Departamento de Economía
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Documentos de Trabajo

Armington Elasticities: Estimates for Uruguayan Manufacturing Sectors

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Documento No. 07/10
Junio 2010

ISSN 1688-5031

Armington elasticities

Estimates for Uruguayan manufacturing sectors

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May, 2010

JEL: B40/F14/F17

Abstract

Armington elasticities of substitution – AEs – are a crucial set of parameters that allows CGEMs applied to trade to be operational. In the case of Uruguay, no estimated values for these parameters have been available until now, forcing researchers to impose them arbitrarily. We here start filling this gap by providing estimated AEs for 32 Uruguayan 4-digit manufacturing industries belonging to the Food, Beverages and Tobacco; Chemical Products; and Textiles economic sectors, using monthly and quarterly data along 1989-2001. The specification of the models follows the simplified benchmark proposed by Armington (1969) that has been used in most of the existing applied research. The resulting estimated AEs are in line with those reported by the international literature and hence of a smaller size than expected by CGEM modellers. Our econometric analyses also show that the low values of the estimated elasticities are not due to the characteristics of the available data and/or the methodology used. Instead, a plausible explanation suggested by our results relates to the theoretical models used being misspecified, particularly due to the omission of relevant variables.

Keywords: Armington elasticity, Substitutability, Computable General Equilibrium Model

Resumen

Las elasticidades de sustitución de Armington – EAs – son parámetros clave en términos de la operatividad de los MEGCs. En el caso de Uruguay, sus valores han sido impuestos arbitrariamente hasta ahora, debido a la inexistencia de estimadores de EAs. Aquí comenzamos a llenar este vacío, reportando EAs para 32 industrias manufactureras a 4 dígitos pertenecientes a Alimentos, Bebidas y Tabaco; Productos Químicos; y Textiles, usando información mensual y trimestral para 1989-2001. La especificación de los modelos se enmarca en la propuesta simplificada de Armington (1969) de uso generalizado en la investigación aplicada existente. Los valores estimados son consistentes con los reportados en la literatura internacional y, por ende, resultan menores a lo esperado por quienes construyen MEGCs. Los análisis econométricos realizados muestran que la escasa magnitud de las elasticidades no se vincula a las características de la información disponible ni a la metodología empleada. Una explicación alternativa sugerida por los resultados obtenidos refiere a la incorrecta especificación de los modelos teóricos utilizados, en particular en lo que respecta a la omisión de variables relevantes.

Palabras clave: Elasticidad de Armington, Sustituibilidad, Modelo de Equilibrio General Computable

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Introduction

The high degree of openness of the Uruguayan economy and the fact that the country is characterised by being constantly subject to shocks, strongly suggest the use of simulation tools that allow for predicting its future evolution under different scenarios. Currently, Computable General Equilibrium Models (CGEMs) applied to trade are one of the most potentially powerful instruments for doing such analyses. Although there exist some research performed using this methodology for Uruguay, accumulation in the area is still scarce (the earliest reference is Laens and Terra, 2000, while latest contributions are Terra, 2003; Terra et al., 2005; Laens and Terra, 2008).

As it is well known, operational CGEMs critically rely on the availability of many parameters, especially those related to elasticities. In the case of multi-country models and of those designed for an open economy, Armington elasticities of substitution are one of the crucial sets needed. These parameters have often been imposed in Uruguayan CGEMs, either arbitrarily or by taking the values estimated for other economies. Hence, in order to obtain more robust results, it is of upmost interest to specify and estimate Armington models that would provide estimators of the elasticities using Uruguayan data. The work here summarized intends to start filling in this gap.

In the following section the theoretical framework chosen is exposed. In Section 3 we briefly sketch the econometric models to be estimated, the results of which are detailed in Section 4. Conclusions and future suggested lines of research are summarised in the last section.

Armington Elasticities

The failure of traditional international trade theories in explaining several of the trade patterns observed in the 60s gave raise to new developments that in the 80s were known as New Trade Theories (NTT). One key assumption that is questioned by these new approaches is the complete specialization of each country in those goods in which they have comparative advantages, an assumption crucial for the validity of the Law of One Price. Further, the traditional theories look only at the supply side, while disregarding the possibility of increasing returns to scale.

Another main contribution of the NTT relates to them highlighting that the homogeneity of goods may not be linked exclusively to the technical characteristics of production but also to secondary attributes such as commercialization practices or brands. Further, heterogeneity in quality and hence prices was also introduced in the models.

These novel contributions were related also to the supply side of the market, being the demand side relatively disregarded. However, it was long before that P.S. Armington (1969) had analysed the possibility of differentiation of goods stemming from the perception of consumers on them being heterogeneous. In the proposed model differentiation is limited to the one derived from the national origin of production. While assumptions of perfect competition and constant returns to scale are kept, the origin of production is taken as a distinctive feature of otherwise homogeneous goods. Heterogeneity need not be an objective characteristic related to the actual existence of differences but if goods are being so perceived by consumers, they do alter the relative demand of the various national varieties[1].

As a consequence, goods previously treated as homogeneous in trade models had to be considered heterogeneous according to this new dimension, determining that consumers would not perfectly substitute one variety for the other. More specifically, the degree in which those varieties are substituted is a key parameter when analysing the real effects of shocks or policy changes that are reflected in relative prices' shifts. Thus, the degree of substitutability between national and imported varieties of a good, known in the literature as the "Armington elasticity", started to be considered as having a main role in trade models.

An Armington structure implies that consumption decisions include at least two stages. First, given the budget constraint consumers decide upon the quantity demanded of each good. Afterwards, the proportions of national varieties of each good are decided. Some extensions of the model inspired in the original paper incorporate an intermediate stage in which the imported share of each good is decided in the second stage and then distributed – in a third stage - among the diverse foreign countries offering the merchandise. Each national variety of a good is denominated by Armington as a "product". Markets are thus

[1] No matter its specificities, the national differentiation of goods overlaps horizontal and vertical differentiation as defined in the NTTs.

defined depending on the definition of homogeneous goods except for their origin of production, so that many products are traded within each market.

