

**The Effects of Competition and Market Characteristics  
on the Pricing of Production Sharing Imports.**

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***Abstract:***

Internationally fragmented production accounts for a growing share of international trade flows. However, while many theories of outsourcing emphasize the importance of cross country cost differences in guiding outsourcing decisions, little is known about the nature of competition in outsourcing relationships. To study this question, this paper tests how production costs and competitor prices affect the prices of products imported through the U.S. 9802 overseas assembly program. The empirical results show that while production costs are incompletely passed-through generally, when assembly is located in more highly educated countries production cost changes are passed-through to a much higher degree. The prices of 9802 imports also respond to prices chosen by other countries, with the responsiveness being largest for products in capital intense industries.

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## ***Introduction***

A growing body of work on international trade shows that international fragmentation of production has contributed significantly to the growth of trade volumes.<sup>1</sup> In explaining this phenomenon, costs are often cited as a critical factor. To begin, the international fragmentation of production processes enables producers to take advantage of factor price differences and may even facilitate factor price equalization.<sup>2</sup> Further, the cost of managing increasingly dispersed production processes is said to be fostered by declines in telecommunications and transport costs. However, as recent work by Grossman and Helpman (2002, 2004) emphasizes, country cost differences are not sufficient in of themselves to generate overseas fragmentation. While cost differences provide an incentive for vertical specialization, firms must first identify overseas partners and then perform relationship specific investments to finalize the arrangement. In the end, the size of these costs and their influence on the market thickness for partners, ultimately determine whether firms search for partners in the low cost location.

While many theories of outsourcing are underpinned by the idea that cross country cost differences guide outsourcing decisions, little is known about the nature of competition between alternative country sources. To study the competitive environment, I examine the pricing of outsourcing imports brought to the U.S. through the 9802 overseas assembly program. The empirical examination tests the implications of a simple

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<sup>1</sup> Hummels, Ishii and Yi (2001) present evidence from 10 OECD and four emerging markets which indicates that increases in vertical specialization can account for 30% of export growth between 1970 and 1990. In 1990 vertical specialization accounted for 21% of these countries' exports. A broad review of the trends is contained in Feenstra (1998). In related work Hanson, Mataloni and Slaughter (2003) document that U.S. multinationals increased their vertical activities in the 1990's, while Gorg (2000) and Swenson (2004) study the empirical determinants of outsourcing location.

<sup>2</sup> See Jones and Kierkowski (1990), Arndt (2001) and Deardorff (2001).

Bertrand model with differentiated goods which accounts for the cost structure and tariff treatment of outsourcing producers who utilized the 9802 program between 1991 and 2000.

A number of findings emerge. First, only twenty to forty percent of the changes in assembly costs are passed through to product prices. However, the degree of pass-through is not uniform across all country suppliers. Those countries that have a more highly educated workforce can more completely pass through cost increases than can countries with less educated workforces. Further, tariff costs are generally passed-through at a higher rate than assembly costs, suggesting that firms have a greater ability to pass through costs that are commonly borne by all producers.

Second, prices chosen reflect the prices selected by competing assemblers in other countries. A ten percent increase in prices chosen by competitors results in a two to four percent increase in prices chosen. However, the responsiveness to competitor prices differs across industries in a manner that reflects differences in capital intensity: prices are strongly correlated with competitors' prices in capital intense industries, while there is little correlation for industries that are not. Overall it appears that 9802 assembly is characterized by a highly competitive environment, with competition abated only in those sectors that are more capital intense, and for countries that have higher levels of education.

The paper is structured as follows. Section two reviews evidence from the U.S. outsourcing conducted through the Overseas Assembly Program. Section three develops an estimation approach that modifies a Bertrand model of competition to capture the procedural features of the 9802 program. The model is followed by empirical tests in

section four that examine how production costs, tariffs and competitor prices affected the prices of 9802 imports. The economic implications of the results are discussed in a brief conclusion.

## ***2. The Data and an Overview of 9802 Activities***

To gain insight into one venue for outsourcing, I use data from the U.S. program known as the Overseas Assembly Provision, which is codified in section 9802 of the current tariff code. The 9802 regulations are designed to assist firms that use U.S.-origin parts, materials or components in their overseas assembly operations. When these firms ship final products to the U.S. they pay no tariffs on the U.S.-origin portion of product value. To facilitate the proper tariff assessment, the Customs department collects information on the product composition of 9802 imports, noting the portion of product value that derives from dutiable 9802 import as opposed to non-dutiable U.S. components and parts.<sup>3</sup>

This paper follows all 9802 activity conducted between 1991 and 2000. The original data, which are recorded at the 10-digit harmonized system (HS) product level, are first aggregated to the 8-digit level which corresponds to the aggregation at which tariffs are assessed. During this period, 4676 distinct 8-digit HS products entered the U.S. through the 9802 program. The country composition of 9802 activity is displayed in Table 1. Although 9802 imports were shipped to the U.S. from 182 different countries, any of these countries had only a slight involvement with the program.<sup>4</sup> In contrast,

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<sup>3</sup> See Hanson (1997) for a history of the OAP program.

