique (HS8 product)-year transactions respectively. In contrast, while U.S. OAP imports at least a few products from most countries, distant countries participate less frequently. The importance of geographical proximity is not surprising, as use of the OAP program implies that firms ship their U.S. inputs, not only from the assembly country to the U.S., but also from the U.S. to the overseas location for assembly. [8]

To illustrate the industry composition of U.S. OAP outsourcing imports, Table 2 displays OAP activity for 2-digit HS industries (HS2).[9] Sorting industries according to the total value of U.S. inputs contained in industry OAP imports, the top three OAP industries are electrical machinery (HS2 85), transportation equipment

[8] In addition to direct costs of transportation, Hummels (2001) and Evans and Harrigan (2005) show how international distance imposes time costs.

[9] To avoid compositional changes that may have followed from the implementation of NAFTA, the data in Table 2 show the industry breakdown for 1993. However, later years are fairly similar, as Canada and Mexico's participation in OAP remained strong throughout the entire sample. In addition, while the robustness checks experiment with the exclusion of Canada and Mexico from the sample, the treatment of NAFTA countries does not appear to affect the qualitative results.

(HS2 87), and apparel and clothing, not knitted or crocheted (HS2 62).[10]

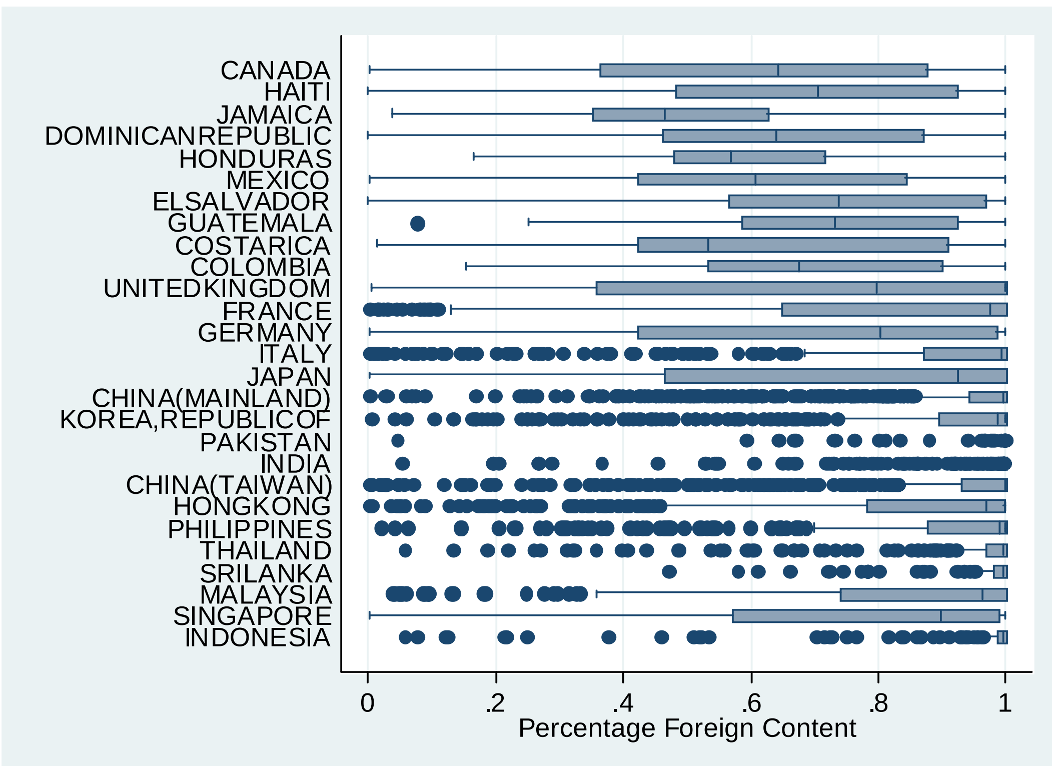
For each of the HS2 industries, Table 2 also lists the identity of the primary country supplier, where the *primary supplier* is defined as the country that shipped the largest total value of OAP products in that HS2 industry. Since Mexico or Canada was the primary suppliers for nineteen of the thirty largest OAP industries, the industry-level data confirm again the importance of geographical proximity as a locational determinant for U.S. outsourcing assembly. Nonetheless, more distant countries were primary suppliers in some industries. The fact that Malaysia was the primary supplier for footwear (HS2 64), while Hong Kong was the primary supplier for imitation jewelry (HS2 71), and Switzerland was the primary supplier for clocks and watches (HS2 91), suggests that outsourcing production decisions also reflect traditional sources of comparative advantage.

To characterize production methods, Table 2 reports the *U.S. percentage*, which is defined as the percentage of total product value attributable to U.S. parts and materials. Since U.S. inputs are exempt from tariff, administration of the OAP program requires firms to separately report the portions of product value derived from dutiable foreign inputs and assembly, and from U.S.-origin parts and components. Thus, these declarations enable one to observe the relative reliance on U.S. and foreign inputs at a product-country level. For OAP imports in the sample the average U.S. percentage was 36 percent, while the average foreign percentage was 64 percent. However, the relative reliance on U.S. inputs differs dramatically both across industries and countries.

[10] These are followed by, non-electrical machinery (HS2 84), apparel and clothing, knitted or crocheted (HS2 61), Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus (HS2 90), Aircraft and spacecraft (HS2 88), and footwear (HS2 64).

