ALTERNATIVE MEASURES FOR TRADE RESTRICTIVENESS.  
*A GRAVITY APPROACH*

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ABSTRACT

We show that it is possible to estimate the cost of protection in terms of the trade loss for the protected country using a widely accepted and theory-based specification of the gravity model in combination with descriptive trade policy indicators. Data and implementation requirements are lower than in CGE models and this permits estimations with wider samples of countries and years. The outcome can be interpreted as the uniform tariff that synthesizes both the direct effect of trade barriers and the indirect effect of import substitution. The estimated tariff equivalents confirm the underestimation of protection costs by more than 40% when using weighted average tariffs, in accordance with previous literature, with a greater measurement error for less developed countries. Furthermore, substitution elasticities are shown to be a key mechanism for the restrictiveness of tariff policies.

Keywords: Tariff policy, cost of protection, foreign trade, gravity equation, tariff equivalent.

JEL Classification: F13, C23

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Introduction

A number of different empirical analyses of trade policy need previous measures of trade policy barriers. Current research areas such as the openness-growth literature, international trade negotiations or even analysis of the determinants of trade must have some kind of indicators not only of the levels of trade barriers but also of the effects of such barriers on trade and/or welfare. Different objectives will imply different needs. For example, some participants in trade negotiations may be interested in increasing a country’s welfare through trade liberalization, while others – such as exporters – are more concerned with the effects of changes in access to markets. These effects are not straightforwardly obtained from existing data on nominal or effective tariffs.

This paper adds to the discussion on how to measure the effects of trade policy on access to markets at country level. It offers an instrument for estimating an outcome measure of the protection cost in the form of an equivalent tariff which takes into account not only the direct effect of policy barriers to trade but also structural features such as the import elasticity of substitution. Our approach keeps data requirements relatively low, so that it can be used for large samples of countries or years.

The traditional measures of trade protection have been widely questioned because they underestimate the cost of protection and because they do not necessarily reflect the effects of protection on trade flows or welfare. Some very recent methods try to obtain synthetic indicators of protection using Computable General Equilibrium (CGE) models, or simplifications of them, such as the Trade Restrictiveness Indexes of Anderson and Neary (1994, 2003), but they are quite information-intensive and sensitive to the assumptions adopted, which makes it difficult to apply them to groups of countries or long periods of time.

One approach proposed to overcome this problem is the use of gravity models, which are generally very successful in predictions and allow us to obtain the degree to which the trade of a country differs from that predicted by the model as an approximation
of the cost of protection. The advantages of this approach are that it implicitly adopts a general equilibrium approach, by considering the cross price effects between sectors and, moreover, it does not require extremely demanding information.

The objective of this paper is to use a gravity model to estimate the cost of tariff protection in terms of trade restrictions in a more ambitious context than in previous papers (with a starting point in Wall [1999], who focused on the USA and for just one year). For the largest possible sample of bilateral partners and for the period 1970-2000, various trade policy indicators are used in the gravity equation in order to evaluate the robustness of the results. With the aim of achieving a more direct comparison between countries and periods, the estimations are used to construct a tariff equivalent for each country and year.

In the next section, there is a summary of the main discussions on the measurement of protection costs in the theoretical and applied literature. The second section presents the specification chosen for the gravity model and the data sources for our variables. The third section comments on the results of the estimated model. The fourth presents their translation into a tariff equivalent comparable between countries. Finally, there is a brief summary and the conclusions.
1. Protection cost measurement: theoretical and empirical approaches

In spite of the generalised acknowledgment of the growing liberalisation of trade flows between countries, there are still numerous obstacles to international trade, both of the tariff and non-tariff type, in practically all the countries in the world. Classical economic theory defends trade liberalisation as a source of greater welfare for countries, although more recent developments in growth theory and the new theory of international trade, in their effort to get closer to the complexity of trade relations and their policies, reduce the number of occasions on which the recommendation of greater openness can be made unquestioningly.

The effects of trade protection on the country that introduces it have been widely described in theoretical terms. They range from the direct effects on international trade, production and internal consumption, to increases in inefficiency, dominant market positions or diversion of resources because of rent seeking, among others. In any case, the most accepted view is that protection has a cost in the efficient allocation of resources in the protected economy. This cost is related to the capacity of the instruments of protection (tariffs, quotas, administrative barriers, prohibitions, among others) to reduce the trade flows with respect to those that would exist without barriers, given that the direct effect of the barriers that are imposed is to hinder the entry of foreign products in order to protect the national production.

Traditionally, the way of making comparisons of protection between countries or over time has been by elaborating summary indexes of the level of protection using simple or weighted average tariffs, nominal or effective protection or the degrees of incidence of the non-tariff barriers. The main defect of these indexes is that their level is not directly translatable to the degree of trade restriction or to the costs in terms of welfare. The same tariff level can have different effects on two economies or on two different dates, depending on the elasticity of their trade when faced with relative increases in the import price, as well as on the cross-effects with other importing sectors or with non-traded products. Therefore, the indexes are not necessarily representative of the effects of
obstruction to trade caused, for example, by a tariff. It might be supposed that the higher the taxes applied, the more likely they will influence the flow of imports, but the restriction they cause is not proportional to their level. Another important drawback is the problem of aggregation faced by whoever tries to obtain an overall image of the level or of the effects of the protection of a country. It is practically insurmountable and is mainly due to the fact that the weights related to the situation that is the alternative to protection, namely, to the unobservable quantities or prices that exist in free trade, are not available. In their absence, actual imports are normally used to weight the tariffs of the different products, so that it is possible to obtain the opposite impression to that which is being looked for with respect to the effective trade restriction: the bigger the decrease in the imports, the lower the weight of the product in the tariff.

Measurements of the effects of protection that go beyond the representative indexes and try to quantify losses in production, employment, welfare or trade, have been much less satisfactory than the theoretical advances. There have been improvements in the measurement of effective protection rates and of the cost of national resources. Leaving aside the assumptions necessary for their assessment, critics of these advances insist that they still represent only partial and static effects.