<sup>4</sup> For example, Bahrain, Bhutan, Fiji, Kuwait, Palau, Pitcairn Island, Senegal, Sudan, and Vatican City each shipped a single HS8 product for a single year during the 1991-2000 interval.

geographical proximity appears to have favored the conduct of 9802 activities in Canada and Mexico, which had 3518 and 7940 positive (HS8 product)-year activities in the program during the sample period.<sup>5</sup> For each HS8-year pair that had positive activity during the period of observation, the average pair had 3.5 suppliers, while the median was 2. The maximum number of suppliers in a year for a product was 56. Over the full 10-year period, the average HS8 product was shipped to the U.S. from 4.75 different suppliers, with a median of 2, and an extreme of 78.

Measured by frequency, most 9802 activity involves assembly activity conducted in a developing country. If development is gauged by membership in the OECD, only 19% of the positive HS8-year pairs involved developed country activity. When the definition of developed country is expanded to encompass any countries where the average education level was 6 or more years, 37% of the positive HS8-year pairs involved developed country activity.

To provide a snapshot of overseas assembly, Table 2 displays the industry composition for the 9802 program in 1993. I choose the 1993 data because the volume of 9802 imports from Mexico declined somewhat in the late 1990's, following the implementation of the NAFTA accord.<sup>6</sup> The data are aggregated to the 2-digit HS level, and sorted by the 1993 value of U.S. inputs in the 9802 products. By this ranking, the top three 9802 outsourcing industries were electrical machinery (85), transportation equipment (87), and apparel and clothing, not knitted or crocheted (62).<sup>7</sup> For each of the

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<sup>5</sup> The importance of distance and its relation to time is discussed by Hummels (2001), and Evans and Harrigan (2003).

<sup>6</sup> The 9802 program still provided benefits for assembly operations located in Mexico or Canada after the NAFTA was implemented due to the 9802 program's provision regarding the general custom's user's fee.

<sup>7</sup> These are followed by, non-electrical machinery (84), apparel and clothing, knitted or crocheted (61), Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus (90), Aircraft and spacecraft (88), and footwear (64).

HS2 categories, the table 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 9802 products in that category. As one would expect, distance appears to be an important element influencing the location of 9802 activities. Of the 30 industries that involve the largest U.S. contribution to value added in dollar terms, either Mexico or Canada are the prime location for 19 of them. However, more distant sources top the list for other categories, such as Peru in apparel and clothing (62), Malaysia in footwear (64), Hong Kong in Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation jewelry (71), and Switzerland in clocks and watches (91).

Finally, to characterize input usage Table 2 reports the U.S. percentage, which is defined as the value of U.S. parts and materials relative to the total value of the product imported through 9802. For all industries, the average U.S. percentage of product value was 36%. However, examination of the U.S. percentage values shows that there was great heterogeneity in production techniques across industries. This variation could be consistent with differences that are driven by the comparative advantage of the U.S. in different industries, or by differences in organizational form that exist across industries. Variation could also arise as a natural consequence of industry differences in the relative importance of parts and assembly. Cross product tariff differences should also condition the incentive to use U.S.-origin parts and materials. However, while the raw sample correlation between 9802 product imports by HS8 category and MFN tariffs is positive as expected, it is only 0.0746.

### 3. *A model of pricing decisions*

In this section I introduce measures of outsourcing costs that account for the unique input and tariff structure of imports shipped through the 9802 program. I then modify a Bertrand model of competition in internationally differentiated goods to relate the pricing of 9802 imports to a producer's outsourcing costs as well as the pricing decisions of its competitors.