Trade models along the last decades have increasingly incorporated the national differentiation of goods as proposed by Armington. In doing so, they also assume the existence of market rigidities and that national/foreign industries may exert a certain degree of market power.

Armington elasticities have also acquired a starring role among most researchers advocated to building Computable General Equilibrium Models (CGEM), both multi-regional and multi-country models, partly due to them allowing for a better approximation of the specialisation patterns observed especially during and after a trade liberalisation process. As such, its magnitude becomes crucial for a correct quantification of the overall effects of any change in trade policies, while simulations performed using CGEMs may even lack any sense for certain range of values of these parameters.

The fact that reliable CGEMs simulations depend critically on Armington elasticities forced researchers in the past to impose their value, at times making use of those provided by other existing models. However, the strategy casted doubts on the appropriateness of the imputed parameters for the particular economy under study, while at times the CGEM in need of Armington elasticities had a level of disaggregation inconsistent with respect to the one giving rise to the available parameters.

The above stated shortcomings motivated an upsurge of econometric analyses focusing on the estimation of Armington models for diverse individual economies as well as for sets of countries/regions, using different levels of aggregation for defining goods and markets. The availability of estimated elasticities of substitution for the countries for which simulations are being performed should guarantee that a more accurate and reliable result is obtained from simulations, as they would presumably incorporate the specificities of the particular economy under analysis.

However, the current econometric literature focused on Armington elasticities has not yet provided with estimates that fulfil the CGEMs needs, a fact that has in turn triggered a profuse interest on studying various theoretical and methodological issues, some of which were previously unforeseen.

Among the topics currently under debate it is worth mentioning the consequences of relaxing theoretical assumptions such as the separability of preferences that limit the feasible utility functions; the considerations that have to be taken into account for defining homogeneous goods; or the implications of using a two or three stages decision process. Methodological issues are concerned with the consequences of using different sorts of information sets; the correct specification of models; the choice of estimation methods; or the quality of available data; among many others[2].

No matter the obstacles that have still to be surmounted, the accessibility to estimated values that are obtained for the specific economy under study is the only means by which simulations can be considered reliable, since it is well known that the impact of policies cannot be expected to be independent of the specificities of each spatial/temporal case study, while consumption preferences may substantially differ between economies.

The Model

The Armington model proposes mechanisms explaining an underlying structure that intends to reflect actual international trade patterns. Perfect competition and constant returns to scale are assumed, while goods are considered homogenous except for the national origin of production. Consumers are expected to decide on the bundles of goods that report them the maximum utility level attainable given prices and subject to their budget constraint. As preferences are assumed to be separable, after deciding on the quantity to be purchased of each good, it is possible to independently decide on the foreign/national composition of the demand for each good. In doing so they take into account the relative prices – local to import prices – being the relative quantities demanded of the products determined depending on the ease with which they substitute varieties once relative prices vary – the magnitude of the Armington elasticity of substitution. In order to solve the resulting optimisation programme, it is further assumed that consumers get more satisfaction whenever they are able to increase the quantities consumed (non-satiation), while the utility level increases proportionally when equally augmenting the quantities consumed of all goods (homotheticity of the utility function).

The above assumptions imply that the demand for each good and product is independent of what happens in all other markets. The marginal rate of substitution is not a function of the

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[2] For a discussion on the topic, see Cassoni and Flores (2009) and Flores (2008).

absolute quantities consumed or the absolute level of income. Thus, the demand for each good/product depends only on the level of expenditure assigned exclusively to its consumption and not on what is devoted to the demand of other goods/varieties, while the relevant prices are only those operating in each specific market (separability).

The model and the derived solution of the associated optimisation programmes can be stated as follows:

Stage 1: $Max_X\ U \equiv U\,(X_1\,,\ \ldots,\ X_n\,)$ s.t. $D = \sum_i (P_i X_i) \Rightarrow X^*_i = X_i\,(D,\ P_1,\ \ldots,\ P_n\,)$

Stage 2: $Min_{NiMi}\ PN_i N_i + PM_i M_i$ s.t. $X^*_i = \Phi_i\,(N_i, M_i\,)$ *for each i = 1,…,n*

$$\Rightarrow \quad N^*_i = N_i(X^*_i, PN_i/PM_i\,)$$

$$M^*_i = M_i(X^*_i, PN_i/PM_i) \text{ for each } i = 1,\ldots,n$$

Where U is the utility of consumption; X_i and P_i are the quantities demanded and the prices of good '*i*', respectively; D is the level of expenditure; N_i and M_i are the quantities demanded of domestic and foreign varieties of good '*i*', respectively; PN_i and PM_i the corresponding prices. An aster in variables refers to its optimum value.

Further, as the price of each good should be equal to the weighted average of the prices of its varieties, the following identity should also be verified:

$$P_i = P_{i1}/(\partial\Phi_i/\partial X_{i1}) = \ldots = P_{im}/(\partial\Phi_i/\partial X_{im})$$

$$P_i = \textstyle\sum_j (P_{ij}X_{ij})/X_i\ ;\ P_i = P_j(X_i/X_j)^{1/\sigma}\ i = 1,\ldots,n\ j = 1,\ldots,m$$

A widely used functional form that has the above stated properties is the Constant Elasticity of Substitution (CES). As its name indicates, the ease of substitutability of goods is constant all along the indifference curves, while the elasticity of substitution is identical between all pairs of goods/products. A CES utility function in the case of two goods can be denoted as:

$$U(X_1,X_2) = A[\,\beta X_1^{-\gamma} + (1-\beta)X_2^{-\gamma}]^{-1/\gamma}$$

Where A is a scale parameter; β is a distribution parameter; and $\lambda=1/(1+\gamma)$ is the elasticity of substitution. The relative demand for goods after solving the optimisation programme is:

$$(X_1/X_2)^* = [(1-\beta)/\beta]^{-1/(1+\gamma)}\ (P_{X1}/P_{X2})^{-1/(1+\gamma)}$$