Some authors who try to use estimations of trade orientation or levels of protection – for example, in the literature on openness and growth - point out that, with tariff indexes or indicators of non-tariff barriers, an element that is previous to the effects of protection is being included. Baldwin (1989) calls these representations of the instruments of trade policy “incidence indicators” and those that try to measure their consequences in deviations of prices, trade volume or trade structure are called “outcome indicators” (Pritchett 1996; Edwards, 1998 uses a similar classification). Among the latter appear, as new instruments

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1 See, for example, Edwards (1993) or various contributions in Grossman and Rogoff (1995).
2 Anderson and Neary (1994, 2003, 2007) point to a deeper criticism: the lack of theoretical support for these measurements.
3 Particularly, assessments of the cost of protection based on this type of measures have always shown seemingly low figures, which run counter to intuition on the importance of the distortions that protective barriers introduce into economies. See a complete review of the numerous and varied applications in Corden (1984) and up-dates in Greenaway and Milner (1993) and Panagariya (2002).
4 An approximation to the aggregates price distortions that protection imposes between the general sectors of the economy (exporters, domestic competitors for imports and non-traded goods) is obtained by means of the
for evaluating trade barriers in terms of trade loss or distortion, models that from a general
equilibrium approach compare real trade with that forecasted by the factor endowments of
the countries, and attribute all the difference to trade policy (Leamer 1988, Estevadeordal
1997). This interesting approach has the drawback of not being adaptable as a theoretical
explanation of all the bilateral relationships and of not being able to be reproduced easily
for a numerous group of countries or various dates, given its high level of information
requirements.

Furthermore, the difference between the estimated and expected values of the cost
of protection has been justified, at least in part, by the absence of considerations of general
equilibrium in the first applications, which has led to the construction of CGE. This
alternative has the disadvantage of having rather high information requirements about the
functioning of the economy and about the multiple protection instruments in use, as well as
the assumptions about production structure and demand. Because of this, its results offer
only approximate figures and comparisons between countries are very difficult.

Anderson and Neary (1994, 2003) have made a very interesting contribution
towards solving these problems using the general equilibrium approach. They theoretically
derive a way to construct a summary index of the protective structure of an economy,
which they call the Trade Restrictiveness Index (TRI). TRI is the uniform tariff that
corresponds to a level of welfare equivalent to that of the tariffs and non-tariff barriers in
use. Analogously, they propose a uniform tariff equivalent in terms of the volume of trade
(the Mercantilist Trade Restrictiveness Index, MTRI). With these indexes, the idea is to
measure results, not policies, by combining the level of protection with its effects through
demand elasticities. In both cases they use a CGE that is simple with respect to production
combined with a more complex protection structure, a model they apply equally to all
countries. The MTRI solves various problems that the weighted average tariff presents:
according to the authors, it eliminates the substitution bias; it includes transfers of general
equilibrium and provides the volume of imports as a benchmark for comparisons.

\[\text{incidence of protection approach, as summarised in Greenaway and Milner (1993). See a recent application in Asensio and Pardos (2002).}\]
\[\text{5 They derive uniform tariff equivalents that summarize the information of the protection structure in the economy. The first presentation of this procedure can be found in Corden (1966).}\]
They apply their indexes to a limited sample of countries and for one or few years, and demonstrate the biases existing in other measurements (such as weighted average tariffs) with respect to their proposal. These estimations, however, still suffer from high information needs and require the application of the same CGE model for all the countries, which makes wider comparisons in space and over time difficult6.

The alternative method that is proposed here is the inference of trade costs from trade flows, using the gravity equation. As is well known, the gravity equation relates bilateral trade flows to national income, population and distance as their main explanatory variables. Theoretical foundations for this model have been well established, as in Bergstrand (1985) or Deardorff (1998), among others. The use of this method for our purposes requires much less information than the approach based on general equilibrium models, but maintains the advantages of the latter, and is applied to the estimation of the effects of protection on the volume of trade. In doing so, we partly follow Wall (1999). This author estimates a traditional gravity equation for U.S. trade with 85 partners in the mid-nineties, using their bilateral trade, GDP and population, and employing a model of fixed effects. Trade policy is considered explicitly through an indicator of the average level of the barriers. Given the problems that any index of this type causes, he opts for a homogeneously elaborated one to be used in international comparisons, the Index of Economic Freedom of the Heritage Foundation. He obtains an estimation of the percentage by which the imports of the protected country and the exports of the rest of the world are reduced when the level of protection is increased. With these values and the comparison with the level of free trade, an estimation of the cost of protection for the USA is obtained.

We base our gravity specification on the excellent survey by Anderson and van Wincoop (2004). These authors distinguish very clearly between traditional and theory-based gravity models and summarise the main applications and results in the literature. Assuming bilateral trade barriers $t_{ij}$ as a common loglinear multiplicative function of the observables $z_{ijm}$, and normalised so that $z_{ijm}=1$ is the free trade case or zero trade barriers

$$t_{ij} = \Pi_{m=1}^M (z_{ijm})^{\lambda_m}$$

where \( m \) refers to the particular trade barrier under study, the theory-based aggregate empirical gravity equation in its logarithmic form—after dropping the constant term and assuming asymmetric trade costs—becomes:

\[
\ln X_{ij} = \ln Y_i + \ln Y_j + \sum_{m=1}^{M} \lambda_m \ln(z_{ij}^m) - (1-\sigma)\ln(P_i) - (1-\sigma)\ln(\Pi_j) + \varepsilon_{ij} \tag{1}
\]

where \( X_{ij} \) are the bilateral exports from country \( i \) to partner \( j \); \( Y_i \) and \( Y_j \) are the GDPs for each country; \( \sigma \) is the elasticity of substitution among products in a Constant Elasticity of Substitution (CES) demand structure; \( \Pi_j \) and \( P_i \) are the price indexes called outward and inward multilateral resistance, respectively, which summarise the average trade resistance between a country and its trading partners, and \( \varepsilon_{ij} \) is the error term. The main insight from this equation is that bilateral trade depends on relative trade barriers and, because of the normalisation of the observables \( z_{ij}^m \), trade barriers can be measured relative to the benchmark of free trade as the tax equivalent associated with variable \( m \) in the following way:

\[
(z_{ij}^m)^{\sigma/(1-\sigma)} - 1 \tag{2}
\]