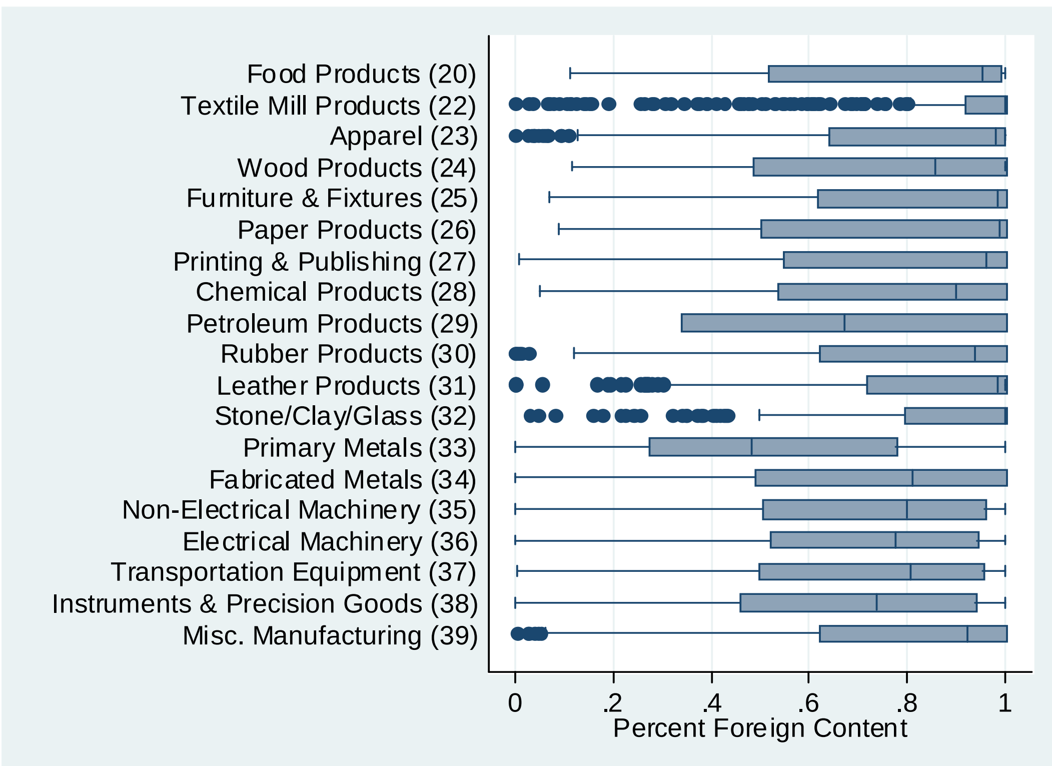
Figure 2 illustrates the extent of variation in production techniques across countries, through a box-whisker plot which displays the average foreign content percentage for the 27 countries that were the most frequent OAP participants. Each country has many foreign content observations, since each of the countries shipped a wide range of OAP outsourcing products to the U.S. Thus, the bottom, dividing and top points for each country's box represent the foreign content percentages observed for the country's assembly operations at the 25th, 50th and 75th percentiles.

Figure 2: Cross-Country Differences in Production Techniques



Countries in Figure 2 are ordered according to their distance of their national capitals from the U.S. capital; the top countries in the figure are closer to the U.S. than those at the bottom. In general, this ordering demonstrates that more distant assembly countries use a higher percentage of foreign content than do assembly countries located near the U.S. Nonetheless, within each production country input choices vary considerably across products. With only a few country exceptions, the difference in the level of foreign content between a country's products at the 25th percentile and the countries products at the 75th percentile exceeded 20 percentage points. As a result, country-level cost shocks generate very different effects for different outsourcing products assembled within a country.

Figure 3: Cross-Industry Differences in Production Techniques



For an alternative perspective on production differences within industries, Figure 3 displays a box-whisker plot of foreign content percentages for OAP imports organized by 2-digit SIC industry. Each SIC industry has multiple observations, since many HS8 products are contained in each 2-digit industry, and because most those products were assembled in more than one country. The figure demonstrates that producer input decisions varied greatly across OAP outsourcing producers even within industries, as with only two SIC industry exceptions the reliance on foreign content for assembly operations at the 25th percentile in an industry was 20 percentage points lower than the use of foreign content for the industry's products at the 75th .

Since input choices varied so widely across countries and products, the variation in production techniques is exploited to construct cost measures for the empirical exercise that vary uniquely across products and countries. For example, consider a set of outsourcing products assembled in China. Each product is characterized by the percentage U.S. and foreign content in its production. When Chinese production costs rise, production cost increases are especially pronounced for those products with the highest percentage of their production located in China. A heavy reliance on Chinese inputs also proves costly in product sectors that face the highest U.S. import tariffs. In contrast, products characterized by a high percentage of Chinese-origin inputs benefit from lower transportation costs since there is less back and forth shipment of U.S.-origin parts and material. Naturally, products which contain a high share of Chinese content are also relatively advantaged when the relative cost of U.S. inputs rises.

3. A model of pricing decisions

3.1 Production

Following Mendez (1993), OAP assembly is modeled as a Leontieff production process. When OAP producers assemble product i in country c, they combine a fixed bundle of U.S. inputs with a fixed bundle of foreign inputs and assembly.[11] To characterize input bundles, it is useful to describe OAP assembly as involving a set of tasks on the unit interval that must be completed in an ordered succession. Consequently, a firm's decision to engage in OAP outsourcing reveals that the U.S. has comparative advantage in the early stage tasks, while the foreign country has comparative advantage in the later tasks and assembly. If the stage where U.S. processing ends and foreign production begins is denoted by β_{ic} on the unit interval, and each task requires physical inputs M_i, then U.S. input requirements are given by $\beta_{ic}*M_i$ while the foreign input requirement is $(1- \beta_{ic})* M_i$. Since assembly countries differ in their abilities and distance from the U.S., the input coefficient β_{ic} is not the same for all countries involved in the assembly of good i. If the price of U.S. inputs is given by w_{us}, while the U.S. dollar price of foreign inputs is w_c, and the transportation of the U.S.-origin inputs to the foreign assembler involve an ad valorem trade cost g_{ic}, the resulting *production cost* when product i is assembled in country c is:

(1) $C_{ic} = [\beta_{ic}*w_{us}* (1+g_{ic}) + (1- \beta_{ic})*w_c]*M_i$.

