The sensitivity of trade flows to trade barriers

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The sensitivity of trade flows to trade barriers

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Abstract

This study analyzes the sensitivity of trade flows to trade barriers from gravity equations, using different econometric techniques recently highlighted in the literature. Specifically, we compare a benchmark OLS fixed effects specification a la Feenstra (2002) with three emerging estimation methods: the standard Heckman correction for selection bias, to account for zero trade flows; the Eaton and Tamura (1994) Tobit estimator, to solve limited-dependent variable issues; and, finally, the Poisson pseudo-maximum-likelihood (PPML) technique, to correct for the presence of heteroskedasticity. Our gravity model includes trade among 193 exporter and 99 importer countries, in 18 food industry sectors. The paper achieves two goals: First it provides estimates of the elasticity of substitution obtained using the four estimation techniques; Second, it gives a dimension to the trade reduction effect induced by existing border protection, by simulating the effect of a full trade liberalization scenario on 18 food sectors. The estimates reveal interesting variations in the elasticity of substitution across products and procedures. The simulation indicates that trade liberalization will strongly increase food exports, especially from emerging and developing countries.

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Introduction

The motivation for this study came from the renewed interest in the use of gravity equations to explain bilateral trade flows, an interest partly driven by the sounder theoretical foundation of gravity model that emerged in the last decade (see Anderson and van Wincoop, 2004). As a consequence of the growing popularity of gravity models, a great deal of controversy and uncertainty has emerged over the *correct* estimation method (see, e.g., Schaefer et al. 2008, Santo Silva and Tenreyro 2008, Helpman et al. 2008).

An influential paper by Santos Silva and Tenreyro (2006) criticised the standard estimation approach that fails to properly take into account in log linear model for both heteroskedasticity and the presence of zero-value in the dependent variables. As an alternative approach they recommended the Poisson Pseudo Maximum-Likelihood (PPML) estimator. However, Martin and Pham (2008) have shown that the PPML approach produces biased results when used in the presence of a large fraction of zero trade flows, a situation consistent with recent trade models with firms heterogeneity (Melitz 2003; Helpman et al. 2008) and very frequent working at a disaggregated product level. As an alternative to the PPML method they propose the Eaton and Tamura (1994) Tobit estimator and the Heckman procedure. The first appears more consistent in the presence of limited dependent-variable issues, when the heteroskedasticity problem is dealt with; the second, by adding a variable that adjusts for sample selection issues overcomes the omitted variable bias, and is a good estimation procedure whether *true* identify restrictions are available.

In the Santos Silva and Tenreyro (2006), and the Martin and Pham (2008), papers the bias in the gravity estimation is discussed focusing especially on the 'correct' magnitude of two important coefficients of the gravity equation: distance and the GDP coefficients. However, what about sensitivity to other gravity parameters? The present paper aims at contributing to the literature by estimating the sensitivity of trade flows to tariff barriers under different estimation techniques. Indeed, a key potential of the 'gravity theory' is the possibility of identifying the import substitution elasticity between home and foreign varieties, an elasticity that represents the key behavioural parameter for capturing the general equilibrium response of trade flows to falling trade barriers (see Lai and Zhu, 2004; Lai and Trefler, 2004; Bergstrand et al., 2007).

Thus, the first objective of the study is to analyze the sensitivity of the estimated elasticity of substitutions from gravity-like equations, using different econometric techniques recently highlighted in the literature. Specifically, we compare a benchmark OLS fixed effects specification *a* la Feenstra (2002), with three emerging estimation methods: the standard Heckman correction for selection bias (Heckman, 1979), to account for zero trade flows; the Eaton and Tamura (1994) Tobit estimator recently proposed by Martin and Pham (2008) to solve limited-dependent variable issues; and, finally, the PPML technique first proposed by Santos Silva and Tenreyro (2006), to correct for the presence of heteroskedasticity.

Our second goal is to simulate the trade liberalization effect on 18 food industry sectors, using the estimation results of the best procedure in terms of 'forecast accuracy'. Specifically, we performed a mis-specification test (Ramsey's RESET test) and a goodness-of-fit test (Theil, 1961) to choose which estimated gravity model is best suited to simulating hypothetical tariff removal.

The paper is organised as follows. Section (2) justifies and presents the empirical specification of the gravity models. Section (3) describes the variables used and the data sources. Section (4) discusses the regression results and the mis-specification tests. The results from our free trade simulation exercise is reported in Section (5). Finally, Section (6) concludes.

