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# Elasticity of Substitution in the U.S. Market with Endogenous Transport Costs: a Sectoral Approach

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**Resumen.** En este artículo se presentan estimaciones de la elasticidad de sustitución de bienes importados al mercado de los EEUU en el periodo 1990–2003, siguiendo a Anderson y Wincoop (2004). Estas estimaciones aprovechan la disponibilidad de la información sobre costos de transporte de bienes publicada por la Oficina del Censo de los Estados Unidos, desagregándola a seis dígitos.

Se obtienen dos estimaciones diferentes de la elasticidad de sustitución: una a nivel agregado promedio y otra a nivel sectorial. Como puede esperarse, las estimaciones que tienen en cuenta la endogeneidad de los costos de transporte son estadísticamente diferentes en un punto porcentual a los resultados obtenidos cuando no se contempla la estructura de los costos de transporte. Esta diferencia es incluso superior cuando comparamos los resultados obtenidos utilizando la clasificación sectorial a nivel de dos dígitos de la clasificación ISIC revisión 2.

**Palabras clave:** Elasticidad de Sustitución, Costos de Transporte, Clasificación ISIC.

**Clasificación JEL:** F14, F17.

**Abstract.** Following Anderson and Wincoop (2004) we estimate the elasticity of substitution of the goods imported by the U.S. market for the period comprehended between 1990 - 2003. Our estimates take advantage of the data on transport costs available at six digit commodity level of the U.S. import data published by the U.S. Census Bureau.

We obtain two different estimates of the elasticity of substitution; one at the average aggregate level and a second one at the sectoral level. As expected, the estimates that take into account the endogeneity of transport costs are statistically different in one unit from the results obtained when we ignore the structure of transport costs. This difference is even higher when we compare

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the results obtained using the sectoral classification at the two digit level of the ISIC revision 2 classification.

**Keywords:** Elasticity of substitution, Transport Costs, ISIC Classification.
**JEL classification:** F14, F17.

## 1. Introduction

Within the last ten years, the world has probably experienced the most important change on bilateral trade relations. In 2002, the second most important market for trade was created; the European Union began the circulation of a common currency within all the members. As we know, the creation of the Eurozone entitled new economic rules common to all country members, which applied to several topics, being trade one of them. At the same time, the world entered into a phase of globalization that implied, among many other changes, the general reduction of barriers of trade, paying special attention to tariff barriers of trade. As a whole, WTO members have engaged in a general reduction of trade barriers.

As an example of this trend, by 1999 - 2001, Mexico and Canada were already trading with the U.S. under the free trade agreements of NAFTA and CUFTA. Latin America has not been absent to these processes. Brazil, Argentina, Bolivia, Uruguay and Chile are all engaged in the region's most important trade agreement: MERCOSUR, and at the moment of writing this paper, Chile was negotiating bilateral trade agreements with Colombia and other Andean countries.

It could be said that the most interesting negotiations for Latin American countries have been taking place within the last three years; as the U.S. negotiated bilateral free trade agreements with several countries of the region,[1] and as expected, the main objective of these treaties has been to reduce bilateral tariffs and bilateral non-tariffs barriers of trade.

It may be taken as some sort of redundancy, but it must be remarked that the effects of trade costs are a very important determinant of trade patterns between countries. Future reductions of trade costs will have important effects on the type and amount of goods exported from foreign countries, and in the present context this would imply an important source of trade diversion or trade creation for those countries that could potentially decrease the trade costs of exporting products to foreign locations. As an example of this pattern, several Latin American countries have made important airport modernization decisions in order to increase the efficiency of their cargo handling. A perfect example of this strategy is Colombia, which in 2006 approved and started upgrading of El Dorado, the most important cargo airport of South America. Panama also, in 2004, initiated an investment plan to upgrade the inter-ocean Channel to satisfy the current cargo requirements of maritime ships.

[1] Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Peru.

Taking all these into account, the present paper focuses on the estimation of the elasticity of substitution of imported products to the U.S. market for the period comprehended between 1990 and 2003. Taking advantage of the quality of the data available for imports to the U.S., we use information available for 4512 different products imported to the U.S. from all over the world, at the six digit level of disaggregation of the Harmonized System Code. Our empirical exercise builds up on the theoretical model developed by Anderson and Wincoop (op. cit) and we estimate the average elasticity of substitution for our sample of products imported by the U.S. market. Given the features of the data, we also were able to classify each product within eight economic sectors.[2] We use this structure to estimate elasticities of substitution by sector. Finally and as an additional extension, we endogenize transport costs, and compare these estimates against the standard estimates that were obtained under the assumption on exogenous transport costs.As previous trade literature has already explained, trade costs are determined by all the costs contained on the process of delivering a final good to a consumer. In particular, the cost structure is determined by a whole set of factors that include transportation costs, policy barriers of trade, information costs, contract enforcement, currency costs, other legal and regulatory costs and local market distribution costs. Rough estimates of trade costs for industrialized countries have found that their importance for trade is equivalent to an ad–valorem tax rate of around 170%, which can be decomposed in the following aggregate components: "21 percent is explained by transportation costs, 44 percent is related to border trade barriers and the other 55 percent is related to retail and wholesale distributional costs".[3] So trade costs do matter!