Existing analyses consider different values of the elasticity of substitution \( \sigma \), and the results of the estimations are very sensitive to this assumption. From among the most frequent elasticity values in the literature, Anderson and Wincoop (2004) choose the values 5, 8 and 10; the survey of Hummels (2001) enumerates the sigmas implicit in various papers such as that of Helliwell for the OECD (4.18 and 2) or in estimations of gravity (4.59 and 2.2). Finally, in Salter (1991) average elasticities of 2.6 are considered without taking into account the geographical origins of the imports, and approximately double if, as in theory-based gravity equations, these origins are taken into consideration.

This aggregate specification can be accepted as valid for all types of countries without the need to define their type of trade specialisation. Moreover, country-specific dummies can be used to capture the effects of omitted variables (such as price indexes) and, thus, obtain unbiased estimates of the parameters \( \lambda_m \). Therefore, wide samples, both in the number of countries and in the dates, can be considered.
In this paper, we opt for a theory-based gravity equation on the bilateral trade between a wide sample of 113 developed and developing countries and on seven dates between 1970 and 20007. Given the discussion about the choice of a variable that represents the protective intention of trade policy, we follow Hummels (2001) by assuming a multiplicative function of trade costs $T_{ij} = (1 + t_j) \prod TP_{m\lambda m}$, where we consider the average tariff ($t_j$) together with alternative indicators of trade policy ($TP_m$) and compare the robustness of the results. Among the pool of alternative measures that could serve as such indicators, we have chosen arithmetic and trade weighted average tariffs and tariff dispersion. We acknowledge the aforementioned problems with these measures and the lack of theoretical support for these tariff moments to represent the effects of tariff protection has already been shown (Anderson and Neary, 2007). But we are not using them as direct indicators, only as inputs in our gravity equation in order to estimate an outcome measure of their effects8. And, in more practical terms, they are available for more countries and years and calculated more comparably than the rest9.

Our specification considers all the countries in the sample to be exporters and importers, which we believe gives results that are closer to average behaviours than in previous studies which only focused on one importer (such as that already mentioned of Wall (1999) for the USA). Furthermore, our results are presented in the form of tariff equivalents, as a synthetic measure of the import restriction that is obtained, which will allow future comparisons with the calculations of other tariff equivalents.

2. The gravity model. Specification, sources and estimation

The theory-based equation [1] is the one to be estimated in this paper, where the group of observables is reduced to four different approximations to tariff-based trade policy10. In addition, population is also included to control for the size of the countries.

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7 The countries included in our sample are listed in Annex I.
8 Moreover, these indicators are closer to the ideal. Anderson and Neary (2007) show that with homothetic CES utility functions, like the ones implicit in our gravity specification, and with imperfect substitution of imports for home-produced goods, observed tariff moments are closer to generalised moments.
9 See Rose (2004) for a recent summary of the wide array of measures of trade policy in the literature, their sources and availability.
10 Wall (1999) considers only the index of trade freedom among these observable variables.
As was indicated above, the sample includes all the available observations for 113 countries, both developed and developing, with their bilateral trade relationships, in the years 1970, 1975, 1980, 1985, 1990, 1995 and 2000. Thus, we have a wide panel of available data, in which we have considered different possibilities to control for omitted variables. To control two familiar problems in gravity models, the omission of relevant variables and the drawbacks of the measurement of geographical variables, country-specific dummies may be included in the equation. For example, Wall (1999) proposes an estimation based on the model of fixed effects, so that in such effects, which are different between pairs of countries, all the invariant variables over time are included – for instance, contiguity, language and other similar variables. Furthermore, as Cheng and Wall (2005) justify, it must be decided whether to adopt symmetrical or asymmetrical fixed effects, given that the results seem to be quite sensitive to the choice of one or the other. The former imply that it is indifferent which country is the importer or exporter because the fixed effect only depends on the bilateral relationships and particular characteristics between the pair of partners; the latter differentiate the roles of importer and exporter. This second option seems more adequate for our objective and is the one we have chosen.

Finally, the gravity equation to be estimated is the following, with all the variables in logarithms due to its CES-utility theoretical foundation.

\[
\log X_{yrp} = \alpha_{yrp} + \beta_1 \log GDP_{yr} + \beta_2 \log GDP_{yp} + \beta_3 \log POP_{yr} + \beta_4 \log POP_{yp} + \beta_5 \log (1+t_{yp}) + \\
\beta_6 \sum_m \log TP_{myp} + \sum_{i=70}^{00} \beta_i \text{time}_i + \varepsilon_{yrp}
\]

(3)

where for each year \(y\), \(r\) is the exporter or reporter country and \(p\) is the importer or partner in the COMTRADE database of the United Nations, from which the data on bilateral trade have been taken, in current dollars. Data on Gross Domestic Product (GDP) and population (POP) have been obtained from the Penn World Table 6.1., expressed in purchasing power

\[11\text{ We have tested the estimation with symmetrical effects and the results are sensitive to the change, as Cheng and Wall (2005) argue, mainly because both the fit achieved and the coefficient figures, as well as the significance of some variables, are lower.}\]
dollars and thousands of people, respectively. Time dummies have been included (time), and the proxy variables used to represent trade policy (TP) have been:

a) The average tariff and its standard deviation across products, both from the World Development Indicators of the World Bank, for the available years and countries. Both have been standardized by expressing them as a cost over price which equals 1 for zero tariff and zero deviation: avtariffst = (1 + t/100) and devst = (1 + s/100), with t measuring the percentage of average tariff and s the standard deviation percentage. The figures for average tariffs are available from 1970 and those of standard deviations from 1990, a restriction that greatly reduces the sample for the estimation.

