Aggregation Problems in Estimates of Armington Elasticities and Pass-Through Effects

Jorge Chami Batista[a], Nelson Isaac Abrahão Junior[b]

[a] *Instituto de Economia, Universidade Federal do Rio de Janeiro (IE-UFRJ), Brasil*
[b] *Escola de Pós-Graduação em Economia, Fundação Getulio Vargas (EPGE/FGV), Rio de Janeiro, Brasil*

Abstract

This article examines the level of aggregation problem for which Armington price elasticity of substitution and pass-through effects are usually estimated. On the basis of U.S. import data from 1995 to 2004 of wood products from Brazil and Mexico, it is argued that the usual levels of aggregation used in the estimates for the elasticity of substitution are too high, since they tend to aggregate perfectly elastic products together with products whose elasticities vary from zero to any negative number. Analogously, the elasticity of relative prices with respect to the exchange rate, a measure of the pass-through effect, tends to be underestimated in the U.S. by the presence of homogeneous products whose prices are set in dollars and tend to equalize through arbitrage. Therefore, pricing-to-market estimates may be grossly overestimated for some industries in the U.S.

Keywords: Homogeneous Products, Differentiated Product, Pass-Through, Pricing-to-Market, Law of One Price

Revista EconomiA *July 2005*

JEL Classification: F10, F14, F31, F32, F41

Resumo

Este artigo examina o problema do nível de agregação para o qual a elasticidade preço de substituição de Armington e o efeito repasse cambial são usualmente estimados. Com base nos dados de importação dos EUA de 1995 até 2004 de produtos de madeira com origem no Brasil e México, argumenta-se que os níveis usuais de agregação usados nas estimativas de elasticidade de substituição são muito elevados, já que eles tendem a agregar produtos que são substitutos perfeitos juntos com produtos cujas elasticidades variam de zero a qualquer número negativo. Analogamente, a elasticidade dos preços relativos com respeito à taxa de câmbio, uma medida do efeito de repasse cambial, tende a ser subestimada nos EUA pela presença de produtos homogêneos cujos preços estabelecidos em dólares tendem a se equalizar por arbitragem. Portanto, a insensibilidade da inflação ao câmbio pode estar bastante superestimada para algumas indústrias nos EUA.

⋆ This paper has been materially improved by commentary of Hugo Boff, Getulio da Silveira and two anonymous referees, though it may still not satisfy their high standards. It also benefited from the reactions of the participants of a seminar at the Research Institute for Economics and Business Administration of Kobe University.
Email address: jchami@uol.com.br (Jorge Chami Batista)

1 Introduction

Assuming that goods are generally traded under imperfect competition, many studies have adopted this hypothesis to estimate substitution elasticities between products from different countries (known as the Armington[1] elasticity) and price elasticities with respect to the exchange rate (known as the degree of pass-through effect) across industries. Estimates of Armington price elasticity of substitution by sector have been a major parameter for trade policy analysis. In particular, simulation models of trade agreements, be them partial equilibrium or general equilibrium models, almost inevitably apply estimates of Armington elasticities for calculating trade creation and trade diversion effects.

Some attempts to estimate Armington elasticity of substitution covering several industries have appeared in the literature in the last three decades. For U.S. imports, Stern et al. (1976) made estimates for 28 industries at the 3-digit ISIC level, Shiells et al. (1986) estimated the elasticities for 163 industries and Reinert and Roland-Host (1992) covered 163 U.S. mining and manufacturing industries. Shiells and Reinert (1993) broke U.S. imports down into those from Nafta countries and those from other countries, finding estimates for 128 mining and manufacturing industries. The most recent, disaggregated and comprehensive estimates were made by Gallaway et al. (2000), covering 311 industries at the 4-digit SIC level.

In the developing world, but along the same lines as in the U.S., Kapuscinski and Waar (1999) estimated substitution elasticities for the Philippines considering 33 industries, while Touri-

[1] Armington (1969) is a reference for most studies of trade agreements.

nho et al. (2002) estimated Armington elasticities for Brazil's imports, covering 28 industries.

In most cases, especially in the most recent ones, substitution elasticities were calculated on the basis of a one level utility that is a function of domestic output and quantities imported by all countries taken together. Therefore, changes in relative prices among different exporters are assumed away. The paper by Shiells and Reinert (1993) is an exception with this regard, as they consider quantities of imported goods from each separate source. They used two-tier utility functions or merger them into a one level utility function, but maintaining imports from different sources. They refer to two other studies which also apply the two-tier utility function: Hamilton and Whalley (1985) and Brown and Stern (1987).

The most recent studies apply cointegration methods to avoid spurious correlations and obtain long-term relationships. They find that statistically significant estimates for the long-term elasticity of substitution vary from almost zero to less than five in the U.S., as well as in Brazil and in the Philippines.

All the above-mentioned studies apply time series econometric analyses to estimate the substitution elasticities. Hummels (2001), on the other hand, applies a different methodology, using information on freight rates for a number of importers by different exporters. His cross-sectional estimates for substitution elasticities are much higher, averaging 6.9 at the 3-digit level. Therefore, substitution elasticities tend to be sensitive to the chosen estimation technique.