The structure of this paper goes as follows: Section 2 describes the model and the endogenous trade costs specification to be used to determine the estimation equations of transport costs and imports demand, which will be used to estimate the elasticities of substitution. Section 3 describes the data. Section 4 reports the results and finally Section 5 presents some conclusive remarks and directions for future research.

## 2. The Model

Following Anderson and Wincoop (op. cit), we develop a general equilibrium model that is used to estimate the elasticity of substitution of the products imported by the U.S., within the period comprehended between 1990 - 2003. Our model builds on two facts. As the authors explain, the impact of trade costs over trade is important, and is equivalent to the effect of an ad-valorem tax of 170%. Therefore, it would be interesting to take a step forward and try to endogenize it. The gain is given by the conceptual idea that imports' levels and transport costs are both endogenous since obviously imports are affected by transporting costs; i.e. insurances.

[2]The industrial sectors correspond to the classification at the two-digit disaggregatation of the ISIC revision classification. We only work with the products classified within sectors 11- 39

[3]Anderson and Wincoop (2004), p. 692.

For estimation purposes, the direct consequence of this problem is that the estimates of the elasticity of substitution among goods are biased. As expected, we could potentially reduce this problem by modeling the transport cost structure of goods. As we know, modeling transport costs is not a new concept, Hummels (1999) and Micco (2006), among others, have already modeled transport costs. But the implications of the estimates of the elasticity of substitution might give a new conception of the effects of transport costs on trade, not only for their direct effect on imports but also for the effect of the assumption of the level of substitution between imported-competing goods.

Second, and from a policy perspective view, low transport costs for exporters which are near to the U.S. market would give some advantage to nearby producers in comparison to producers located in remote locations that are directly associated by distance. Thereby, countries that are located far away form the American market could potentially reduce the bias implied by transport costs by implementing policies aimed to decrease their transport methods; i.e. increasing infrastructure level or implementing new and more efficient methods of transportation. As a general policy example, if Chinese exporters could reduce their transporting costs to the U.S. market, this would potentially reduce the level of exports of other competing countries to the American market.

In the following section we proceed to derive the model. First we develop Anderson and Wincoop's (op. cit) general equilibrium model, and then we endogenize the transport cost structure. This would give us the basic estimation equations that we are going to use to estimate the average and the sectoral elasticities of substitution.

### *2.1. The Demand*

We should begin by stating the following assumptions: (i) all the consumers in the U.S. market have the same type of preferences, and they can be represented through a two-level utility function; and (ii) the preferences of a representative consumer in the U.S. market are given by the following utility function: [4]

$$U_{J,T} = \prod_{s \in S} C_{j,s,t}^{\theta_{j,s}} \tag{1}$$

Where $C_{j,s,t}$ is the composite demand of consumers in the U.S. market $(j)$, of goods classified in economic sector at period . Furthermore, we assume that consumers in the U.S. market do have a love for variety. Therefore, consumption within each economic sector is determined by the following sub- utility function:

[4]The underlying assumption is that consumption decisions between economic sectors are independent. There is no substitution effect between consumption of goods between sectors. This assumption can be levied, and we could assume some other functional form able to capture this substitution effect among products; i.e. a C.E.S utility function in the first stage.

$$C_{j,s,t} = \left[ \sum_{c} \sum_{j \in s} \phi_{i,s,c}^{\frac{1}{\sigma_s}} q_{j,i,s,c,t}^{\frac{\sigma_s}{\sigma_s - 1}} \right]^{\frac{\sigma_s}{\sigma_s - 1}} , \quad \sigma_s > 1 \ \ \forall s,t \tag{2}$$

Where $q_{j,i,s,c,t}$ is the quantity consumed of good $i$, classified in economic sector $s$, imported from country $c$ at period $t$. For notation purposes, since each product is country specific, from now on we drop subscript $c$. It is important to notice that our specification allows for a different elasticity of substitution per economic sector $\sigma_s$.