Due to the Leontieff production structure, U.S.-based and foreign-based production costs are included in a single term dollar-denominated term. Thus, while the robustness checks include a regression which breaks the cost equation into two components to focus on the pass-through of the foreign-based costs, the nature of OAP production suggests that separating the cost term into its individual components will introduce measurement error.

[11] While Swenson (2005b) demonstrates that relative production costs and tariffs influence OAP input choices as predicted by cost minimization, the tiny economic magnitudes of these responses by OAP producers supports the decision to use a Leontieff production structure.

Later, when assembled OAP products are shipped from the assembly country to the U.S. two additional costs arise. First, the appropriate U.S. import tariff τ_i is applied to the foreign portion of product value, $(1- \beta_{ic})*w_c*M_i$. In addition, the transportation of the completed product to the U.S. incurs the ad valorem shipping cost g_{ic}.

3.2 Demand

Products are internationally differentiated and market competition is Bertrand. Each country produces a unique variety of the outsourced good, which is an imperfect substitute for products manufactured in other country locations. Product demand for each individual producer, $q_{ic} = d(P_{ic}^C, P^{\sim}_{ic}, E_h)$, is negatively related to the producer's choice of consumer price P_{ic}^C, while it is positively related to competitor prices $P^{\sim}_{ic}$ and to overall expenditure E_h on the industry h that includes good i.

Given $\alpha_{us,ic}$, the U.S. share of product value that is exempt from tariff, the relationship between the consumer and producer price P_{ic}^P is:[12]

(2) $P_{ic}^C = [P_{ic}^P *(1+g_{ic}) + (1-\alpha_{us,ic})* P_{ic}^P * \tau_i]$.

This can be rearranged to yield the producer price,

(3) $P_{ic}^P = P_{ic}^C * [(1+g_{ic}) + (1-\alpha_{us,ic})* \tau_i]^{-1}$.

Firms now choose producer price P_{ic}^P to maximize profits:

(4) $\pi = P_{ic}^C * [(1+g_{ic}) + (1-\alpha_{us,ic})* \tau_i]^{-1}* d(P_{ic}^C, P^{\sim}_{ic}, E_h) - C_{ic}*d(P_{ic}^C, P^{\sim}_{ic}, E_h)$,

which generates the familiar first order condition:

(5) $P_{ic}^C (1+ 1/ \eta_i) = [(1+g_{ic}) + (1-\alpha_{us,ic})* \tau_i]*C_{ic}$.

Prices are determined by a markup over marginal cost, where the markup is

[12] The U.S.-origin contribution to product value, $\alpha_{us,ic} = [\beta_{ic}*w_{us}* (1+g_{ic})]/[\beta_{ic}*w_{us}* (1+g_{ic}) + (1- \beta_{ic})*w_c]$.

determined by the elasticity of demand, η_i. The marginal cost has two components: trade costs are given by $[(1+g_{ic}) + (1-\alpha_{us,ic})^* \tau_i]$, while the production cost component C_{ic} is from equation (1). For purposes of estimation, we follow Feenstra (1989) to arrive at the following reduced form price relationship (6).

(6) $P_{ic}^{C} = \Gamma [\{(1+g_{ic}) + (1-\alpha_{us,ic})^* \tau_i \}^* C_{ic}), P^{\sim}_{ic}, E_h]$.

Restoring time subscripts and adopting a log-linear form generates the familiar pass-through regression equation:

(7) $\ln P_{ict}^{C} = \theta + \beta_1 \ln([(1+g_{ict}) + (1-\alpha_{us,ic})^* \tau_{it}]) + \beta_2 \ln(C_{ict}) + \gamma \ln(P^{\sim}_{ict}) + \delta \ln E_{ht} + \varepsilon_{ict}$.

Equation (7) is modified since recent work on import prices demonstrates that cross country differences in quality are present even when trade data are disaggregated to the fine product level.[13] To account for unobserved differences in product quality that are correlated with country development I add a measure of country development D_c to the basic specification. In addition, the regression will be augmented by a full set of time dummies (Y_t) to account for year to year developments (e.g., changes in U.S. income) that affect price setting, but which are not already included in the basic equation. This yields the primary estimating equation that is used to analyze outsourcing import prices.

(7') $\ln P_{ict}^{C} = \theta + \beta_1 \ln([(1+g_{ict}) + (1-\alpha_{us,ic})^* \tau_{it}]) + \beta_2 \ln(C_{ict}) + \gamma \ln(P^{\sim}_{ict}) + \delta \ln E_{ht}$
$+ \lambda \ln D_c + \Sigma Y_t + \varepsilon_{ict}$.

In this specification, the coefficient β_1 measures the pass-through of trade costs, while β_2 measures the pass-through of production costs. As in the pass-through literature, the coefficients β_1 and β_2 are both expected to be in the interval [0, 1], which runs from the extreme of no pass-through, to the extreme which implies complete pass-through of any

[13] See Hummels and Klenow (2005), Schott (2003, 2004) and Hallak (2006).

cost changes.[14] In addition, the coefficients on competitor prices γ and country development λ are both expected to be positive.

Finally, one may expect a high degree of pricing heterogeneity across outsourcing products that may arise from unmeasured differences in product quality, differences in supplier availability or factor costs that vary at a country or industry level, or differences in institutions. For this reason, controls are added to the regression to capture the effects of unmeasured factors that influence outsourcing prices. Initially, the estimation using OLS adds a set of HS2 industry dummies to regression (7'). When the regressions move to panel estimation, the error term is assumed to have an HS8 product-country component ζ_{ic} in addition to an iid error, ν_{ict}, or $\varepsilon_{ict} = \zeta_{ic} + \nu_{ict}$. The product-country component of the error term is particularly important if it captures unmeasured variation in quality that influences product prices.

4. Results

4.1 Data

To examine the extent of pass-through in outsourcing transactions, the dependent variable for the analysis is import prices from OAP import transactions between 1991 and 2000. These prices, which are measured by import unit values, are annual observations recorded at the country-product level. OAP import transaction prices are also used to measure competitor prices $P^{\sim}$, which are defined as the average import price for competing country producers in the same HS8 product and year.