Typically, however, all these estimates have very high standard deviations, which implies that point estimates should be used with caution and sensitivity analysis is highly recommended.

Nevertheless, McDaniel and Balistrery (2002), p.6 point out that there are a few robust findings: "first, long-run estimates are much higher than short-run. Second, the level of aggregation is important; the more disaggregate the sample the higher the estimated substitution elasticity. Finally, single equation time-series approaches identify smaller responses relative to cross-sectional estimation that includes a consideration of supply conditions". They also correctly point out that econometric specifications used in most estimation "suffer from the general critique that they are structurally inconsistent with general equilibrium because they do not consider the supply side of the market".

Among the studies that estimate the degree of pass-through effects in different industries, we can mention Knetter (1993), Yang (1998), Goldberg and Knetter (1997) and Olivei (2002). Industries in these studies are generally defined from the 4-digit level to the 7-digit level. Some of these studies focus on the export prices of individual products or groups of products from a single country to a number of destinations, while in others the pass-through effect is taken as the effect of changes in the nominal exchange rate on the changes in the import price, controlling for changes in domestic price and in prices in other countries. Generally, estimates of pass-through effects are relatively low [2]. The paper by Campa and Goldberg (2002) is an exception as it examines import unit value indices (aggregated across all imports and disaggregated into major industry groups) for 25 OECD countries and finds that pass-through effects go from 60% in the short-run to 80% in the long run. But this does not include the U.S. where the pass-through effect is only 25% in the short run and 40% in the long run.

We argue here that the fact that within a particular industry

[2] See Obstfeld (2002) for an excellent discussion on the implications of low pass-through effects on expenditure-switching policies.

there may be products that are traded under different competitive regimes tends to produce an aggregation bias. More specifically, if within a particular industry there are homogeneous products whose prices from different exporters tend to equalize through arbitrage, so that suppliers are price-takers under perfectly competitive markets, applying a specification that assumes imperfect competition will tend to overestimate the substitution elasticities, since individual suppliers of these products are confronted with perfectly elastic demand curves. Analogously, assuming products are priced in U.S. dollars, the pass-through effect in the U.S. will tend to be underestimated, as suppliers of these products are price-takers, therefore, their relative prices are insensitive to changes in exchange rates.

Modelers may not have been too concerned with that, since most of the literature show that price arbitrage, or the law of one price (LOP), tends to be violated for manufacturing products and even for primary commodities defined at very high levels of disaggregation [3]. This law states that homogeneous products must be traded at the same price, regardless of where they are sold, as long as prices are expressed in the same currency and taking due account of transfer costs. These include transportation costs, tariff and non-tariff barriers. Any price difference should be rapidly eliminated by commodity arbitrage.

However, new evidence has appeared in the literature in support of the law of one price and the purchasing power parity [4]. Other

[3] Classical articles on the subject are Isard (1977), Kravis and Lipsey (1978) and Richardson (1978). Thursby et al. (1986) take the case of a primary commodity defined at a very high level of disaggregation, while Giovanini (1988) finds evidence against the LOP for very narrowly defined commodity manufactures. See also Rogoff (1996) for a recent review of the literature on the LOP.

[4] See, for instance, Parsley and Wei (1996), Cecchetti et al. (2000),

recent studies[5] have shown that the law of one price cannot be rejected for a number of very narrowly defined commodities. Furthermore, there are indications that homogeneous goods following the law of one price are more easily found amongst manufactured commodities that go through some basic industrial processing than within the group of primary goods.

The remainder of this paper is organized as follows. Section 2 presents the Armington differentiated goods model and contrasts it with the law of one price model. Section 3 describes the methodology applied to classify products as differentiated or homogeneous and applies it to Brazil's and Mexico's exports of wood to the U.S. Section 4 concludes.

2 Armington Differentiated Goods *Versus* Homogeneous Goods

Armington differentiated good (DG) model[6] assumes that a commodity produced by one country is an imperfect substitute in demand for the "same" commodity produced by another country. He refers to these commodities as goods and to the good produced by a particular country as a product. However, in order to derive his elasticity of substitution he has to make the assumption of independence; i.e., marginal rates of substitution between any two products of the same kind must be independent of the quantities of the products of all other kinds; and quantity index functions, relating the quantity of a good to the quantities of its products, must be linear and homogeneous.

and Goldberg and Verboven (2001).

[5] See Chami Batista and Silveira (2003) and Chami Batista (2004).

[6] See Armington (1969).

He can then relate the relative quantities of two countries or products, according to his convention, to their relative prices. Thus, further assuming that the long-run price elasticity of substitution is constant, it follows that:

$$d\left(Q_i^*/Q_j^*\right)/\left(Q_i^*/Q_j^*\right) = \sigma d\left(P_i^*/P_j^*\right)/\left(P_i^*/P_j^*\right), \qquad (1)$$

where σ is Armington's long-run elasticity of substitution between two products.

In point of fact, the hypothesis of independence assumed by DG models depends crucially on the level of aggregation. As Armington (1969), pp. 164–165 points out: "in theory, the assumption of independence might be viewed as tautological; for independence could well be taken as a *defining* characteristic of products distinguished by their kind... In practice, however, goods must be identified within the framework of some available classification scheme... Given this constraint, independence is not necessarily tautological... Within the limitation imposed by the available classification scheme, the analyst may attempt to select a vector of goods that renders the independence assumption as realistic as possible".