Therefore, at every period $t$, the representative consumer must decide the budget share that he is going to spend on each economic sector $s$. Then, he has to determine how is he going to allocate the expenditure between the products classified in that sector. Following this idea, the agent first has to solve the following problem:

$$\max C_{s,t} = U_{j,t} \max C_{j,s,t} \prod_{s \in S} C_{j,s,t}^{\theta_{j,s}} \quad s.t. : Y_{j,t} = \sum_{s \in S} P_{j,s,t} C_{j,s,t} \tag{3}$$

Where $Y_{j,t}$ and $P_{j,s,t}$ are income and the sectoral price index in period $t$. Therefore, the optimal sectoral bundle $(C_{j,s,t})$ and price index $(P_{j,t})$ are given by the following two equations:

$$C_{j,s,t} = \frac{\theta_{j,s} Y_{j,t}}{\left[\sum_{s \in S} \theta_{j,s}\right] P_{j,s,t}} \tag{4}$$

Where:

$$P_{j,t} = \prod_{s} P_{j,s,t}^{\theta_{j,s}}$$

Which implies that the expenditure allocated per sector is given by the following expression:

$$P_{j,s,t} C_{j,s,t} = \frac{\theta_{j,s} Y_{j,t}}{\left[\sum_{s \in S} \theta_{j,s}\right]} = Z_{j,s,t} \tag{5}$$

Under the assumption that the first level utility function is first-degree homogeneous in consumption, we know that the level of expenditure per economic sector is given by linear Engel curves.[5]

$$P_{s,t} C_{s,t} = \theta_{j,s} Y_{j,t} = Z_{j,s,t} \tag{6}$$

[5] Recent literature has levied this assumption by introducing the estimation of non parametric Engel curves within demand systems. Deaton and Ng (1998) provide a discussion of the alternative estimation approaches that can be used to test whether preferences are homothetic or not.

Once we have determined the level of consumption per economic sector, the consumer needs to establish the optimal demand per good classified within this sector. Therefore, the second step is given by the following equation:

$$\max_{q_{j,i,s,t}} C_{j,s,t} = \max_{q_{i,s,t}} \left[ \sum_{i \in s} \phi_{j,i}^{\frac{1-\sigma_s}{\sigma_s}} q_{j,i,s,t}^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}}, \quad \sigma_s > 1 \tag{7}$$

$$s.t. : Z_{j,s,t} = \sum_{i \in s} p_{j,i,s,t} q_{j,i,s,t}$$

Where $P_{j,i,s,t}$ is the price of product $i$, classified in sector $s$ at period $t$ and $\phi_{i,s}$ is a weighting parameter associated to the relative importance of the good within the sector and the relative importance of the export within the sector.

Therefore, the demand per good is given by the following expression:

$$q_{j,i,s,t} = \frac{Z_{j,s,t} \phi_{i,s}^{1-\sigma_s}}{p_{j,i,s,t}^{\sigma_s} \left[ \sum_{i \in s} \phi_{i,s} p_{j,i,s,t}^{1-\sigma_s} \right]} \tag{8}$$

Or equivalently, the expenditure per good in sector is given by:

$$p_{j,i,s,t} q_{j,i,s,t} = Z_{j,s,t} \left[ \frac{\phi_{i,s} p_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s}$$

$$x_{j,i,s,t} = \theta_{j,s} Y_{j,t} \left[ \frac{\phi_{i,s} p_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \tag{9}$$

Where the sectoral price index $P_{j,s,t}$ is given by:

$$P_{j,s,t} = \left[ \sum_{i \in s} \left( \phi_{i,s} p_{j,i,s,t} \right)^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}, \quad \forall s \tag{10}$$

The price that the consumer pays in the U.S. market is determined by: the price set by the foreign supplier, the tariff level imposed to products imported from that $i(1+\tau_{j,i,s,t})$[6] country and the transport costs associated to product $(t\,c_{j,i,s,t})$. Therefore, the unit price of a good is determined by the following expression:

$$P_{j,i,s,t} = P_{j,s,t}^{sup} t\,a\,r_{j,i,s,t}\, t\,c_{j,i,s,t} \tag{11}$$

From our general equilibrium setup, by the market clearing condition we have:

$$Y_{i,s,t} = \sum_{j} x_{j,i,s,t}$$

[6] For notational purposes we assume that $i(1 + t_{i,s,t}) = \text{tar}_{i,s,t}$

$$Y_{i,s,t} = \sum_j \theta_{j,s} Y_{j,t} \left[ \frac{\phi_{i,s} p_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \tag{12}$$

By substituting equation (11) in equation (12) we obtain the following alternative expression:

$$Y_{i,s,t} = \left[ \phi_{i,s} p^{sup}_{i,s,t} \right]^{1-\sigma_s} \sum_j \theta_{j,s} Y_{j,t} \left[ \frac{t\,a\,r_{j,i,s,t} t c_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \tag{13}$$