2. The empirical framework

The standard CES monopolistic competition trade model with iceberg trade costs introduced by Krugman (1980) represents the 'benchmark' from which we derive the gravity-like equations estimated in this paper. Specifically, we rely on Lai and Zhu (2004) who show that adding a rich set of international asymmetries to the standard monopolistic competition trade model helps us to identify the key structural parameters, namely the elasticity of substitution (σ). In the estimable version of their model the bilateral trade flow from *j* to *i* can be summarized by the following log-linear bilateral trade equation:

(1) $$\log M_{ij} = \beta_0 + \lambda_j + \chi_i + (1-\sigma)\gamma \log D_{ij} + (1-\sigma)\log \tau_{ij} + u_{ij},$$

with λ_j and χ_i the exporter and importer fixed effects to control for the unobserved number of varieties (firms) and the price term of the exporter, and for the expenditure and the unobserved price term of the importer. D_{ij} is the transport costs proxy by distance between i and j; τ_{ij} is the *ad valorem* bilateral tariff; $\sigma > 1$ is the elasticity of substitution between home and foreign goods; finally u_{ij} is an error term. We are first interested in the estimation of the key parameter $\beta_2 = (1 - \sigma)$, from which we will infer the derived structural parameter $\sigma = 1 - \beta_2$,

When equation (1) is applied at the disaggregated level, the first problem that emerges is the presence of a high number of zero bilateral trade flows. One of the most common methods of dealing with zero trade is the Heckman (1979) two stage selection correction: i) a Probit equation where all the trade flows determinants are regressed on the indicator variable, T_{ij}, equal to 1 when j exports to i and 0 when it does not; ii) an OLS second-stage with the same regressors as the Probit equation, plus the inverse Mills ratio from the first stage, correcting the biases generated by the sample selection problems. Following the modification suggested by Helpman et al. (2008) and supported by Martin and Pham (2008), we omitted in the OLS an independent variable associated with the fixed trade costs of establishing trade flows[1].

Since the logarithm of zero is not defined, another way to solve for zero trade flows in the log linear gravity equation is to use a Tobit estimator. Thus, following Martin and Pham (2008), we implemented the Eaton and Tamura (1994) Tobit estimation procedure. Here, to derive the maximum likelihood function, the bilateral trade flows, M_{ij}, are modeled as follows:

$$(4) \quad \log(M_{ij}^{*} + A) = \beta_0 + \lambda_j + \chi_i + (1-\sigma)\gamma \log D_{ij} + (1-\sigma)\log \tau_{ij} + u_{ij}$$

where $M_{ij} = M_{ij}^{*}$ if $M_{ij}^{*} > 0$

$M_{ij} = 0$ otherwise

Equation (4) specifies that the right-hand side has to reach a minimum threshold (A) before bilateral trade takes a positive value. A is a parameter to be estimated (see Eaton and Tamura, 1994). Moreover, due the very large sample of our database, we introduced the adjustment for heteroskedasticity recently proposed by Martin and

[1] Martin and Pham (2008) noted that the Heckman sample selection estimators gave poor results when estimated with the same variables in the selection and estimation equation.

Pham (2008). They improved the performance of the E-T Tobit model using the adjustments proposed by Maddala (1985), specifying the error variance by the process $\sigma_i^2 = (\xi + \delta\ (x_i\ \beta))^2$, where ξ and δ are parameters estimated together with the parameters of interest.

Finally, the last estimation technique is the Poisson Pseudo-Maximum-Likelihood estimator. For several reasons, this method has met with success in gravity literature since the important contribution of Santos Silva and Tenreyro (2006). Indeed these authors suggest that, as a consequence of Jensen's inequality, $E(\ln y) \neq \ln E(y)$. Thus, the standard practice of interpreting the parameters of a log-linearized model estimated by OLS as elasticity can be highly misleading in the presence of heteroskedasticity (Santos Silva and Tenreyro 2006, 641). The PPML estimator is very simple to implement with standard econometric programs, as with this method the gravity equation is estimated in its multiplicative form, thus with the dependent variable in levels, representing also a natural way to deal with zero trade flows.

4. The data

Our gravity model includes trade among 193 exporter and 99 importer countries, of 18 food industry sectors. The number of countries is limited by the availability of importer bilateral tariff data that precludes the possibility of squaring the dataset. We used the UN Comtrade database for bilateral trade at the HS-96 6-digit level, reported by the importer countries, then aggregated at the 4-digit ISIC industry classification. To partially reduce the zero data of one year's observations, we used the average value of trade for the years 2002-03-04. However, more than the 70% of the 222,457 observations in our dataset are zero trade flows (see Figure 1). As suggested by Martin and Pham (2008), some of the zero reflects errors, omissions and, rarely, rounding error due to reported low trade values. However, it appears that most of the zero trade flows between country pairs reflects a true absence of trade.

Output data come from the UNIDO database and are for the most part based on ISIC rev. 3 at 4-digits (code from 1511 to 1600), supplemented by the UNIDO ISIC rev. 2 data in the case of missing values. Transport costs are proxied by bilateral distances between cities, weighted by the share of the city in the country's overall population. Data on distance, with dummies for other trade costs normally used in similar exercises (contiguity, language, colony, and common colonizer), are taken from CEPII (Centre d'Etude Prospectives et d'Informations Internationales).

Bilateral tariff data come from the MAcMap database jointly developed by ITC (UNCTAD and WTO, Geneva) and CEPII (Paris). It includes *ad-valorem*, as well as specific components of each bilateral tariff line at the six digit level of the Harmonized System (HS). Average tariffs are computed starting from the HS 6-digit bilateral tariffs, then aggregated at the ISIC 4-digit level using import weights based on the reference group method of Bouët et al. (2007).

5. Estimation results

We estimate equation (1) to examine the sensitivity of trade flows to trade barriers, using two sets of gravity estimates: one pooled over the 18 food industries (Table 1), the other considering each of the 4-digit food sectors separately (Table 2). Table 1 is structured as follows: column 1 reports the OLS benchmark; column 2 the first stage Probit for the Heckman procedure; column 3 the second Heckman' stage; column 4 the E-T Tobit model results; column 5 the PPML estimates using only the sub-sample of positive trade pairs[2].