Note that in contrast with Armington's assumption that products are imperfect substitutes in demand, they may well turn out to be perfect substitutes. In other words, they can be homogeneous products, following the law of one price (LOP).

The LOP can be tested internationally (across countries) or intranationally (within countries). Here, we are interested in testing whether prices from different exporters tend to equalize in a specific destination market. Formally, a strict version of the LOP among exporters to a particular destination market may be expressed as:

$$P_i^*/P_j^* = 1, \qquad (2)$$

where P_i^* and P_j^* are the domestic prices paid in a given market for the same good (or perfect substitute goods) imported from countries i and j [7], respectively. These are cif (cost, insurance and freight) prices plus import duties, so they may be written as:

$$P_i^* = (P_i/E_i)\,(1+t_i)\,, \tag{3}$$

where P_i is the cif export price expressed in country i's currency, E_i is the exchange rate relating the value of country i's currency to one unit of the market currency and t_i is the *ad valorem* import tariff (plus any non-tariff *ad valorem* equivalent) for country i.

A weaker version of LOP would allow a price difference (premium), but no variations in relative prices:

$$d\left(P_i^*/P_j^*\right)/dt = 0 \tag{4}$$

The presumption behind the law of one price is that suppliers are price takers in perfect competitive markets. It should be noted that in both versions of the LOP, the demand side of the importing market plays no part in determining changes in exporting countries' market shares [8]. These changes depend entirely on suppliers' conditions, since the demand price elasticity of substitution is infinite by definition. Therefore, although changes in the exchange rate or in cost conditions have no effect on relative prices from different exporting countries, they may well affect the export performance or the relative quantities supplied to the market by these countries [9].

If the chosen definition of an industry is such that it contains

[7] Country j may also be the domestic producer in the market.
[8] It is assumed that there exists more than one exporting country.
[9] There may be some delay between changes in costs and changes in supply, though this is not the usual rationale for the J Curve.

some products that are perfect substitutes to each other, then DG models are a misspecification that will lead to bias estimates for the substitution elasticities.

2.1 Pass-through effects and pricing-to-market strategies

Under imperfect competition, suppliers may decide to maintain their final prices and market shares relatively stable, despite fluctuations in their costs and, as a result, allow variations in their mark-ups. This pricing-to-market strategy makes particular sense when fluctuations in costs are thought to be temporary rather than permanent. The extent to which changes in cost are actually transmitted into changes in final prices is known in the literature as the pass-through effect. This effect is expected to be greater if products are highly differentiated, marginal production costs is rather stable and import penetration is high [10].

Assuming a mark-up pricing, we can re-write equation (3) as:

$$P_i^* = \{[c_i (1 + m_i)] / E_i\} (1 + t_i) , \tag{5}$$

where c_i is the marginal cost of the product from country i and m_i is the mark-up for the same country. If in view of an appreciation of the exchange rate, an exporter maintains its domestic price (P_i) constant, allowing its destination price (P_i^*) to rise in line with the exchange rate appreciation (or any other increase in costs), we have a complete pass-through effect. However, if the exporter decides to reduce its domestic price in the same proportion of the exchange rate appreciation, we have a complete pricing-to-market strategy.

[10] See Yang (1998).

3 Testing Product Homogeneity, Differentiation and Pricing-to-Market

In order to decide if a product is either homogeneous and follows the law of one price in a particular market or is a differentiated product, we apply a quite simple test. First, we apply the Augmented Dickey-Fuller (ADF) test to individual price time series [11] . As commodity prices we expect them to be non-stationary. Second, as long as they are non-stationary, we apply the ADF test to relative prices dividing the prices of pairs of countries. If the time series of relative prices are non-stationary, we reject the hypothesis of homogeneous products following the law of one price and conclude that they are differentiated products.

In order to estimate the substitution elasticity between differentiated products, we once again apply the ADF test now to relative quantities of the same pairs of countries. Assuming they are non-stationary, we can apply the Johansen cointegration test [12] to find out if relative quantities and prices are cointegrated. If they are, the coefficient of relative prices is the long-run Armington elasticity of substitution.

If relative prices between different exporters are found to be stationary, we cannot reject the hypothesis of the law of one price or the hypothesis of complete pricing-to-market. However, if the series of relative quantities is non-stationary, we can reject the hypothesis of complete pricing-to-market and conclude that products are homogeneous and prices are equalized through arbitrage.

[11] See Enders (1995).
[12] Ibid.

Examining Brazil's and Mexico's exports of wood products to the U.S., it can be observed that few products, defined by the Harmonised System (HS) at the 10-digit level, account for a large share of total exports of each country [13]. In the case of Brazil, the top eight products responded for 43% of export earnings in the industry in the period from 1996 to 2004. In the case of Mexico, concentration was even higher, since only three products accounted for 52% of the industry export earnings to the U.S. in the same period.