Furthermore, and as shown in Appendix 1, if we substitute equation (13) within our demand equation (equation 9) we obtain the following closed-form solution for the expenditure level:

$$x_{j,i,s,t} = \frac{Y_{i,s,t} Y_{j,s,t}}{Y^w_{s,t}} \left[ \frac{t\,a\,r_{j,i,s,t}\, t\, c_{j,i,s,t}}{P_{j,s,t} P_{i,s,t}} \right]^{1-\sigma_s} \tag{14}$$

Through logarithms[7] and applying a first-order Taylor expansion on both $t\,a\,\tilde{r}_{j,i,s,t}$ and $t\,\tilde{c}_{j,i,s,t}$ we obtain the following equation:

$$\tilde{x}_{j,i,s,t} = \tilde{Y}_{i,s,t} + \tilde{Y}_{j,s,t} + \tilde{Y}^w_{s,t} \left(1 - \sigma_s\right) \left[ t\,a\,\tilde{r}_{j,i,s,t} + t\,\tilde{c}_{j,i,s,t} - P_{j,s,t} - P_{i,s,t} \right] \tag{15}$$

This is the equation that we want to estimate. But two considerations must be taken into account. First, as explained by Micco (2006), transport costs are endogenous to the demand, since the insurance component of this cost depends on the quantity imported by country $j$. Second, we do not have information for either the sectoral production level or the sectoral price indexes per country.

In order to be able to estimate this equation, we have to address both problems. The endogeneity of transport costs can be approached in two ways, either we could potentially use the orthogonal component of the transport cost to the import value[8] or we could estimate a reduced-form solution of transport costs per product, and the omitted variable bias can be reduced by using proxies for the price indexes and the level of production of each country.

### *2.2. Transport Costs*

Following the second approach and assuming the standard literature procedure (Anderson and Wincoop, op. Cit), we know that transport costs can be approached through the following ad-hoc specification:[9]

[7] We use ˜ to denote logarithm.

[8] This would wipe out the insurance component of the transport cost, which is a component that is affected by the import value of the merchandise.

[9] Under the assumption that we do not have any specification bias generated by the implicit structure of the transport cost equation.

$$t\tilde{c}_{j,i,s,t} = \left[e^{\Lambda H_{i,j}+\xi_{j,i,s,t}}\right] \prod\nolimits_k w_{k,j,i,s,t}^{\psi_k} \tag{16}$$

Taking logs, we obtain the following transport cost specification:[10]

$$tc_{j,i,s,t} = \Lambda H_{j,i} + \sum_{K} \psi_k w_{k,j,i,s,t} + \xi_{j,i,s,t} \tag{17}$$

Where $H_{j,i}$ is a vector of country–specific variables that do not change over time. The set of variables specified within $H_{j,i}$ are bilateral distance, common language, common colonizer and common border. Within the set of variables identified by $w_k$ we include all the variables that are product-specific and may change over time, and $\xi_{j,i,s,t}$, accounts for the non-observable component that we will assume orthogonal to both transport costs and the non-observable variables in equation (15).

In particular, the transport cost equation that we want to estimate is given by the following specification:

$$\begin{aligned} t\,c_{j,i,s,t} =& \Lambda_0 + \Lambda_1 \text{ dist}_{j,i} + \Lambda_2 \text{ rule}_{c,t} + \Lambda_3 \text{ cc}_{c,t} + \Lambda_4 \text{ inf } r_{j,c,t} \\ &+ \psi_1 \text{ weight } \tilde{t}_{j,i,s,t} + \prod D_c \; + \Omega \; D_{s,t} + Y D_i + \xi_{j,i,s,t} \end{aligned} \tag{18}$$

Here $\text{dist}_{j,i}$ accounts for the bilateral distance between countries. Rule of law and control of corruption ($\text{rule}_{c,t}$, $cc$) are variables to be used as proxies of the possible country components related to security that could change over time and potentially affect transport costs. The variable inf $r_{i,j}$ controls for the infrastructure level of country $i$, and $weight\ \tilde{t}_{j,i,s,t}$ accounts for the freight component of the transport cost per good imported from the exporter. In addition, we use country-product, sector-year and country fixed effects ($D_{c,i}$, $D_{s,t}$ and $D_{c,t}$). This flexible specification allows us to control for any specific transport cost component directly associated to good $i$; this is, we are controlling for any transport costs component, specific to goods classified within a sector, that might actually change through time, and we are also controlling for any aggregate factor that might affect transport costs between the importer and the exporter countries.

Summing up, our estimation strategy follows a two-stage process. First, we estimate and obtain the predicted value of transport costs as given by equation (18) and we proceed to replace it in equation (15). Then we proceed to estimate the second stage by replacing the transport cost rate with our predicted value.

As mentioned before, we do not have information for either the sectoral price indexes or the sectoral income level per country. There are two ways of dealing with this problem, we could proxy income and price indexes with GDP deflactors or we could proxy the later by sector-year fixed effects.