Assuming that there are n goods, and using N_i and M_i as notation for national and imported varieties, the optimum level of demand for each good '*i*' is:

$$X_i^* = \Phi_i(N_i,M_i) =[b_iN_i^{-\rho}+ (1-b_i)M_i^{-\rho}]^{-1/\rho} \qquad i= 1, ..., n$$

Once all X_i^* are determined, the second optimisation programme has to be solved, yielding:

$$(N_i /M_i)^* =[(1-b_i)/b_i]^{-1/(1+\rho)} (PM_i/PN_i)^{-1/(1+\rho)}$$

Taking logs, the model to be estimated is:

$$Ln(N_i /M_i) =Ln[(1-b_i)/b_i]^{-1/(1+\rho)} + Ln(PM_i/PN_i)^{-1/(1+\rho)}$$

$$Ln(N_i /M_i) = \alpha - \sigma_i Ln(PM_i /PN_i) \text{ for each } i = 1,...,n \qquad (1)$$

Where $\alpha=Ln[(1-b_i)/b_i]^{-1/(1+\rho)}$ and $\sigma_i =1/(1+\rho_i)$

Data and methodological issues

We estimate models basically specified as equation (1) at a 4-digit level of disaggregation (ISIC, Rev.2) for 32 manufacturing sectors along 1989 to 2001, using monthly and quarterly data.

The different frequency of the data is due to the fact that although we estimated the models with quarterly information so as to avoid the excessive and non informative volatility of monthly observations, we considered that the analyses of the order of integration and the existence of cointegration gained robustness by using larger time series.

Although data was available until 2004 by the time this study had started, we considered that observations were not enough to properly model the changes occurring after the huge shock to the economy that took place in 2002. Further, by mid-2002 there was a change in the methodology used to construct price indexes, so that making the series compatible would have implied an extensive additional work on the data, exceeding the goal of this first approach to the subject.

We chose to work with a subset of the 57 sectors for which data was available as a first step in the research. The chosen industries belong to three broad categories referring to Food, Beverages and Tobacco, traditionally net exporting sectors; Chemical Products, which are mainly net importing industries; and Textiles, a sector gathering both types of industries and with a changing pattern of international insertion over time. The strategy was adopted so as to control for the eventual role that the industries' international insertion may play in the specification of the models. A description of the considered classification codes is presented in Appendix 1.

We approximate relative demands of varieties by the value of sales and imports, thus assuming no effective supply restrictions are present, neither internationally nor domestically. The assumption has to be tested for in the case of local supply, being Uruguay a small economy. Data on local sales and prices stem from the National Statistics Institute (INE) while those referring to imports and import prices are obtained from the Customs Office and the Central Bank of Uruguay (BCU). Import price series are price indexes of imports by sector, published by BCU.

Quantities imported are not the best proxy for the demand of foreign varieties since they refer to the entrance of products and not to their effective sale in the local market. The consequent asynchronicity between entry and consumption of imported goods - especially when using monthly data - forces the use of many binary variables to account for atypical observations. Exchange rates data are provided by the BCU while tariffs stem from the Latin America Integration Association (ALADI). As tariffs and traded values are reported at a 6-digit level of NCM product classification, they had to be aggregated to match the price variables sector classification (ISIC).

A seasonal pattern was included in all models as well as a deterministic trend whenever the analysis of the order of integration of variables or the cointegration results imposed such a strategy.

Econometric results

Specification, estimation and statistical analysis of the models

As a first step in the econometric analysis, we studied the statistical properties of the stochastic processes involved – integration order; balance of proposed estimable models; and existence of cointegration relations when pertinent. We used ADF tests, with an initially high number of lags that were afterwards sequentially reduced, and Engle and Granger´s (1987) procedure for testing cointegration[3].

[3] The econometric software used was EViews.

A hypothesis of interest in our research relates to the possibility of changes in tariffs and/or exchange rates having overshooting effects on relative demands. The idea stems from the fact that exchange rates have been historically used as anti-inflationary policy instruments in Uruguay, so that agents may perceive their variations in a distinctive way than those of other prices. We tested for the hypothesis by adding these two variables in the standard Armington model and afterwards tested for the statistical significance of their associated coefficients. Consequently, we also performed the order of integration and cointegration analyses including these variables.

The ADF tests on the order of integration of time series were performed using the three versions originally proposed by Dickey and Fuller (1979), so as to jointly study the outcomes and decide on the stationarity of processes[4].

Our results on the order of integration of the time series involved signal at relative prices and quantities being mostly I(1) and rarely I(2). A non negligible number of relative prices are found to be stationary processes, as it is also the case for the exchange rate (Table 1).

Table 1: Order of Integration - Summary of results

Relative demands - Relative prices – Tariffs – Exchange rate

Food Beverage & Tobacco – Textiles – Chemical Products (4-digit ISIC industries)

1991- 2001 (monthly data)

	q		**p**		**t**		**E**	
Order of Integration	Number of industries	%	Number of industries	%	Number of industries	%	Number of industries	%
I(0)	2	6,3	10	31,3	9	28,1	1	100,0
I(1)	26	81,3	18	56,3	19	59,4		0,0
I(2)	4	12,5	4	12,5	4	12,5		0,0
Total	**32**	100	**32**	100	**32**	100	**1**	100

Note: *q* is the log of the ratio of imported to domestically produced sales; *p* is the log of the relative prices of goods – local to imported; *t* is the log of 1 plus the tariff rate; and *e* is the log of the exchange rate.

