IMPORT DEMAND ELASTICITIES AND TRADE DISTORTIONS*

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Abstract

This paper provides a systematic estimation of import demand elasticities for a broad group of countries at a very disaggregated level of product detail. We use a semiflexible translog GDP function approach to formally derive import demands and their elasticities, which are estimated with data on prices and endowments. Within a theoretically consistent framework, we use the estimated elasticities to construct Feenstra's (1995) simplification of Anderson and Neary's trade restrictiveness index (TRI). The difference between TRI and import-weighted tariff is shown to depend on the variance of tariffs and the covariance between tariffs and import demand elasticities. On average, TRIs are 40 to 50 percent higher than the simple and import-weighted average tariffs, causing deadweight loss to be higher. Deadweight loss is further decomposed into parts associated with import-weighted average tariffs, tariff variance, and the covariance between tariffs and import demand elasticities. In most countries, tariff variance and covariance with import elasticities make up more than 50 percent of the total deadweight loss. In the U.S., nearly 80 percent of the total deadweight loss is attributed to higher tariffs levied on more elastic imports, which suggests that industries that face strong import competition are more organized and consistently lobby for higher tariffs.

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1 Introduction

Import demand elasticities are crucial inputs into many ex-ante analyses of trade reform. To evaluate the impact of regional trade agreements on trade flows or customs revenue, one needs to first answer the question of how trade volumes would adjust. To estimate ad-valorem equivalents of quotas or other non-tariff barriers one often needs to transform quantity impacts into their price equivalent, for which import elasticities are necessary. Moreover, trade policy is often determined at much higher levels of disaggregation than existing import demand elasticities.[1] This mismatch can lead to serious aggregation biases when calculating the impact of trade interventions that have become more of a surgical procedure. Finally, to evaluate trade restrictiveness and welfare loss across different countries and time, one would need to have a consistent set of trade elasticities, estimated using the same data and methodology. These do not exist. The closest substitute and the one often used by trade economists is the survey of the empirical literature put together by Stern et al. (1976). More recent attempts to provide disaggregate estimates of import demand elasticities have been country specific and have mainly focused on the United States.[2]

The objective of the paper is threefold. First, to fill in the gap in the literature by providing a systematic estimation of import demand elasticities for a broad range of countries at a fairly disaggregated level of product detail. Second, using the estimated elasticities and within a theoretically consistent framework, we construct measures of trade restrictiveness based on Feenstra's (1995) simplification of Anderson and Neary's trade restrictiveness index (TRI).[3] The TRI is the uniform tariff that would maintain welfare at its current level given the existing tariff structure. Finally, using TRIs we study the size and composition of tariff induced trade distortions.

The basic theoretical setup for the estimation of import demand elasticities is the production based GDP function approach as in Kohli (1991) and Harrigan (1997). This GDP function approach is consistent with neoclassical trade theories. It takes into account general equilibrium effects

[1]Trade policy is (almost by definition) often determined at the tariff line level. To our knowledge the only set of estimates of import demand elasticities at the six digit level of the Harmonized System (HS) that exist in the literature are the one provides by Panagariya *et al.* (2001) for the import demand elasticity faced by Bangladesh exporters of apparel and the elasticities of substitution across exporters to the US by Broda and Weinstein (2003).

[2]These include Shiells, Stern and Deardorff (1986), Shiells, Roland-Holst and Reinert (1993), Marquez (1999), Broda and Weinstein (2003) and Gallaway, McDaniel and Rivera (2003). Note that some of these studies focus on Armington or income elasticities rather than price elasticities.

[3]See Anderson and Neary (1994, 1996 and 2004).

associated with the reallocation of resources due to exogenous changes in prices and endowments. As in Sanyal and Jones (1983), imports are the middle products, and are considered as inputs into domestic production, for given exogenous world prices, productivity and endowments.[4] In a world where a significant share of growth in world trade is explained by vertical specialization (Yi, 2003), the fact that imports are treated as inputs into the GDP function – rather than as final consumption goods as in most of the previous literature – seems an attractive feature of this approach.

While Kohli (1991) focuses mainly on aggregate import demand and export supply functions and Harrigan (1997) on industry level export supply functions, this paper modifies the GDP function approach to estimate import demand elasticities at the six digit of the Harmonized System (HS). When estimating elasticities of the 4600 goods at tariff line level, dealing with cross-price effects can become insurmountable. In order to avoid running out of degrees of freedom in the estimation of the structural parameters of the GDP function, we reparametrize the fully flexible translog function to be semiflexible, or flexible of degree one, due to Diewert and Wales (1988). This reparametrization significantly reduces the number of price related translog parameters from $N(N-1)/2+N$, which is more than 10 millions a year, to only N, which is about 4600, and yet is flexible enough to approximate any arbitrary twice continuously differentiable function form to the second order at some point, except the matrix of second order partial derivatives with respect to prices is restricted to have maximum rank one instead of the maximum possible tank of $N-1$. Similar technique is also used in Neary (2004) for the estimation of the AIDS and QUAIDS systems. Another practical problem we are facing is that the HS classification was only introduced in the late 1980s, so even if we solve the n-good problem, we may still run out of degrees of freedom if we were to estimate the different parameters using only the time variation in the data. Thus, assuming that the structural parameters of the GDP function are common across countries (up to a constant) as in Harrigan (1997), we take advantage of the panel dimension of the data set by applying within estimators. Finally, as in Kohli (1991), to ensure that second order conditions of the GDP maximization program are satisfied we impose the necessary curvature conditions which ensure that all estimated import demand elasticities are negative.

More than 300,000 import demand elasticities of HS six digit products have been estimated

[4] Sanyal and Jones (1982) argue that most imported products when sold in the domestic market have some domestic value added embedded, i.e., marketing and transport costs, which justifies the assumption that they are inputs into the GDP function.

across 117 countries. The simple average across all countries and goods is about -1.67 and the median is -1.08. The overall fit of the import demand elasticities is good. The median t-statistics obtained through bootstrapping is 11.96, and 91 percent of the estimates are significant at the 5 percent level. The estimated import demand elasticities have some interesting variations across products and countries that are consistent with some intuitive hypothesis. First, homogenous goods are shown to be more elastic than heterogenous goods. Second, import demand is more elastic when estimated at the product level than at industry level. Third, larger countries tend to have more elastic import demands, due to a larger availability of domestic substitutes. Fourth, more developed countries tend to have less elastic import demands, mainly driven by a larger proportion of heterogenous goods in import demand.

Using the estimated import demand elasticities, we construct TRIs for 88 countries for which tariff schedules are available. We show that the difference between TRI and import-weighted tariff depends on the variance of tariffs and the covariance between tariffs and import demand elasticities. Results suggest that the variance of tariffs and its covariance with import demand elasticities are indeed high such that both simple and import-weighted average tariffs underestimate the restrictiveness of a country's tariff regime by 40 to 50 percent on average. In some countries such as the U.S., TRI is nearly 4 times as large as the import-weighted average tariff. This indicates the presence of disproportionately large tariff variance and covariance with import demand elasticities.

We then study the role played by the tariff variance and covariance with import demand elasticities in determining the size and composition of the deadweight loss. It turns out that by omitting variance of tariffs and their covariance with import elasticities, we tend to underestimate the size of total deadweight loss by 50 percent. In other words, the overall deadweight loss due to tariffs is twice as high as the average tariffs would imply. Countries that have the largest share of deadweight loss due to tariff variance are Oman, Latvia, Estonia, Norway and Japan. Countries where most of the deadweight loss is driven by the covariance between tariffs and import elasticities are U.S., Sudan, Nicaragua, Turkey and China. In particular, at $10 billion per year, the U.S. overall loss is the largest in the sample, and nearly $8 billion could be attributed to higher tariffs on more elastic imports. Given that a high import demand elasticity could be due to close domestic substitutes, this result may be explained by the fact that industries that face severe import competition have the largest incentives to get organized to lobby for tariff protection. A result that can help inform lobbying models.

The paper is organized as follows. Section 2 provides the theoretical framework to estimate import demand elasticities, whereas section 3 describes the empirical strategy. Section 4 discusses data sources. Section 5 presents the results of the estimation of import demand elasticities and explores patterns across goods and countries. Section 6 applies the estimated import demand elasticities to construct TRIs, as well as deadweight losses associated with existing tariff structures and their decomposition. Section 7 presents some caveats and robustness checks and Section 8 presents the concluding remarks.

2 Theoretical Model – GDP Function Approach

The theoretical model follows Kohli's (1991) GDP function approach for the estimation of trade elasticities. We also draw on Harrigan's (1997) treatment of productivity terms in GDP functions. We will first derive the GDP and import demand functions for one country. However, assuming that the GDP function is common across all countries up to a country specific term –which controls for country productivity differences– it is then easily generalized to a multi-country setting in the next section.

Consider a small open economy in period t.[5] Let $\mathbf{S}^t \subset \mathbf{R}^{N+M}$ be the strictly convex production set in t of its net output vector $q^t = \left(q_1^t, q_2^t, ..., q_N^t\right)$ and factor endowment vector $v^t = \left(v_1^t, v_2^t, ..., v_M^t\right) \geq 0$. For the elements in the net output vector q^t, we adopt the convention that positive numbers denote outputs, which include exports, and negative numbers denote inputs, which include imported goods. We consider imported goods and competing domestically produced goods as differentiated products. Similarly domestic products sold in the domestic market are differentiated from products sold in foreign markets (i.e., exported).