Starting from the pooled results (Table 1), the first point to note is that tariff coefficients, always negative and highly statistically significant, are remarkably similar in the OLS and Heckman procedures. The derived elasticity of substitution[3] for food industry products ranges between 2.56 and 2.61, thus very close to the 2.53 value estimated by Lai and Trefler (2004) using a more complex dynamic panel method.

The Probit results strongly confirm that the same variables that impact export volumes also affect the probability that country *j* exports to country *i*, and the impact is in the same direction. Indeed, the presence of tariffs reduces the probability of registering positive trade flows by more than 50%.[4] At the end, when we consider overall food trade, both the Eaton-Tamura and the Poisson results show that tariffs play a smaller role compared with OLS estimates. Moreover, the PPML estimates

[2] Poisson estimates using the whole sample present very similar results; the tariff coefficients are always slightly lower than in Poisson with only positive trade.

[3] Remember that from equation (1) the tariff coefficient is equal to $(1 - \sigma)$, thus the substitution elasticity estimates are equal to the absolute tariff coefficients plus 1.

[4] Note that, for the second stage estimation, Martin and Pham (2008) suggested excluding variables that affect fixed trade costs but do not affect variable trade costs. Following other authors, we selected common language and common colonizer, variables that have substantial explanatory power for the formation of trading relationships, and statistically significant in the probit first-stage.

indicate that sharing a common language and having colonial relationship does not influence trade flows.

This preliminary evidence gives a broad confirmation of the Santos Silva and Tenreyro' (2006) findings, namely that estimating the gravity model with the PPML technique tends to produce lower (absolute) estimated coefficients of distance and other trade costs parameters. The innovation here is that a similar effect also applies to the bilateral tariff coefficient, from which we can infer our structural parameter of interest, the elasticity of substitution. Thus, at the aggregate level, the PPML approach displays lower substitution elasticity than other estimation methods.

Table 2 shows the substitution elasticities obtained from tariff coefficients of gravity regressions estimated for each 4-digit ISIC sector separately. The specification is identical to the regressions of Table 1, except for the exclusion of importer and exporter production values that now are subsumed by importer and exporter fixed effects. As expected, the results at the (disaggregated) product level show that bilateral tariffs generally affect trade flows significantly more, but with strong heterogeneity across industries. This result is perfectly in line with the notion that the magnitude of the substitution elasticity estimate tends to increase with the level of the disaggregation of the analysis (see Anderson and van Wincoop, 2004). All the estimated elasticises are positive, and about 15 of the 18 are statistically significant at the 5% level or more. The estimated values across all methods range from 1.5 to 14, with mean and median values equal to 4.32 and 3.48, respectively. These figures are broadly comparable with previous evidence (see, e.g., Hummels, 2001; Hertel et al 2004), although direct comparison is problematic as our disaggregation level tends to be significantly higher than in the previous exercise based on a similar approach.

Useful comparison can be made with the results of Broda and Weinstein (2006), who estimated import substitution elasticities at a very disaggregated level using the Feenstra' (1994) import demand equations approach. Aggregating their elasticity estimates at the ISIC 4-digit level (from SITC 4-digit) we have mean and median values of 4.49 and 5.48 respectively, which, as expected, are just slightly higher than our estimate. Thus, we conclude that our estimates appear broadly within the range of existing evidence.

Next, by comparing the results across different estimation methods, several interesting differences emerge. In the OLS benchmark estimate the average magnitude of the elasticity across products is 4.2, thus significantly higher than the previous pooled regression, and ranging from 2.4 (spirits) to 9.2 (fish). Differently, when we correct for selection bias (column 2) the elasticities decrease, on average, by 16%, while with the E-T Tobit model the reduction is about 34%. By contrast, using the PPML approach (column 4), we observe a remarkable growth in the estimated elasticities of about 70%, associated with a generalized lower distance elasticity (not reported). Interestingly, for many products, the elasticity estimates with the PPML method is more than two times the benchmark OLS value. Thus, the PPML results at the product level go in the opposite direction with respect to the aggregated level, suggesting that potential aggregation bias are driving the results.

The rank correlation between the substitution elasticities obtained with different econometric methods adds further considerations to the analysis. Indeed, a strong positive correlation exists between the OLS and the Heckman techniques (0.91); the correlation drops somewhat on passing to the E-T Tobit model (0.51)[5]. By contrast, the Poisson's substitution elasticities present a weak rank correlation with both the OLS (0.28), and with the other methods. This evidence seems to suggest that, at the disaggregate level, the difference between PPML and other methods is largely driven by the large fraction of zero trade flows, more than by heteroskedasticity problems.

The strong heterogeneity in the results discussed above raises the question about which is the best estimation strategy to reach the second goal of our paper, namely the simulation of the trade effect induced by tariff removal. To deal with this we performed two formal tests: a mis-specification test and a goodness-of-fit test. Mis-specification can cause significant bias and efficiency problems for econometric models, thus, following Santos Silva and Tenreyro (2006) we checked the adequacy of the estimated models with the RESET test (Ramsey, 1969). The test is performed by adding an additional regressor, constructed as $(x^{'}b)^2$ where *b* is a vector of estimated parameters, and checking its significance.