The creation of cost measures, which vary at the country-product level, is one of

[14] Pass-through of anti-dumping duties exceeds one in magnitude in Blonigen and Haynes (2002). However, this unusual outcome is due to dynamic incentives generated by administrative features of anti-dumping policy.

the most important elements of this paper, since meaningful variation at the country-product level is required for identification. Typically, microeconomic research on pass-through focuses on a single product such as passenger automobiles. In such projects, it is feasible to use country-specific producer price indices to represent local costs for the handful of producers in these studies.

In contrast, since this project involves almost 5,000 products and 100 countries, it is not possible to locate data on production costs that correspond to the country-product disaggregation of the data set. For this reason, when the cost measure C_{ic} is constructed according to equation (1), country-level price indices from the Penn World Tables are used to represent general input costs w_c and w_{us}. One benefit of using these price measures is that they encompasses the prices of a wide range of inputs (labor, materials, energy) that are involved in the assembly process. More importantly, since OAP outsourcing is often conducted in countries where wage data is sparse, absent, or poorly measured, this measure maximizes the number of observations that can be retained in the sample.[15]

Nonetheless, while country-level measures are used to represent local production costs in different countries, production costs constructed according to equation (1) will vary at the country-product level, due to the wide variation at the country-product level in the relative use of foreign versus U.S. content. As section 2 illustrates, the U.S. and foreign shares of production value, which can be learned from the content declarations

[15] For most of the analysis, a general country-level price index is applied to the formula shown in equation (1). However, to check for robustness, I also discuss results which are based on a wage-based cost measure. For countries that have wage data, the correlation between wages and the price deflators use in this paper is 0.62. This high correlation is unsurprising, as Warner's (2006) analysis of economic measures for 58 countries reports that the correlation between wages and GDP per worker is almost one for one.

that accompany OAP import records, provide abundant variation to assist in identification. Country-product cost variation also arises due to transportation costs which vary over time, and are specific to country-product pairs.

Since the cost measure is tied to equation (1), all costs are converted to dollars. As a result, this project focuses on the estimation of a single pass-through coefficient for the pass-through of dollar-denominated production costs. While this departs from practice of estimating separate pass-through coefficients for exchange rate and local production cost shocks, the specification is motivated by the theory, which implies that the cost function for outsourcing producers takes the form shown in equation (1). [16]

Finally, the trade cost measure (the first term in the regression framework (7')) was constructed by combining country-product transportation costs and country-level tariffs, with information on country-product production choices. Since the remaining variables in this project come from traditional sources, the data appendix provides a fuller discussion of the data set, including the sources for the remaining variables used in the analysis.

4.2 Estimation of the basic framework

Table 3 presents benchmark estimates for regression (7'). When the regression includes separate coefficients for own production costs and own trade costs, as shown in column (1), the estimated rate of pass-through for these separate cost components is

[16] Aggregate studies on cost pass-through, such as Mazarri and Sheets (2007), use a single foreign price index converted to dollars to measure of foreign costs. In a practical sense, the estimation of a single pass-through term may be sufficient, as Goldberg and Knetter's (1999) observe that the majority of cost changes are attributable to large fluctuations in currency values rather than relatively minor changes in country production costs denominated in national currency.

almost identical.[17] This finding, which indicates that production cost pass-through is symmetric to the rate of pass-through of trade costs due to tariffs and transportation charges, is consistent with Feenstra's (1989) original discovery of symmetric pass-through in U.S. automobile import prices. This similarity is worthy of note, because it suggests that symmetry remains, even though production cost and tariff terms are different for outsourcing firms than they are for firms which trade final goods. Because the regression results support symmetry, and because symmetry is predicted by the theory, the remainder of the regressions presented in this paper impose a single coefficient on *total cost*, rather than estimating separate coefficients for production and trade costs.

The results in Table 3 also reveal a positive relationship between OAP import prices and the prices charged by other country competitors in the same product area. The OLS estimates imply that assemblers incorporated forty percent of competitor price changes in their own prices, while the random effects panel estimates in columns (3) and (4) imply that OAP producers mimicked one-eighth of their competitors' price changes.

To allow for differences in product quality that are related to country development, the regressions include country education levels. Consistent with quality differentiation related to worker human capital, OAP import prices are indeed higher for products assembled in more educated countries.[18] The positive and significant coefficient on assembly country education suggests that more highly educated countries produced

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[17] An F-test fails to reject the hypothesis that the coefficients are equal in magnitude.

[18] This result is consistent with the results from Schott (2003, 2004), Hummels and Klenow (2005), and Hallak (2006), which note a strong connection between a country's development and the prices of its exports. This paper uses Barro and Lee's measure of average education for individuals 25 or older to proxy for product quality differences across countries. However, the result remains if other education measures from the Barro/Lee dataset, dummy variables for country membership in the OECD or GDP per capita, are used instead to capture cross-country differences in product quality.

higher quality varieties of the HS8 goods, or varieties of the goods that were more differentiated and thus could command higher markups due to a lower elasticity of demand.[19] The results in column (4) of Table 3 show that this effect is not purely attributable to differences in country-level endowments, as the country education coefficient remains significant, even after measures of country-level capital and labor abundance are added to the basic regression.

To test whether endogeneity affects the estimated coefficient on the competitor price variable, I used the U.S. producer price index as an instrument and estimated the equation by IV. This approach is called for if there were changes in the U.S. market that influenced both competitor prices and the dependent variable. The results in column (5) show that such endogeneity appeared to be relevant, as the coefficient on competitor rises in magnitude. I also tested whether endogeneity influenced the coefficient on expenditure by using U.S. government expenditure as an instrument. However, such instrumenting does not appear to matter in this context, as the basic coefficients were not changed.

Comparison of pass-through in regressions (2) and (3) in Table 3 demonstrates that pass-through estimates are not affected by the choice of regression technique. For this reason, only coefficients from random effects panel estimation are reported from this point onwards.[20]

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[19] See Khandewal (2007) for empirical evidence on quality differentiation and competition, including the evidence that quality differentiation helps to insulate U.S. industries from low wage competition.