Given the exogenous world price vector $\tilde{p}^t = \left(\tilde{p}_1^t, \tilde{p}_2^t, ..., \tilde{p}_N^t\right) > 0$, the country specific endowments, v^t, and N-dimensional diagonal Hicks-neutral productivity matrix $\mathbf{A}^t = diag\left\{A_1^t, A_2^t, ..., A_N^t\right\}$,

[5] For a discussion of the relevance of the small country assumption when estimating trade elasticities, see Riedel (1988) and Panagariya *et al.* (2001).

perfect competition leads firms to choose a mixed of goods that maximizes GDP in each period t :

$$G^t\left(\tilde{p}^t, \mathbf{A}^t, v^t\right) \equiv \max_{q^t}\left\{\tilde{p}^t \cdot \mathbf{A}^t q^t : \left(q^t, v^t\right) \in \mathbf{S}^t\right\} \Rightarrow \tag{1}$$

$$G^t\left(\tilde{p}^t \mathbf{A}^t, v^t\right) \equiv \max_{q^t}\left\{\tilde{p}^t \mathbf{A}^t \cdot q^t : \left(q^t, v^t\right) \in \mathbf{S}^t\right\}, \tag{2}$$

where $G^t\left(\tilde{p}^t \mathbf{A}^t, v^t\right)$, is the maximum value of goods the economy can produce given prices, Hicks-neutral productivity and factor endowments in period t. It equals to the total value of output for exports and final domestic consumption minus the total value of imports ($q_n^t < 0$ for imports). In other words, the optimal net output vector is chosen to maximize GDP in equilibrium, given prices, productivity and endowments. We shall refer to the optimal net output vector as the GDP maximizing net output vector, which includes GDP maximizing import demands.

As shown in Harrigan (1997), Equation (2) highlights that price and productivity enter multiplicatively in the GDP function, $G^t\left(\tilde{p}^t \mathbf{A}^t, v^t\right)$. This property allows us to re-express the GDP function, by defining the productivity inclusive price vector, $p^t = \left(p_1^t, p_2^t, ..., p_N^t\right) > 0$:

$$G^t\left(p^t, v^t\right) = \max_{q^t}\left\{p^t \cdot q^t : \left(q^t, v^t\right) \in \mathbf{S}^t\right\}, \text{ with} \tag{3}$$

$$p^t \equiv \tilde{p}^t \mathbf{A}^t, \text{ and } p_n^t \equiv \tilde{p}_n^t A_n^t, \forall n. \tag{4}$$

Notice that the productivity inclusive price vector, p^t, is no longer common across country even though the world price vector, $\tilde{p}^t$, is identical across countries. This allows the model to better fit the data where different world prices are observed for the same good in different countries. In a recent study, Schott (2004) successfully explains variation in unit values for goods in the same tariff line but in different countries with GDP per capita levels. To the extent that GDP per capita is a proxy for labor productivity, Schott's finding provides support for our productivity inclusive price level, p^t.

For $G^t\left(p^t, v^t\right)$ to be a well defined GDP function, it is assumed to be homogeneous of degree one with respect to prices. Moreover, strict convexity of $\mathbf{S}^t$ also ensures that the second order sufficient conditions are satisfied, such that $G^t\left(p^t, v^t\right)$ is twice differentiable and it is convex in p^t and concave in v^t. To derive import demand function, we apply the Envelope Theorem, which shows that the gradient of $G^t\left(p^t, v^t\right)$ with respect to p^t is the GDP maximizing net output vector, $q^t\left(p^t, v^t\right)$:

$$\frac{\partial G^t\left(p^t, v^t\right)}{\partial p_n^t} = q_n^t\left(p^t, v^t\right), \ \forall n = 1, ..., N. \tag{5}$$

Thus if good n is an imported good, Equation (5) would be the GDP maximizing import demand function of good n, which is a function of prices and endowments. It also implies that an increase in import prices would reduce GDP (i.e., $q_n^t < 0$ if n is an imported good). Given that $G^t\left(p^t, v^t\right)$ is continuous and twice differentiable, and is convex and homogeneous of degree one with respect to prices, the Euler Theorem implies that q_n^t is homogenous of degree zero in prices, has non-negative own price effects and has symmetric cross price effects:[6]

$$\frac{\partial^2 G^t\left(p^t, v^t\right)}{\partial p_n^t \partial p_k^t} = \begin{cases} \frac{\partial q_n^t\left(p^t, v^t\right)}{\partial p_n^t} \geq 0, \ \forall n = k \\ \frac{\partial q_n^t\left(p^t, v^t\right)}{\partial p_k^t} = \frac{\partial q_k^t\left(p^t, v^t\right)}{\partial p_n^t}, \ \forall n \neq k \end{cases}. \tag{6}$$

In other words, for every final good, including exports, a price increase *raises* output *supply*; for every input, including imports, an increase in prices *decreases* input *demand*. In addition, if an increase in the price of an imported input causes supply of an exported output to decrease, then an increase in the price of the exported output would increase the demand of the imported input in the same magnitude.

Equation (5) shows that the GDP maximizing import demand function of good n is a function of prices and factor endowments. Thus, the implied own price effects of imports, and the import demand elasticities, are therefore conditioned on prices of other goods and aggregate endowments being fixed. Thus, the GDP maximizing import demand functions do not depend on income or utility, unlike the expenditure minimizing Hicksian import demand functions or the utility maximizing Marshallian import demand functions. This is because, aggregate factor income and welfare are in fact endogenous to prices and endowments. Such a set up is more relevant for general equilibrium trade models, but may not be relevant for partial equilibrium micro models which often take aggregate income as exogenous. As a result, comparing the GDP maximizing import demand elasticities to the existing Hicksian or Marshallian import demand elasticities in the literature may not be appropriate. Finally, we will not be able to derive income elasticities from the GDP maximizing import demand functions, but instead, we would be able to estimate the Rybczynski elasticities

[6] The latter by Young's Theorem.

from Equation (5), which shows how import demand reacts to changes in factor endowments.[7]

To implement the above GDP function empirically, let's assume, without loss of generality, that $G^t(p^t, v^t)$ follows a flexible translog functional form with respect to prices and endowments, where n and k index goods, and m and l index factor endowments:

$$\begin{aligned}
\ln G^t\left(p^t, v^t\right) &= a_{00}^t + \sum_{n=1}^{N} a_{0n}^t \ln p_n^t + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N} a_{nk}^t \ln p_n^t \ln p_k^t \\
&\quad + \sum_{m=1}^{M} b_{0m}^t \ln v_m^t + \frac{1}{2}\sum_{m=1}^{M}\sum_{l=1}^{M} b_{ml}^t \ln v_m^t \ln v_l^t \\
&\quad + \sum_{n=1}^{N}\sum_{m=1}^{M} c_{nm}^t \ln p_n^t \ln v_m^t, \qquad (7)
\end{aligned}$$

where all the translog parameters a, b and $c's$ are indexed by t to allow for changes over time. In order to make sure that Equation (7) satisfies the homogeneity and symmetry properties of a GDP function, we impose the following restrictions:

$$\sum_{n=1}^{N} a_{0n}^t = 1,\ \sum_{k=1}^{N} a_{nk}^t = \sum_{n=1}^{N} c_{nm}^t = 0,\ a_{nk}^t = a_{kn}^t,\ \forall n, k = 1, ..., N,\ \forall m = 1, ..., M. \qquad (8)$$

Furthermore, if we assume that the GDP function is homogeneous of degree one in factor endowments, then we also need to impose the following restrictions:

$$\sum_{n=1}^{N} b_{0n}^t = 1,\ \sum_{k=1}^{N} b_{nk}^t = \sum_{m=1}^{M} c_{nm}^t = 0,\ b_{nk}^t = b_{kn}^t,\ \forall n, k = 1, ..., N,\ \forall m = 1, ..., M. \qquad (9)$$

Given the translog functional form and the symmetry and homogeneity restrictions, the derivative of $\ln G^t(p^t, v^t)$ with respect to $\ln p_n^t$ gives us the equilibrium share of good n in GDP at period t:

$$\begin{aligned}
s_n^t\left(p^t, v^t\right) &\equiv \frac{p_n^t q_n^t\left(p^t, v^t\right)}{G^t\left(p^t, v^t\right)} = a_{0n}^t + \sum_{k=1}^{N} a_{nk}^t \ln p_k^t + \sum_{m=1}^{M} c_{nm}^t \ln v_m^t \\
&= a_{0n}^t + a_{nn}^t \ln p_n^t + \sum_{k\neq n} a_{nk}^t \ln p_k^t + \sum_{m=1}^{M} c_{nm}^t \ln v_m^t,\ \forall n = 1, ..., N, \qquad (10)
\end{aligned}$$

[7] See Section 5.3 of Kohli (1991) for a thorough discussion on the various import demand specifications.

where s_n^t is the share of good n in GDP ($s_n^t < 0$ if good n is an input as in the case of imports). From Equation (10) it can be shown that, if good n is an imported good, then the import demand elasticity of good n derived from its GDP maximizing demand function is:[8]

$$\varepsilon_{nn}^t \equiv \frac{\partial q_n^t\left(p^t, v^t\right)}{\partial p_n^t}\frac{p_n^t}{q_n^t} = \frac{a_{nn}^t}{s_n^t} + s_n^t - 1 \leq 0,\ \forall s_n^t < 0. \tag{11}$$

Thus we can infer the import demand elasticities once a_{nn} is properly estimated based on Equation (10). Note that the size of the import elasticity, ε_{nn}^t, depends on the sign of a_{nn}^t, which captures the changes in the share of good n in GDP when price of good n increases by 1 percent:

$$\varepsilon_{nn}^t \begin{cases} < -1 \text{ if } a_{nn}^t > 0, \\ = -1 \text{ if } a_{nn}^t = 0, \\ > -1 \text{ if } a_{nn}^t < 0. \end{cases}$$