Considering the estimates pooled over the 18 food industries, the corresponding *p*-values of the Reset tests are reported at the bottom of Table 1. It shows that, with the

[5] Despite the average substitution elasticities of the E-T procedure being absolutely similar when estimated with the classical procedure, and with the Martin and Pham (2008) heteroskedasticity correction (2.346 *vs.* 2.335), the rank correlation between OLS and E-T Tobit classical procedure presents a higher value (0.83 *vs.* 0.51).

exclusion of the Heckman and PPML methods, all other 'aggregated' gravity models are mis-specified.

On the other hand, applying the RESET test at the product level (see Table 3), there emerges a strong heterogeneity in the results, suggesting that when zero trade flows represent a large fraction of the data, misspecification issues are definitely more severe.[6] The *p*-values for the tests are extremely small in both the OLS and the E-T Tobit models for almost all sectors, indicating serious mis-specification problems. By contrast, most product estimates obtained using the Heckman and the PPML procedure pass the test, and this is particularly true for the Heckman method.

The second test we performed, to better understand which estimation procedure to use for the simulation, is Theil's *U*-statistic (see Martinez-Zarzoso et al. 2007). It is a measure of forecast accuracy suggested by Henry Theil (1961), and is measured as the square root of the sum of the squared deviations of the prediction from the observed values, divided by the square root of the sum of the squared actual values. Theil's *U*-statistic reaches its lowest boundary of zero for perfect forecasts. The values obtained at the product level are reported in table 4, and show that OLS and the Heckman procedure give better forecast accuracy than Tobit and Poisson in most of food industry sectors analysed. Exceptions are bakery production and macaroni, noodle and couscous products, where the PPML Theil's statistics are lower than those obtained with the other methods.

Summarizing, the RESET test and the *U*-statistic, taken together, suggest that the best estimation method for our purpose is the Heckman, a conclusion in line with recent empirical evidence (Helpman et al. 2008, Martin and Pham 2008, Cipollina and Salvatici 2008). Thus we chose to use the Heckman two-stage estimation results for our simulation of a hypothetical elimination of existing tariffs.

6. The trade effects of tariff removal

In this section we deal with the economic implications of our model by simulating the extent to which bilateral tariffs restrict the volume of trade. More specifically, following Lai and Zhu (2004), we simulated a hypothetical trade liberalization effect

[6] Working al product level, the omission of country production variable increase the number of trading countries and, consequently, the presence of zero trade. The zero trade represents 50% of trade in results of table 1, and up to 77% in estimations of table 2.

as the percentage change in trade due to the elimination of tariffs. This tariff effect is formally estimated as

$$\text{Tariff effect} = \frac{\sum_i \sum_j \left[E\left(M_{ij} \middle| \tau_{ij} = 0\right) - E\left(M_{ij} \middle| \tau_{ij} > 0\right) \right]}{\sum_i \sum_j E\left(M_{ij} \middle| \tau_{ij} > 0\right)}.$$

We calculated the tariff effects using the estimates of the Heckman procedure for the 18 food sectors, reported in Table A.1. In analysing the simulation results it is important to keep in mind that they actually represent very rough, and preliminary, estimations. This is because they are obviously calculated disregarding the unexplained part of the model, and moreover they totally disregard other channels through which trade liberalization exerts its effects, like via outputs (varieties), wages and terms of trade variations.

Because most trade is among ‘rich’ countries, especially European countries, and the highest tariffs are among ‘poor’ countries (developing and emerging), we selected three exporting country groups to better evaluate the tariff liberalization effects. The first two groups are those of high income and low to medium income, as defined by the World Bank, and are labelled as ‘high income’ and ‘developing’ countries. The last group considers the ‘emerging’ countries, selected on the basis of the FTSE group classification[7].

Table 5 shows the results of the estimated tariff effect, revealing that this trade barrier reduced food industry world trade by 16% in the observed period. This figure appears comparable with the results of Francois et al. (2005), who, using global computable general equilibrium model, find a liberalization impact of the 21% on agricultural and food trade.

The simulated effect of tariff removal is particularly important for the ‘emerging’ and ‘developing’ country groups where the exports increase by 31% and 22%, respectively. By contrast, ‘rich’ countries food export, wich trade value represents more than two third of world trade, grows by about 10%, a result fairly close to the 16% obtained by Anderson et al. (2006) for ‘high income’ export grow of, both, agricultural and food trade, using a dynamic computable general equilibrium model.

[7] The FTSE group is an independent company owned by the Financial Times and the London Stock Exchange. Emerging markets are identified as those developing countries with superior growth prospects. See http://www.ftse.com/index.jsp. Note that using other classifications for emerging countries does not to any degree affect the qualitative results and conclusions of the analysis.

Not surprisingly, these aggregate effects of tariff removal mask substantial heterogeneity across the product level. Specifically, the highest increase is on grain mill products, where trade volume is almost doubled, driven by 'emerging' countries exports that would benefit from tariff removal, increasing, by two times, their grain mill export volumes. These countries realize the most impressive growth in market share on 'high income' countries markets.