[10] It is important to notice that our transport cost measure is the transport cost rate. In addition, we proxy the logarithm of transport cost using a first-order Taylor expansion, therefore we have that: $\tilde{\tau}c_{j,i,s,t} = \ln(1 + tc_{j,i,s,t})\,\tilde{}\,tc_{j,i,s,t}$ where: $tc_{j,i,s,t} =$ transport cost $\text{value}_{j,i,s,t}$/value of the mechandise sold by $\text{exporter}_{j,i,s,t}$

Since the GDP deflator is constructed using information of both tradable and non-tradable goods, we prefer to follow the second approach in order to avoid any compositional problems that would bias the estimates. Therefore, our second stage specification is given by the following equation:[11]

$$\begin{aligned}\tilde{x}_{j,i,s,t} =& \beta_1 + \beta_2\ G\ D\ P_{i,t} + \beta_3\ t\,a\,r_{j,i,s,t} + \beta_4\ t\ \hat{c}_{j,i,s,t} + \Pi\ D_c \\ &+ \Omega\ D_{s,t} + Y\ D_i + \xi_{j,i,s,t} + \varepsilon_{j,i,s,t}\end{aligned} \quad (19)$$

## 3. Data

In order to be able to estimate equations (18) and (19), we have used several sources of data. Import data was obtained from the U.S. Census Bureau. In particular, we used the import data (at six digit level of disaggregation) of the harmonized system for years 1990 up to 2003. This information was only compiled for the products classified in the industrial sectors (Industrial Sector Classification ISIC rev 2) 11 through 39. For all these products we were able to obtain their information related to import value and transport costs and the duties paid by the importers at product level. Following Romalis (2005), we used a second measure of tariffs data at the product level, obtained form the US Census Bureau.

We must clarify two important points. The U.S. import data originally reported at a ten digit level. To be able to aggregate the tariff rate at a six digit level, one have to take into account the relative importance of the good at this level. Second, we used a second measure of tariff data, which comes originally at a level of disaggregation of eight digits (HS). Therefore, accordingly, one has to apply the same relative importance criteria to be able to calculate the tariff data at the six digit level.

Our infrastructure index was constructed following Limao and Venables (2001) but expanded to the sample period 1990 - 2003. The distance variable was obtained using the great distance equation. Country coordinates were obtained from CIA (2007). GDP has been taken from World Bank Development Indicators, and rule of law and control of corruption indexes come from Kaufmann et al. (2007).

## 4. Results

As mentioned before, we proceeded to estimate equations (18) and (19). We focus our attention on the estimates obtained for parameters $\beta_3$ and $\beta_4$ which correspond to the $1 - \sigma$ parameter in equation (15). Furthermore, we estimate the elasticities of substitution under the assumptions of either exogenous or endogenous trade costs. Tables 1, 2 and 3 report the results obtained through the different specifications.

[11] As we did before, we approximate the tariff ad-valorem rate by a first order Taylor expansion. Therefore: $\tau\tilde{a}r_{j,i,s,t} = \ln(1 + \tau_{j,i,s,t})\tilde{\ } tar_{j,i,s,t}$ where: $tar_{j,i,s,t} =$ value of duty$_{j,i,s,t}$/value of the merchandise sold by exporter$_{j,i,s,t}$

### 4.1. First Stage: Endogenous Transport Costs

Table 1 reports the results obtained with endogenous transport costs structure, as following equation (18). For all the specifications we find that transport costs are positively related to bilateral distance and to tariff trade barriers, and negatively related to the weight of the cargo and to the GDP level of the exporter country. Therefore, the higher the exporters' GDP is, the lower transport costs are. All the results are statistically different from zero at 1%.

Following Micco (op. cit), columns two through six show the controls for the foreign country infrastructure index. As shown for all our specifications, an increase in the infrastructure level of a country decreases transport costs, and its effect on transport costs is more important than the effect of bilateral distance. Furthermore, when we control for the level of corruption and the enforcement of law as proxies for criminal activity which could potentially increase transport costs, we gladly find that countries with higher control of corruption and higher law enforcement actually happen to have lower transport costs.

### 4.2. Second Stage: Elasticity of Substitution

Table 2 summarizes the results obtained when we assume that all the goods have the same elasticity of substitution. The first column estimates the average elasticity of substitution under the assumption of exogenous transport costs. The second column shows results of endogenous transport costs estimated by using the results obtained in column 6, Table 1. As expected, all the variables in both specifications show the right sign, and they are significantly different from zero. Bilateral trade agreements increase trade and trade among countries with higher level of GDP is higher as well. Reinforcing rationale, increasing tariff and transport costs reduce trade. However, two results called for our attention. First, the estimates of $(1-\sigma)$ in the second column (endogenous trade costs) are higher than the values obtained under the assumption of exogenous transport costs. Second, after we tested whether the coefficients of transport costs and tariffs are equal in magnitude, the results, as observed in Table 2, are different. In the first model the results are different at a 10% confidence level, but in the second specification we found that both of them are statistically equal at a 1% confidence level. This happens to be the theoretical implication contained in equation (15). Furthermore, in non reported statistics we also tested for the similarity of coefficients between columns, and as expected, they are not equal.