[4] Although the widespread practice regarding the decision on the order of integration of processes using ADF tests is to discard the trend and constant included and/or the constant included versions of the AR(p) model proposed for proxying the DGP, we believe that it is better to jointly analyse the results for all models, using the highest order dynamic structure allowed for by the data (for a discussion of the topic, see for example Banerjee *et al.*, 1993). Consequently, we decided without taking as fully proven the non rejection of the existence of constant and/or trend in the Dickey-Fuller models.

The stationarity of the exchange rate is not rejected when the model includes a deterministic time trend. The result is consistent with the prefixed exchange rate policy exerted by the monetary authorities along most of the period, although most probably not sustainable if analysed in a longer period of time.

Tariffs are mostly integrated processes, hence of infinite memory. The result supports the hypothesis of permanent effects of policy changes and particularly of structural institutional changes, such as the Mercosur formation, on either their level – when it is I(1) - or both on their level and their rate of change – when I(2) - as is the case for a third part of the sectors analysed. The result suggests that care should be posed when using tariffs as short run policy instruments, since the effects would anyway persist for a long time.

It is thus possible to state that in many markets shocks do have permanent effects on the temporal evolution of relative demands, relative prices and tariffs, either on their mean value and/or their variance. This property should be kept in mind when instrumenting policies but also when faced to exogenous events, such as an increase in the level of international supply that in turn reduces prices, or a liberalisation process that results in a reduction of tariffs, or even when an idiosyncratic change in tastes that may increase the demand of goods of a particular origin of production is verified.

In cases in which stationarity of relative quantities or prices is not rejected, on the contrary, the processes are characterised by having short memory, so that the effect of exogenous shocks disappears as time goes by. A most likely underlying cause is that the components of relative quantities and/or prices have a common stochastic trend so that shocks have long lasting effects on the individual components without generating changes in their relationship in the long run. In Table 2 below the frequency of the diverse possible outcomes is summarised.

In the particular case of relative prices being stationary and given the exchange rate is I(0), the evidence would support the validity of the Law of One Price (LOP) in those markets, at least along the period under analysis. Analogously, if the order of integration of local and international prices are I(2) and the relative price is I(1), then there exists one common unit root, thus signalling at the validity of the relative version of the LOP. On the contrary, if non cointegration among domestic and international prices exists, that is, when the order of integration of these series is different or whenever the order of integration of relative prices is equal to that of both of its components, the evidence is inconsistent with the validity of the LOP in any of its versions.

Table 2: Order of Integration - Summary of results

Import demand – Domestic demand - Import prices – Domestic prices

Food Beverage & Tobacco – Textiles – Chemical Products

1991- 2001 (4, 3 and 2 digit ISIC industries monthly data)

OI	M	N	PM	PN
I(0)	25	18	5	15
I(1)	12	18	11	21
I(2)	4	5	25	5
Total	**41**	**41**	**41**	**41**

Note: *M* is the log of the index of the real value of imported goods; *N* is the log of the index of the real value of domestically produced goods; *PM* is the log of the imports price index; *PN* is the log of the domestic price index.

A second step involved analysing if the models were balanced and hence allow for analysing the existence of cointegration[5]. This was verified in all cases at a 90% level of confidence, as shown in Table 3.

Although a joint analysis of the order of integration of the processes by sector would shed light on omitted sectoral specificities relevant for the specification of models, we did not carry on its study as it exceeded the aim of this research.

[5] In a balanced model the right hand side variables should have an order of integration such it is possible that a linear combination of them has the same order of integration of the variable in the left hand side. Cointegration exists when this linear combination does exist. Obviously, the existence of cointegration among variables of an unbalanced model is not possible.

Table 3: Balance of models

Food Beverage & Tobacco – Textiles – Chemical Products

1991- 2001 (4-digit ISIC industries monthly data)

Industries	q	p	t
3111	I(2)	I(2)	I(2)
3112	I(1)	I(0)	I(1)
3113	I(1)	I(0)	I(1)
3115	I(1)	I(0)	I(1)
3116	I(1)	I(0)	I(1)
3117	I(1)	I(1)	I(1)
3118	I(0)	I(1)	I(1)
3119	I(1)	I(1)	I(1)
3121	I(1)	I(2)	I(2)
3122	I(1)	I(1)	I(1)
3131	I(1)	I(1)	I(0)
3132	I(0)	I(0)	I(0)
3133	I(1)	I(1)	I(1)
3134	I(1)	I(1)	I(1)
3140	I(1)	I(1)	I(0)
3211	I(1)	I(0)	I(1)
3212	I(1)	I(1)	I(0)
3213	I(1)	I(1)	I(0)
3214	I(2)	I(2)	I(0)
3215	I(1)	I(0)	I(1)
3219	I(1)	I(1)	I(0)
3220	I(1)	I(1)	I(0)
3240	I(1)	I(1)	I(0)
3511	I(1)	I(0)	I(1)
3512	I(1)	I(1)	I(1)
3521	I(1)	I(0)	I(1)
3522	I(2)	I(2)	I(2)
3523	I(2)	I(0)	I(2)
3529	I(1)	I(1)	I(1)
3530	I(1)	I(1)	I(1)
3551	I(1)	I(1)	I(1)
3560	I(1)	I(1)	I(1)

Once verified the empirical consistency of the relations as stated in the models, cointegration analyses were performed. At a 90% confidence level, cointegration was rejected only in one industry, for which the confidence level for non rejection was 82%. However, the sector is Petroleum Refineries, its price being set by the government and frequently used as an anti-inflationary instrument so that it is most likely that the equilibrium relation is not observed as it is being exogenously distorted (Table 4).