Following Mendez (1993) 9802 production is assumed to take a Leontieff form. To produce product  $i$  in country  $c$ , 9802 producers combine a fixed bundle of U.S. inputs with a fixed bundle of foreign inputs and assembly. To characterize input bundles, I assume that 9802 assembly involves a set of tasks on the unit interval that must be completed in sequence. A firm's decision to participate in 9802 indicates 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 point on the unit interval at which U.S. processing ends and foreign production begins is denoted by  $\beta_{ic}$ , and each task requires physical labor input  $L_i$ , then U.S. input requirements are given by  $\beta_{ic} * L_i$  while foreign inputs in each product are represented by  $(1 - \beta_{ic}) * L_i$ . If the price of U.S. inputs is  $w_{us}$ , the U.S. dollar price of foreign inputs is  $w_c$ , and U.S. inputs are transported to the foreign assembler at ad valorem cost  $g_{ic}$ , the resulting production cost when the good is assembled in country  $c$  is:

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

Since assembly countries differ in their abilities and distance from the U.S., the value of  $\beta_{i,c}$  will not be the same for all countries involved in the assembly of good  $i$ .<sup>8</sup>

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<sup>8</sup> Distance matters not only due to transportation costs, which are directly included in the measure of costs, but also due to time costs associated with distance, as highlighted by Evans and Harrigan (2003).

When 9802 products are shipped from the assembly country to the U.S. two further costs arise. First, the U.S. import tariff  $\tau_i$  is levied against the foreign contribution to product value,  $(1 - \beta_{ic}) * w_c * L_i$ . In addition, the ad valorem shipping cost  $g_{ic}$  applies to the return of the completed product to the U.S.

As the cost calculations show, the cost of OAP products will differ by assembly location for a number of reasons, including cross-country differences in factor and transportation costs for the movement of parts and materials. Cross-country variation is also generated by differences in production techniques that cause the Leontieff input choices to vary by location as dictated by skills, endowments and production costs. Finally, while time subscripts have been excluded for notational simplicity, the costs related to overseas assembly will also change over time as wages, transportation costs and tariffs change.

To model pricing decisions, I assume that each country produces a unique variety of the outsourced good which is an imperfect substitute for the products arriving from other country locations. I assume further that product market competition is Bertrand. This implies that the producer of any particular good faces product demand that is given by,  $q_{ic} = d(P_{ic}^C, P_{ic}^{C*}, E_i)$ , where the demand for each product is negatively related to the producer's own choice of consumer price  $P_{ic}^C$ , and positively related to the price vector of prices  $P_{ic}^{C*}$  of its competitors and to overall expenditure  $E_i$  on product  $i$ .

Although firm profit depends on the price the producer receives for the product, the demand for the product depends on the consumer price. To show the relationship between the producer and consumer prices, I denote the producer price by  $P_{ic}^P$ . If we

now define  $\alpha_{us,ic}$  as the non-foreign fraction of product value that is free from tariff, the relationship between the two prices is given by:<sup>9</sup>

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

This can be arranged to yield,

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

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

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

This generates the familiar first order condition:

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

Price is determined as a markup over marginal cost, with the markup determined by the elasticity of demand for product i. For purposes of estimation, we can follow (5), arriving at the relationship to be estimated.

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

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<sup>9</sup> The U.S.-origin contribution to product value is given by:  $\alpha_{us,ic} = [\beta_{ic} * w_{us} * (1+g_{ic})] / [\beta_{ic} * w_{us} * (1+g_{ic}) + (1-\beta_{ic}) * w_c]$ .

Following Feenstra (1989) and restoring time subscripts, we can write this in log-linear form, and estimate the follow price regression:

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

However, I modify the estimating equation to account for the recent work Hummels & Skiba (2002), Hummels and Irwin (2002) and Schott (2003) which provide evidence that cross country differences in quality are present even at the finest product classification of traded products. The basic specification is augmented to include a development measure  $D_c$  to control for unobserved differences in product quality that are correlated with country development levels. This yields the primary estimating equation that is used in the analysis.

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

## **5. Results**

I estimate the pricing relationship using both OLS and panel regression techniques that control for serial correlation. The findings support the price predictions emerging from a Bertrand model of competition. In particular, unit import prices for 9802 products are positively related to production costs, and tariffs generally. They are also positively related to the prices charged by competitors. In addition, price levels and

responsiveness are found to vary with industry capital intensity and country education levels.

The basic results that are based on estimating equation (7') are presented in Table 3. The estimated coefficients uniformly show that unit product prices are positively related to its input costs, though the implied degree of pass-through is only ten to forty percent. The regressions also imply that tariff costs are incompletely passed through. In each of the specifications the pass-through of tariff costs is somewhat higher than the pass-through of production costs. In addition, the differences in pass-through magnitudes are statistically distinct, though the weakest results shown in column (3) are only statistically different at the 6% level. The greater pass through of trade costs could be consistent with firm responses where profit maximizing firms are able to pass-through common cost changes to a greater extent than they pass-through idiosyncratic cost changes.<sup>10</sup>

The results in Table 3 also show that there is a strong positive relationship between prices charged by 9802 assemblers and the prices charged by their competitors. The OLS regressions imply that assemblers incorporate 40 percent of competitor price changes in their own prices, while the later panel regressions in columns (2), (3) and (4) imply that roughly 25 percent of competitor price changes emerge in the 9802 producer's prices.