On the basis of these products, we have constructed a monthly price index for Brazilian and Mexican wood exports to the U.S. from January 1995 to December 2004 [14]. Given that some of these products were not exported in some months, we have used a chained moving base index [15]. As expected, Laspeyres index

[13] Data are from U.S. International Trade Commission (USITC) and are based on land duty-paid value (which includes import tariffs) and first unit quantity imports. Import unit values were calculated dividing land duty-paid values by first unit quantities.

[14] We are thankful to one of the referees for suggesting that we worked with longer series. Originally, we had worked with the period between 1996 and 2002. Our series now have ten years, as we added 1995, 2003 and 2004 to our original series. We would have liked to have worked with an even longer period of time, but the quality of the data for earlier periods appears to be significantly lower than for this most recent period, due to the increased use of data received through automated collection programs. During the early 1990s, the U.S. Census introduced various programs to reduce reporting errors. In 2001, U.S. Census collected trade statistics on more than 33 million import transactions and approximately 99% of them were received electronically by Customs. See Bureau of the Census (2002). Furthermore, the Harmonised Classification System suffered major changes between 1995 and 1996.

[15] Changes in the price indices were calculated for each pair of consecutive months, considering the products that were exported by each

tended to overestimate the price changes, whereas Paache index did the opposite. Thus, we have constructed a Fisher price index, calculating the geometric mean of the two other indices.

The quantity index was indirectly constructed, dividing the export value index of each country by their correspondent price index. Relative price and quantity indices were calculated dividing Brazil's indices by Mexico's. All series of price and quantity indices were transformed into their logarithmic forms and are shown in Graph (1). It can be seen that Brazil's price falls relatively to Mexico's, while export volume from Brazil rises relatively to Mexico's.

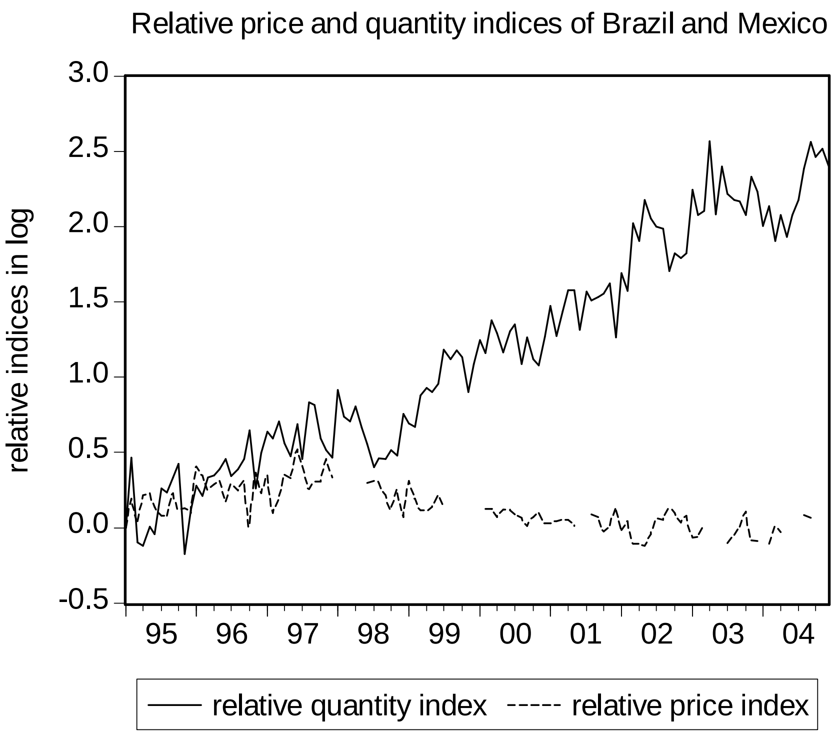
Before relating relative quantities to relative prices, we have applied the Augmented Dickey-Fuller (ADF) test [16] to Brazil's and Mexico's series of Fisher price indices. They were both non-stationary, as one would expect [17]. The ADF test was then applied to the relative price between Brazil and Mexico and, again, the series turned out to be non-stationary. Therefore, price behaviour appears to reveal that exports of wood from Brazil and Mexico to the U.S. should be regarded as differentiated products.

As it happened, the series of quantity indices were also found to be non-stationary, both individually as well as in relative terms. Therefore, complete pricing-to-market could be ruled out. Thus, we were ready to test if the series of relative prices cointegrates with the series of relative quantities. We have applied Johansen

country. The series were then constructed taking the first month as the base month. The list of the products considered to construct the series is presented in Appendix 1.

[16] The ADF tests were run using Eviews 4.0 package. The results are shown in Appendix 2. The data and all econometric results are available and may be requested by readers.

[17] Some outliers were removed from Mexico's price indices.



Graph 1.

cointegration test and found that cointegration between the two series could not be rejected at both the 5% and 1% levels of significance[18]. The long-term elasticity of substitution was estimated at -6.98; i.e, a 10% reduction in the price of Brazil's exports of wood relatively to Mexico's export price would increase Brazil's export quantity relatively to Mexico's by 69.8%. This is a relatively high elasticity indeed[19].

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[18] Intercept (no trend) in CE – no intercept in VAR, and no lags in first differences.