The rationale is straightforward. If the share of imports in GDP does not vary with import prices $\left(a_{nn}^t = 0\right)$, then the implied import demand is unitary elastic such that an increase in import price induces an equi-proportional decrease in import quantities and leaves the value of imports unchanged. If the share of imports in GDP, which is negative by construction, decreases with import price $\left(a_{nn}^t < 0\right)$, then the implied import demand is inelastic, so that an increase in import price induces a less than proportionate decrease in import quantities. Finally, if the share of import in GDP increases with import prices $\left(a_{nn}^t > 0\right)$, then the implied import demand must be elastic such that an increase in the price of import induces a more than proportionate decrease in import quantity.[9]

3 Empirical Strategy

With data on output shares, unit values and factor endowments, Equation (10) is the basis of our estimation of import elasticities. In principle, we could first estimate the own price effects, a_{nn}^t, for every good according to Equation (10), and apply Equation (11) to derive the implied estimated

[8] Cross-price elasticities of import demand are given by: $\varepsilon_{nk}^t \equiv \frac{\partial q_n^t\left(p^t, v^t\right)}{\partial p_k^t}\frac{p_k^t}{q_n^t} = \frac{a_{nk}^t}{s_n^t} + s_k^t,\ \forall n \neq k.$

[9] Kohli (1991) found an inelastic demand for the aggregate US imports with $a_{nn} < 0$, while highly elastic demand for the durables and services imports of the US, with the corresponding $a_{nn} > 0$, when the aggregate import is broken down into 3 disaggregate groups.

elasticities, since the own price elasticity is a linear function of own partial effects. There are, however, at least three problems with the estimation of the elasticities using (10). First, there are more than 4600 HS 6 digit goods traded among the countries in any given year. Moreover, there is also a large number of non-traded commodities that compete for scarce factor endowments and contribute to GDP in each country. Thus the number of explanatory variables in Equation (10) could easily exhausts our degrees of freedom or introduce serious collinearity problems. Second, even after solving this first problem, we could also run out of degrees of freedom given the short time span of trade data available at the six digit of the HS –which only started being used in the late 1980s. Finally, there is nothing so far to ensure that the estimated elasticities satisfy second order conditions of GDP maximization, i.e., there are negative. We tackle these three problems in turn.

3.1 Estimating the N-good share equations

To estimate all the own price and cross price effects, a_{nk}^t, for each of the 4600 HS 6 digit goods is equivalent to estimate the upper triangle of the N by N second order substitution matrix. This works out to be $N(N-1)/2+N$ parameters to be estimated, which in our case are more than 10 million parameters for each time period t! This is obviously not a small task, even if we restrict all the translog parameters to be time invariant, and the normal system of share equation techniques used in Kohli (1991) or Harrigan (1997) would not have been sufficient. We need a way to legitimately reduce the number of parameter estimates and only focuses on those parameters that are of interests. In the case of own price import demand elasticities, would be the 4600 diagonal elements of the substitution matrix.

We adopt a *semiflexible functional form* developed in Diewert and Wales (1988) specifically design to handle models with a large number of goods. We first restrict all the translog parameters to be time invariant. Next, rather than having the full rank substitution matrix of $\left[a_{nk}^t\right]$ to be fully flexible to approximate any arbitrary twice continuously differentiable function to the second order at any arbitrary point (Diewert, 1974), we impose the following restrictions to reduce the number of parameters needed:

$$
\begin{aligned}
a^t_{nk} &= a_{nk} = \gamma a_n a_k, \forall n \neq k, & (12)\\
a^t_{nn} &= a_{nn} = -\gamma a_n \sum_{k\neq n} a_k & (13)
\end{aligned}
$$

where γ, a_n and a_k are constants. It could be easily verified that for any good n, the above reparametrization satisfies the homogeneity constraint, such that $a_{nn} + \sum_{k\neq n} a_{nk} = 0$, as well as symmetry constraint, such that $a_{nk} = a_{kn.}$ In other words, we approximate the full rank second order substitution matrix by the product of two column vectors, $a = [a_1, ..., a_N]'$, a column vector of scalars a_n, and its transpose, and adjust the diagonal elements to satisfy all homogeneity constraints (13) :

$$
\left[a^t_{nk}\right]_{N\times N} = \gamma a_{N\times 1} a'_{1\times N} - diag\left[\gamma a_n a_n + \gamma a_n \sum_{k\neq n} a_k\right]_{N\times N}.
$$

This effectively reduces the full rank symmetric substitution matrix $[a_{nk}]$ to rank one. Diewert and Wales (1988) shows that by replacing the full rank substitution matrix with lower-rank matrixes, starting with rank one, a semiflexible functional form, or in our case, a *flexible of degree one functional form,* can still approximate an arbitrary twice continuously differentiable function form to the second order at some point, except the matrix of second order partial derivatives of the functional form with respect to prices is restricted to have maximum rank one instead of the maximum possible rank, $N - 1$.[10] They further show that the cost of estimating a semiflexible function form instead of a fully flexible functional form, is that we will miss out all the parts of $[a_{nt}]$ that have to the smaller eigen values, but in many situations, this cost is small.[11]

[10] Neary (2004) uses this approach to estimate the AIDS or QUAIDS systems from an expenditure function. He starts with rank 1, then uses the maximum likelihood estimates as the starting values for the estimation of a rank 2 matrix. With each iteration, one more column is added, so is the rank of the matrix. Due to the number of good involved, we stop at rank 1, in view of the enormous complexity of going to higher rank.

[11] Diewert and Wales (1988) also use an example of Canadian per capita time series data for ten consumer expenditure categories to illustrate that, semiflexible functional form, when the rank is small, may lead to inelastic demand estimates. For our current data, as shown in the result section, the average estimated import elasticity is -1.67, and median elasticity is -1.08, and more than 90% of the elasticity estimates are significant. Thus the issue of inelastic demand may not be a severe problem in our data set.

The resulting share equation for each good n would be

$$\begin{aligned} s_n^t\left(p^t, v^t\right) &= a_{0n} - \gamma a_n \sum_{k\neq n} a_k \ln p_n^t + \gamma a_n \sum_{k\neq n} a_k \ln p_k^t + \sum_{m=1}^{M} c_{nm} \ln v_m^t,\ \forall n = 1, ..., N, \\ &= a_{0n} - \gamma a_n \left(\sum_{k\neq n} a_k\right) \ln p_n^t + \gamma a_n \left(\sum_{k\neq n} a_k\right) \sum_{k\neq n} \frac{a_k}{\sum_{k\neq n} a_k} \ln p_k^t + \sum_{m=1}^{M} c_{nm} \ln v_m^t \\ &= a_{0n} - \gamma a_n \left(\sum_{k\neq n} a_k\right) \left(\ln p_n^t - \overline{\ln p_k^t}\right) + \sum_{m=1}^{M} c_{nm} \ln v_m^t, \\ &= a_{0n} + a_{nn} \ln \frac{p_n^t}{\overline{\overline{p_k^t}}} + \sum_{m=1}^{M} c_{nm} \ln v_m^t, \end{aligned}$$

where $\overline{\ln p_k^t} = \sum_{k\neq n} \frac{a_k}{\sum_{k\neq n} a_k} \ln p_k^t$ is an weighted average of the log prices of all non-n goods. Thus with this reparametrization, the share equation of good n depends linearly on the log price of good n relative to an average price of all non-i goods, and the endowments. This significantly reduces the number of variables on the right-hand side from $N + M$, to $1 + M$.[12]

We further impose homogeneity constraints on endowments, such that $\sum_{m=1}^{M} c_{nm} = 0$, $\forall n = 1, ..., N$. This reduces the number of right-hand side variables to only M :

$$s_n^t\left(p^t, v^t\right) = a_{0n} + a_{nn} \ln \frac{p_n^t}{\overline{\overline{p_k^t}}} + \sum_{m\neq l, m=1}^{M} c_{nm} \ln \frac{v_m^t}{v_l^t}, \forall n = 1, ..., N.$$

Notice that, the weights used to construct the average price of all non-n goods are all unknown, we proxy the average price with the observed Tornqvist price index of all non-n goods, $\ln p_{-n}$, which is the average share weighted average prices of all non-n goods. This approximation introduces an

[12] We are not the first in the literature to reparametrize the translog revenue function in order to reduce the number of parameters to be estimated. Recently, Feenstra (2003) explores the "symmetric" translog indirect expenditure function where he found that with symmetry, $a_{0n} = 1/N$, $a_{nk} = \gamma/N$ and $a_{nn} = -\gamma\left(1 - 1/N\right)$. Feenstra shows that such a reparametrization is very convenient, especially when it comes to introduce new variety of goods into the expenditure function – increase in the number of goods, increases N, which decreases a_{nk} and a_{nn}. The decrease in a_{nn} due to an increase in number goods will further increases own price elasticity of good n in magnitude, and reduces the markups of each existing good, which represents the pro-competitive effect of entry of new goods in a monopolistic competition model. In our current setting, increases in new goods increases $\sum_{k\neq n} K_k$ for each good n, which also decreases a_{nn} for all existing good n, and increases demand elasticities of all existing good n in magnitude. Thus without imposing complete symmetry as in Feenstra (2003), our current setting is also capable in capturing the effects of new goods in the GDP function, via its effects on the reparametrized slope coefficients of the share equations.

additive error terms to reflect measurement error for each share equation, μ_n^t :

$$\begin{aligned} \ln p_{-n}^t &\equiv \sum_{k \neq n} \frac{\bar{s}_k^t}{\sum_{k \neq n} \bar{s}_k^t} \ln p_k^t, \text{ where } \bar{s}_k^t = \frac{1}{2}\left(s_k^t + s_k^{t-1}\right) \\ \overline{\ln p_k^t} &= \ln p_{-n}^t + \mu_n^t, && (14) \\ s_n^t\left(p^t, v^t\right) &= a_{0n} + a_{nn} \ln \frac{p_n^t}{p_{-n}^t} + \sum_{m \neq l, m=1}^{M} c_{nm} \ln \frac{v_m^t}{v_l^t} + \mu_n^t, \forall n = 1, ..., N. && (15) \end{aligned}$$

Equation (15) is the basis used for the estimation of own price effect, a_{nn}, and hence own price import elasticity, ε_{nn}.