As the work of Schott (2003), and Hummels and Irwin (2002) and Hummels and Klenow (2002) suggests, product unit values are also highly correlated with country

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<sup>10</sup> Gron and Swenson (2000) find a similar phenomenon in U.S. car prices, while Besanko, Dranove, and Shanley (2001) provide empirical evidence showing that firms pass-through common shocks to a greater degree than they pass through idiosyncratic cost shocks.

development. My primary method for measuring development is the use of an indicator variable for OECD countries. The strong positive coefficient on this variable indicates that within 8-digit HS product imports, OECD products do indeed command higher prices. This finding is consistent with the idea that within product categories, OECD countries produce higher quality varieties. To examine the correlation between assembler country characteristics and product import unit values, I also proxy country development using an indicator variable for highly educated countries, or the log of country per capita income.<sup>11</sup> While any of these measures is highly correlated with unit prices, their inclusion does not change the general findings.

The only coefficients that change as the definition of development is changed are the coefficients on production cost. The coefficient magnitude rises when development is indicated by country education, and fall when country development is given by per capita GDP. Since per-capita GDP is highly correlated with wages, and hence, country costs, the inclusion of the per-capita GDP variable may cause the apparent drop in the pass-through of production costs. In contrast, when a country education variable is included, the apparent pass-through of production costs rises. This could happen if accounting for country education helps to control for differences in country costs that are related to otherwise unmeasured differences in worker quality.

Recent work on outsourcing, such as Grossman and Helpman (2002, 2004) emphasizes that the initiation and development of outsourcing relationships may be complicated by the need to locate a suitable partner. Firms will only seek outsourcing partners, rather than completing projects in house, when an outsourcing relationship is

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<sup>11</sup> Following Riker and Brainard (1997), countries are defined as “highly educated” if the average education level for the country is six or more years.

expected to yield higher profits. In this context the relative attractiveness of outsourcing relationships depends on the difficulty and cost of finding a partner in addition to the relative costs of outsourcing versus in house production. In the industry dimension, it seems likely that the difficulty and cost of finding a partner will be highest for products that require complex and highly specified production skills. To proxy production skill-intensity and specificity, I now include the capital output ratio in my regressions that are reported in table 4.<sup>12</sup> The results show that industry capital intensity is highly correlated with the unit values of 9802 imports. In addition, the results show that industry capital intensity affects the unit values of developed and developing countries differently. The most notable effect of including capital intensity in the regressions, is that the estimated cost pass through coefficient rises somewhat to roughly 28 percent. In contrast, the magnitude of the coefficients on competitor prices remain unchanged.

The one coefficient that changes markedly across specifications in Table 4 is the coefficient measuring the pass-through of trade costs. It is possible that the instability of this coefficient is driven by the correlation between tariff levels and industry capital intensity; U.S. tariffs are higher in less capital intense industries.<sup>13</sup> As a result, the coefficients on the trade cost variable may reflect not only pass-through of tariffs and transportation costs, but also the effects of industrial structure related to capital intensity.

Finally Table 4 uses the following specification to examine whether industry capital intensity influences the degree of response to competitor price changes or the degree of production cost pass-through.

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<sup>12</sup> The number of observations declines since it is not possible to map all HS 8 codes to a 1987-value SIC code, which is needed to connect the data to industry variables.

$$(8) \ln P_{ict}^C = \alpha + (\beta_1 + \beta_{1K} * \ln(K_i)) * \ln([(1 + g_{ict}) + (1 - \alpha_{us,ic}) * \tau_{it}]) + (\beta_2 + \beta_{2K} * \ln(K_i)) * \ln(C_{ict}) \\ + (\gamma + \gamma_K * \ln(K_i)) * \ln(P_{ict}^*) + \delta \ln E_{it} + \theta * \ln(K_i) + \lambda \ln D_c + \varepsilon_{ict}$$

Here, industry capital intensity  $K_i$  is used to create a number of interactions terms for the pass through and competitor response effects.

The main change I discover relates to the effect of competitor prices on pricing decisions. The estimated coefficient on the interaction term between capital intensity and competitor prices indicates that the tendency to mimic competitor country price increases is positively affected by industry capital intensity. If capital intensity presents a barrier to quick entry, assemblers in capital intense industries might feel more confident that they could increase their prices when their competitors do, without spawning great entry by new outsourcing partners.