Furthermore, malt product world exports increase by 62% due to the increase of the 'high income' countries exports. The meat products industry, which is the most important traded product representing about 16% of the world food trade, increases its exports by about 13%. The effect is lightly higher than the Hertel and Keeney (2006) results obtained for 'cattle' and 'other' meat, respectively 10.3% and 10.8%, using GTAP-AGR model in a partial liberalization scenario, and slightly lower than the estimate of Ghazalian et al. (2007) for bovine meat (18%), obtained using a gravity model accounting for the vertical production linkages between primary and processed cattle/beef products. Moreover, in line with their results, we find that, among the 'high income' countries, United States, Australia, Canada and New Zealand are the exporting countries that stand to benefit the most from tariff removal, increasing especially their export towards the European Union and Japan.

Finally, particularly interesting is the analysis of bilateral trade variations among groups reported on Table 6. The 'rich' country group presents the least percentage increase in imports. However, as this country group already accounts of almost the 80% of world food imports, its increase in the volume of imports is always the highest. What is worth notice from these bilateral effects is that the percentage increase in exports of both Developing and Emerging countries is generally higher within themselves than towards the High income countries. Thus, while in term of exports volume these groups should focus their strategy to lowering trade barriers of High income countries, also lowering trade barriers among themselves should represent an important priority in trade negotiations.

7. Conclusions

A key potential of the 'gravity theory' is the possibility to identify the import substitution elasticity between home and foreign varieties, an elasticity that represents the key behavioural parameter for capturing the general equilibrium response of trade flows to falling trade barriers. In this paper, we show that the value of these elasticities are very sensitive to both the level of aggregation in trade data and, especially, the econometric technique. In contrast to the influential paper of Santos Silva and Tenreyro (2006) our results at disaggregated level show that the standard Heckman sample-selection two step estimators, when properly specified, perform well and this appears especially true when the estimated model is used for statistical forecast. By contrast, the PPML approach works very well at the aggregate level, but appears dominated by the Heckman procedure at disaggregate level, and often also in term of forecasts performance.

Our substitution elasticity estimates are in the range of the most recent evidence confirming the validity of the gravity-like model to identify this important structural parameters. At food industry 4-digit level our preferred substitutions elasticity estimates have a mean and median value of 3.68 and 3.38, respectively. Finally we show that a very simple simulation of an hypothetical full trade liberalization scenario produce bilateral trade effects that are not so far from actual evidence based on more complex approaches. From this point of view, we conclude that more investments in econometric work to estimate the gains from trade liberalization could represent an interesting avenue for future researches.

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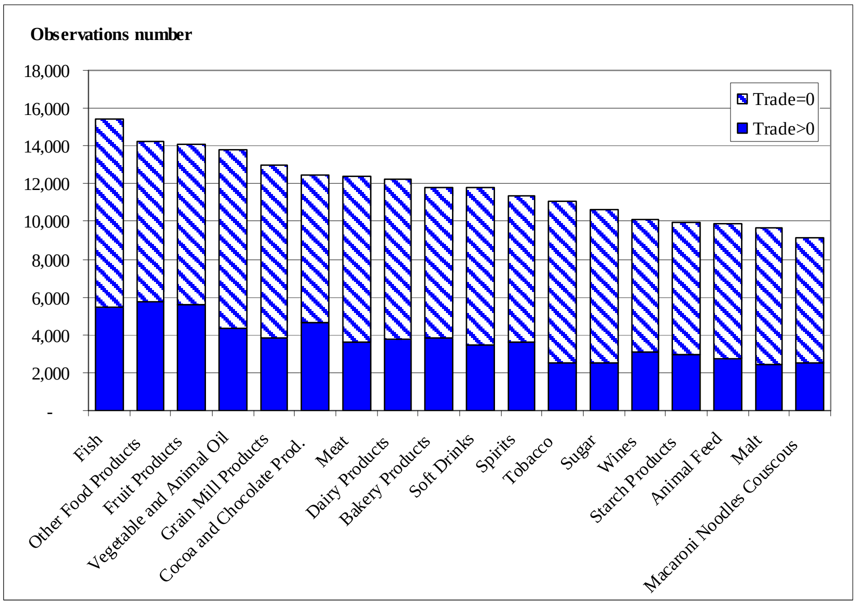

Figure 1. Number of observations with positive and zero trade in the period 2002-2004, disaggregated at 4-digit ISIC industry classification