[19] In the U.S., the long run Armington elasticity between domestic output and imports of wood products was estimated at 3.195 for softwood veneer and plywood and 1.109 for prefabricated wood buildings; see Gallaway et al. (2000). The substitution elasticity between

Out of the products we considered in constructing the price indices, two of them are exported by both Brazil and Mexico: door and their frames [20] and standard wood moldings [21]. Together these two products account for 40% of the sample of Brazil's exports and 58% of the sample of Mexico's exports. Thus, we have applied the same tests to these products individually. Note that prices and quantities now are not indices, but the logarithm of actual U.S. import unit values and actual U.S. import quantities from each exporting country.

Graph (2) reports the time series of Brazil's and Mexico's unit values of doors and their frames. The ADF test applied to door and their frames revealed that both relative unit values and quantities were non-stationary. Therefore, door and their frames should be regarded as a differentiated product. Graph (3) shows the time series of relative unit values and quantities. Note that again Brazil gains market share in quantities as its relative unit values fall. The Johansen cointegration test indicated that the series cointegrate at both 5% and 1% levels [22]. But the long-term price elasticity of substitution was estimated at only -1.66. Therefore, this estimate for the substitution elasticity is much lower than that estimated for the industry as a whole.

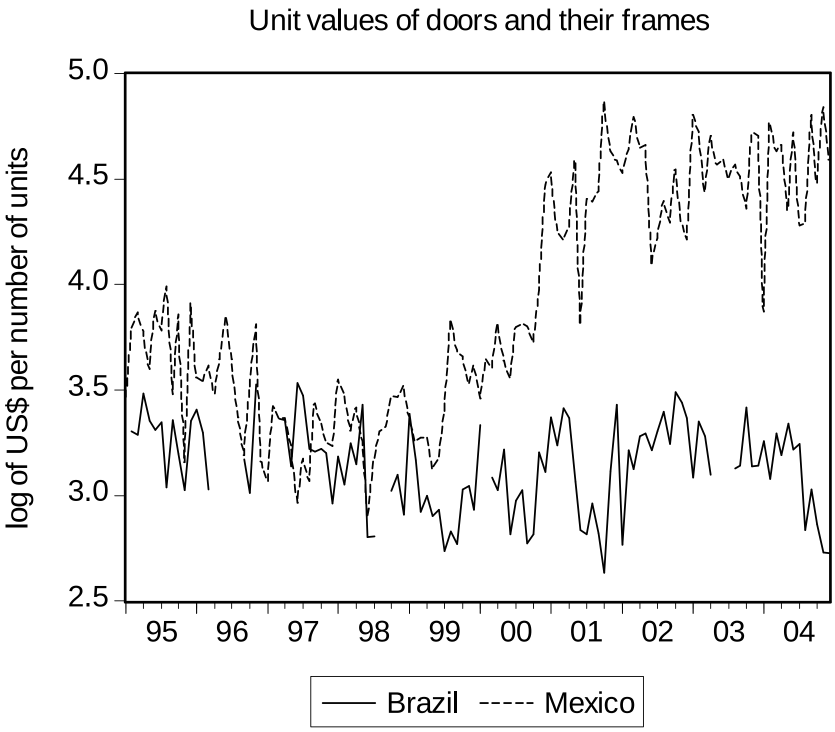
However, when the ADF test is applied to Brazil's and Mexico's unit values of standard wood molding, it is found that both series

domestic production and imports of the wood and furniture industry in Brazil was estimated at 2.73; see Tourinho et al. (2002). Note that we are not comparing exactly the same elasticity since in our case the elasticity is between two different exporters to the U.S.

[20] HS 441820.8060 – doors and their frames and thresholds, of wood, nesoi.

[21] HS 440910.4000 – pine (pinus spp.) standard wood molding.

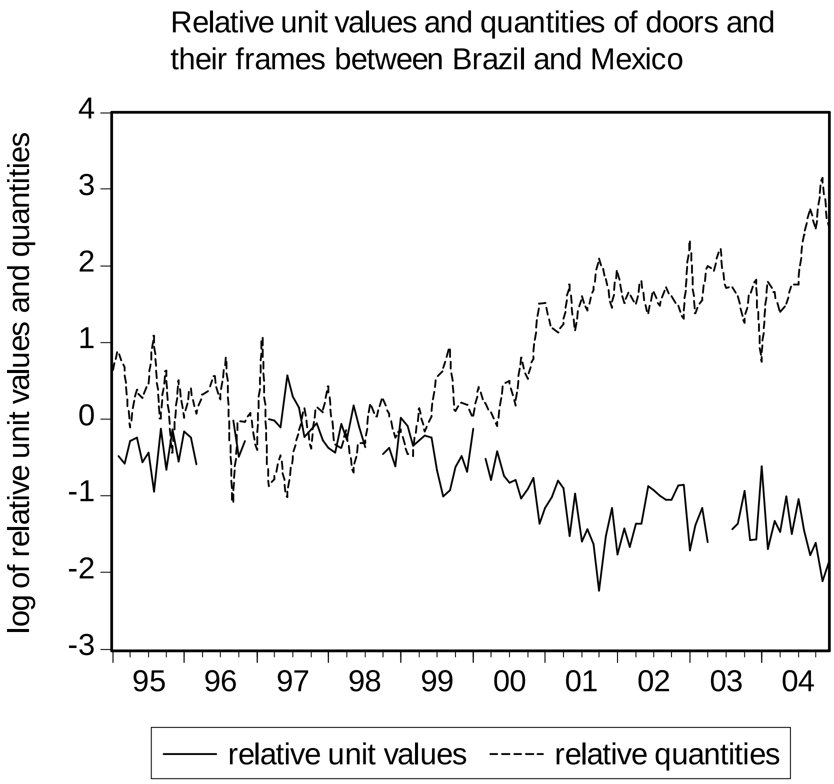
[22] Intercept (no trend) in CE – no intercept in VAR, and no lags in first differences.