[20] If the regression is estimated by fixed effects, the pass-through coefficient falls to .347(.044). However, I focus on random effects results, since fixed effects estimation is rejected by the Hausman test.

4.3 Heterogeneous Responses by Country

The primary estimating equation assumes that pass-through and market reactions are uniform for all products in the sample. However, the assumption of a uniform coefficient is not appropriate if market characteristics condition the degree of competition in product markets. For example, country differences in information quality may influence the elasticity of substitution between internationally differentiated product varieties, as is shown in Rauch and Trindade's (2003) matching model.[21] While Rauch and Trindade explore how informational improvements affect the formation of international joint ventures, informationally-based matching frictions might similarly reduce outsourcing trade elasticities when country information uncertainty is the greatest.

Price responses may also vary by country if country characteristics are correlated with product demand elasticities. In fact, while the pass-through regression is based on the assumption of a common market elasticity, this may well be violated in a systematic fashion that is related to assembly country education levels. Suppose countries with less educated workforces produce more homogenous products (such as simple sewn items), while high education countries, which have more skilled and educated workforces, generally produce more complex products. Then pass-though will be greater for products assembled in more educated locations, if the more differentiated and sophisticated products assembled in those locations benefit from lower demand elasticities.

Finally, pricing responses may be related to education levels in the assembly country if country development influences the nature of foreign investment. In particular,

[21] Rauch and Trindade (2003) show how product differentiation and uncertainty in international partner search combine to create a degree of "natural protection". Similarly, when Grossman and Helpman (2005) incorporate search frictions in a model of outsourcing, they show that firms in equilibrium will not necessarily do all their outsourcing in the low factor cost location.

Blonigen and Wang (2005) find that the factors influencing foreign investment by multinational firms differ according to host country development. To the extent that multinational investment in investment locations differs in its motives and in the nature of its operations, and if foreign investment facilitates outsourcing trade, this may create differential pricing incentives that are correlated with country development.

While it is not possible in this project to determine why country development matters for pricing decisions, the next regressions augment the estimating framework by adding interaction terms based on country education, $EDUC_c$. In the new estimating equation the coefficient β_{1E} lets one test whether there are differences in pass-through that are related to assembly country education levels.

$$(8)\quad \ln P_{ict}^{C} = \theta_{ic} + (\beta_1 + \beta_{1E}*EDUC_c)*\ln [\, ((1+g_{ict}) + (1-\alpha_{us,ic})*\tau_{it}) + \ln(C_{ict})\,] + (\gamma + \gamma_E*EDUC_c)*\ln(P^{\sim}_{ict}) + \delta \ln E_{ht} + \lambda EDUC_c + \varepsilon_{ict}$$

This new specification captures the idea that product elasticities may differ with country human capital, either because of country specialization in different types of goods, or because of differences in the form of foreign operations. Equation (8) is also consistent with matching models if one assumes that country education levels are correlated with matching costs. For example, while primary education generally focuses on a relatively common set of reading and math skills, higher education is likely to generate more heterogeneous skill outcomes across countries.[22] As a result, firms seeking more highly educated or skilled workers will face higher search costs, since their search criteria are no longer based on relatively homogenous workers who have attained

[22] Worker heterogeneity is likely to rise with country education since college educated workers move into a wide array of majors, and become increasingly specialized as they move from undergraduate to graduate education. For vocational workers, heterogeneity will also rise with training, if the training of highly-skilled technicians also requires specialization in specific techniques or procedures.

a minimum education, but on identifying workers who possess training in particular skills or methods.

Table 4 displays estimates based on specification (8). The results show that country education levels influence the degree of production cost pass-through by different country assemblers. For example, column (1) indicates that while outsourcing firms located in lower education locations passed-through only 58 percent of cost shocks, outsourcing assembly conducted in high-education countries passed-through 96 percent.[23]

To examine the robustness of the positive association between country education and pass-through, Table 4 tests a number of specifications based on alternative measures of country education or human capital. In column (2) of Table 4, the high education country dummy is replaced by the actual number of years of educational attainment for each country's adult population aged 25 or over. As before, the estimates indicate that higher education countries pass-through a greater share of cost shocks. The estimates in column (2) suggest that a country at the bottom 25% level of education would pass through 35.4 percent of a cost shock, while a country at the top 25% based on education, would pass through 78.8 percent. Finally, when Hall and Jones's (1999) measure of country human capital intensity is used to characterize $EDUC_c$, in column (3), the degree of pass-though is again found to be higher for countries that have higher levels of human capital. Similarly, when countries are classified by Hall and Jones's human capital measure, the estimates imply outsourcing products assembled in countries whose human capital is the bottom 25% of the distribution would pass-through 67.1 percent of cost

[23] Following Riker and Brainard (1997), countries are defined as "highly educated" if the average education level for the adults 25 or over in a country is six or more years.

shocks, while outsourcing operations located in countries at the top 25% of the human capital distribution would pass through cost shocks at the higher rate of 95.6%.

The estimation results displayed in Table 4 also reveal the importance of the second set of human-capital interaction terms in equation (8), which capture differential responses to competitor prices. When competitor prices rise, the degree of emulation is found to be highest for assemblers located in countries that have highly educated workforces or higher levels of human capital.

4.4 Robustness Checks

Unless otherwise noted, robustness checks were based on the functional form reported in column (2) of Table 3.

First, the data were checked to learn whether pass-though varied across industries, in a fashion that is obscured in the general results. For example, since the presence of quantitative restrictions on U.S. imports of textiles and footwear may have influenced pass-though in the impacted product segments, the pass-through regression was estimated separately for the group of products that were subject to quantitative restrictions (HS2 chapters 61 through 64). While pass-through for this group of industries, 0.48(.011), is somewhat lower than it is for the full sample, the coefficient is nonetheless in the general range observed in studies on pass-through. Next, regression (7') was individually estimated for each HS2 industry to learn whether there were significant differences in pass-through by industry. These differences may result from differences in the competitiveness of U.S. market in different industry segments. The differences might also arise if the organization of trade, including the extent and management of foreign enterprises, differs across industries. However, while industry estimation reveals some heterogeneity in pass-through across industries, the median industry pass-through coefficient of 0.62 is only a small bit below the estimated pass-through for the full sample.