Table 1. Results at Aggregated Level across Different Methods

	OLS	*Probit*	Heckman	E-T Tobit	PPML>0
Log(production)i	-0.049	**-0.057**	**-0.073**	**-0.126**	-0.191
	(0.03)	(0.01)	(0.03)	(0.02)	(0.10)
Log (production)j	**0.643**	**0.200**	**0.719**	**0.793**	**0.810**
	(0.03)	(0.01)	(0.03)	(0.02)	(0.06)
Log Distance	**-1.361**	**-0.770**	**-1.604**	**-1.678**	**-1.065**
	(0.06)	(0.02)	(0.09)	(0.03)	(0.07)
Log (1+ tariff)	**-1.561**	**-0.526**	**-1.607**	**-1.550**	**-1.199**
	(0.24)	(0.06)	(0.22)	(0.11)	(0.44)
Common Language	**0.300**	**0.292**		**0.566**	0.244
	(0.15)	(0.05)		(0.07)	(0.13)
Common Border	**1.025**	**0.683**	**1.226**	**0.656**	**0.511**
	(0.13)	(0.09)	(0.14)	(0.08)	(0.14)
Colonial Relationship	**0.768**	**0.843**		**0.893**	0.220
	(0.17)	(0.08)		(0.08)	(0.15)
Common Colonizer	**1.615**	**1.102**	**2.082**	**2.624**	**1.604**
	(0.28)	(0.05)	(0.31)	(0.11)	(0.33)
Mills ratio			**1.123**		
			(0.18)		
A				**2.585**	
				(0.10)	
Observations	16,095	31,105	16,095	31,105	16,095
RESET test p-value	0.000		0.628	0.000	0.892
U-Theil coeff.	0.210		0.209	0.232	0.556

Notes: Exporter, Importer and 3-digit industry fixed effects included in each regression. Marginal effects at sample means reported for Probit. Standard errors in parentheses. Pseudo R-squared reported for Probit and Poisson. Number in Bold (*Italic*) when the significant level is higher than 5% (10%).

Table 2. Substitution Elasticities at ISIC 4-digit Level

	OLS	**Heckman**	**E-T Tobit Heterosc.**	**PPML>0**	**Obs Trade>0 Tot.trade**
Meat	**3.050**	**2.424**	1.016	2.083	3,621
1511	(3.36)	(2.48)	(0.05)	(1.25)	12,389
Fish	**9.190**	**7.128**	**3.266**	**12.540**	5,447
1512	(5.78)	(4.70)	(2.59)	(2.97)	15,445
Fruit Products	**4.234**	**3.132**	**2.420**	**8.695**	5,619
1513	(3.72)	(2.64)	(3.26)	(6.42)	14,122
Vegetable and Animal Oil	**4.766**	**4.129**	**2.614**	2.007	4,373
1514	(2.48)	(2.38)	(1.81)	(0.56)	13,769
Dairy Products	**5.011**	**3.933**	**2.357**	**3.989**	3,728
1520	(5.43)	(4.34)	(3.31)	(4.32)	12,258
Grain Mill Products	**3.700**	**3.382**	**2.332**	**4.590**	3,850
1531	(4.84)	(4.52)	(4.44)	(7.67)	12,969
Starch Products	**4.440**	**3.855**	**2.078**	**3.409**	2,979
1532	(5.53)	(4.77)	(2.61)	(4.62)	9,949
Animal Feed	**4.758**	*3.068*	0.781	*4.007*	2,753
1533	(3.39)	(1.86)	(0.31)	(1.77)	9,901
Bakery Products	**5.187**	**5.417**	**5.655**	**14.160**	3,827
1541	(2.45)	(2.60)	(7.46)	(7.09)	11,793
Sugar	*1.790*	1.214	**0.208**	**3.313**	2,521
1542	(1.94)	(0.52)	(2.05)	(4.28)	10,633
Cocoa and Chocolate Prod.	**7.633**	**7.214**	**6.527**	**14.150**	4,661
1543	(5.70)	(5.87)	(8.83)	(6.31)	12,457
Macaroni Noodles Couscous	1.822	1.507	**2.602**	**6.886**	2,501
1544	(0.82)	(0.50)	(2.47)	(4.80)	9,149
Other Food Products	**3.533**	*3.131*	**2.117**	**8.707**	5,752
1549	(2.14)	(1.85)	(1.96)	(4.02)	14,214
Spirits	**2.401**	2.077	0.566	3.199	3,607
1551	(2.08)	(1.64)	(1.11)	(1.62)	11,374
Wines	**2.791**	**2.448**	**2.183**	**9.448**	3,113
1552	(2.38)	(2.10)	(3.09)	(2.94)	10,076
Malt	**4.916**	**5.605**	**6.485**	**6.717**	2,449
1553	(6.02)	(6.27)	(8.54)	(3.48)	9,691
Soft Drinks	**4.295**	*4.034*	**2.628**	*6.113*	3,449
1554	(1.92)	(1.79)	(2.71)	(1.73)	11,785
Tobacco	**2.539**	**2.692**	**3.426**	**5.387**	2,533
1600	(2.31)	(2.52)	(6.22)	(2.81)	11,094

Notes: Regressions include: Exporter and Importer fixed effects, as well as all the variables used in regressions of Table 1. Absolute *t*-statistic in parentheses. The adj R-squared of the OLS regressions range from 0.45 to 0.68. Number in Bold (*Italic*) when the significant level higher than 5% (10%).