Graph 2.

of unit values are non-stationary, but the series of relative unit values is stationary[23]. Graph (4) reveals the co-movements of Brazil's and Mexico's unit values.

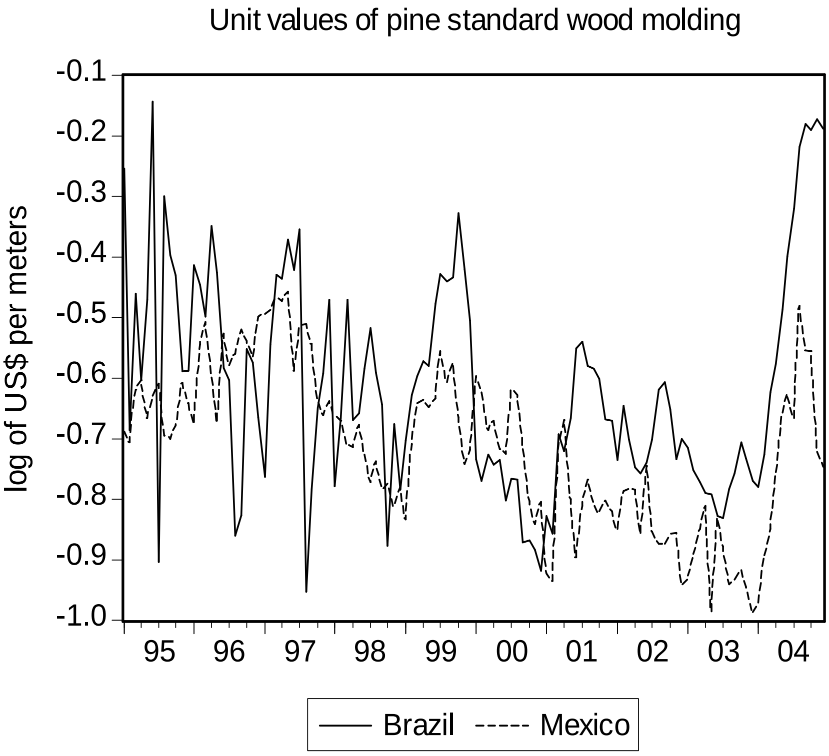
[23] The series of U.S. import unit values of pine standard wood molding from Chile, another major exporter of this product to the U.S., could also be included in the analysis. ADF tests show that relative prices between Chile and Brazil and between Chile and Mexico were also stationary, see Chami Batista and Silveira (2003). The series of unit values of Brazil and Mexico also cointegrate at both 5% and 1% levels with an intercept and no lags in first differences. After imposing the restriction that the coefficients are 1 and -1, we have found a p-value equal to 0,49. Therefore, we cannot reject the hypothesis of the weaker version of the law of one price.



Graph 3.

Note in Graph (5) that relative quantities show an increase in Brazilian exports at the expense of a fall in Mexico's exports[24]. In other words, pricing-to-market does not seem to be a plausible hypothesis here, since such a strategy is implemented to avoid changes in market shares. But in this case, Mexico shows a continuous loss of market share to Brazil. Therefore, this product should be regarded as a homogeneous product that follows the law of one price. U.S. imports of standard wood molding from Brazil and Mexico are perfect substitutes or the price elasticity

[24] The results of ADF tests on the series of quantities of standard wood molding exported by Brazil and Mexico may also be seen in Appendix 2.