Following our theoretical model, we levied the assumption that all the goods have the same elasticity of substitution, and we proceeded to estimate the elasticity of substitution per sector. Results, reported in Table 3, columns 1 and 2 follow the same specification as before. Again, some results are interesting. First, as shown in column 1, all the sectoral elasticities have the right sign (exemption made of sector 2). Second, the results obtained in column 2 are completely different. In four sectors we find elasticity estimates that actually have opposite signs to the expected ones: they happen to result positive. We argue that this problem may arise from the fact that in the first stage (Table 1), our instruments show low explanatory power, as we could only capture 3% of the variance of transport costs, and thereby in further exercises we should address this problem by incorporating variables more capable of taking advantage of the data that we have compiled. A second reason might be a specification bias generated by the strong assumption that we made regarding the transport costs specification (equation 16). In the future this problem should be addressed by testing the effects of assuming more flexible functional forms, and perhaps a new approach could be given by implementing semi parametric estimations, and assuming linear forms on the fixed bilateral parameters and non parametric functions for the remaining variables. Third, when we tested for the equality between the transport cost and the tariff data coefficients per economic sector, we found that they were not equal in either of the two specifications.

As a whole, our results show the aggregate importance of endogenous transport costs and the different results that they have for each economic sector.

## 5. Concluding Remarks

Following Anderson and Wincoop (op. cit) we have estimated the elasticity of substitution of the goods imported to the U.S. market for the period comprising 1990 - 2003. Our estimates take advantage of the data on transport costs, available at the commodity level of the U.S. import data of the U.S. Census Bureau. We obtain two different estimates of the elasticity of substitution; one at the average aggregated level and a second one at the sectoral level. Additionally, we estimate both elasticities using estimates of transport costs.

As expected, the estimates that take into account the endogeneity of transport costs are different from the results obtained under the exogeneity assumption. Under the assumption that all goods have the same elasticity of substitution, exogenous transport costs' results actually underestimate the elasticity of substitution in 1 elasticity unit. This implies a big difference on the effects to be obtained when using these elasticities to measure the change in imported goods from certain countries due to changes on import tariffs, or on any other variable that could potentially change the prices of these goods. On general basis this can be approached by aggregating the effect of the change in prices in the demand equation obtained in equation (14).

We consider that further work should be aimed to improve the estimates of transport costs, and that it should also address the estimation of transport costs functions different from the ad-hoc structure we assume on this paper. Another future exercise can be developed in order to estimate the elasticities of substitution at a higher level of product disaggregation (10 HS digits; as following Broda and Weinstein, 2006) and at a higher level of sector classification; three or four digits of disaggregation of the ISIC rev 2 industrial code.

Finally, to take advantage of the estimates, future research should make use of the elasticities in order to measure different policy scenarios; i.e. to analyze, within a general equilibrium simulation approach, the crossed effects that imports may have in different free trade agreement areas.

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## Appendix 1

Following equation (13), we can solve for $\left[\phi_{i,s} p_{i,s,t}^{sup}\right]^{1-\sigma_s}$

$$\left[\phi_{i,s}\, p_{i,s,t}^{sup}\right]^{1-\sigma_s} = Y_{i,s,t}\left[\sum_j Y_{j,s,t}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}\right]^{-1} \tag{20}$$

By equation (9), we know that the level of expenditure of any product is given by:

$$x_{j,i,s,t} = \theta_{j,s}\; Y_{j,t}\left[\frac{\phi_{i,s}\; p_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s} \tag{21}$$

Through some algebra and by substituting equation (20) in equation (21), we obtain the following result:

$$x_{j,i,s,t} = \theta_{j,s}\ Y_{j,t}\left[\phi_{i,s}\ p_{i,s,t}^{sup}\right]^{1-\sigma_s}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}$$

$$x_{j,i,s,t} = \left[\phi_{i,s}\ p_{i,s,t}^{sup}\right]^{1-\sigma_s}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s} Y_{j,s,t}$$

$$x_{j,i,s,t} = Y_{i,s,t}\left[\sum_j Y_{j,s,t}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}\right]^{-1}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s} Y_{j,s,t}$$

$$x_{j,i,s,t} = Y_{i,s,t}Y_{j,s,t}\frac{\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}}{\sum_j Y_{j,s,t}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}} \tag{22}$$