Table 3. RESET test (p-value)

	Estimation procedure			
Food industry sector	OLS	Heckman	E-T Tobit	PPML
Meat-1511	0.000	0.064	0.001	0.038
Fish -1512	0.000	0.861	0.001	0.000
Fruit Products-1513	0.000	0.621	0.034	0.200
Vegetable and Animal Oil-1514	0.143	0.036	0.000	0.000
Dairy Products-1520	0.001	0.118	0.041	0.352
Grain Mill Products-1531	0.021	0.961	0.000	0.000
Starch Products-1532	0.005	0.800	0.000	0.978
Animal Feed-1533	0.000	0.569	0.008	0.008
Bakery Products-1541	0.000	0.535	0.030	0.363
Sugar-1542	0.000	0.011	0.000	0.000
Cocoa and Chocolate Prod.-1543	0.000	0.166	0.316	0.698
Macaroni Noodles Couscous-1544	0.000	0.032	0.000	0.002
Other Food Products-1549	0.000	0.062	0.002	0.000
Spirits-1551	0.001	0.132	0.001	0.966
Wines-1552	0.000	0.044	0.562	0.013
Malt-1553	0.163	0.459	0.000	0.000
Soft Drinks-1554	0.003	0.519	0.000	0.064
Tobacco-1600	0.063	0.084	0.000	0.000

See text.

Table 4. U-Theil statistic

Food industry sector	Estimation procedure			
	OLS	Heckman	E-T Tobit	PPML
Meat-1511	0.3375	0.3358	0.4069	0.4521
Fish -1512	0.3324	0.3309	0.3915	0.4421
Fruit Products-1513	0.3364	0.3386	0.3689	0.3843
Vegetable and Animal Oil-1514	0.3670	0.3678	0.4391	0.5984
Dairy Products-1520	0.3478	0.3453	0.4156	0.4280
Grain Mill Products-1531	0.4033	0.4033	0.4777	0.4151
Starch Products-1532	0.3762	0.3756	0.4317	0.3931
Animal Feed-1533	0.3411	0.3397	0.3957	0.3195
Bakery Products-1541	0.3870	0.3901	0.4363	0.2396
Sugar-1542	0.4455	0.4449	0.7533	0.6243
Cocoa and Chocolate Prod.-1543	0.3568	0.3554	0.4018	0.2981
Macaroni Noodles Couscous-1544	0.4336	0.4372	0.5059	0.2715
Other Food Products-1549	0.3609	0.3555	0.3980	0.4104
Spirits-1551	0.3943	0.3911	0.4770	0.4317
Wines-1552	0.3697	0.3692	0.4548	0.3368
Malt-1553	0.4022	0.4059	0.4700	0.4632
Soft Drinks-1554	0.4272	0.4295	0.4873	0.4318
Tobacco-1600	0.4424	0.4373	0.5840	0.4446

See text.

Table 5. Tariff Effect (%) and Trade Value (million US$)

Tariff effect (%)

Product		Exporter High Income	Developing	Emerging	World
1511	Meat	7.6%	19.9%	39.2%	13.3%
1512	Fish	14.8%	12.5%	26.1%	19.3%
1513	Fruit Products	5.0%	9.8%	21.4%	11.3%
1514	Vegetable and Animal Oil	8.3%	7.4%	17.5%	13.5%
1520	Dairy Products	15.1%	85.1%	86.0%	21.7%
1531	Grain Mill Products	13.9%	50.6%	210.5%	85.7%
1532	Starch Products	7.7%	41.0%	33.7%	12.8%
1533	Animal Feed	3.2%	27.1%	14.8%	5.2%
1541	Bakery Products	6.8%	20.2%	27.4%	9.6%
1542	Sugar	1.3%	7.4%	6.5%	4.9%
1543	Cocoa and Chocolate Prod.	12.7%	45.0%	76.8%	26.0%
1544	Macaroni Noodles Couscous	1.6%	2.6%	4.9%	2.3%
1549	Other Food Products	8.4%	12.5%	21.4%	10.6%
1551	Spirits	4.2%	4.5%	4.2%	4.2%
1552	Wines	4.5%	18.6%	12.7%	5.7%
1553	Malt	70.6%	43.7%	40.9%	62.7%
1554	Soft Drinks	5.8%	17.8%	16.3%	7.9%
1600	Tobacco	18.0%	24.3%	135.4%	26.6%
15-16	Processed Food	10.4%	22.4%	30.9%	16.4%

Trade value (million US$)

Product		Exporter High Income	Developing	Emerging	World
1511	Meat	44,824	1,807	9,343	55,974
1512	Fish	20,667	8,284	22,140	51,091
1513	Fruit Products	17,351	1,368	10,911	29,630
1514	Vegetable and Animal Oil	13,294	2,467	20,596	36,356
1520	Dairy Products	29,200	1,179	1,827	32,207
1531	Grain Mill Products	6,167	964	3,820	10,951
1532	Starch Products	4,358	168	850	5,376
1533	Animal Feed	7,584	214	1,132	8,929
1541	Bakery Products	9,102	358	1,193	10,653
1542	Sugar	3,350	2,616	3,569	9,534
1543	Cocoa and Chocolate Prod.	12,926	1,391	2,877	17,194
1544	Macaroni Noodles Couscous	2,294	76	614	2,984
1549	Other Food Products	21,181	1,186	4,059	26,426
1551	Spirits	11,332	721	1,541	13,594
1552	Wines	15,228	482	1,673	17,382
1553	Malt	5,576	275	1,797	7,648
1554	Soft Drinks	5,546	311	973	6,829
1600	Tobacco	12,345	781	989	14,116
15-16	Processed Food	242,324	24,648	89,903	356,875

Notes: Tariff effect is calculated using the estimates of the Heckman correction second stage procedure for the 18 food sectors (see Table A.1). Trade volume refers to the average values used in the model.