To examine whether the availability of alternative outsourcing partners appears to be conditioned by industry capital intensity, I regressed the count of competitors, which was measured as the number of countries that provided a particular HS8 product for at least some of the years between 1991 and 2000, on measures of industry capital intensity. The negative coefficient on average industry capital intensity, shown in specification (1), documents that the number of source countries is negatively related to industry capital intensity for 9802 products.

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<sup>13</sup> In this sample, the regression of an industry's tariff rate on the industry's capital intensity and time yields:  $\text{Tariff Rate}_{it} = .185(.015) - .031(.001) * \ln(\text{average KY}_i) - .0016(.0002) * \text{yr}$  This regression is based on the 24253 unique HS8 product-year combinations.

<b>The Effect of Capital Intensity on the Number of Countries Providing Products: Negative Binomial Regressions</b>			
<b>Specification</b>	<b>Dependent Variable</b>	<b>Independent Variable</b>	
		$\ln(\text{Average KY})_i$	$\ln(\text{KY})_{it}$
(1)	Count of Competitors 1991-2000	-1.033 (.038)	
(2)	Count of OECD Competitors 1991-2000	-.690 (.083)	
(3)	Count of Non-OECD Competitors 1991-2000	-6.478 (.329)	
(4)	Number of Countries Supplying HS8 product in year 1991-1996		-.287 (.060)

To further explore how capital intensity conditions the number of competing countries in an industry, I created separate competitor counts for OECD and non-OECD countries. This distinction makes sense if differences in skill mix, for example, cause the assembly tasks performed in high skilled locations to differ from those performed in low skill locations, or if the products assembled in OECD locations are closer substitutes for each other than they are for non-OECD products. When the count of competitors is defined by OECD membership, as it is in specifications (2) and (3), the regression results show that capital intensity appears to exert a much stronger hindrance to the presence of non-OECD suppliers than it does to the presence of competing OECD suppliers.

Since the data I use to measure capital intensity are only available through 1996 it is not possible to track yearly capital intensity and competitor counts for the entire sample period. However, as specification (4) shows, the number of countries providing overseas

assembly assistance declined for U.S. industries that became more capital intense between 1991 and 1996.

All of the auxiliary regressions suggest that entry is less likely in industries that are more capital intense. This may explain why firms in more capital intense industries are more likely to match their competitor's price changes: if they raise their prices, they are less likely to be displaced by the entry of new competitors from other countries, possibly due to difficulties and requirements involved in successful partner matches. This view of competition has some similarity to Feenstra, Gagnon and Knetter's (1996) finding that exchange rate pass-through for passenger cars was higher for producers who had a higher market share. While it would be attractive to estimate the specification using their techniques, the lack of similarly disaggregated production data for the U.S. domestic industry precludes the creation of market share terms.<sup>14</sup>

An alternative way to look for evidence that industry matching matters is to include industry skill requirements rather than capital intensity in the regressions. Table 5 does this by examining whether industry skill requirements affect product price levels or price sensitivity. To measure industry skill intensity, I define the skilled wage percentage at the industry level as [non-production worker wages]/[Total wages]. Columns (1) and (2) begin the inquiry by examining the direct effects of including skill measures in the regressions. The coefficients on the skill measures show that the unit values for 9802 imports were higher in industries that were characterized by a relatively

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<sup>14</sup> The data in this sample reveal a high correlation between capital intensity and 9802 market share, defined as a country's share of 9802 product exports in a given industry. In this sample, OLS regression of a country's average market share in an industry on the industry's average capital intensity and a set of country dummies yields:  $\text{Average Market Share}_{ic} = .216(.006) * \ln(\text{average KY})_i + \sum C_c$ . Over time, country market shares of producing countries grew in size if industry capital intensity rose. When the regression is estimated using a panel regression with random effects for country-industry pairs,  $\text{Market Share}_{ict} = 177(.006) * \ln(\text{KY})_{it} + \varepsilon_{ict}$ .

high skilled wage percentage. In addition, unit import values are higher for products which are assembled in countries whose workforces are more highly educated.