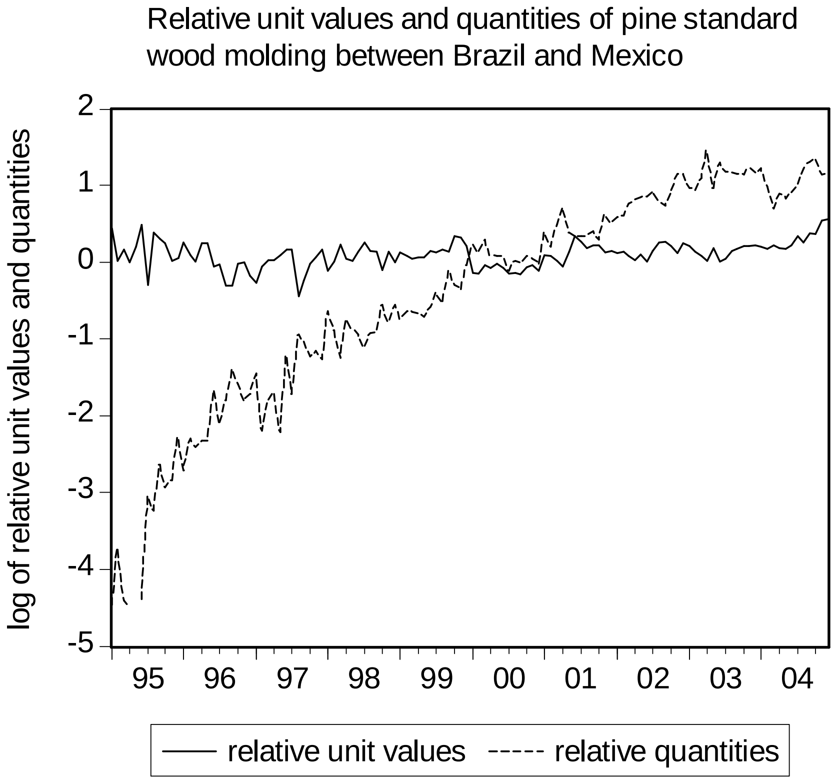


Graph 4.

of substitution is infinite.

The market gain of Brazil should be ascribed to supply conditions rather than to demand conditions, since relative prices remain stationary and suppliers are likely to behave as price takers [25] .

[25] Indeed, the wood industry is normally classified as a low technology industry, as for instance in Hatzichronoglou (1997). The number of small and medium size suppliers is reported to be large in Brazil, according to the Brazilian Association of Mechanically Processed Wood Manufacturing – Ambici, and in the U.S., according to the USITC (2002).



Graph 5.

The relative price indices of Brazil and Mexico for the wood industry as a whole also cointegrate with the real exchange rate (real/peso), calculated as the nominal exchange rate deflated by consumer price indices (CPI). The relative import price elasticity with respect to changes in the real exchange rate is estimated at 0.21; i.e., a 10% real devaluation of the real against the peso would reduce Brazil's price index of wood by only 2.1% relatively to Mexico's price. When the relative price indices of Brazil and Mexico are cointegrated with the nominal exchange rate (real/peso), with both CPI of Brazil and Mexico included as exogenous variables, the implicit elasticity is 0.32. Therefore, the implied pass-through effect is very low.

Now when relative unit values of doors and their frames are cointegrated with the real exchange rate (real/peso), the elasticity is estimated at 0.93. Therefore, changes in the real exchange rate are almost fully transmitted to relative prices of this differentiated product [26] .

On the other hand, as the series of nominal and real exchange rates are non-stationary, they cannot cointegrate with the series of relative prices of pine standard wood moldings, which we have found to be stationary. Therefore, the change in the real exchange rate has no effect on destination prices in the U.S., but has a direct effect on the change in relative quantities.

Therefore, the apparent pricing-to-market (or the low pass-through) result for the industry as a whole is simply an aggregation bias that ignores the presence, within the industry, of homogeneous products that follow the law of one price in the U.S.

Note that the implicit effect of changes in the real exchange rate on the relative quantities exported by Brazil and Mexico for the industry as a whole also seems to have been underestimated, since it was smaller than the same effect for doors and their frames and for the pine standard wood molding. The effect of the real exchange rate on relative quantities is estimated as $d\text{ln}q/d\ln e = (d\ln q/d\ln p).(d\ln p/d\ln e)$, where the last two terms are the elasticities of relative quantities with respect to relative prices (the elasticity of substitution) and of relative prices with respect to the real exchange rate. For the industry as a whole these elasticities were estimated at 6.98 and 0.21, while

[26] When relative unit values of doors and their frames are cointegrated with the nominal exchange rate (real/peso), with both the CPI of Brazil and Mexico included as exogenous variables, we find a pass-through effect of 114%.

for doors and their frames they were 1.66 and 0.93, respectively. Therefore, the implicit elasticity of relative quantities with respect to the real exchange rate is 1.47 for the industry as a whole and 1.54 for doors and their frames. The direct estimate for the elasticity of relative quantities with respect to the real exchange rate is 2.5 for pine standard wood molding.

4 Conclusions

Some industries defined at the 4-digit level or at more aggregate levels may include homogeneous products that follow the law of one price. When they do, estimates of substitution elasticities for the industry are in fact averaging the elasticities of traded products that compete under different regimes. As products that follow the law of one price have substitution elasticities equal to infinite, the industry's estimated elasticity becomes largely dependent on the weight of these products in the industry. In point of fact, these estimates can be seen as hopeless attempts to find the mean between zero and infinite. Therefore, it should come as no surprise the fact that the literature reveals very different estimates for these elasticities.

Indeed, this point has been illustrated by the elasticity of substitution between Brazil's and Mexico's exports of wood products to the U.S.. It has been shown that one of the main types of wood exported by Brazil and Mexico to the U.S. is not differentiated at all by country of origin. The presence of this good tends to raise the estimated elasticity of substitution between Brazil's and Mexico's exports of an aggregated of wood products. The same can happen with the elasticity of substitution between U.S. domestic production and imports of wood products.

Typically, substitution elasticities estimates for industries that include homogeneous products tend to be overestimated due to this aggregation bias, though some narrowly defined products may have substitution elasticities that are much higher than the most common estimated range for industries. Therefore, an effort ought to be made to obtain more disaggregated data, especially on domestic output, and thus obtain more precise estimates of substitution elasticities. The effects of trade policies and trade agreements on the trade of homogeneous products, whose prices tend to equalize in a particular market, should be examined separately from the effects on the trade of differentiated goods.