b) The percentage of tariff revenue on total trade, to include the impact on import quantities when tariffs are charged, in which either their restrictive nature or their tax collecting effect may prevail. Data are again standardized as a cost over price: trst=(1 + tr/100). Data on tax revenues on international trade are taken from the Fraser Institute dataset.

c) The Index of Trade Freedom of the Fraser Institute, a usual index in the literature. From 1970 to 2000 it is available on a five years basis only. Among all the indicators of trade and monetary policy it considers, we have selected only the three mentioned in sections a) and b) involving tariff policy in order to make our estimations comparable. This index interpolates the mean tariff rates, their deviations and revenue figures between 1 and 10, with 10 equivalent to free trade, and combines the three indexes into a simple average to obtain the ratings, also between 1 and 10. However, we redefine the index in order to standardize it as a cost over price. In this way, higher values of our index will represent higher trade barriers. Thus we call our indicator the “non-free trade index”.

Table 1 shows the results of estimating the gravity equation [3] with the different variables of trade policy, using OLS with asymmetric fixed effects. The different columns show, successively, the estimations without including any variable of trade policy in

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12 The Fraser Institute offers data of taxes on international trade as a percentage of exports plus imports, using the IMF sources. Thus, the tariff revenue indicator is similar to the weighted average tariff, the very controversial indicator of tariff protection, but not identical, since the latter considers only imports.

13 The index used by Wall (1999), from the Heritage Foundation, has only been available since the end of the nineties and offers much less variation, from 1 to 5, with 1 representing maximum trade freedom.
column (1), with the standardized mean tariff rate in column (2), with both this average tariff and the standard deviation in column (3), the Fraser indexes corresponding to these two indicators in column (4), also including the tariff revenue in columns (5) and (6) and, finally, with the non-free trade index in column (7). There are no zeros in trade data, the coefficient estimators are consistent and unbiased and the standard errors are heteroskedasticity-consistent.

### Table 1: Gravity equation for different trade policy indicators

<table>
<thead>
<tr>
<th>Trade policy Indicators</th>
<th>(1) Average Tariff</th>
<th>(2) Av. Tariff dispersion (indexes)</th>
<th>(3) Av. Tariff dispersion</th>
<th>(4) Av. Tariff % tariff revenue</th>
<th>(5) Av. Tariff % tariff revenue (indexes)</th>
<th>(6) Non-free trade Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPOPr</td>
<td>-0.77 [-9.23]</td>
<td>-0.88 [-6.84]</td>
<td>-1.34 [-4.48]</td>
<td>-1.34 [-4.49]</td>
<td>-1.41 [-4.67]</td>
<td>-1.41 [-4.62]</td>
</tr>
<tr>
<td>LPOPp</td>
<td>-0.53 [-26.43]</td>
<td>-0.37 [-2.80]</td>
<td>0.21 [0.69]</td>
<td>0.09 [0.30]</td>
<td>-0.14 [-0.42]</td>
<td>-0.25 [-0.79]</td>
</tr>
<tr>
<td>D75</td>
<td>2.81 [26.04]</td>
<td>2.90 [17.97]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D85</td>
<td>0.99 [17.27]</td>
<td>1.04 [12.48]</td>
<td>0.28 [1.32]</td>
<td>0.36 [1.68]</td>
<td>0.33 [1.51]</td>
<td>0.37 [1.72]</td>
</tr>
<tr>
<td>D90</td>
<td>0.73 [18.53]</td>
<td>0.79 [14.51]</td>
<td>0.56 [5.31]</td>
<td>0.60 [5.59]</td>
<td>0.59 [5.41]</td>
<td>0.61 [5.60]</td>
</tr>
<tr>
<td>D95</td>
<td>0.50 [19.39]</td>
<td>0.56 [18.35]</td>
<td>0.47 [8.97]</td>
<td>0.47 [8.93]</td>
<td>0.49 [9.22]</td>
<td>0.49 [9.10]</td>
</tr>
<tr>
<td>L Trade policy</td>
<td>-1.23 [-7.26]</td>
<td>-0.60 [-2.05]</td>
<td>-0.37 [-1.61]</td>
<td>-0.77 [-2.40]</td>
<td>-0.77 [-1.74]</td>
<td>-0.42 [-1.74]</td>
</tr>
</tbody>
</table>

| Obs.                    | 43150              | 29847                            | 16366                    | 16366                         | 15957                                   | 15957                  |
| Adj R²                  | 0.55               | 0.89                             | 0.92                     | 0.92                          | 0.92                                    | 0.96                   |
| S.E.                    | 1.30               | 1.18                             | 0.99                     | 0.99                          | 0.99                                    | 0.99                   |
| LM het. Test p-value    | 2883.5 0.000       | 1959.5 0.000                     | 941.3 0.000              | 940.8 0.000                   | 951.6                                   | 951.5 0.000            |
Using trade policy as an explanatory variable improves the explanatory capacity of the gravity model by more than 34%. The mean tariff always has a negative and significant effect, with a price elasticity of −1.23 and a fit of 89% when it is considered alone (column 2). If the standard deviation of tariffs is incorporated, the price elasticity of the imports is reduced to −0.60; contrary to what would be expected, the standard deviation presents a positive sign and is significant (column 3)14. It has been tested that, in the sample, there is a high correlation between the mean tariff and its deviation (72%), as well as with the percentage of tariff revenue (72%), which may be biasing the estimated coefficients. To avoid the problem of multicollinearity, the indexes of the mean tariff and the standard deviation offered by the Fraser Institute have been used. As the general Index of Trade Freedom, these indicators vary between 1 and 10, which in turn has the added advantage of reducing their variance. These indicators have also been standardized as price multipliers, as the estimation of the equation of gravity requires. They yield a high fit (92%) and the expected negative signs, although their significance is lower and the price elasticity has been reduced to −0.37, as indicated in column (4) of Table 1.