The description of partner search in Grossman and Helpman’s work on outsourcing shows how low search costs enable firms to conduct more intensive searches, and how in general equilibrium the expansion of search efforts will create a “thick markets” externality, or the greater entry of potential partners. In the 9802 context, we might expect that the search costs for highly skilled assembly partners will be lower in countries that have highly educated workforces. If this is the source of the “thick markets” externalities, then country education should matter the most for those industries that most heavily utilize skilled workers. To test this idea, columns (3) and (4) add an interaction term which multiplies the industry skilled wage percentage by an indicator variable that denotes whether a country’s population is highly educated. The strong positive coefficient on the interaction term suggests that unit values are particularly high when a skilled industry product is produced by more highly educated workers.

Finally, I augment my estimating equation with interaction terms that are based on a high education indicator variable  $HE_c$  to test whether the sensitivity of pricing responses is related to country education levels.

$$(9) \ln P_{ict}^C = \alpha_{ic} + (\beta_1 + \beta_{1HE} * HE_c) * \ln[(1 + g_{ict}) + (1 - \alpha_{us,ic}) * \tau_{it}] + (\beta_2 + \beta_{2HE} * HE_c) * \ln(C_{ict}) \\ + (\gamma + \gamma_{HE} * HE_c) * \ln(P_{ict}^*) + \delta \ln E_{it} + \lambda HE_c + \varepsilon_{ict}$$

The results show that country education levels influence the ability of assemblers to pass-through production costs to prices. Column (6) of Table 5 suggests that assemblers

located in low education countries could only pass-through 30 percent of their production costs changes. In contrast, producers located in highly educated countries were able to pass-through 97 percent of their production cost changes. The contrast in these magnitudes seems to suggest that country education appears to move countries away from perfect competition.

To further investigate the effects of education, I performed the analysis a second time, measuring country education by the number of years educational attainment in a country's adult population aged 25 or over. Overall, the results reported in Table 6 echo the findings from Table 5. However, one new question that can be answered is whether an additional year of education has a similar effect on low and high education countries. In particular, is an additional year of education correlated with a greater increase in product value for high or low education assembly countries? To look at this issue, column (4) adds an interaction term to measure the benefits of extra education for those countries that had 6 years or greater education. The results show that a 10% increase in educational attainment for countries whose attainment was less than 6 years, implied a 3.5% increase in product prices, while a 10% increase for countries whose residents averaged 6 or more years education, implied an 7.5% increase in product prices.

I again test for evidence that is consistent with Grossman and Helpman's arguments of "thick market" externalities by adding an interaction variable in column (3) that multiplies the industry skilled wage measure with country educational attainment.<sup>15</sup>

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<sup>15</sup> I assume here that the supply of high skilled assemblers is greater in countries that have highly educated workers, and that the cost of locating a match is highest for industries that require skilled workers. The effect may be more complicated if, as in Grossman and Helpman (2003), the compensation paid to the foreign assembler depends on the assemblers outside options, which are themselves correlated with education levels. The indicator variables  $HE_c$  in equation (9) are now replaced with  $HE_c * \ln(\text{Education})_c$ .

As before, the new interaction term has a strong positive coefficient, indicating that product prices are especially high when a skill-intensive product is assembled in a country with a highly educated workforce.

Finally, I test whether the level of education affects the pass through of production costs. As column (6) of Table 6 shows, the ability to pass through production cost changes to import prices is strongly related to the education level of the assembly location. The coefficient magnitude implies that the median country would be able to pass through 25% of its cost changes. In contrast, a country in the top 25%, by education, could pass through 94% of their cost changes, while a country in the top 10% would pass through 99%.

## **6. Conclusion**

This paper examines the pricing decisions for producers who assembled their goods abroad and imported them to the U.S. through the U.S. Overseas Assembly Provision, or section 9802 of the tariff code. In general, changes in production costs are only partially passed through to import prices; the full sample results imply that a country assembling 9802 products is only able to pass-through 40 percent of any production cost shock it faces. However, assemblers located in countries with highly educated workforces are able to pass-through a much larger percentage of production cost changes than are assemblers located in countries whose workforces are less educated. The results also show that the degree of price responsiveness to competitor prices is diminished in capital intense industries. These facts both appear to validate the premise of outsourcing models that are based on costly search costs and the requirement that firms match with suitable outsourcing partners.

However, there are a number of reasons to be cautious in applying the lessons from 9802 purchases to all fragmented production in general. Since 9802 is designed to promote the use of U.S.-origin parts in foreign assembly, a large portion of many foreign countries' contributions is assembly. If assembly tasks are well defined, and simpler to match and conduct than the average outsourcing task, then 9802 production may be characterized by industry conditions and pricing outcomes that are closer to perfect competition than is true for outsourcing operations in other contexts.