A second question is whether the cost measure, which is based on composite of production costs, masks differential pass-through of foreign-source production costs. When a separate coefficient is estimated for foreign production costs it implies that the pass-through of foreign-source costs is .415(.016).[24] Alternatively, if a composite term is created with combines the foreign production costs with the ad valorem costs of international shipment, and the payment of any relevant tariffs, as was done for the original specification displayed in column (2) of Table 3, the estimated pass-through of foreign costs is .459(.032). While both of these pass-through estimates are lower than those reported in the original regressions, these tests involve a serious departure from the cost measure {equation (1)} implied by the model, which is a Leontieff function.[25] Thus, to the extent that the cost measure employed in this check suffers from measurement error, the estimated coefficient may be biased downwards.

It is also important to learn whether the results are sensitive to the specification chosen. For example, the primary specification assumes that pass-through is immediate. However, current prices may reflect cost developments from previous years. To test for the importance of timing, I estimated new specifications that were based on the cost measure lagged one period, or based on the inclusion of the cost measure lagged both one

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[24] In this robustness check, shipment and tariff costs are included separately as was done in the original specification reported in column (1) of Table 3.

[25] The Leontieff function follows work of Mendez (1993). Further, Swenson's (2005b) analysis of OAP input choices finds the Leontieff assumption of fixed input choices is consistent with the fact that OAP input choices vary only slightly over time.

and two years. In the one lag specification, the pass-through estimate is .717(.026) and the overall results are very similar to those presented in the primary results.

Another question is whether the availability of alternative trade programs, such as the NAFTA, affected the results through selection effects.[26] The presence of alternative trade programs could affect the observed degree of pass-through if there was a correlation between pricing behavior, and the identity of producers who decided to enter their U.S. imports through NAFTA instead of the OAP. Thus, to check whether NAFTA participation decisions affected the results, I dropped observations for OAP imports brought in from Mexico or Canada. In their absence, the estimated cost pass-through coefficient is 0.679(.016), which is again very similar to the full sample estimate presented earlier. This suggests that there were no systematic differences in the pricing behavior of firms that left the OAP to use NAFTA trade channels instead.

Next, I turned to alternative measures of production costs. To the extent that OAP production includes assembly tasks, wages may be an especially important component of costs. To see whether a wage-based cost measure performed differently, I generated new production costs measures according to equation (1) using UNIDO manufacturing wages as the measure of local costs. While the new pass-through coefficient falls to .123(.009), the other regression coefficients retain magnitudes that are very similar to those originally presented. The fact that the qualitative results are not changed is probably due to the high correlation (0.62) between UNIDO wages and the original measure of local production costs. However, to the extent that foreign activities involve foreign components and materials in addition to assembly, the movement to a wage-based cost

[26] Even after NAFTA was implemented, provisions regarding the general custom's user's fee continued to benefit OAP participants. In addition, many U.S. tariffs on Canadian and Mexican imports were non-zero during the sample period, since the progression towards zero tariffs was subject to phase-in.

measure may also introduce measurement error that causes the pass-through coefficient to decline in magnitude. As a further experiment, I created separate foreign and domestic cost terms under the assumption that the cost function was Leontieff, and that national producer price indices best represented local costs. When I did so, the coefficient on the pass-through of producers costs was .329(.024).

The general regression specification assumes that product quality differences can be captured by measures of country development, such as education. However, the representation will be incomplete if country product quality evolved over the sample period. It will also be incomplete if there were country developments during the time period that affected the costs of outsourcing. (e.g., industry deregulation, changes in infrastructure provision, or changes in local supplier access). To account for such developments, country-specific time trends were added to regression specification (7'). When country-specific trend variables are included, the pass-through coefficient declines to .343(.037), while the competitor price coefficient is almost unchanged at .141(.004). However, the decline in the pass-through coefficient magnitude is not surprising, as costs that trended upward over the time period, and were passed-through to product prices will be absorbed by the country trend terms.

Finally, I experimented with changes in the expenditure term, since the reported regressions are run with HS2 expenditure variables. However, re-running the regressions with expenditure measured at the more finely disaggregated HS4, HS6 or HS8 levels does not appear to influence the estimated magnitudes of the pass-through or competitor response coefficients which are the focus of this study.[27]

5. Conclusion

This paper studies pass-through for a wide range of U.S. outsourcing imports between 1991 and 2000. In this context a number of regularities are observed. First, cost pass-through is found to be roughly 75 percent, which demonstrates that pass-through in outsourcing transactions is very similar to the rate of pass-through found more generally in micro studies which have focused on general trade. In addition, outsourcing firms are found to emulate the prices set by competitor firms. However, this effect is relatively small as the estimates imply that outsourcing firms will raise the prices of the products they ship to the U.S. by 1.4 percent when their competitors raise their prices by ten percent.

This project also finds that the degree of pass-through and competitor price emulation is highest for outsourcing assembly firms located in high education countries. Differential effects of this sort could arise for one of many reasons including differential elasticities in product markets, worker matching frictions, or differences in foreign investment patterns that are correlated with assembly country education. Nonetheless, while the source of these differences will require further study, the systematic differences suggest that intensity of international competition is related to country education levels,

[27] For example, when the regression in column (3) of Table 3 is re-estimated using HS8 expenditure rather than HS2 expenditure, the key coefficient estimates are: Ln (Total Cost) .748(.026), Ln (Competitor Price) .153(.006), ln(Education) .664(.031).

and that country integration in the international economy is influenced by country characteristics.