Finally, according to Caves, Christensen, and Diewert (1982), given that $G\left(p^t, v^t\right)$ is translog with time invariant parameters, the underlying GDP deflator is a Tornqvist price index of all goods, $\ln p^t$:

$$\begin{aligned} \ln p^t &\equiv \sum_{k} \bar{s}_k^t \ln p_k^t \\ &= \bar{s}_n^t \ln p_n^t + \sum_{k \neq n} \bar{s}_k^t \ln p_k^t \\ &= \bar{s}_n^t \ln p_n^t + \left(1 - \bar{s}_n^t\right) \sum_{k \neq n} \frac{\bar{s}_k^t}{\sum_{k \neq n} \bar{s}_k^t} \ln p_k^t, \text{ since } 1 - \bar{s}_n^t = \sum_{k \neq n} \bar{s}_k^t \\ &= \bar{s}_n^t \ln p_n^t + \left(1 - \bar{s}_n^t\right) \ln p_{-n}^t. \end{aligned}$$

Thus, we can use the published GDP deflator net of the share adjusted price of good n to construct the average price of all non-n goods:

$$\ln p_{-n} = \frac{\ln p^t - \bar{s}_n^t \ln p_n^t}{1 - \bar{s}_n^t}, \forall n = 1, ..., N.$$

3.2 Using the panel variation in the data

Due to the limited time variation in the data and to take advantage of the panel nature of the sample, Equation (15) is pooled across countries and years for each good n. We assume that the structural parameters of the GDP function are time and country invariant (up to a constant) as in Harrigan (1997). Notice that even though we assume that a_{nn} is common across all countries, the implied own price elasticities will still vary across countries, given that s_{nc}^t is country specific (see

Equation (11)).

Pooling the data across countries and years and introducing country subscript c in Equation (15), we further assume that the stochastic term, μ_n^t, has a two way error: one is country specific, a_{nc}, and the other one is year specific, a_n^t:

$$\begin{aligned} s_{nc}^t\left(p_{nc}^t, p_{-nc}^t, v_c^t\right) &= a_{0n} + a_{nn}\ln\frac{p_{nc}^t}{p_{-nc}^t} + \sum_{m\neq l, m=1}^{M} c_{nm}\ln\frac{v_{mc}^t}{v_{lc}^t} + \mu_{nc}^t,\ \forall n, c,\ \text{with} \\ \mu_{nc}^t &= a_{nc} + a_n^t + u_{nc}^t,\ u_{nc}^t \sim \mathcal{N}\left(0, \sigma_n^2\right),\ \Rightarrow \\ s_{nc}^t\left(p_{nc}^t, p_{-nc}^t, v_c^t\right) &= a_{0n} + a_{nc} + a_n^t + a_{nn}\ln\frac{p_{nc}^t}{p_{-nc}^t} + \sum_{m\neq l, m=1}^{M} c_{nm}\ln\frac{v_{mc}^t}{v_{lc}^t} + u_{nc}^t,\ \forall n. \end{aligned} \tag{16}$$

Equation (16) allows for country and year fixed-effects, which enable us to capture any systematic shift in the share equation that is country or year specific. We apply the within estimator to estimate Equation (16), by appropriately removing the country means and year means from each variable (and adding back the overall mean), and express all variables in deviation form (with suffix d) :

$$ds_{nc}^t = a_{0n} + a_{nn}d\ln\frac{p_{nc}^t}{p_{-nc}^t} + \sum_{m\neq l, m=1}^{M} c_{nm}d\ln\frac{v_{mc}^t}{v_{lc}^t} + u_{nc}^t,\ \forall n. \tag{17}$$

3.3 Ensuring second order conditions

For Equation (17) to be the solution to the GDP maximization program, second order necessary conditions need to be satisfied (the Hessian matrix needs to be negative semi-definite). Such conditions are also known as the curvature conditions which ensure that the GDP function is smooth, differentiable, and convex with respect to output prices and concave with respect to input prices and endowments. This implies that the estimated import elasticities are not positive (see Equation (6)), i.e.:

$$a_{nn} \geq s_{nc}^t\left(1 - s_{nc}^t\right), \forall c, t, n.$$

Given that by construction $s_{nc}^t < 0$, the above is true if

$$a_{nn} \geq \hat{s}_n\left(1 - \hat{s}_n\right), \tag{18}$$

where $\hat{s}_n$ is the maximum (negative) share in the sample for good n. For all variables we denote such an observation (the $\hat{s}_n$ maximum) with a over-hat. To ensure that the curvature conditions are satisfied, we first need to difference all observations with respect to the observation where the curvature condition is most likely to be violated, and add back $\hat{s}_n$, so that the expected value of the intercept equals the maximum share:

$$\begin{aligned} ds_{nc}^t - d\hat{s}_n + \hat{s}_n &= \tilde{a}_{0n} + a_{nn}\left(d\ln\frac{p_{nc}^t}{p_{-nc}^t} - d\ln\frac{\hat{p}_n}{\hat{p}_{-n}}\right) \\ &+ \sum_{m\neq l,m=1}^{M} c_{nm}\left(d\ln\frac{v_{mc}^t}{v_{lc}^t} - d\ln\frac{\hat{v}_m}{\hat{v}_l}\right) + u_{nc}^t - \hat{u},\ \forall n. \end{aligned} \tag{19}$$

Such a procedure ensure that the expected value of the intercept is equal to the maximum share, $\hat{s}_n$, without affecting the slope coefficients, a_{nn} and c_{nm}. We then impose the constraint provided by Equation (18) , by reparameterizing a_{nn} in Equation (19) as follows:

$$a_{nn} = \tau_{nn}^2 + \tilde{a}_{0n}\left(1 - \tilde{a}_{0n}\right),$$

where $\tilde{a}_{0n}$ and $\tau_n n$ are parameters to be estimated nonlinearly. Thus, the final version of the share equation is

$$\begin{aligned} ds_{nc}^t - d\hat{s}_n + \hat{s}_n &= \tilde{a}_{0n} + \left(\tau_{nn}^2 + \tilde{a}_{0n} - \tilde{a}_{0n}^2\right)\left(d\ln\frac{p_{nc}^t}{p_{-nc}^t} - d\ln\frac{\hat{p}_n}{\hat{p}_{-n}}\right) \\ &+ \sum_{m=1}^{M} c_{nm}\left(d\ln\frac{v_{mc}^t}{v_{lc}^t} - d\ln\frac{\hat{v}_m}{\hat{v}_l}\right) + \tilde{u}_{nc}^t, \end{aligned} \tag{20}$$

where regression error term, $\tilde{u}_{nc}^t$, has a normal distribution with expected value of zero and variance $\tilde{\sigma}^2$. Given that $\tilde{a}_{0n}$ and τ is nonlinear with respect to $\tilde{u}_{nc}^t$, nonlinear estimation techniques are necessary.

Note that this may not be enough to ensure that all import demand elasticities are negative. Indeed, if the estimated $\tilde{a}_{0n}$ turns out to be smaller than $\hat{s}_n$, then some of the elasticities may still turn out to be non-negative. In other words, this is not a deterministic setup and $\hat{s}_n$ is only the $E(\tilde{a}_{0n})$. Thus, when estimating the import share equation prior to differencing with respect to the observation where the second order condition is more likely to be violated, if the error term of a particular observation is positive, then the estimated elasticity for this observation will also be positive. In those cases we impose $\tilde{a}_{0n} \equiv \hat{s}_n$ in the estimation procedure, which ensures that all elasticities are negative. This occurs in less than 3 percent of the sample.

Finally, given that the import demand elasticity is non-linear in the estimated parameters we estimate the standard errors of the import demand elasticities through bootstrapping (50 random draws for each six digit HS good).

4 Data

The data consists of import values and quantities reported by different countries to the UN Comtrade system at the six digit of the HS (around 4600 products).[13] The HS was introduced in 1988, but a wide use of this classification system only started in the mid 1990s. The basic data set consists of an unbalanced panel of imports for 117 countries at the six digit level of the HS for the period 1988-2002. The number of countries obviously varies across products depending on the presence of import flows and on the availability of trade statistics at the HS level.

There are three factor endowments included in the regression: labor, capital stock and agriculture land. Data on labor force and agriculture land are from the World Development Indicators (WDI, 2003). Data on capital endowments is constructed using the perpetual inventory method based on real investment data in WDI (2003).

The estimation sample did not include tariff lines where the recorded trade value at the at the six digit level of the HS was below $50 thousand per year. This eliminated less than 0.1 percent of imports in the sample, and it is necessary in order to avoid biasing our results with economically meaningless imports. The elasticities are constructed following Equation (11), where the import share is the sample average (i.e., we constrained the elasticities to be time invariant). We also purged the reported results from extreme values by dropping from the sample the top and bottom 0.5 percent of the estimates.

[13] It is available at the World Bank through the World Integrated Trade System (WITS).