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
HUNGARY	300	NEPAL	46	GRENADA	10

The table displays the number of distinct HS8 product-year observations of 9802 unit import values that are available for each country. The full sample has 48,788 observations. Countries with fewer than ten HS8-year observations are omitted from the table.

**Table 2: 9802 Sourcing Activity by HS Industry, 1993**

HS2	Total Value of 9802 Imports (\$mill)	U.S.-origin Value of 9802 Imports (\$mill)	U.S. %	Largest Source Country	HS2	Total Value of 9802 Imports (\$mill)	U.S.-origin Value of 9802 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 9802. U.S. % is computed for each HS2 category as,  $100 * [\text{US Value of 9802 Imports}] / [\text{Total Value of 9802 Imports}]$ .

<b>Table 3: The Effect of Costs and Competitor Prices on 9802 Prices</b>				
	(1)	(2)	(3)	(4)
ln(Production Cost)	.197 (.015)	.200 (.030)	.413 (.031)	.097 (.038)
ln(Trade Cost)	.913 (.037)	.630 (.063)	.549 (.064)	.696 (.064)
ln(P*)	.415 (.006)	.253 (.004)	.247 (.004)	.253 (.004)
Development Measure	OECD	OECD	Highly Educated	Ln(Per-Capita GDP)
Development	1.587 (.033)	1.693 (0.039)	1.017 (.035)	.685 (.024)
ln(Expenditure)	-.097 (.004)	.003 (.004)	-.003 (.004)	-.002 (.004)
Year and HS2 Dummies	Yes, Yes	Yes, No	Yes, No	Yes, No
Rho		.347	.347	.347
R2	.553	.362	.342	.343
Observations	47,573	47,573	47,573	47,573

Notes: Standard Errors in ( ). Regression (1) is estimated by OLS. Regressions (2), (3), (4) are estimated by random effects panel methods which allow for a first-order autoregressive error term.

<b>Table 4: The Effect of Capital Intensity on Price Responses</b>					
	(1)	(2)	(3)	(4)	(5)
ln(Production Cost)	.275 (.022)	.281 (.021)	.275 (.039)	.217 (.043)	.178 (.067)
ln(Production Cost)*ln(KY)				.321 (.186)	.363 (.206)
ln(Trade Cost)	1.611 (.132)	1.659 (.132)	-.342 (.172)	3.527 (.243)	1.229 (.319)
ln(Trade Cost) * ln(KY)				-7.888 (.988)	-5.284 (.934)
ln(P*)	.400 (.008)	.400 (.008)	.197 (.005)	.355 (.015)	.123 (.010)
ln(P*)*ln(KY)				.177 (.041)	.224 (.026)
OECD	1.528 (.041)	1.852 (.098)	2.122 (.097)	1.723 (.111)	1.982 (.113)
ln(KY)	-.606 (.045)				
ln(KY) *OECD		-.404 (.071)	-.718 (.060)	-.340 (.083)	-.751 (.074)
ln(KY) * (1-OECD)		-.665 (.044)	-.886 (.036)	-.521 (.054)	-.832 (.050)
ln(Expenditure)	-.099 (.004)	-0.098 (.004)	-.007 (.004)	-.095 (.004)	-.008 (.004)
Year and HS2 Dummies	Yes, Yes	Yes, Yes	Yes, No	Yes, Yes	Yes, No
Rho			.394		.394
R2	.548	.549	.350	.554	.354
Observations	31,888	31,888	31,888	31,888	31,888

Notes: Standard Errors in (. Regressions (1), (2), and (4) estimated by OLS. Regressions (3), and (5) estimated by random effects panel methods which allow for a first-order autoregressive error term.

<b>Table 5: The Effect of Country Education on Price Responses</b>						
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Production Cost)	.338 (.023)	.406 (.040)	.349 (.023)	.416 (.040)	.078 (.025)	.301 (.043)
ln(Production Cost)* Highly Educ					1.284 (.056)	.672 (.086)
ln(Trade Cost)	.747 (.141)	.199 (.176)	.975 (.141)	.303 (.175)	1.212 (.158)	1.123 (.215)
ln(Trade Cost) *Highly Educ					-1.513 (.298)	-2.518 (.370)
ln(P*)	.416 (.146)	.224 (.005)	.413 (.008)	.221 (.005)	.395 (.009)	.225 (.007)
ln(P*)* Highly Educ					.024 (.011)	-.001 (.009)
Skilled Wage Percentage	.401 (.146)	.768 (.143)	-.713 (.150)	-1.244 (.193)	-.383 (.150)	-1.078 (.193)
Highly Educated	.934 (.029)	1.018 (0.44)	-.087 (.084)	-.562 (.111)	.381 (.112)	-.088 (.128)
Skilled Wage % * Highly Ed			2.833 (.251)	4.337 (.279)	1.989 (.255)	3.668 (.285)
ln(Expenditure)	-.102 (.004)	-.004 (.004)	-.104 (.004)	-.005 (.004)	-.101 (.004)	-.003 (.004)
Year and HS2 Dummies	Yes, Yes	Yes, No	Yes, Yes	Yes, No	Yes, Yes	Yes, No
Rho		.394		.394		.394
R2	.530	.313	.534	.319	.543	.333
Observations	31,888	31,888	31,888	31,888	31,888	31,888