There are a number of reasons to be cautious in applying the lessons from OAP purchases to all outsourcing relationships. In particular, if OAP assembly tasks are well defined, and simpler to match and conduct than other forms of overseas outsourcing, then OAP production may be characterized by industry conditions and pricing outcomes that are closer to perfect competition than is true for overseas outsourcing conducted in other contexts.

Table 1: OAP Outsourcing Activities, 1991-2000					
Country	**#Trans**	**Country**	**#Trans**	**Country**	**#Trans**
MEXICO	7940	VIETNAM	284	MAURITIUS	45
CANADA	3518	NICARAGUA	225	URUGUAY	44
CHINA	2993	BANGLADESH	219	BOLIVIA	41
DOMINICAN REPUBLIC	2434	TURKEY	212	MONACO	40
HONGKONG	2103	BARBADOS	191	THE CZECH REPUBLIC	38
KOREA	1698	NETHERLANDS	190	BELARUS	38
TAIWAN	1686	BRAZIL	190	GREECE	34
INDIA	1602	SWITZERLAND	188	FINLAND	33
COSTARICA	1580	IRELAND	169	NORWAY	33
COLOMBIA	1535	POLAND	155	NEW ZEALAND	32
GUATEMALA	1498	TRINIDAD AND TOBAGO	150	MONTSERRAT	31
ELSALVADOR	1437	PERU	136	VENEZUELA	30
PHILIPPINES	1326	PORTUGAL	126	LITHUANIA	29
JAPAN	1270	BELGIUM	123	OMAN	25
HONDURAS	1230	SPAIN	115	SLOVENIA	24
HAITI	1140	SWEDEN	109	SLOVAKIA	23
ITALY	1057	RUSSIA	101	DOMINICA	21
JAMAICA	718	AUSTRALIA	100	TUNISIA	20
UNITED KINGDOM	700	EGYPT	100	MALDIVE ISLANDS	19
THAILAND	649	UKRAINE	98	LESOTHO	18
GERMANY	595	PANAMA	98	MACEDONIA	17
INDONESIA	559	AUSTRIA	96	UZBEKISTAN	16
MALAYSIA	530	ST.VINCENT	95	BURMA	15
PAKISTAN	503	NETHERLANDS ANTILLES	95	MALTA	15
SRILANKA	503	ROMANIA	83	ARGENTINA	14
SINGAPORE	483	BELIZE	70	CROATIA	13
FRANCE	463	UNITED ARAB EMIRATES	65	SIERRA LEONE	11
MACAO	349	ISRAEL	64	KENYA	11
ST. LUCIA	327	DENMARK	59	QATAR	11
ECUADOR	318	MOROCCO	54	SOUTH AFRICA	11
ST.KITTS NEVIS	312	CHILE	50	PARAGUAY	10
GUYANA	302	BULGARIA	47	MOZAMBIQUE	10

"#Trans" is the number of distinct HS8 product-year observations of OAP import values that are available for each country.

Table 2: OAP Sourcing Activity by HS Industry

HS2	Total Value of OAP Imports ($mill)	U.S.-origin Value of OAP Imports ($mill)	U.S. %	Largest Source Country	HS2	Total Value of OAP Imports ($mill)	U.S.-origin Value of OAP Imports ($mill)	U.S. %	Largest Source Country
85	14,255	6,910	48.5	Canada	91	98	30	31.1	Switzerland
87	27,879	3,660	13.1	Canada	86	64	27	43.1	Canada
62	3,840	2,131	55.5	Peru	48	36	19	51.2	Canada
84	4,303	1,236	28.7	Canada	65	28	16	56.6	Canada
61	1,331	977	73.4	Mexico	82	40	15	37.6	Taiwan
90	1,503	674	44.8	Canada	59	41	15	37.0	Canada
88	712	299	42.0	Canada	92	105	15	12.1	Japan
76	274	218	79.7	Canada	40	18	13	69.0	Mexico
64	1,135	194	17.1	Malaysia	89	84	12	12.0	Canada
29	155	149	95.8	France	70	23	10	40.4	Canada
63	204	124	61.0	Peru	44	21	9	44.2	Canada
94	191	107	56.0	Canada	58	11	9	39.2	India
72	160	105	65.7	United Kingdom	49	10	4	43.8	Mexico
73	268	97	36.3	Canada	69	16	4	25.7	Mexico
83	109	77	70.8	Mexico	56	5	4	67.3	Mexico
95	143	70	49.1	Mexico	93	15	4	20.8	Japan
39	114	69	60.9	Canada	30	8	3	33.8	Germany
71	72	61	85.6	Hong Kong	28	5	3	49.8	Germany
37	116	58	50.3	Netherlands	54	2	2	77.8	China
74	63	48	76.6	Canada	36	4	2	39.3	Mexico
42	106	46	43.9	Mexico	81	3	2	57.9	Germany
96	65	34	53.7	China	68	2	1	68.0	Italy

Notes: Largest Source Country denotes the country which had the largest total value shipped through the OAP. U.S. % is computed for each HS2 category as, 100*[US Value of OAP Imports]/ [Total Value of OAP Imports]. The largest source country is the country responsible for the greatest dollar value of OAP imports in the HS2 industry.