5 Empirical Results

To be precise, we estimate a total of 315451 import demand elasticities at the six digit level of the HS for 117 countries. The simple average across all countries and goods is -1.67 and the standard deviation is 2.47 suggesting quite a bit of variance in the estimates. Figure 1 shows the Kernel density estimate of the distribution of all estimated elasticities. The vertical line to the left denotes the sample mean (-1.67), and the line to the right the sample median (-1.08).

All import demand elasticities are quite precisely estimated. The median t-statistics is around -11.96. Around 89 percent of the elasticities are significant at the 1 percent level; 91 percent at the 5 percent level and 93 percent at the 10 percent level.

The estimates vary substantially across countries. The top three countries with the highest average elasticity are Japan, United States and Brazil (-4.05, -3.39 and -3.38, respectively). The three countries with the lowest average import demand elasticities are Surinam, Belize and Guyana (-1.02, -1.03 and -1.03, respectively). Table 1 summarizes the elasticities by country providing the simple average, the standard deviation, the median and the import-weighted average elasticity.

The estimate also show some variation across products. Goods with the more elastic import demands (on average across countries) at the six digit level of the HS include HS 520635 (Cotton yarn), 854290 (Electronic integrated circuits), and 100810 (Buckwheat), with average elasticities of -16.29, -12.89 and -11.72, respectively. Similarly, the least elastic import demands are found in HS 140291 (Vegetable residuals for stuffing), HS 420232 (Articles for pocket, plastic/textile materials) and HS 290521 (Allyl Alcohol), with average elasticities of -0.52, -0.65 and -0.66.

Given the lack of existing estimates at the tariff line level, we need some guidelines to judge our results. Below we enumerate some predictions we expect to find in the estimated import demand elasticities:

1. The import demand for homogenous goods is more elastic than for heterogenous goods. Rauch (1999) classifies goods into these categories, which we can use to test the hypothesis.

2. Import demand is more elastic at the disaggregate level – the substitution effect between cotton shirts and wool shirts is larger than the substitution effect between shirts and pants, or garment and electronics. Thus, we expect the HS six digit estimates to be larger in magnitude (more negative) than estimates at a more aggregate level, i.e., three digit level

ISIC classification, which is formed of 29 industries, respectively. Broda and Weinstein (2004) uses a similar guideline for their elasticities of substitution estimates.

3. Import demand is more elastic in large countries. The rationale is that in large countries there is a larger range of domestically produced goods and therefore the sensitivity of import demand to import prices is expected to be larger. In other words, it is easier to substitute away from imports into domestically produced goods in large economies.

4. Import demand is less elastic in more developed countries. The relative demand for heterogenous goods is probably higher in rich countries. Given that heterogenous goods are less elastic, we expect the import demand to be less elastic in rich countries.

To test the homogenous versus heterogenous goods hypotheses, we use Rauch's (1999) classification. Rauch groups four digit SITC goods into three categories: differentiated, reference priced and homogenous goods. By matching our HS six digit products to the SITC schedule, we are able to classify our products according to Rauch's schedule. Table 2 provides the sample averages, medians and standard deviations of the estimated import demand elasticities according to the three categories of goods. It is clear that the average elasticity is larger in magnitude for homogenous goods, follows by the reference priced and differentiated goods. Simple mean tests supported the hypotheses that homogenous goods are more elastic than reference priced goods, and reference priced goods are more elastic than differentiated goods. The t-statistics of the two tests are 7.23 and 19.50 respectively. Similarly, the median elasticity for differentiated goods is smaller in magnitude than both reference priced and homogeneous goods. A simple rank test shows that the median elasticity of differentiated goods is statistically smaller in magnitude than the rest, with a p-value close to 0, while the difference between the median elasticities of reference price goods and homogenous goods is not statistically significant. All this suggests that differentiated goods are less elastic than reference priced and homogeneous goods, which confirms our first *a priori*.

To test the second hypothesis, we reestimated import demand elasticities at the industry level, through a concordance linking HS six digit classification to ISIC three digit industry classification. Table 3 provides the average elasticity by country at the different levels of aggregation. It confirms that elasticities are smaller in magnitude when estimated at the industry level than at the tariff line level. On average elasticities estimated at the six digit level of the HS are 39 percent higher than those estimated at the three digit level of the ISIC.

In order to test the last two hypothesis we run the average elasticity at the country level on log of GDP and GDP per capita. The conditional plots of these relationships are provided in Figures 3 and 4, as well as the estimated coefficient and its standard error. They confirm that import demand is more elastic in large and less developed countries. Thus, the last two hypotheses cannot be rejected.[14]

6 Calculating TRIs and Decomposing Deadweight Losses

The estimated import demand elasticities allow us to examine the trade restrictiveness and welfare losses associated with the existing tariff structure in 88 countries for which tariff schedules are available.[15] More importantly, this can be done within a theoretically-sound framework. The literature has traditionally measure trade restrictiveness using a-theoretical measures such as simple and import-weighted tariffs.[16] As argued by Anderson and Neary (1994, 1996, 2004) these have little theoretical foundations. Import-weighted averages tend to be downward bias, as for example, they put zero weight on prohibitive tariffs and simple average tariffs put identical weights on tariffs that may have very different economic significance. Anderson and Neary (1994, 1996) propose a trade restrictiveness index (TRI), which has a theoretically sound averaging procedure. TRI is defined as the uniform tariff that yields the same real income, and therefore national welfare, as the existing tariff structure. Deadweight loss measures can also be constructed using TRIs and theoretically consistent estimates of import demand elasticities, which in turn allows for comparisons of welfare distortions associated with each country's tariff structure.

To calculate the TRI, one would ideally need to solve a full-fledged general equilibrium model for the uniform tariff that could keep welfare constant given the observed tariff structure. Feenstra (1995) provides a simplification of TRI, which only requires information on import demand

[14] We found similar patterns when regressing on the median elasticity by country. The coefficient on GDP is 0.03 and on GDP per capita - 0.02 and both are statistically significant at the 1 percent level.

[15] Data sources for tariff data are United Nations' Comtrade and the Integrated Database of the WTO. In this paper, we abstract from measuring the trade restrictiveness of non-tariff barriers, as well as the role of tariff preferences in eroding trade restrictiveness. For an attempt to do so, see Kee, Nicita and Olarreaga (2005).

[16] If NTB measures are to be considered, trade economist often use simple or import-weigthed coverage ratios of NTBs.

elasticities, share of imports and the current tariff schedule:[17]

$$\text{TRI}_c = \left[\frac{\frac{1}{2}\sum_n (dq_{nc}/dp_{nc})t_{nc}^2}{\frac{1}{2}\sum_n (dq_{nc}/dp_{nc})}\right]^{1/2} = \left[\frac{\sum_n s_{nc}\varepsilon_{nnc}t_{nc}^2}{\sum_n s_{nc}\varepsilon_{nnc}}\right]^{1/2}, \tag{21}$$

with t_{nc} is the tariff on good n in country c. Thus, the simplified TRI is the square root of a weighted average of square tariffs, where weights are determined by the import demand elasticities in each country. Given that we are using GDP maximizing import demand elasticities instead of Hicksian elasticities as in Feenstra (1995), our measures of TRI and DWL are consistent with GDP maximization.[18]

It is clear from Equation (21) that when tariffs are uniform, the TRI equals both import-weighted and simple average tariffs. When tariffs are not uniform, this is not longer the case, except under very unlikely conditions. To see this, let $\bar{t}_c$ denote the import-weighted average tariff of country c, σ_c^2 the import-weighted variance of the tariff schedule, $\bar{\varepsilon}_c$ the import-weighted average elasticities of c, $\tilde{\varepsilon}_{nc}$ the import demand elasticity of good n in c re-scaled by $\bar{\varepsilon}_c$, and ρ_c the import-weighted covariance between tariff square and import demand elasticities:

$$\begin{aligned} \bar{t}_c &\equiv \sum_n s_{nc}t_{nc},\ \sigma_c^2 \equiv \sum_n s_{nc}\left(t_{nc}-\bar{t}_c\right)^2 > 0, \\ \bar{\varepsilon}_c &\equiv \sum_n s_{nc}\varepsilon_{nnc},\ \tilde{\varepsilon}_{nc} \equiv \frac{\varepsilon_{nnc}}{\bar{\varepsilon}_c} > 0,\ \rho_c \equiv \text{Cov}\left(\tilde{\varepsilon}_{nc}, t_{nc}^2\right). \end{aligned}$$

Then using Equation (21) it can be shown that:[19]

$$\text{TRI}_c = \left[\sum_n s_{nc}\tilde{\varepsilon}_{nc}t_{nc}^2\right]^{1/2} = \left[E\left(\tilde{\varepsilon}_{nc}t_{nc}^2\right)\right]^{1/2} = \left[\bar{t}_c^2 + \sigma_c^2 + \rho_c\right]^{1/2}. \tag{22}$$

Thus, according to Equation (22), TRI increases with import-weighted tariffs, their variance and their covariance with import demand elasticities. As in Feenstra (1995) and Anderson and Neary (2004), everything else equal, the larger the tariff variance, the larger is TRI_c relative to $\bar{t}_c$. More interestingly, TRI_c will be larger than $\bar{t}_c$, if high tariffs are levied on more elastic imported goods

[17] See Equation (3.5) in Feenstra (1995). Note that given our setup, the derivation in Feenstra (1995) is equivalent to deriving the TRI that would keep GDP at its maximum level given the existing tariff structure.

[18] See Kohli (1991), Equations 18.27 to 18.31.