$$x_{j,i,s,t} = \frac{Y_{i,s,t}Y_{j,s,t}}{Y_{s,t}^{w}}\frac{\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}}{\sum_j \frac{Y_{j,s,t}}{Y_{s,t}^{w}}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}}$$

$$x_{j,i,s,t} = \frac{Y_{i,s,t}Y_{j,s,t}}{Y_{s,t}^{w}}\frac{\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}}{\sum_j \alpha_{j,s,t}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right]^{1-\sigma_s}}$$

$$x_{j,i,s,t} = \frac{Y_{i,s,t}Y_{j,s,t}}{Y_{s,t}^{w}}\left[\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}\ \Pi_{i,s,t}}\right]^{1-\sigma_s}$$

Where:

$$\alpha_{j,s,t} = \frac{Y_{j,s,t}}{Y_{s,t}^{w}}$$

$$Y_{s,t}^{w} = \sum_j Y_{j,s,t} \tag{23}$$

$$\Pi_{i,s,t} = \left[\sum_j\left(\frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}}\right)^{1-\sigma_s}\alpha_{j,s,t}\right]^{\frac{1}{1-\sigma_s}} \tag{24}$$

$$P_{j,s,t} = \left[\sum_i\left(\phi_{i,s}\ P_{j,i,s,t}\right)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}}$$

$$P_{j,s,t} = \left[\sum_i\left(\phi_{i,s}\ P_{i,s,t}^{sup}\ t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}\right)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}}$$

$$P_{j,s,t} = \left[ \sum_i \left( \phi_{i,s}\ P_{i,s,t}^{sup} \right)^{1-\sigma_s} (t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t})^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}$$

$$P_{j,s,t} = \left[ \sum_i Y_{i,s,t} \,(t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t})^{1-\sigma_s} \left[ \sum_j Y_{j,s,t} \left[ \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \right]^{-1} \right]^{\frac{1}{1-\sigma_s}} \tag{25}$$

$$P_{j,s,t} = \left[ \sum_i \left[ \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{\left[ \sum_j Y_{j,s,t} \left[ \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}} \right]^{1-\sigma_s} Y_{i,s,t} \right]^{\frac{1}{1-\sigma_s}}$$

$$P_{j,s,t} = \left[ \sum_i \left[ \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{\left[ \sum_j \left[ \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}} \right]^{1-\sigma_s} \frac{Y_{j,s,t}}{Y_{s,t}^{w}} \right]^{\frac{1}{1-\sigma_s}}} \right]^{1-\sigma_s} \frac{Y_{i,s,t}}{Y_{s,t}^{w}} \right]^{\frac{1}{1-\sigma_s}}$$

$$P_{j,s,t} = \left[ \sum_i \left( \frac{t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t}}{P_{j,s,t}} \right)^{1-\sigma_s} \alpha_{j,s,t} \right]^{\frac{1}{1-\sigma_s}}$$

Imposing symmetry on tariffs and transport costs, we obtain the following equality among price indexes:

$$\Pi_{i,s,t} = P_{i,s,t} \tag{26}$$

Therefore we obtain that is equal to the following expression:

$$P_{j,s,t}^{1-\sigma_s} = \sum_i P_{i,s,t}^{\sigma_s - 1} \alpha_{s,t}^{1-\sigma_s} t\,a\,r_{j,i,s,t}\,t\,c_{j,i,s,t} \tag{27}$$

## Appendix 2

**Table 1.** Estimates of Transport Costs Structure. First Stage
Dependent Variable: Transport Cost

| Variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Distance (ln) | 0.026 | 0.031 | 0.010 | 0.012 | 0.009 |
| | (0.008) * ** | (0.008) * ** | (0.009) | (0.009) | (0.009) |
| Weight,(ln) | −0.006 | −0.006 | −0.006 | −0.006 | −0.006 |
| | (0.000) * ** | (0.000) * ** | (0.000) * ** | (0.000) * ** | (0.000) * ** |
| GDP Foreign Cty. (ln) | −0.013 | −0.014 | −0.013 | −0.012 | −0.013 |
| | (0.002) * ** | (0.002) * ** | (0.003) * ** | (0.003) * ** | (0.003) * ** |
| Tariff IV (ln) | 0.048 | 0.049 | 0.047 | 0.047 | 0.047 |
| | (0.018) * ** | (0.018) * ** | (0.018) * ** | (0.018) * ** | (0.018) * ** |
| Infra. Index Limao and (ln) | | −0.014 | −0.015 | −0.015 | −0.015 |
| Venables, Foreign Cty. | | (0.005) * ** | (0.005) * ** | (0.005) * ** | (0.005) * ** |
| Control of Corruption, | | | −0.006 | | −0.004 |
| Foreing Cty. | | | (0.002) * ** | | (0.002) * * |
| Rule of Law, Foreing Cty. | | | | −0.007 | −0.006 |
| | | | | (0.003) * ** | (0.003) * * |
| Product Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Sector Year Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Country Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Observations | 1103316 | 1103251 | 1103117 | 1103251 | 1103117 |
| R-squared | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1% Source: Own authors estimations.