Analogously, import prices in the U.S. from different exporting countries for one type of wood product were shown to equalize through arbitrage, turning these prices insensitive to changes in the exchange rate of the U.S. dollar with respect to the currencies of the main exporting countries. As a result, pricing-to-market estimates proved to be grossly overestimated for the wood industry as a whole.

It should be noted that if world prices of homogeneous products are set in U.S. dollars, the presence of these products following the law of one price in a particular industry and market leads to an underestimation of the exchange rate pass-through effect on relative prices, since the pass-through effect is zero by definition for these products in the U.S. Therefore, pricing-to-market estimates for these industries may be grossly overestimated. However, the pass-through effect in other countries will be complete for these products. Pricing-to-market in this case will be grossly underestimated by the presence of homogeneous products, following the law of one price worldwide, while the effect of expenditure-switching policies will be overestimated.

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Appendix 1: Price and Quantity Indices

The unit values and quantities for the following products were used to construct the indices:

For Brazil

Harmonized tariff system	Product Description	Period
4418208060	DOORS AND THEIR FRAMES AND THRESHOLDS, OF WOOD, NESOI	1995:01-2004:12
4409104000	PINE (PINUS SPP.) STANDARD WOOD MOLDING	1995:01-2004:12
4411110095	FIBERBOARD OF WOOD OR OTHER LIGNEOUS MATERIALS, OF A DENSITY EXCEEDING 0.8 G/CM3, NOT MECHANICALLY WORKED OR SURFACE COVERED NESOI	1995:01-2004:12
4412143060	PLYWOOD WITH AT LEAST ONE OUTER PLY OF NONCONIFEROUS WOOD, CONSISTING SOLELY OF SHEETS NOT SURFACE COVERED, OF WOOD NOT OVER 6 MM THICK, NESOI	1996:01-2001:12
4407100047	SOUTHERN YELLOW/LONG LEAF/PITCH/SHORT LEAF/SLASH/VIRGINIA PINE WD, SAWN OR CHIPPD LENGTHWISE, THICKNESS EXCEED 6MM, NOT TREATD, NESOI EX FINGER-JOINTD	1997:07-2004:12
4412134060	PLYWOOD WITH AT LEAST 1 OUTER PLY OF SPECIAL TROPICAL WOOD, LESS THAN 6MM THICK, NOT SURFACE COVERED, NESOI	1996:01-2004:12
4407100001	WOOD SAWN OR CHIPPED LENGTHWISE, SLICED OR PEELED, WHETHER OR NOT PLANED, SANDED OR FINGER-JOINTED, OF A THICKNESS EX 6MM: FINGER-JOINTED WOOD ONLY	1997:01-2004:12
4412194031	PLYWD 1 OUTER PLY LONG LEAF/SHORT LEAF/SOUTHERN YELLOW/SLASH/PITCH/VA PINE BOTH OUTER PLIES SOFTWD, SHEETS WOOD ONLY, ROUGH/TOUCH SANDED FOR SIZING	2004:12 1995:01-

For Mexico

4418208060	DOORS AND THEIR FRAMES AND THRESHOLDS, OF WOOD, NESOI	1995:01-2004:12
4409104000	PINE (PINUS SPP.) STANDARD WOOD MOLDING	1995:01-2004:12
4414000000	WOODEN FRAMES FOR PAINTINGS, PHOTOGRAPHS, MIRRORS OR SIMILAR OBJECTS	1995:01-2004:12

Appendix 2: Results of ADF Tests

All tests were carried out in level and with intercept. Lags were selected on the basis of the Schwarz criterion.

Series	Lags	Result	5% Critical value
Brazil price index	1	-2.15164	-2.8859
Brazil quantity index	3	-2.75718	-2.8863
Mexico price index	0	-2.841732	-2.8936
Mexico quantity index	4	-1.14611	-2.8865
Relative price index	1	-1.966437	-2.8963
Relative quantity index	2	-0.48293	-2.8861
Brazil unit value of doors and frames	3	-2.80476	-2.8967
Brazil quantity of doors and frames	3	-1.735942	-2.8863
Mexico unit value of doors and frames	2	-0.99244	-2.8861
Mexico quantity of doors and frames	1	-2.145847	-2.8859
Relative unit values of doors and frames	3	-1.111876	-2.8967
Relative quantity of doors and frames	1	-0.96487	-2.8859
Brazil unit value of standard wood molding	1	-2.813461	-2.8859
Brazil quantity of standard wood molding	3	-2.57485	-2.8874
Mexico unit value of standard wood molding	2	-1.99963	-2.8861
Mexico quantity of standard wood molding	1	-2.063626	-2.8859
Relative unit values of standard wood molding	0	-6.100504	-2.8857
Relative quantity of standard wood molding	3	-2.223177	-2.8874
Real exchange rate real-peso	3	-1.30467	-2.8863
Nominal exchange rate	3	-1.080448	-2.8863

The test fails to reject the hypothesis of a unit root for all series but for the relative unit values of standard wood molding.