[19] In the third equality note that the expected value of $\tilde{\varepsilon}_{nc}$ equals 1 by construction.

so that the covariance between elasticities and tariff square is positive. In short, the ratio and difference between TRI and $\bar{t}_c$ reflects both the variance of tariffs and the correlation between tariffs and import demand elasticities:

$$\ln \frac{\text{TRI}_c}{\bar{t}_c} = \frac{1}{2} \ln \left(1 + \frac{\sigma_c^2}{\bar{t}_c^2} + \frac{\rho_c}{\bar{t}_c^2} \right), \tag{23}$$

$$\text{TRI}_c - \bar{t}_c = \frac{\sigma_c^2 + \rho_c}{\text{TRI}_c + \bar{t}_c}. \tag{24}$$

Using Equations (21) and (22), one can further compute the linear approximation to the deadweight losses (DWL) associated with the existing tariff structure as:

$$\text{DWL}_c \equiv \frac{1}{2} \text{GDP}_c \sum_n s_{nc} \varepsilon_{nnc} t_{nc}^2 \tag{25}$$

$$= \frac{1}{2} \left(\text{TRI}_c\right)^2 \text{GDP}_c \sum_n s_{nc} \varepsilon_{nnc} \tag{26}$$

$$= \underbrace{\frac{1}{2} \bar{t}_c^2 \text{GDP}_c \bar{\varepsilon}_c}_{\text{Tariff average}} + \underbrace{\frac{1}{2} \sigma_c^2 \text{GDP}_c \bar{\varepsilon}_c}_{\text{Tariff variance}} + \underbrace{\frac{1}{2} \rho_c \text{GDP}_c \bar{\varepsilon}_c}_{\text{Tariff-elasticity covariance}}. \tag{27}$$

Equation (26) shows how we can infer the deadweight loss associated with the existing tariff regime using the constructed TRI_c. Equation (27) shows how the deadweight loss can be decomposed into the three elements that define TRI_c.

Table 4 presents TRIs computed using Equation (21) for a sample of 88 countries where tariff schedules are available. Countries with the highest TRIs include India (36.62%), Morocco (32.61%), Tunisia (30.42%), Oman (28.55%) and Nicaragua (27.87%). The lowest TRIs are found in Hong Kong (0%), Singapore (0%), Estonia (2.37%), New Zealand (5.08%), and Madagascar (6.09%). For comparison, Table 4 also shows the simple and import-weighted average tariffs. The sample mean average tariffs, import-weighted tariffs, and TRI are 10.04, 8.93 and 13.11, respectively. While the three indicators of trade restrictiveness are highly correlated–the correlation coefficient between TRI and the two other measures is about 0.89, and the correlation between the simple average tariff and the import-weighted tariff is 0.95–pair-wise comparisons yield some interesting results. For example, Oman is among the countries with the highest TRI but has an average tariff of only 7.64 percent. On the other hand, while Norway's average and import-weighted tariffs are only a fraction of that of Madagascar, Norway's TRI is 50 percent higher. These examples indicate that tariff variance and its covariance with import demand elasticities do matter, and due to their contributions to trade restrictiveness, the TRI is on average 50 percent higher than import-weighted tariffs in the sample.[20]

Table 4 highlights the countries where TRI is larger than import-weighted average tariff by at least 20, 50 and 100 percent with *, ** and ***, respectively. Nearly three quarter of the sample countries falls into these 3 categories. Among the countries where TRIs are at least twice as large as import-weighted tariffs, Sudan, the U.S., Malaysia and Turkey also have higher than average TRIs, ranging from 15 to 20 percent, despite relatively low average tariffs. To illustrate the differences between TRIs and import-weighted average tariffs, Figure 4 plots these two for the 88 countries in our sample, along with the 45 degree line. For each country, the distance above the 45 degree line indicates the wedge between TRI and import-weighted tariff as shown in Equation (24). Countries that have large differences between TRI and import-weighted tariff locate closer to the North-East corner.

What causes import-weighted tariff to hugely underestimate TRI for these countries? Equation (23) indicates that tariffs variance and their (positive) covariance with import demand elasticities are the two forces behind this difference. To assess the role played by the former, Table 4 also provides the import-weighted (and unweighted) variance of tariffs. It is clear that in Norway, Estonia, Sudan and Malaysia, large tariff variances are an important force behind the spread. In fact, for most countries in the sample, tariff variance is the major driving force behind the spread between TRI and import-weighted tariffs. However, among the countries where TRI is at least twice as large as the import-weighted tariff, the variance of U.S. and Sudan are found to be relatively small which indicates the presence of disproportionately large covariances between tariffs and import demand elasticities. Other countries that have disproportionately large covariances are Nicaragua, China, Argentina, and Turkey, Peru and France.

The relative contribution of the tariff average, variance and covariance in distorting trade is most clear when we use TRI to construct and decompose total DWL into it three elements, according to Equation (27). The total DWL and its components in millions of US dollars are presented in Table 5. In terms of total DWL, the U.S., China, Mexico, India and Germany have the largest

[20] The TRI is also 40 percent higher than simple average tariffs. Note that, here and from here onwards, percentage difference is calculated using log differences, as in Equation (23).

losses associated with their existing tariff structure. In particular, at nearly $10 billion per year, the DWL of the United States is about 30 percent of the sum of welfare losses in our sample, which is about $34 billion per year. In per capita terms, Oman, Mauritius, Norway, Slovenia and the U.S. face the largest losses.

Decomposition of DWL shows that, average tariffs can explain more than 80 percent of total DWL in Chile, Peru, Bolivia, Uruguay and Bangladesh. These countries have relatively small tariff variance and covariance with import demand elasticities and thus are located very close to the 45 degree line in Figure 4. Countries where the variance of tariff is the largest element contributing to the overall DWL include Oman, Latvia, Estonia, Norway and Japan. More than 75 percent of the total DWL can be attributed to the variance of tariffs in these countries.

The last component of DWL is the covariance between tariffs and import demand elasticities. Covariance between tariffs and import demand elasticities lowers DWL if it is negative, rises DWL if it is positive. Negative covariance between tariffs and import demand elasticities indicates that higher tariffs are levied on more inelastic imports. This happens in countries such as Australia, Bangladesh, Korea and Oman, which have negative contributions of covariance between tariffs and elasticities. However, a majority of the countries listed in Table 5 have positive contributions due to the covariances. This suggests that in most countries higher tariffs are imposed on more elastic imports. This is most significant in the U.S., Sudan, Nicaragua, Turkey and China, when more than half of the DWL is due to the positive covariance between tariffs and import demand elasticities. In particular, in the U.S., the covariance between tariffs and elasticities contributes to $7.7 billion in DWL, which is more than three quarter of the total DWL. Given that imports that are close substitutes with domestic products tend to have higher import demand elasticities, the positive covariance between tariffs and import elasticities shows that domestic industries that are more organized to lobby for higher tariff protection are those that produce import substitutes. This result is consistent with lobbying theories of a welfare maximizing government setting tariff schedule under the influence of domestic lobbies facing import competition.

7 Caveats and Robustness Checks

A few assumptions imposed by the theoretical model may affect our estimates. First, by adopting a semiflexible translog specification, we assume that the elasticity of substitution between goods are not constant, and the underlying production function is not weakly separable (Blackorby and Russell, 1981).[21] Similar to Feenstra (2003), such a translog specification is very useful in studying the effect of new goods in a monopolistic competitive model. Differences in the own price effect on the share of good n, a_{nn}, reflects the number of relevant variety, such that when the competing variety is more, a_{nn} is larger in magnitude, so is the implied demand elasticity, ε_{nn}, and a lower equilibrium markups. This useful property would be missing if we were to adopt a CES specification where number of goods is a priori assumed fixed.

Second, in the current GDP maximizing approach, imports are considered as inputs into the production of domestic outputs, such that in equilibrium shares of imports depend on relative prices of goods and aggregate endowments. Alternative, the literature has been using an expenditure minimizing approach, where imports are considered as part of the final good consumption bundle, such that the equilibrium import demands depend on relative prices and income or welfare level. These two approaches yield import demand elasticities that have different meaning: the latter measures the responsiveness of imported final goods when price of import changes, hold income or welfare constant, while the formal measures the import responsiveness holding aggregate endowments constant while allowing factor income and shares to change simultaneously due to the change in an import price. Thus the import demand elasticity from the current GDP function approach is more general equilibrium while expenditure approach is arguably more partial equilibrium. Moreover, in a world where a significant share of growth in world trade is explained by vertical specialization (Yi, 2003), the fact that imports are treated as inputs into the GDP function – rather than as final consumption goods as in most of the previous literature – seems an attractive feature of this approach and is following the middle product approach of Sanyal and Jones (1982).

In addition, if the expenditure approach assume a CES objective function such as that of Feenstra (1994) and Broda and Weinstein (2003), the estimated elasticity is the elasticity of *substitution*

[21] The only CES function that is compatable with a translog GDP function is a Cobb-Douglas function, which has constant shares of goods. The fact that we can estimate the share equations indicating that good shares are not constant and do depend on relative prices and endowments which contradict a Cobb-Douglas production function.

between import and domestic products, which is also known as the Armington elasticity, not import demand elasticity. The difference between the two elasticities is the cross price demand elasticity between domestic and imported goods.[22] Only by assuming that cross price elasticity is zero such as that of a Cobb-Douglas utility function will the Armington elasticity and own price elasticity be equal. But in this case, the elasticities should both be equal to one by construction.

Third, for a small set of goods we have imposed the curvature conditions to make sure that the estimated import demand elasticities are negative. However, given that this happens to less than 3 percent of our sample, the effect of such conditions on TRI and the associated DWL is at best minimum.