In column (5), the standardized tariff revenue has also been included, given that – although imperfect - it can be a proxy for the restrictive effect of the tariff structure through its combination of tariff levels and import price elasticities, when used together with the mean tariff rate and its standard deviation. The import price elasticity rises to −0.77 when both the deviation and the restrictive capacity of the tariff structure are controlled for.

Column (6) of Table 1 uses the three variables measured as indexes and yields the best fit (96%). All the estimated coefficients are negative, as expected. The use of indexes presents a somewhat lower price elasticity, -0.42, as opposed to -0.77 with the standardized data. In the sample, the countries with higher mean tariffs and lower deviations – indicative of a high level of protection that is similar for all products - have higher rates of tariff revenue. In other words, tariff protection seems to be concentrated on products with low price elasticity, so the effect measured through tariff revenue comes, mainly, from the quantity collected and not so much from imports restriction, which would seem to be

14 However, Anderson and Neary (2007) explain this possibility in theoretical terms: the generalized standard deviation of tariffs usually increases trade.
confirmed by its non-significant effect in the gravity equation\textsuperscript{15}. Thus, the use of indexes allows us to palliate the multicollinearity that has been detected, and it is convenient to include the percentage of tariff revenue to avoid the bias produced by its omission.

Although the non-free trade index is available for a wider sample, in column (7) we maintain the same sample of countries for which we had data for tariffs, deviations and revenues. It gives an elasticity of \(-0.80\), very similar to the price elasticity of the tariff (\(-0.77\))\textsuperscript{16}.

The results obtained, all with a similar and very high fit, give evidence of the usefulness of indexes to avoid problems of multicollinearity between the variables, and of incorporating the information from the tariff revenue index to detect whether the protection is concentrated on imports that are sensitive to price variations or if its objective is merely to raise revenue. All this shows the necessity of considering, together with the weighted average tariff, the average level and the deviation by products of the tariff protection, which allow the evaluation of its restrictive effect on imports.

Table 1 offers another interesting result. According to Feenstra (2002, 2004), the coefficient obtained for the mean tariff is equal to \((1- \sigma) = -\varepsilon\), where \(\varepsilon\) is the price elasticity of imports. Therefore, the value of the elasticity of substitution estimated by using the mean tariff and the standard deviation is 1.60 (column 3). This elasticity rises to 1.77 if the data on the percentage of tariff revenue is included (column 5); it seems logical that, if the cross-elasticity derived from the tariff structure is incorporated, the sensitivity to price variations due to the tariff should rise.

The values obtained are always lower than those considered in the literature, but our results are very close to the recent, exhaustive estimation work of Kee, Nicita and

\textsuperscript{15} In fact, the tariff revenue depends positively on the average tariff and negatively on the deviation, always significantly, and with a coefficient of partial fit of 0.81 if it is estimated with standardized data and of 0.83 if indexes are used. Likewise, the percentage of tariff revenue is not individually significant in the gravity equation, so its main function appears to be helping to adjust the coefficients of the mean tariff and of the standard deviation, as well as to increase the joint explanatory capacity.

\textsuperscript{16} The sample for the non-free trade index is larger, with 16,366 observations, because the Fraser Institute always offers a figure for the index, even if some of its components are missing. The most complete sample, with 40,340 observations gives an elasticity of \(-0.42\). Given the similarity of the results, the index provides a good proxy for calculating the t-equivalent, but it should be pointed out that its coefficient is not strictly the import price elasticity.
Olarreaga (2004) (KNO, henceforth). These authors estimate the price elasticities for a wide group of countries at both tariff line and industry level and report the average estimated elasticities for the 90s, yielding a country average of 1.67.

The value of the elasticities obtained is somewhat lower using trade policy indexes instead of the data, with a value of 1.80 for the non-free trade index (column 7), practically the same as the values mentioned above. In the estimation that considers the three components of the non-free trade index, or indexes of average tariff, standard deviation and tariff revenue, the elasticity of substitution falls to 1.42 (1.37 with the first two components), which may be the result of correcting the bias produced by the correlation between the variables of trade policy.

In any case, with the data or the trade policy indexes, the incorporation of the tariff revenue variable implies a greater elasticity of substitution, which could indicate that this component introduces the effect of the tariff structure by products and the cross-price elasticity, leaving a more adjusted value of the price elasticity, as the coefficient of the average tariff shows.

3. Estimated tariff equivalents and the cost of protection

Having estimated the previous gravity model, in which tariff policy forms an explicit part of trade costs, our interest now turns to obtaining a tariff equivalent that can be used as a measure of the cost of protection for each country, and to analyzing to what extent it overcomes the problem of the underestimation of the weighted average tariff. Therefore, we calculate the tariff equivalent in different estimations and samples as an outcome measure that synthesizes direct (price) and indirect (substitution) effects of the set of trade barriers in the country considered, keeping the trade volume constant. Because it is an index expressed as a percentage of import prices, it can be compared with the weighted average tariffs.

17 Their main objective is to compute the Trade Restrictiveness Index of Anderson and Neary (1994, 2003), derived from a general equilibrium model.
18 Therefore, both estimates are close to the lower range of gravity estimations of the elasticity of substitution in the literature, as shown in the previous section. This would support the notion of aggregate elasticity values
3.1 Equivalent tariffs for the average country

Table 2 shows the tariff equivalent for the average country in the estimated gravity equation, as well as for the subsample with information about the weighted average tariff. For the gravity sample the estimated structural elasticities 1.37, 1.42 or 1.80 have been considered, depending on the trade policy variables used.