**Table 2.** Estimates Average Elasticity of Substitution.
Endogenous Variable: Import Value

| Variable | (1) | (2) |
|---|---|---|
| Bilateral Trade Agreement, Dummy | 0.070 | 0.069 |
| | (0.010) * ** | (0.010) * ** |
| GDP, Foreign Cty. (ln) | 0.109 | 0.097 |
| | (0.015) * ** | (0.015) * ** |
| Transport Costs (ln) | −0.338 | −1.308 |
| | (0.205)* | (0.296) * ** |
| Tariff (ln) | −0.977 | −0.997 |
| | (0.319) * ** | (0.325) * ** |
| IV Transport Costs | *No* | *Yes* |
| IV Tariffs | *No Yes* | *No Yes* |
| Product Fixed Effect Sector Year | *Yes Yes* | *Yes Yes* |
| Fixed Effect Country Fixed Effect | | |
| Observations | 1103316 | 1103251 |
| R-squared | 0.329 | 0.327 |
| F test: Tr.Costs = Tariff (a) | 2.74 | 0.50 |
| $Prob > F$ | 0.098 | 0.480 |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

(a)We test if coefficient of Transport Costs is equal to the coefficient associated to tariffs. Source: Own author's results.

**Table 3.** Import Price Elasticity per Economic Sector
Endogenous Variable: Import Value

| Variable | (1) | (2) |
|---|---|---|
| Bilateral Trade Agreement, Dummy | 0.069<br>(0.009) * ** | 0.043<br>(0.009) * ** |
| GDP Foreign Cty. (ln) | 0.094<br>(0.014) * ** | 0.222<br>(0.015) * ** |
| Transport Cost, Sector 1 | −0.071<br>(0.022) * ** | 10.135<br>(0.861) * ** |
| Transport Cost, Sector 2 | 0.469<br>(0.057) * ** | −9.609<br>(5.473)* |
| Transport Cost, Sector 3 | −1.488<br>(0.059) * ** | 6.745<br>(0.470) * ** |
| Transport Cost, Sector 4 | −2.567<br>(0.023) * ** | 11.859<br>(0.300) * ** |
| Transport Cost, Sector 5 | −2.333<br>(0.064) * ** | −9.435<br>(1.071) * ** |
| Transport Cost, Sector 6 | −0.084<br>(0.006) * ** | −5.885<br>(0.542) * ** |
| Transport Cost, Sector 7 | −2.379<br>(0.028) * ** | −1.220<br>(0.301) * ** |
| Transport Cost, Sector 8 | −3.447<br>(0.114) * ** | 9.174<br>(0.933) * ** |
| Tariff, Sector 1 | −3.193<br>(0.286) * ** | −4.468<br>(0.288) * ** |
| Tariff, Sector 2 | −7.733<br>(2.004) * ** | −9.671<br>(2.017) * ** |
| Tariff, Sector 3 | −1.245<br>(0.122) * ** | −1.985<br>(0.124) * ** |
| Tariff, Sector 4 | −0.943<br>(0.042) * ** | −2.356<br>(0.046) * ** |

Continúa.

| | | |
|---|---|---|
| Tariff, Sector 5 | −3.829<br>(0.376) ∗ ∗∗ | −3.073<br>(0.380) ∗ ∗∗ |
| Tariff, Sector 6 | −3.185<br>(0.173) ∗ ∗∗ | −2.559<br>(0.176) ∗ ∗∗ |
| Tariff, Sector 7 | −0.230<br>(0.060) ∗ ∗∗ | −0.094<br>(0.062) |
| Tariff, Sector 8 | −0.170<br>(0.311) | −1.238<br>(0.315) ∗ ∗∗ |
| IV Transport Costs | *No* | *Yes* |
| IV Tariffs | *No* | *No* |
| Product Fixed Effect | *Yes* | *Yes* |
| Sector Year Fixed Effect | *Yes* | *Yes* |
| Country Fixed Effect | *Yes* | *Yes* |
| Observations | 1103316 | 1103251 |
| R-squared | 0.341 | 0.334 |
| F test: Tr.Costs = Tariff (a) | 344.67 | 776.41 |
| Prob > F | 0.000 | 0.000 |

Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

(a) We Test for each sectoral coefficient to be equal, i.e. tariff sector 1 = Tr. Costs sector 1, etc. Source: Own authors estimations