Table 4: Cointegration Analyses

Order of Integration of residuals of static regressions

Models with and without deterministic trend

Food Beverage & Tobacco – Textiles – Chemical Products

1991- 2001 (4-digit ISIC industries monthly data)

Industries	Static regression with trend			Static regression without trend		
	Lags	ADF	OI	Lags	ADF	OI
3111	10	-5,426 ***	I(0)	10	-5,374 ***	I(0)
3112	2	-7,947 ***	I(0)	2	-7,900 ***	I(0)
3113	0	-5,439 ***	I(0)	0	-5,413 ***	I(0)
3115	1	-5,598 ***	I(0)	1	-5,197 ***	I(0)
3116	9	-5,950 ***	I(0)	6	-4,976 ***	I(0)
3117	0	-6,545 ***	I(0)	0	-5,651 ***	I(0)
3118	9	-5,103 **	I(0)	9	-5,317 ***	I(0)
3119	13	-4,468 *	I(0)	13	-4,443 **	I(0)
3121	1	-5,427 ***	I(0)	1	-4,570 **	I(0)
3122	4	-4,754 **	I(0)	4	-2,845	No I(0)
3131	3	-4,582 **	I(0)	3	-4,590 **	I(0)
3132	0	-8,599 ***	I(0)	0	-8,063 ***	I(0)
3133	1	-5,664 ***	I(0)	1	-5,312 ***	I(0)
3134	2	-6,110 ***	I(0)	3	-3,879 *	I(0)
3140	2	-6,659 ***	I(0)	1	-4,828 ***	I(0)
3211	0	-8,020 ***	I(0)	7	-2,268	No I(0)
3212	0	-7,809 ***	I(0)	1	-3,749	No I(0)
3213	0	-8,756 ***	I(0)	0	-7,595 ***	I(0)
3214	1	-6,380 ***	I(0)	1	-5,870 ***	I(0)
3215	0	-10,698 ***	I(0)	0	-8,407 ***	I(0)
3219	1	-5,194 ***	I(0)	1	-4,837 ***	I(0)
3220	0	-7,741 ***	I(0)	0	-7,636 ***	I(0)
3240	0	-7,550 ***	I(0)	0	-7,239 ***	I(0)
3511	0	-9,977 ***	I(0)	0	-9,370 ***	I(0)
3512	0	-8,574 ***	I(0)	0	-8,420 ***	I(0)
3521	0	-8,800 ***	I(0)	0	-6,686 ***	I(0)
3522	1	-5,273 ***	I(0)	4	-1,929	No I(0)
3523	0	-5,618 ***	I(0)	0	-4,448 **	I(0)
3529	2	-4,703 **	I(0)	2	-4,705 **	I(0)
3530	1	-2,986	No I(0)	2	-2,196	No I(0)
3551	0	-10,914 ***	I(0)	0	-9,602 ***	I(0)
3560	1	-4,216	No I(0)	1	-4,220 **	I(0)

Notes: Lags refers to the maximum number of lags included in the model for performing the ADF test; ADF is the value of the statistic; ***/**/* refer to the significance level of the tests being 1%/5%/10% according to Mackinnon response surfaces; OI is the order of integration of residuals.

In spite of the evidence supporting relations are not spurious, we believe that in some cases the low level of confidence necessary for not rejecting cointegration signals at the need of including additional variables accounting for the role of other phenomena. We thus proceed to estimating the Armington models in its dynamic versions due to the data frequency used.

Models were estimated for all 32 sectors individually using Least Squares. We performed an in depth evaluation of the validity of all statistical assumptions underlying the original specification, its results being taken into account for respecifying the original versions of the models. The results of the misspecification tests are reported in Appendix 2.

The initial dynamic structure of order 5 imposed to all models was afterwards modified by sequentially discarding non significant lags. Normality tests were intensively used as a means of identifying outliers that were thus modelled by means of binary variables. Heteroskedasticity was not an issue while changes in parameters were found in a few cases and thus included in the models. Exogeneity of prices, only credible if there were no restrictions from the supply side, was in most cases rejected using Hausman's test (1978). The results of exogeneity tests are reported in Appendix 3.

When strong exogeneity was rejected, the models were re-estimated by Instrumental Variables Methods, using lags of the price variable as instruments. The differences between the estimated values of the Armington elasticities using both estimation methods were not large in absolute terms, although statistically significant. It is worth noting that the LS endogeneity biases found were both positive and negative depending on the industry, so that no unique effect on the estimated value of the elasticity can be stated in terms of ignoring endogeneity of prices.

In many models we included a time trend, either following the cointegration relation specification or as the result of statistical tests signalling at its incorrect omission. These trends might be capturing factors linked to technical progress, differentiated by origin of production, or else revealing changes in the composition of demand.

Further, the hypothesis of an existing overshooting impact of tariffs was not rejected in a non negligible number of cases when performing the cointegration analyses with monthly data. However, when switching to quarterly data the effect disappeared in most markets.

The result may be read as a quarter being the necessary time period for a reversal of the initial overreaction of agents to changes in tariffs[6].

The estimated value of the Armington Elasticity

The estimated values of the long-run Armington elasticities vary in a range of 0.5 to 4.3 depending on the good/industry (see Table 5 below). No estimated elasticities are nil, so that the evidence supports that there exist a degree of substitutability between imported and domestic varieties of all the analysed goods. The point estimates of the elasticity are greater than 1 in almost 60% of the cases, although the interval estimation excludes the unity only in half of those cases. On the opposite, elasticities are statistically lower than 1 just in 4 economic sectors.

Further, if looking at the value of the upper bound of the interval estimates, the estimated elasticity ranges from 0.68 to 6.35, being over 1.5 in 55% of the cases, of which two thirds are over 2. These figures, as well as the point estimates at a lesser extent, are quite in line with those reported in Donnelly, Johnson and Tsigas (2004), who perform a matching of the USITC elasticities with those of the default GTAP-41 commodity model. The figures there reported range from 1.0 to 5.2, the minimum value being lower that that used in GTAP (1.8).