Table 3: Pass-Through and OAP Prices

	(1) OLS	(2) OLS	(3) RE	(4) RE	(5) RE
ln(Total Cost)		.750[a] (.017)	.729[a] (.026)	.353[a] (.037)	.776[a] (.026)
ln(Production Cost)	.757[a] (.019)				
ln(Trade Cost)	.707[a] (.045)				
ln(Competitor Price)	.395[a] (.004)	.395[a] (.004)	.139[a] (.004)	.137[a] (.004)	.332[a] (.039)
Ln(Education)	.701[a] (.016)	.700[a] (.016)	.694[a] (.031)	.421[a] (.039)	.700[a] (.016)
ln(Expend)	-.049[a] (.020)	-.049[a] (.020)	.173[a] (.006)	.188[a] (.007)	-.049[a] (.020)
Ln(Coun K/L)				.311[a] (.029)	
Ln(Coun H/L)				1.201[a] (.136)	
Controls	Industry Dummies, Year Dummies	Industry Dummies, Year Dummies	Country-Product RE, Year Dummies	Country-Product RE, Year Dummies	Industry FE, Year Dummies
F-test, HS2 Industry dummies = 0	F = 186.0 [0.0000]	F = 152.7 [0.0000]	---	---	---
Test stat, Year dummies = 0 [Prob]	F = 7.76 [0.0000]	F = 7.74 [0.0000]	Chi-sq 286.0 [0.0000]	Chi-sq 291.0 [0.0000]	Chi-sq 89.42 [0.0000]
Country-Product RE (% variation)	---	---	88.8	88.7	86.8
R^2	.529	.528	.299	.283	.389
Observations	46,070	46,070	46,070	41,863	46,070

Notes: Standard Errors in ( ). Regressions (1) and (2) are estimated by OLS. Industries dummies in columns (1) and (2) are at the HS2 level of aggregation. Regressions (3), (4), (5) use random effects panel techniques, which include random effects for country- HS8 product pairs. Column (5), which uses Random Effects IV panel estimation includes the U.S. producer price index is as an instrument for the competitor price. [Total Cost] = (Production Cost)*(Trade Cost). The measure "Coun H/L" is the measure of country human capital intensity from Hall and Jones (1999). Similarly, "Coun K/L" is the measure of country capital intensity from Hall and Jones (1999). RE stands for random effects.

Table 4: Country Education and OAP Pass-Through			
	(1)	(2)	(3)
ln(Total Cost)	.583[a] (.032)	.116[a] (.092)	.143 (.095)
*Highly Educ	.375[a] (.063)		
*ln(Education)		.365[a] (.054)	
*ln(Coun H/L)			.913[a] (.134)
ln(Competitor Price)	.111[a] (.005)	.048[a] (.016)	.052[a] (.013)
*Highly Educ	.054[a] (.007)		
*ln(Education)		.050[a] (.008)	
*ln(Coun H/L)			.094[a] (.015)
Ln(Education)	.627[a] (.032)	.685[a] (.033)	.767[a] (.034)
ln(Expend)	.176[a] (.032)	.177[a] (.006)	.176[a] (.007)
Test stat, Year dummies = 0 [Prob]	Chi-sq 293.4 [0.0000]	Chi-sq 291.1 [0.0000]	Chi-sq 285.8 [0.0000]
Country-Product RE (% variation)	88.7	88.7	89.1
R2	.304	.303	.295
Observations	46,070	46,070	41,863

Notes: Standard Errors in ( ). Regressions (1) and (2) and (3) estimated using random effects, where random effects are based on country- HS8 industry/product. [Total Cost] = (Production Cost)*(Trade Cost). "Highly Educ" is a dummy variable equal to 1 if the average education in the country's population over the age of 25 is 6 or more years. Education = the average education level for the country's population over 25 in years. The measure "Coun H/L" is the measure of human capital from Hall and Jones (1999). RE stands for random effects.

Data Appendix

Trade data

Data on U.S. OAP imports for 1991-2000 were taken from United States International Trade Commission (USITC) trade data as reported in the December editions of the IM146A. The import data, which are recorded at the 10-digit HS level, were first aggregated to the 8-digit level, which is the level at which U.S. import tariffs are set. The dependent variable for the analysis is the unit value of imports, based on the 8-digit aggregates of the cost insurance and freight (CIF) import values. For each country (c) HS8 product (i) year (t) observation unit values representing the average sales price, were calculated by: Unit $Value_{cit}$ = $[\text{Import value}]_{cit}$ /$[\text{Import quantity}]_{cit}$. While unit values are often noisy to measurement error, there is no reason to expect the measurement error to vary systematically by product or country, thus biasing the regression results.

Competitor prices $P^{\sim}$ are the average price of similar 8-digit HS products imported through the OAP from all other countries, or $P_{cit}^{\sim} = \{\Sigma_{c'\neq c}[\text{Import value}]_{c'it}\}/\{\Sigma_{c'\neq c}[\text{Import quantity}]_{c'it}\}$. Expenditure is defined by overall spending for OAP imports from all countries within an HS 2 grouping in the year. Expenditure $E_h = \Sigma_c \Sigma_{i\in HS2}$ $[\text{Import value}]_{cit}$. Alternative expenditure variables for the robustness checks at the HS4, HS6 and HS8 level were similarly constructed.

The U.S percentage of product value, $\alpha_{us,ic}$, is constructed from the OAP data. It is equal to the U.S.-value for imports from country c and industry i, divided by the total value of the imports from country c, industry i. To avoid endogeneity problems, the sample period average value of $\alpha_{us,ic}$ for each county-product pair was used to create the production and trade cost measures.

Tariff rates (τ_{it}) and transportation costs (g_{ict}) were taken from Peter Schott's website: http://www.som.yale.edu/faculty/pks4/sub_international.htm. to create the trade cost measure, $[(1+g_{ict}) + (1-\alpha_{us,ic})* \tau_{it}]$. A detailed description of Schott's data is contained in Feenstra, Romalis and Schott (2002).

Macroeconomic Variables

Macroeconomic Variables were collected from the Penn World Tables: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002. Their variable p, the price level of GDP, is the primary measure of country-level input costs in cost equation (1). However, the cost equation (1) was recomputed in the robustness checks using country wages as the measure of local country input costs. For this purpose country manufacturing wages from UNIDO were used.

Education and Human Capital

Barro and Lee's data on educational attainment were downloaded from the National Bureau of Economic Research web site, http://www.nber.org/data_index.html. Following Riker and Brainard (1997), the high education indicator variable is set to one for all countries whose education level for adults 25 and older averaged 6 or more years in 1990. Cross country differences in human capital abundance were also measured using Hall and Jones' (1999) measures, which are available at: http://elsa.berkeley.edu/~chad/datasets.html.

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