Notes: Standard Errors in (. Regressions (1), (3), and (5) estimated by OLS. Regressions (2), (4), (6) estimated by random effects panel methods which allow for a first-order autoregressive error term.

<b>Table 6: The Effect of Country Education Levels on Price Responses</b>						
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Production Cost)	.394 (.023)	.467 (.040)	.459 (.040)	.345 (.041)	.021 (.027)	.249 (.045)
ln(Prod'n Cost)* ln(Education)* Highly Educated					.637 (.029)	.331 (.043)
ln(Trade Cost)	1.431 (.138)	.475 (.178)	.570 (.177)	.217 (.179)	1.078 (.163)	1.371 (.220)
ln(Trade Cost)* ln(Education)* Highly Educated					-1.028 (.148)	-1.610 (.177)
ln(P*)	.415 (.008)	.220 (.005)	.218 (.005)	.219 (.005)	.390 (.009)	.229 (.007)
ln(P*)* ln(Education)* Highly Educated					.007 (.005)	-.005 (.004)
Skilled Wage Percentage	.530 (.148)	.867 (.147)	-10.889 (.644)	.841 (.147)	.515 (.145)	.672 (.146)
Ln(Country Education)	1.062 (.029)	1.080 (.052)	-1.176 (.131)	.345 (.079)	.557 (.030)	.329 (.080)
ln(Country Education)*Highly Educated				.405 (.033)	.408 (.029)	.556 (.038)
Skilled Wage % * ln(Country Education)			6.628 (.353)			
ln(Expenditure)	-.099 (.005)	.001 (.005)	.002 (.005)	.001 (.005)	-.097 (.004)	.004 (.005)
Year and HS2 Dummies	Yes, Yes	Yes, No	Yes, No	Yes, Yes	Yes, No	Yes, No
Rho		.396	.396	.396		.396
R <sup>2</sup>	.532	.306	.318	.310	.547	.330
Observations	30,868	30,868	30,868	30,868	30,868	30,868

Notes: Standard Errors in (.). Columns (1) and (5) are estimated by OLS, while the remaining regressions in this table are estimated using random effects panel methods which allow for a first-order autoregressive error term.

## ***Data Appendix***

### Trade data

The 9802 import data for 1991-2000 are taken from United States International Trade Commission (USITC) trade data as reported by the December editions of the IM146A. The dependent variable for the analysis is the CIF unit value of imports. Competitor prices  $P^*$  are given by the average price of similar 9802 products are imported from all other countries.

While the data are collected at the 10-digit HS level, the 10-digit data were first aggregated to the 8-digit level. To facilitate comparison with U.S. industry production data, the data are connected to 4-digit SIC identifiers using Peter Schott's "HTS10 to SIC4 Concordance, 1989 to 2001". Tariff rates and transportation costs were also collected from Schott's at: [http://www.som.yale.edu/faculty/pks4/sub\\_international.htm](http://www.som.yale.edu/faculty/pks4/sub_international.htm). A description of these data is contained in Feenstra, Romalis and Schott (2002).

### Industry Characteristics

Data on 4-digit SIC industry capital intensity, and skill requirements were collected from the NBER Manufacturing Database, which is available from the National Bureau of Economic Research data site, at [http://www.nber.org/data\\_index.html](http://www.nber.org/data_index.html), as constructed by Bartlesman, Becker and Gray. Capital intensity is measured as the ratio of Capital to output, while worker skill requirements were measured by using the ratio of non-production worker wages to total wages.

### 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. The variable  $p$ , the price level of GDP, is used to characterize input costs when I use equation (1) to calculate production costs.

### Education

The data on educational attainment were taken from Barro and Lee's data, maintained at the, National Bureau of Economic Research, at [http://www.nber.org/data\\_index.html](http://www.nber.org/data_index.html). The high education indicator variable is set to 1 for all countries whose education levels for adults 25 and older was 6 or greater years in 1990.

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