Consistent with the assumption of separability of preferences, the estimated models were specified sectorally, guaranteeing that no information relative to what happens in any other market was taken into account. The assumption implies that when deciding relative demands of the varieties of a particular good conditional on the prevailing relative price, consumers do not take into account any information associated to the relative demand or price of other goods nor on the share of income devoted to their consumption. Statistically, the assumption undoubtedly implies that no simultaneity exists among the systematic components of the conditional relative demands for goods, so that no causality links are to be found between the relative demands of each good and hence simultaneous equations econometric models are to be discarded.

[6] The full estimation results are available upon request.

Table 5: Long-run Armington Elasticities – Uniequational Models

Food Beverage & Tobacco – Textiles – Chemical Products

1991- 2001 (4-digit ISIC industries monthly data)

Industry	Starting date	Armington Elasticity	SD.	Confidence Interval Lower Bound	Upper Bound
3111	1992.1	**1.53**	*0.22*	1.11	1.95
3112	1992.1	**0.76**	*0.24*	0.28	1.24
3113	1992.1	**1.96**	*0.25*	1.47	2.46
3115	1992.1	**0.45**	*0.12*	0.22	0.68
3116	1992.1	**0.51**	*0.23*	0.06	0.96
3117	1992.1	**0.98**	*0.18*	0.64	1.33
3118	1992.1	**0.49**	*0.18*	0.15	0.83
3119	1992.1	**0.96**	*0.16*	0.65	1.28
3121	1992.1	**0.92**	*0.17*	0.60	1.25
3122	1992.1	**1.02**	*0.09*	0.84	1.21
3131	1992.1	**0.83**	*0.14*	0.55	1.11
3132	1992.1	**1.17**	*0.57*	0.06	2.27
3133	1992.1	**2.46**	*0.34*	1.8	3.12
3134	1992.1	**1.13**	*0.45*	0.25	2.02
3140	1992.1	**2.3**	*0.56*	1.21	3.39
3211	1991.1	**0.61**	*0.18*	0.25	0.97
3212	1991.1	**4.26**	*1.07*	2.17	6.35
3213	1991.1	**1.63**	*0.55*	0.55	2.72
3214	1991.1	**1.43**	*0.43*	0.6	2.26
3215	1991.1	**1.83**	*0.52*	0.81	2.85
3219	1991.1	**1.31**	*0.09*	1.13	1.49
3220	1991.1	**2.15**	*0.38*	1.42	2.89
3240	1991.1	**1.05**	*0.47*	0.14	1.96
3511	1991.1	**0.83**	*0.1*	0.63	1.03
3512	1991.1	**1.08**	*0.24*	0.62	1.55
3521	1991.1	**0.98**	*0.19*	0.61	1.36
3522	1991.1	**1.52**	*0.23*	1.06	1.97
3523	1991.1	**0.75**	*0.26*	0.24	1.27
3529	1991.1	**1.23**	*0.55*	0.15	2.3
3530	1991.1	**1.51**	*0.23*	1.06	1.96
3551	1991.1	**1.07**	*0.26*	0.56	1.57
3560	1991.1	**0.91**	*0.21*	0.49	1.33

However, the assumption would not be violated if the non systematic components of the processes are contemporaneously correlated as the association is just the result of exogenous shocks affecting many markets and/or phenomena at the same time, even those that are completely unrelated. This would be the case, e.g., for exogenous shocks affecting the international arbitrage mechanisms.

Including such information in the models have no consequence in the value of estimates but do improve the level of accuracy of the inference. We thus specify multivariate models that include seemingly unrelated equations for all industries within each 3-digit groupings and also for the 2-digit ISIC divisions that were estimated by Generalised Least Squares.

It may also occur that the relative prices are also subject to these same effects, so that their non systematic components may also be correlated. Further still, contemporaneous correlation may also exist among prices and quantities. In order to account for this additional possibility the multivariate models were specified including autoregressions for all the prices that were previously found as not weakly exogenous to the relative demand processes. We report the results on the estimated elasticities in Table 6.

Table 6: Long-run Armington Elasticities – Uniequational and Multivariate Models

Food Beverage & Tobacco – Textiles – Chemical Products

1991- 2001 (4-digit ISIC industries monthly data)

Industry		Armington Elasticity	SD	Lower Bound	Upper Bound	Percentage decrease in SD
31	3111	**1.53**	0.18	*1.17*	*1.89*	14.2%
	3112	**0.76**	0.19	*0.39*	*1.13*	22.2%
	3113	**1.96**	0.20	*1.56*	*2.36*	18.9%
	3115	**0.43**	0.09	*0.25*	*0.60*	22.9%
	3116	**0.51**	0.18	*0.15*	*0.87*	19.9%
	3117	**0.98**	0.14	*0.70*	*1.26*	18.9%
	3118	**0.49**	0.13	*0.23*	*0.75*	23.9%
	3119	**0.96**	0.12	*0.72*	*1.20*	23.4%
	3121	**0.92**	0.13	*0.66*	*1.19*	18.9%
	3122	**1.03**	0.08	*0.87*	*1.18*	17.6%
	3131	**0.83**	0.11	*0.61*	*1.04*	22.2%
	3132	**1.17**	0.45	*0.29*	*2.05*	20.5%
	3133	**2.46**	0.26	*1.96*	*2.96*	23.9%
	3134	**1.13**	0.39	*0.37*	*1.89*	14.2%
	3140	**2.30**	0.45	*1.41*	*3.18*	18.9%
32	3211	**0.61**	0.15	*0.32*	*0.90*	18.3%
	3212	**4.26**	0.86	*2.58*	*5.93*	19.8%
	3213	**1.63**	0.45	*0.76*	*2.51*	19.6%
	3214	**1.42**	0.34	*0.75*	*2.09*	20.0%
	3215	**1.81**	0.38	*1.06*	*2.55*	26.7%
	3219	**1.31**	0.08	*1.15*	*1.46*	16.8%
	3220	**2.15**	0.32	*1.53*	*2.78*	14.9%
	3240	**1.05**	0.37	*0.32*	*1.78*	19.7%
35	3511	**0.83**	0.09	*0.66*	*1.00*	15.5%
	3512	**1.08**	0.19	*0.71*	*1.46*	19.8%
	3521	**0.98**	0.15	*0.68*	*1.29*	19.8%
	3522	**1.52**	0.21	*1.11*	*1.92*	10.0%
	3523	**0.74**	0.22	*0.32*	*1.17*	17.9%
	3529	**1.23**	0.47	*0.31*	*2.15*	14.6%
	3530	**1.51**	0.19	*1.14*	*1.89*	16.9%
	3551	**1.07**	0.19	*0.69*	*1.44*	25.9%
	3560	**0.91**	0.17	*0.57*	*1.24*	19.8%
					Average:	19.3%