Fourth, this version of TRI and DWL calculations only take into account the direct own price effects of tariffs. They ignore the cross price effects of other tariffs on import demand. Thus, at best, it represents the first order impact of import demand and welfare due to tariffs. Furthermore, the calculation of TRI and DWL ignore the existence of non-tariff barriers, such as quotas. To the extent that non-tariff barriers are the more binding constraints in distorting imports, TRI and DWL presented here may only capture the lower bound of the nature of trade protection and welfare distortions. Similarly, we have only focused on Most Favored Nation's tariffs, ignoring the numerous preferential agreements that may erode trade restrictiveness. Given the static nature of our analysis, dynamics effects on welfare associated with tariffs are also ignored.

Finally, we only include positive imports in the calculation of TRI and DWL. This ignores prohibitive tariffs. As a robustness check, we apply out of sample prediction for those goods that have zero imports, and re-calculated TRIs to include these goods. Such out of sample prediction does not change our results. While TRI tend to be slightly smaller, the two TRI's series have a correlation coefficient of 0.99. Thus, our results are robust to the presence of prohibitive tariffs.

[22] As shown in Blackorby and Russell (1989), elasticity of substitution equals cross price elasticity minus own price elasticity

$$\sigma_{ij} = \varepsilon_{ji} - \varepsilon_{ii}.$$

Note that σ_{ij} equals σ_{ji} if and only if utility function is of the implicit CES-Cobb-Douglas family. If the utility function is Cobb-Douglas such that $\varepsilon_{ji} = 0$, then $\sigma_{ij} = -\varepsilon_{ii} = 1$.

8 Concluding Remarks

This paper provides a much more systematic estimation of import demand elasticities than those existing in the previous literature for a broad group of countries and at a fairly disaggregated level of product detail. We use a GDP function approach that is consistent with neoclassical trade theories to derive import demand functions and elasticities. Import demand depends on prices of domestic and imported goods, as well as factor endowments, and can be estimated with existing data sets. The overall fit of the estimation of import demand elasticities is good. The sample average import demand elasticities is -1.67, while the sample median is -1.08, with sensible variation across countries and products.

Using the estimated elasticities this paper provides estimates of trade restrictiveness, as well as a study of the size and composition of trade distortions in 88 countries for which tariff schedules are available. Instead of relying on simple average or import-weighted tariffs, we construct a simplification of TRI following Feenstra (1995). A major obstacle to calculate the TRI in the past was the absence of consistently estimated import demand elasticities. This paper overcomes this problem. By showing that TRI is affected by the import-weighted tariff, the variance of tariffs, and the covariance between tariff squares and import demand elasticities, we then decompose deadweight loss into these three components. This paper shows that both a large variance of tariffs and a high covariance between tariff and elasticities can drive a wedge between TRI and import-weighted tariff, causing the latter to underestimate the restrictiveness of tariff regimes and the deadweight losses associated with them by 50 percent. While the variance of tariffs explains most of the trade distortions in Oman, Latvia, Estonia, Norway and Japan, the covariance between tariffs and import demand elasticities explains most of the trade distortions in the U.S., Sudan, Nicaragua, Turkey and China. In the case of the U.S., more than three quarters of the deadweight loss are due to high tariffs levied on more elastic imported goods. Given that high import demand elasticities may be due to close substitution with domestically produced goods, this result may be explained by the fact that industries that face severe import competition are more likely to get organized and lobby for higher tariffs. This empirical observation may help inform lobbying models.

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A Aggregating elasticities to the industry level

Our estimation procedure in Section 3 could be applied to goods at any level of aggregation, provided the adequate price indices have been constructed. This section provides an aggregation procedure from six digit HS estimates to any higher level of aggregation for a translog GDP function.

Let good $n \in A$ belong to industry A and good $n \in B$ belong to industry B, and $A \cup B = \{1, ..., N\}$, $A, B \neq \varnothing$. Then, the shares of good n and industry A in GDP are given by:

$$\begin{aligned} s_n^t\left(p^t, v^t\right) &= a_{0n}^t + \sum_{k=1}^{N} a_{nk}^t \ln p_k^t + \sum_{m=1}^{M} c_{nm}^t \ln v_m^t, \\ s_A^t &\equiv \sum_{n \in A} s_n^t\left(p^t, v^t\right) \\ &= \sum_{n \in A} a_{0n}^t + \sum_{k \in A}\left(\sum_{n \in A} a_{nk}^t\right) \ln p_k^t + \sum_{k \in B}\left(\sum_{n \in A} a_{nk}^t\right) \ln p_k^t + \sum_{n \in A} \sum_{m=1}^{M} c_{nm}^t \ln v_m^t. \quad (28) \end{aligned}$$

The Tornqvist price index at the industry level is the weighted average of goods' price indices within each industry:

$$\begin{aligned} \ln p_A^t &= \frac{1}{1-\bar{s}_A^t} \sum_{k \in A} \bar{s}_k^t \ln p_k^t, \quad (29) \\ \ln p_B^t &= \frac{1}{1-\bar{s}_B^t} \sum_{k \in B} \bar{s}_k^t \ln p_k^t, \end{aligned}$$

where $\bar{s}^t$ denotes the average share between two consecutive periods. To apply the above Tornqvist price index, we need to assume that all the translog parameters a_{nk}^t are time invariant.

If we were to estimate our parameters at the industry level instead of the good level, the share equation of industry A would be given by:

$$s_A^t = a_{0A} + a_{AA} \ln p_A^t + a_{AB} \ln p_B^t + \sum_{m=1}^{M} c_{Am}^t \ln v_m^t. \quad (30)$$

Equating Equations (28) and (30) imply that

$$\begin{aligned} a_{0A} &\equiv \sum_{n \in A} a_{0n}, \text{ and,} \\ a_{AA} \ln p_A^t &\equiv \sum_{k \in A}\left(\sum_{n \in A} a_{nk}\right) \ln p_k^t \Rightarrow \\ a_{AA} &= \frac{\sum_{k \in A}\left(\sum_{n \in A} a_{nk}\right) \ln p_k^t}{\ln p_A^t}, \ \forall n, k \in A. \end{aligned}$$

From Section 2, we know that

$$\begin{aligned}\varepsilon_{AA}^t &= \frac{a_{AA}}{s_A^t} + s_A^t - 1 \Rightarrow \\ &= \frac{\sum_{k\in A}\left(\sum_{n\in A} a_{nk}\right)\ln p_k^t / \ln p_A^t}{s_A^t} + s_A^t - 1.\end{aligned}$$

If industry A is a Hicksian aggregate of all k goods in A, such that all prices of goods are proportionate, which implies that $\ln p_k^t = \ln p_A^t$, $\forall k \in A$, then we can further simplify the industry elasticity to

$$\begin{aligned}\varepsilon_{AA}^t &= \frac{\sum_{k\in A}\sum_{n\in A} a_{nk}}{s_A^t} + s_A^t - 1 \quad (31)\\ &= \frac{1}{s_A^t}\sum_{k\in A}\sum_{n\in A} s_n^t \varepsilon_{nk}^t,\ \forall n,k \in A. \quad (32)\end{aligned}$$

Equation (32) shows that when an industry is formed by goods with proportionate prices (i.e. prices of goods move together), the industry own elasticity is the weighted average of the own and cross price elasticities of all goods within the industry. Cross price elasticity, ε_{nk}^t may be approximated by

$$\begin{aligned}\varepsilon_{nk}^t &= \frac{a_{nk}}{s_n} + s_k \\ &= \frac{\gamma K_n K_k}{s_n} + s_k \\ &= \frac{a_{nn}}{s_n}\left(\frac{K_k}{\sum_{k\neq n} K_k}\right) + s_k \\ &\simeq \frac{a_{nn}}{s_n}\frac{s_k}{\sum_{k\neq n} s_k} + s_k.\end{aligned}$$