For the weighted average tariff subsample we have considered both the structural elasticities from the total sample and the average elasticity of all the countries in the subsample based on the estimations of the individual price elasticities of KNO, with an average value of 1.77, which coincides with our estimations. Hummels (2001) and Feenstra (2002, 2004) show that the theoretical gravity equation yields a coefficient for the price of imports equal to the elasticity of substitution ($\varepsilon = -\sigma$), so we use the estimations of KNO as a good proxy for the elasticities of substitution in our analysis.

Table 2: Equivalent tariff for the average country

<table>
<thead>
<tr>
<th></th>
<th>Mean tariff and deviation (indexes)</th>
<th>Tariff, deviation % tariff revenue (indexes)</th>
<th>Non-free trade (index)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma=1.37$</td>
<td>$\sigma=1.42$</td>
<td>$\sigma=1.80$</td>
</tr>
<tr>
<td>Gravity sample</td>
<td>1.67</td>
<td>1.67</td>
<td>1.30</td>
</tr>
<tr>
<td>Weighted tariff sample</td>
<td>1.58 (1.39)</td>
<td>1.58 (1.42)</td>
<td>1.27 (1.28)</td>
</tr>
</tbody>
</table>

For each indicator of trade policy, the average country of the weighted average tariff sample presents a cost of protection somewhat lower than for the gravity sample, (although there is practically no difference between the two samples when the non-free trade index is used, with a tariff equivalent of nearly 30%). It is interesting to point out that the tariff equivalent is identical, in each sample, when only the mean tariff and the standard deviation indexes are considered, and when the index of tariff revenue is included with the corresponding correction in the elasticity of substitution: 67% for the gravity sample and 58% for the weighted average tariff sample. This result again indicates how it is possible that the inclusion of the tariff revenue in the estimations tells us about the crossed price

being plausibly low. See Reinert and Holst (1992), Gallaway et. al (2003) or Gagnon (2003), the latter with price elasticities.
mechanism that lies behind the tariff structure, and which corrects the bias in the direct elasticity of prices - coefficient of the mean tariff - for the same value of protection.

If we consider the weighted tariff sample and its average elasticity of substitution (1.77), the tariff equivalent is lower, whatever the indicators of trade policy used. This result is logical because this value of elasticity is higher than that estimated in the gravity equations, which indicates that the reduced sample is made up of the countries that are more sensitive to prices and, in particular, to tariffs. The average country of the weighted tariff sample, assuming its average elasticity of 1.77, faces costs of protection that oscillate between 39% and 42%; the use of the non-free trade index indicates 28%, always lower.

3.2 Equivalent tariffs with different trade policies

But the sample is made up of very diverse countries with different tariff structures and import substitution elasticities. In Table 3, we consider the heterogeneity of the trade policies and calculate the tariff equivalents for the countries of the sample for which we have the individual price elasticity – taken from Kee, Nicita and Olarreaga (2004) – as well as the figures about the weighted average tariff, so as to be able to detect whether the cost of protection is undervalued with the latter. The tariff equivalent for the average country of this subsample appears in the first row of the table. The averages for the non-OECD and OECD countries appear in the second and third rows. Below the tariff equivalent, in each case, we indicate its ratio with respect to the weighted average tariff (w.a.t. in Table 3), as a measure of the underestimation of the latter. The variable used to proxy trade policy appears at the head of each column, together with the corresponding import substitution elasticity; both the elasticity estimated in the structural gravity model and the arithmetic average of the sample (1.77) have been considered.
Table 3: Equivalent tariffs with different trade policies and a common elasticity of substitution

( weighted tariff sample)

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Mean tariff (σ=1.37)</th>
<th>Mean tariff (σ=1.42)</th>
<th>Mean tariff (σ=1.80)</th>
<th>Mean tariff (σ=1.77)</th>
<th>Mean tariff (σ=1.77)</th>
<th>Mean tariff (σ=1.77)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean deviation</td>
<td>Tariff revenue</td>
<td>Non-free Trade Index</td>
<td>Mean deviation</td>
<td>Tariff revenue</td>
<td>Non-free Trade Index</td>
</tr>
<tr>
<td>Total</td>
<td>1.58</td>
<td>1.56</td>
<td>1.28</td>
<td>1.39</td>
<td>1.42</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>1.42</td>
<td>1.41</td>
<td>1.16</td>
<td>1.25</td>
<td>1.28</td>
<td>1.17</td>
</tr>
<tr>
<td>Non OCDE</td>
<td>1.68</td>
<td>1.68</td>
<td>1.34</td>
<td>1.47</td>
<td>1.51</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>1.49</td>
<td>1.48</td>
<td>1.18</td>
<td>1.30</td>
<td>1.34</td>
<td>1.20</td>
</tr>
<tr>
<td>OCDE</td>
<td>1.40</td>
<td>1.37</td>
<td>1.18</td>
<td>1.26</td>
<td>1.26</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>1.30</td>
<td>1.29</td>
<td>1.11</td>
<td>1.19</td>
<td>1.19</td>
<td>1.12</td>
</tr>
<tr>
<td>R²=0.71</td>
<td>R²=0.76</td>
<td>R²=0.71</td>
<td>R²=0.78</td>
<td>R²=0.82</td>
<td>R²=0.71</td>
<td></td>
</tr>
</tbody>
</table>

Note: t-eq indicates tariff equivalent and w.a.t. is the weighted average tariff

With the estimated structural elasticities, the average of all the individual tariff equivalents is higher than 50% (58% if only the average tariff and deviation are taken into account and 56% if the tariff revenue is also controlled for). The general index of the non-freedom of trade always gives a lower cost of protection, approximately half (28%); practically the same with both the average elasticity of the subsample and the structural elasticity. Given that the weighted average tariff in the subsample is 11% according to the information from UNIDO, the estimated tariff equivalent is 41-42%, greater.