As expected, the value of the point estimates of the Armington elasticity do not vary significantly with respect to the uniequational models but gains in precision are indeed remarkable, attaining an average reduction of almost 20%. The higher accuracy of results may or may have not significant consequence on the absolute magnitude of the estimates, but it certainly determines that the accuracy and consequent reliability of hypothesis testing and inference in general are improved.

Concluding remarks

The econometric analyses above summarised provide with the first set of estimated Armington elasticities for several Uruguayan manufacturing industries. As such, they constitute the only locally available set of parameters that may be used in CGEMs simulations.

The thorough statistical evaluation performed to the estimated models allows us to guarantee that the results obtained are robust. However, we do believe many of the statistical analyses suggest that the models may be improved by considering additional variables. Further, extending the sample period may provide information that is most likely that is not being here captured given the specificities of the time period considered.

Compared to international estimates, the magnitude of the long-run Armington elasticities obtained seems quite adequate. However, they may still be considered low in terms of the operational needs of CGEMs. We suggest the use of interval estimation in order to have an objective range of values for performing sensitivity analyses.

More work should be done in the future so as to account for some of the suggested shortcomings of this first approach to the topic. A major issue is that of the incorrect omission of eventually key variables related to modelling the supply side of the markets as well as to the assumptions related to the income elasticity being unity.

The above may be also related to the need of further studying how to relax the assumptions underlying the separability of consumers' preferences and the homotheticity of the utility function that would in turn allow for the use of alternative functional forms.

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Appendix 1

International Standard Industrial Classification (Rev. 2)

Considered Divisions, Major Groups and Groups

31 Manufacture of Food, Beverages and Tobacco

- **311 Food manufacturing**
  - **3111** Slaughtering, preparing and preserving meat
  - **3112** Manufacture of dairy products
  - **3113** Canning and preserving of fruits and vegetables
  - **3114** Canning, preserving and processing of fish, crustacea and similar food
  - **3115** Manufacture of vegetable and animal oils and fats
  - **3116** Grain mill products
  - **3117** Manufacture of bakery products
  - **3118** Ingenios y refinerías de azúcar
  - **3119** Manufacture of cocoa, chocolate and sugar confectionery
- **312 Other food products**
  - **3121** Manufacture of food products not elsewhere classified
  - **3122** Manufacture of prepared animal feeds
- **313 Beverage industries**
  - **3131** Distilling, rectifying and blending spirits
  - **3132** Wine industries
  - **3133** Malt liquors and malt
  - **3134** Soft drinks and carbonated waters industries
- **314 Tobacco manufacture**
  - **3140** Tobacco manufacture

32 Textile, Wearing Apparel and Leather Industries

- **321 Manufacture of textiles**
  - **3211** Spinning, weaving and finishing textiles
  - **3212** Manufacture of made-up textile goods except wearing apparel
  - **3213** Knitting mills
  - **3214** Manufacture of carpets and wool
  - **3215** Cordage rope and twine industries
  - **3219** Manufacture of textiles not elsewhere classified
- **322 Manufacture of wearing apparel except footwear**
  - **3220** Manufacture of wearing apparel except footwear
- **323 Manufacture of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel**
  - **3231** Tanneries and leather finishing
  - **3233** Manufacture of products of leather and leather substitutes and fur, except footwear and wearing apparel
- **324 Manufacture of footwear, except vulcanized or molded rubber or plastic footwear**
  - **3240** Manufacture of footwear, except vulcanized or molded rubber or plastic footwear

35 **Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products**

351 **Manufacture of industrial chemicals**

- **3511** Manufacture of basics industrial chemicals except fertilizer
- **3512** Manufacture of fertilizers and pesticides
- **3513** Manufacture of synthetic resins, plastic materials and man-made fibres except glass

352 **Manufacture of other chemical products**

- **3521** Manufacture of paints, varnishes and lacquers
- **3522** Manufacture of drugs and medicines
- **3523** Manufacture of soap and cleaning preparations perfumes, cosmetics and other toilet preparations
- **3529** Manufacture of chemical products not elsewhere classified

353 **Petroleum refineries**

- **3530** Petroleum refineries

354 **Manufacture of miscellaneous products of petroleum and coal**

- **3540** Manufacture of miscellaneous products of petroleum and coal

355 **Manufacture of rubber products**

- **3551** Tyre and tube industries
- **3559** Manufacture of rubber products not elsewhere classified