Table 6. The Estimated Tariff Effect Pooled by Country Group

	Exporter			
Importer	High Income	Developing	Emerging	World
		Tariff effect (%)		
High Income	4.2%	18.2%	31.2%	10.5%
Developing	76.3%	31.3%	40.4%	54.9%
Emerging	31.8%	26.6%	24.7%	28.1%
World	10.4%	22.4%	30.9%	16.4%
		Trade value (million US$)		
High Income	208,043	14,777	57,917	280,736
Developing	12,416	4,256	11,237	27,909
Emerging	21,865	5,615	20,750	48,230
World	242,324	24,648	89,903	356,875

Notes: High Income countries include the 15 European Union countries

Table A.1 Estimations with Heckman procedure

	lnd	lnt	Contiguity	Common colony	Mills ratio	Constant	Observ.	Adjusted R-squared
Meat	**-1.951**	**-1.424**	**0.809**	**1.670**	**1.012**	**10.251**	3,621	0.580
1511	(0.09)	(0.58)	(0.20)	(0.24)	(0.16)	(0.59)		
Fish	**-1.444**	**-6.128**	**1.014**	**1.265**	**1.213**	**10.156**	5,447	0.585
1512	(0.08)	(1.30)	(0.21)	(0.20)	(0.15)	(0.57)		
Fruit Products	**-1.507**	**-2.132**	**1.235**	**1.573**	**0.804**	**8.467**	5,619	0.630
1513	(0.07)	(0.81)	(0.18)	(0.18)	(0.15)	(0.46)		
Vegetable and Animal Oil	**-1.704**	**-3.129**	**0.970**	**0.969**	**0.625**	**9.731**	4,373	0.536
1514	(0.09)	(1.32)	(0.20)	(0.19)	(0.16)	(0.70)		
Dairy Products	**-1.882**	**-2.933**	**1.271**	**1.205**	**1.306**	**8.209**	3,728	0.582
1520	(0.10)	(0.68)	(0.22)	(0.24)	(0.20)	(0.66)		
Grain Mill Products	**-1.701**	**-2.382**	**1.434**	**0.802**	**0.530**	**10.966**	3,850	0.507
1531	(0.11)	(0.53)	(0.24)	(0.26)	(0.16)	(1.07)		
Starch Products	**-1.570**	**-2.855**	**1.162**	**1.337**	**0.706**	**11.189**	2,979	0.568
1532	(0.10)	(0.60)	(0.19)	(0.32)	(0.19)	(0.78)		
Animal Feed	**-1.723**	*-2.068*	**0.966**	**1.224**	**1.220**	**7.122**	2,753	0.535
1533	(0.10)	(1.11)	(0.23)	(0.34)	(0.18)	(0.63)		
Bakery Products	**-2.055**	**-4.417**	**1.570**	**1.377**	**0.838**	**15.954**	3,827	0.593
1541	(0.11)	(1.70)	(0.18)	(0.24)	(0.18)	(0.67)		
Sugar	**-1.755**	-0.214	**0.723**	**0.154**	**1.119**	**11.549**	2,521	0.457
1542	(0.21)	(0.41)	(0.28)	(0.37)	(0.34)	(1.30)		
Cocoa and Chocolate Prod.	**-1.956**	**-6.214**	**0.723**	**1.584**	**1.189**	**10.203**	4,661	0.607
1543	(0.10)	(1.06)	(0.19)	(0.26)	(0.20)	(0.64)		
Macaroni Noodles Couscous	**-1.650**	-0.507	**1.478**	**0.931**	**0.713**	**8.843**	2,501	0.503
1544	(0.13)	(1.01)	(0.24)	(0.26)	(0.21)	(1.29)		
Other Food Products	**-1.862**	*-2.131*	**1.036**	**0.898**	**1.154**	**15.109**	5,752	0.587
1549	(0.09)	(1.15)	(0.18)	(0.18)	(0.18)	(0.65)		
Spirits	**-1.505**	-1.077	**1.201**	**1.896**	**1.237**	**10.113**	3,607	0.565
1551	(0.13)	(0.66)	(0.24)	(0.30)	(0.21)	(0.86)		
Wines	**-1.345**	**-1.448**	**1.096**	**2.658**	**1.427**	**6.401**	3,113	0.662
1552	(0.10)	(0.69)	(0.23)	(0.38)	(0.18)	(0.77)		
Malt	**-1.230**	**-4.605**	**1.845**	**2.066**	**0.467**	**10.569**	2,449	0.521
1553	(0.12)	(0.73)	(0.21)	(0.32)	(0.22)	(0.65)		
Soft Drinks	**-1.560**	*-3.034*	**1.771**	**1.311**	**0.544**	**8.137**	3,449	0.556
1554	(0.09)	(1.70)	(0.19)	(0.25)	(0.13)	(0.56)		
Tobacco	**-1.965**	**-1.692**	**0.886**	**1.933**	**1.506**	**9.648**	2,533	0.512
1600	(0.12)	(0.67)	(0.24)	(0.33)	(0.25)	(1.25)		

Notes: Regressions include: Exporter and Importer fixed effects. Standard errors in parentheses. Number in Bold (*Italic*) when the significant level higher than 5% (10%).