The OECD countries use less tariff policies than the non-OECD countries so, supposing the same elasticity of substitution, the results for both subsamples are very different. The former show, logically, a lower tariff equivalent, of nearly 40% with the structural parameters, of 26% with the average elasticity of the subsample (1.77), and always lower with the non-freedom of trade index (18%). However, the non-OECD countries show tariff equivalents of 68%. Their value is halved when the indicator of non-freedom of trade is used (34%) and around 50% when the average elasticity of this
subsmaple is considered. Thus, the cost of tariff protection for the group of developing countries is almost double than that for the group of developed countries.

All these values are higher than the weighted average tariffs – with the figures of UNIDO, the average of the weighted tariffs of the OECD group is 6% and that of the non-OECD group is 14% – so there is an important underestimation of protection with this measure. For the developed countries the tariff equivalent can be up to 30% higher than the weighted tariff; again, the figure is lower with the non-freedom of trade index (11%). For the developing countries the bias can even reach 49% of the weighted tariff.

With the average elasticity of 1.77, the tariff equivalent will be 39-42% for the total sample; again, the non-OECD countries are those that bear the highest cost, with 47-51%, compared to 26% for the OECD countries. Bearing in mind that each group has different import price elasticities, higher for the OECD sample (2.17 is the average for this group) and lower for the non-OECD group (1.56), the difference between the two tariff equivalents will be even higher.

3.3 Tariff equivalents with individual tariff policies and individual substitution elasticities

In fact, the heterogeneity of the import substitution elasticities will generate greater differences between the countries in terms of costs of protection and underestimation of the weighted tariff, which will increase as the elasticity decreases. In order to observe this fact, Table 4 presents the tariff equivalents and their ratios with respect to the weighted average tariff, for the whole sample and for both groups of countries, including the individual trade policies and individual elasticities of substitution. In this case, the tariff equivalents are 62% for the whole sample, and the gap between the two groups widens with 24% for the OECD group and 86% for the non-OECD group. The interesting finding is that, for the whole sample, the estimated cost of protection is around 40% more than the weighted average tariff, which is a deviation similar to that obtained by Kee, Nicita and Olarreaga

\[19\] Annex II shows the tariff equivalents for the countries of the sample with data on the weighted average tariff, which limits the results to the most recent years. Two different equivalents are offered: first, the ones estimated with an average substitution elasticity of 1.77 and then with individual country elasticities.
(2004). It is worth pointing out that KNO calculate the simplified TRI of Anderson and Neary for a sample very similar to ours in the nineties. Although our initial sample goes back to the 70s, with a greater use of tariffs, the information on standard deviation restricts the period to the 90s, for which our estimation gives, on average, values that are practically the same.

Table 4:
Equivalent tariffs with individual trade policies and individual substitution elasticities (weighted tariff sample)

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Mean tariff Mean deviation σ_1</th>
<th>Mean tariff Mean deviation σ_1</th>
<th>Non-free trade Index σ_i</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean deviation σ_1</td>
<td>Mean deviation σ_1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>t-equivalent</td>
<td>1.62</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>t-eq / w.a.t.</td>
<td>1.46</td>
<td>1.44</td>
</tr>
<tr>
<td>non OCDE</td>
<td>t-equivalent</td>
<td>1.86</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td>t-eq / w.a.t.</td>
<td>1.65</td>
<td>1.62</td>
</tr>
<tr>
<td>OCDE</td>
<td>t-equivalent</td>
<td>1.24</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>t-eq / w.a.t.</td>
<td>1.17</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Note: t-eq indicates tariff equivalent and w.a.t. is the weighted average tariff.

The underestimation of the weighted average tariff is only slightly higher for the whole sample than the ones reported in Table 3, but the different elasticities in each country lead to large differences in the costs of protection across countries. The ratio between the two measures is 17% for the OECD group but up to 65% for the non-OECD group, whose countries have lower import substitution elasticities. The increase that has occurred is especially noteworthy in the non-OECD group, much greater than the decrease in the OECD group. This leads us to think that the increase in the tariff equivalent that occurs with the lowering of the elasticity is not linear, and the same can be said of the underestimation of the weighted average tariff.

Figure 1 shows the correlation between the tariff equivalent, calculated using the average elasticity of the sample and for the three estimations – average tariff and standard deviation, these two together with the tariff revenue, and the non-free trade index – and the
weighted average tariff. Even with the average underestimation mentioned above, the relationship is clearly linear, with correlations of over 70%. The slopes give an idea of the bias of the weighted tariff compared to the calculated cost of protection, with a steeper slope when the tariff revenue is considered, as corresponds to a greater price elasticity given by the structural coefficient of the average tariff (1.42).

The linear relation with the weighted tariff is completely lost when the individual elasticities are considered, as can be seen in Figure 2. The difference between the three graphs is essentially one of magnitude, and the similarity of the cloud of points that opens out along two slopes around a growing average should be noted. Although the average cost estimated is higher, the dispersion around it is lower when the average tariff, standard deviation and the tariff revenue are considered together.

The loss of linearity with the individual elasticities and the similarity of the deviations originated lead us to think that there is a relation between the ratios of the tariff equivalents over the weighted average tariff and the elasticity of substitution, as is confirmed in Figure 3. In the three estimations, the ratio presents a clearly decreasing and convex relationship with the elasticity of substitution. In this way, the countries with a lower elasticity underestimate the cost of protection much more if they use the weighted tariff to measure it, and this underestimation grows as the substitution of imports from trade policies decreases. Likewise, the countries with a greater elasticity of import substitution are those that show greater similarity between the estimated cost of protection and the weighted tariff and, thus, the use of the latter will lead to a lower error of measurement.

Furthermore, the comparison of the three graphs allows us to see, once again, that the joint use of the average tariff and deviation with the tariff revenue produces a convex relation with a smoother slope – e.g. lower underestimation. This seems to indicate that, given an import substitution elasticity as well as the tariff structure, the tariff revenue incorporates the estimation of the resulting tax collection effect when imports are not restricted by trade policy.