356 **Manufacture of plastic products not elsewhere classified**

- **3560** Manufacture of plastic products not elsewhere classified

Appendix 2

Misspecificaton tests

Final models

Ind.	RESET	Jarque-Bera	Breusch y Godfrey	H.S. White	ARCH	TC omision	T omision
3111	0.49	2.08	1.83	1.80	0.05	0.87	0.15
3112	0.04	0.74	1.92	0.64	0.81	0.25	-0.15
3113	0.60	0.13	1.03	0.85	0.03	0.00	0.05
3115	1.38	1.25	-0.15	0.71	0.88	0.99	0.66
3116	-0.06	1.43	-1.05	0.40	0.69	-0.12	0.81
3117	0.31	0.85	0.16	1.14	0.44	0.05	0.29
3118	-0.51	0.99	0.11	1.70	0.50	1.79 *	-0.87
3119	0.54	0.59	0.23	0.85	0.54	0.04	0.59
3121	0.15	0.08	-0.41	0.45	2.51	-0.52	-0.83
3122	1.24	1.33	2.64 *	0.90	0.00	0.85	0.06
3131	0.19	0.32	0.20	1.05	1.48	0.14	0.51
3132	-0.13	5.11 * /2	0.04	0.78	1.37	0.80	0.77
3133	0.74	0.03	-1.50	1.37	2.17	-1.68	-1.68
3134	-0.37	0.62	0.07	1.26	0.72	-1.95	NA
3140	0.02	0.69	0.65	1.77	0.00	7.45 ** /1	0.00
3211	0.60	1.79	-1.62	0.87	0.11	-1.19	-1.19
3212	1.36	2.7	-0.70	1.83	0.68	1.13	-0.64
3213	0.18	0.01	0.05	0.72	0.79	2.11	0.10
3220	0.72	0.56	0.00	0.82	2.92	-1.04	0.44
3240	0.04	1.3	0.12	0.63	0.51	1.29	0.64
3511	0.38	1.1	-0.08	0.92	1.02	0.35	0.94
3512	2.29	0.13	-0.66	0.36	3.27 *	1.16	NA
3521	-0.43	1.31	-1.31	1.00	3.54	0.84	0.42
3522	0.53	1.03	-0.63	1.14	0.08	1.26	1.14
3523	0.52	3.4	0.69	0.79	0.10	1.54	0.01
3529	1.87 *	0.51	-1.95 *	0.87	0.14	-0.08	1.09
3530	0.98	1.3	0.29	0.55	1.87	0.90	0.23
3551	1.85 *	0.04	-1.06	0.60	0.62	-1.16	-0.33
3560	2.11	0.79	0.10	0.79	0.13	0.22	1.32
31	1.47	0.65	0.69	1.07	4.17 **	0.17	0.20
32	0.22	3.97	1.17	0.61	1.20	0.09	0.14
35	0.23	0.22	0.51	0.85	2.56	0.18	-0.08
311	-0.56	0.59	1.17	0.39	1.49	-0.21	-0.31
312	0.46	2.3	0.54	0.83	0.18	-0.48	-1.23
313	-0.83	0.82	-1.24	0.46	0.26	0.31	0.24
321	-0.58	0.87	-1.01	0.63	1.69	-0.94	-1.05
351	-0.07	0.8	-1.13	1.03	0.50	1.31	1.42
352	1.45	1.38	0.05	1.15	0.01	-1.69	1.00

Notes: /1 TC was not includded due to high colinearity with the time trend in the period; /2 Normality is rejected due to the pressence of 3 atypical data whose modelation would excessively reduce the number of degrees of freedom; NA: Not Applicable; * 10% level of significance; ** 5% level of significance; *** 1% level of significance.

Appendix 3

Hausman Test

Final models

Ind.	b_mco	b_vi	q	m /1	
3111	1.202	1.174	-0.028	**8.044**	***
3112	0.441	0.411	-0.029	**62.269**	***
3113	1.402	1.392	-0.010	**1.270**	
3115	0.278	0.286	0.008	**5.253**	**
3116	0.428	0.406	-0.023	**9.824**	***
3117	0.451	0.455	0.004	**1.264**	
3118	0.465	0.430	-0.036	**45.374**	***
3119	0.625	0.614	-0.012	**2.544**	
3121	0.687	0.704	0.017	**6.404**	**
3122	0.852	0.852	0.000	**0.000**	
3131	0.785	0.732	-0.053	**17.608**	***
3132	0.572	0.610	0.038	**66.842**	***
3133	1.409	1.430	0.021	**8.434**	***
3134	0.651	0.693	0.042	**17.369**	***
3140	1.516	1.458	-0.058	**5.278**	*
3211	0.400	0.422	0.022	**29.077**	***
3212	0.547	0.587	0.040	**38.559**	***
3213	0.712	0.695	-0.017	**1.941**	
3214	0.515	0.536	0.021	**10.789**	***
3215	1.327	1.236	-0.091	**41.309**	***
3219	1.144	1.075	-0.069	**35.856**	***
3220	1.408	1.302	-0.106	**30.185**	***
3240	0.585	0.811	0.226	**36.780**	***
3511	0.489	0.518	0.029	**133.797**	***
3512	0.656	0.656	0.000	**0.002**	
3521	0.718	0.750	0.032	**16.251**	***
3522	0.873	0.798	-0.075	**41.790**	***
3523	0.203	0.201	-0.002	**0.336**	
3529	0.552	0.525	-0.027	**20.354**	***
3530	0.904	0.885	-0.018	**2.899**	*
3551	0.878	0.796	-0.082	**49.086**	***
3560	0.382	0.372	-0.011	**2.577**	
311	0.188	0.219	0.032	**59.710**	***
312	0.447	0.462	0.015	**6.928**	***
313	0.688	0.744	0.056	**76.682**	***
321	0.325	0.350	0.025	**28.035**	***
351	0.777	0.698	-0.078	**54.830**	***
352	0.397	0.372	-0.025	**10.511**	***
31	0.219	0.216	-0.003	**0.302**	
32	0.189	0.193	0.003	**1.112**	
35	0.698	0.546	-0.152	**95.491**	***

/1: * 10% level of significance; ** 5% level of significance; *** 1% level of significance.