Identical graphs are obtained for the average structural elasticities of each estimation, which are highly linear, as indicated by the fits of Table 3, and always with the underestimation of the weighted average tariff.
Figure 1: Correlation between the tariff equivalent and weighted average tariff with a common elasticity of substitution ($\sigma=1.77$) and individual trade policies

Indexes of mean tariff, mean deviation and tariff revenue

$R^2=0.82$

Non-free trade index

$R^2=0.71$
Figure 2: Correlation between the tariff equivalent and weighted average tariff with individual trade policies and individual elasticities of substitution

Indexes of mean tariff and mean deviation

Indexes of mean tariff, mean deviation and tariff revenue

Non-free trade index
Figure 3: Ratio (tariff equivalent / w.a.t.) against elasticity of substitution

Indexes of mean tariff and mean deviation

Indexes of mean tariff, mean deviation and tariff revenue

Non-free trade index

Note: w.a.t. is the weighted average tariff
To sum up, for the same tariff policy and the same import substitution elasticity, estimating the effect of tax collection together with the average tariff and deviation allows us to offer more precise values of the cost of protection. Likewise, the market structure and the import substitution elasticity are fundamental characteristics to bear in mind if one wishes to estimate the cost of tariff protection correctly. This is especially true in countries with a limited capacity for restricting their foreign purchases and which, therefore, will obtain revenue but bear a higher cost of protection derived from the lower flexibility of their markets.

4. Conclusions

In this paper, we have offered evidence on an alternative way of estimating the trade restrictiveness of tariff protection in terms of market access, one that takes into account not only the direct (price) effect of tariff policy but also the role of substitution elasticities as a key determinant of the effects of tariffs on trade.

We have shown that it is possible to estimate these costs of protection using a widely accepted and theory-based specification of the gravity model for a wider group of countries and dates than the ones obtained in previous estimations using CGE models. This is achieved thanks to the lower data requirements for its application, and without losing the general equilibrium framework. These results are shown in the form of tariff equivalents in order to make them comparable among themselves and to other authors’ results. One particular element that has been incorporated is the use of asymmetrical fixed effects. In this way, trade determinants that are invariable over time are included in the explanation of the bilateral trade between the 113 countries of the sample from 1970 to 2000, and for each pair of partners, without having to specify variables such as the distance or cultural affinities between them. Furthermore, the differences between the importing and exporting role of each country are taken into account. Time dummies try to control the specific time variation not considered with the other determinants.

The representation of the level of protection can be achieved with different indicators, always expressed as a multiplier of the price of imports. The average nominal tariff, as well as the standard deviation, is considered because the tariff structure is a
fundamental determinant of the import restriction. The additional consideration of the percentage of tariff revenue allows us to obtain a more precise estimation of the elasticity of imports as well as the restrictive effect on them. And a combination of these three measures, the non-freedom of trade index, has been shown to be a good alternative when some of the components are not available.

The estimated tariff equivalents seem reasonable in terms of maximum and minimum values for the countries in the sample, and regarding other authors' results. They confirm the underestimation of protection cost through trade-weighted tariffs by more than 40% and a highly linear relationship between the two. Tariff protection costs (and the corresponding ratio over the trade-weighted tariff) are lower in OECD countries than in developing economies, as expected, using the average elasticity of substitution. However, these results need to be corrected. The strong assumption in many applied papers that use the same substitution elasticity for every country in the sample can be relaxed in this case thanks to the recently available KNO individual elasticities. With the use of individual elasticities, the general conclusion of underestimation when using the weighted average tariff holds, but the cost of protection is now higher, on average, and, more importantly, much higher the lower the elasticity of substitution. Different tariff policies are relevant to explain different protection costs between countries (e.g. OECD/non-OECD groups), but the market structure and the elasticity of substitution of imports are fundamental for a precise estimation of the cost of protection, especially in countries with limited capacity for restricting their foreign purchases.

Our main conclusion is that estimating trade costs from the combination of descriptive trade policy indicators and gravity models seems a plausible alternative for comparing these costs in large samples. Data requirements are lower than with more sophisticated methods and implementation is also relatively easier. From the trade policy indicators used in our estimations, we suggest using the indicators of tariff levels, dispersion and revenues, since they give results that are close to other methods and for a wide sample of countries.

After the preliminary work presented here, some necessary improvements are in order for future work. Firstly, comparisons could be made with tariff equivalents calculated
with other methods (such as the MTRI of Anderson and Neary [2003]). To do so, it is necessary to adjust the samples to make them reasonably comparable. This would imply introducing variations that can give greater validity to our calculations, in the sense of controlling for some measurement differences in trade policy variables (a key concept not considered in our sample is that of being members of trade blocks) and widening the concept of the trade barriers considered. It must be remembered that we are only evaluating tariff barriers and that non-tariff barriers are widely used. The latter can be more important than tariffs, especially in developed countries. Evaluating the impact of tariff dispersion is also still pending. Finally, the creation of such a broad panel of data as the one used here can allow us to propose hypotheses about differential patterns in the costs of protection between more specific groups of countries or over time.
5. References


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Annex I: List of countries for the gravity estimation

Algeria, Argentina, Australia, Austria, Bangladesh, Barbados, Belgium, Belize, Benin, Bolivia, Brazil, Bulgaria, Burundi, Cameroon, Canada, Central African Rep., Chad, Chile, China, Colombia, Congo, Congo Dem. Rep., Costa Rica, Croatia, Cyprus, Czech Rep., Denmark, Dominican Rep., Ecuador, Egypt, El Salvador, Estonia, Fiji, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, Korea, Latvia, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritius, Mexico, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Rwanda, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, Uruguay, USA, Venezuela, Zambia, Zimbabwe.


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