Table 1: *Estimated elasticities: sample moments by country*

Country	Simple Average	Standard Deviation	Median	Import weighted average
Albania (ALB)	-1.12	-1.04	-1.04	-1.06
United Arab Em. (ARE)	-1.38	-1.16	-1.11	-1.07
Argentina (ARG)	-2.52	-1.13	-1.15	-1.26
Armenia (ARM)	-1.09	-1.06	-1.06	-1.05
Australia (AUS)	-2.49	-1.1	-1.1	-1.19
Austria (AUT)	-1.8	-1.05	-1.04	-1.08
Azerbaijan (AZE)	-1.18	-1.11	-1.1	-1.07
Burundi (BDI)	-1.07	-1.19	-1.12	-1.05
Belgium (BEL)	-1.51	-1.04	-1.05	-1.05
Benin (BEN)	-1.11	-1.11	-1.11	-1.05
Burkina Faso (BFA)	-1.1	-1.12	-1.08	-1.05
Bangladesh (BGD)	-1.65	-1.2	-1.19	-1.15
Bulguria (BGR)	-1.18	-1.05	-1.04	-1.06
Belarus (BLR)	-1.17	-1.04	-1.05	-1.05
Belize (BLZ)	-1.03	-1.05	-1.03	-1.03
Bolivia (BOL)	-1.23	-1.07	-1.1	-1.08
Brazil (BRA)	-3.38	-1.3	-1.22	-1.34
Barbados (BRB)	-1.08	-1.04	-1.08	-1.04
Central Afr. Rep. (CAF)	-1.08	-1.15	-1.11	-1.05
Canada (CAN)	-2.29	-1.05	-1.05	-1.13
Switzerland (CHE)	-1.99	-1.07	-1.06	-1.1
Chile (CHL)	-1.61	-1.05	-1.08	-1.1
China (CHN)	-2.54	-1.12	-1.14	-1.13
Cote d'Ivoire (CIV)	-1.32	-1.16	-1.13	-1.08
Cameroon (CMR)	-1.36	-1.21	-1.15	-1.12
Congo (COG)	-1.13	-1.11	-1.09	-1.04
Colombia (COL)	-1.81	-1.13	-1.08	-1.16
Comorros (COM)	-1.04	-1.17	-1.08	-1.03
Costa Rica (CRI)	-1.23	-1.03	-1.04	-1.06
Cyprus (CYP)	-1.17	-1.03	-1.02	-1.05
Czech Rep. (CZE)	-1.36	-1.03	-1.04	-1.05
Germany (DEU)	-2.01	-1.06	-1.07	-1.14
Denmark (DNK)	-1.69	-1.09	-1.07	-1.11
Algeria (DZA)	-1.59	-1.13	-1.14	-1.1
Egypt (EGY)	-1.78	-1.14	-1.13	-1.12
Spain (ESP)	-1.95	-1.06	-1.05	-1.14
Estonia (EST)	-1.09	-1.03	-1.02	-1.03
Ethiopia (ETH)	-1.17	-1.09	-1.06	-1.07
Finland (FIN)	-1.84	-1.07	-1.06	-1.12
France (FRA)	-1.93	-1.05	-1.07	-1.14
Gabon (GAB)	-1.15	-1.11	-1.12	-1.08
United Kingdom (GBR)	-1.91	-1.07	-1.06	-1.13
Georgia (GEO)	-1.15	-1.13	-1.09	-1.05
Ghana (GHA)	-1.15	-1.05	-1.07	-1.05
Guinea (GIN)	-1.19	-1.12	-1.1	-1.08
Gambia (GMB)	-1.04	-1.05	-1.06	-1.04
Greece (GRC)	-1.71	-1.04	-1.03	-1.12
Guatemala (GTM)	-1.38	-1.09	-1.14	-1.09
Guyana (GUY)	-1.03	-1.04	-1.04	-1.02
Hong Kong (HKG)	-1.57	-1.04	-1.02	-1.04
Honduras (HND)	-1.11	-1.05	-1.09	-1.04
Croatia (HRV)	-1.22	-1.04	-1.02	-1.07
Hungary (HUN)	-1.32	-1.06	-1.05	-1.06
Indonesia (IDN)	-2.09	-1.12	-1.13	-1.14
India (IND)	-3.26	-1.31	-1.38	-1.33
Ireland (IRL)	-1.51	-1.04	-1.05	-1.07
Iran (IRN)	-1.87	-1.13	-1.15	-1.11
Iceland (ISL)	-1.2	-1.04	-1.07	-1.07
Israel (ISR)	-1.13	-1.06	-1.03	-1.06
Italy (ITA)	-2.1	-1.06	-1.07	-1.14
Jamaica (JAM)	-1.16	-1.1	-1.08	-1.05
Jordan (JOR)	-1.16	-1.05	-1.07	-1.04
Japan (JPN)	-4.05	-1.23	-1.4	-1.37
Kenya (KEN)	-1.26	-1.14	-1.1	-1.07
Korea (KOR)	-2.08	-1.1	-1.1	-1.1
Lebanon (LBN)	-1.26	-1.03	-1.02	-1.06
Sri Lanka (LKA)	-1.2	-1.1	-1.04	-1.06
Lithuania (LTU)	-1.2	-1.03	-1.02	-1.06
Latvia (LVA)	-1.16	-1.03	-1.02	-1.05
Morocco (MAR)	-1.45	-1.1	-1.05	-1.09
Madagascar (MDG)	-1.17	-1.12	-1.18	-1.09
Maldives (MDV)	-1.04	-1.04	-1.03	-1.02
Mexico (MEX)	-2.08	-1.06	-1.07	-1.11
Macedonia (MKD)	-1.12	-1.04	-1.05	-1.05
Mali (MLI)	-1.15	-1.19	-1.09	-1.06
Malta (MLT)	-1.09	-1.04	-1.02	-1.04
Mongolia (MNG)	-1.05	-1.06	-1.07	-1.03
Mauritius (MUS)	-1.11	-1.05	-1.02	-1.05
Malawi (MWI)	-1.07	-1.11	-1.13	-1.04
Malaysia (MYS)	-1.45	-1.07	-1.06	-1.05
Niger (NER)	-1.12	-1.1	-1.18	-1.06
Nigeria (NGA)	-1.59	-1.29	-1.15	-1.11
Nicaragua (NIC)	-1.06	-1.06	-1.07	-1.03
Netherlands (NLD)	-1.66	-1.04	-1.04	-1.07
Norway (NOR)	-1.93	-1.06	-1.08	-1.11
New Zealand (NZL)	-1.56	-1.11	-1.07	-1.1
Oman (OMN)	-1.23	-1.05	-1.06	-1.05
Panama (PAN)	-1.24	-1.05	-1.09	-1.07
Peru (PER)	-1.74	-1.18	-1.11	-1.16
Philippines (PHL)	-1.61	-1.08	-1.06	-1.07
Poland (POL)	-1.51	-1.08	-1.04	-1.09
Portugal (PRT)	-1.47	-1.05	-1.03	-1.09
Paraguay (PRY)	-1.19	-1.06	-1.02	-1.07
Romania (ROM)	-1.37	-1.04	-1.06	-1.09
Rwanda (RWA)	-1.12	-1.13	-1.14	-1.07
Saudi Arabia (SAU)	-1.86	-1.04	-1.06	-1.13
Sudan (SDN)	-1.32	-1.15	-1.14	-1.08
Senegal (SEN)	-1.16	-1.08	-1.11	-1.05
Singapore (SGP)	-1.3	-1.06	-1.02	-1.04
El Salvador (SLV)	-1.25	-1.06	-1.08	-1.07
Surinam (SUR)	-1.02	-1.05	-1.04	-1.02
Slovakia (SVK)	-1.22	-1.03	-1.02	-1.05
Slovenia (SVN)	-1.24	-1.03	-1.03	-1.05
Sweden (SWE)	-2.01	-1.06	-1.07	-1.11
Togo (TGO)	-1.08	-1.05	-1.06	-1.04
Thailand (THA)	-1.83	-1.15	-1.08	-1.08
Trinidad T. (TTO)	-1.15	-1.07	-1.07	-1.06
Tunisia (TUN)	-1.24	-1.04	-1.06	-1.06
Turkey (TUR)	-1.97	-1.11	-1.09	-1.14
Tanzania (TZA)	-1.28	-1.09	-1.09	-1.11
Uganda (UGA)	-1.22	-1.08	-1.17	-1.09
Ukraine (UKR)	-1.46	-1.05	-1.06	-1.1
Uruguay (URY)	-1.4	-1.08	-1.1	-1.12
United States (USA)	-3.39	-1.1	-1.16	-1.3
Venezuela (VEN)	-1.85	-1.09	-1.12	-1.15
South Africa (ZAF)	-2.04	-1.14	-1.1	-1.16
Zambia (ZMB)	-1.12	-1.06	-1.09	-1.05

Table 2: ***Sample moments of the estimated import demand elasticity by Rauch classification***[a]

	Mean	Median	Standard Deviation
Differentiated goods	-1.59	-1.07	2.25
Referenced price	-1.84	-1.09	2.84
Homogeneous goods	-1.98	-1.09	3.32

[a]The HS six digit schedule is first filtered into the four digit SITC schedule which Rauch (1999) used to classify goods. Homogenous goods are those traded on organized exchanges. Reference priced goods are those listed as having a reference price, and differentiated goods are goods that cannot not be priced by either of these two means.

Table 3: ***Average Estimated elasticities at different levels of aggregation***[a]

Country	HS six digit	ISIC three digit	Country	HS six digit	ISIC three digit
ALB	-1.12	-1.04	**ITA**	-2.10	-1.06
ARE	-1.38	-1.16	**JAM**	-1.16	-1.10
ARG	-2.52	-1.13	**JOR**	-1.16	-1.05
ARM	-1.09	-1.06	**JPN**	-4.05	-1.23
AUS	-2.49	-1.10	**KEN**	-1.26	-1.14
AUT	-1.80	-1.05	**KOR**	-2.08	-1.10
AZE	-1.18	-1.11	**LBN**	-1.26	-1.03
BDI	-1.07	-1.19	**LKA**	-1.20	-1.10
BEL	-1.51	-1.04	**LTU**	-1.20	-1.03
BEN	-1.11	-1.11	**LVA**	-1.16	-1.03
BFA	-1.10	-1.12	**MAR**	-1.45	-1.10
BGD	-1.65	-1.20	**MDG**	-1.17	-1.12
BGR	-1.18	-1.05	**MDV**	-1.04	-1.04
BLR	-1.17	-1.04	**MEX**	-2.08	-1.06
BLZ	-1.03	-1.05	**MKD**	-1.12	-1.04
BOL	-1.23	-1.07	**MLI**	-1.15	-1.19
BRA	-3.38	-1.30	**MLT**	-1.09	-1.04
BRB	-1.08	-1.04	**MNG**	-1.05	-1.06
CAF	-1.08	-1.15	**MUS**	-1.11	-1.05
CAN	-2.29	-1.05	**MWI**	-1.07	-1.11
CHE	-1.99	-1.07	**MYS**	-1.45	-1.07
CHL	-1.61	-1.05	**NER**	-1.12	-1.10
CHN	-2.54	-1.12	**NGA**	-1.59	-1.29
CIV	-1.32	-1.16	**NIC**	-1.06	-1.06
CMR	-1.36	-1.21	**NLD**	-1.66	-1.04
COG	-1.13	-1.11	**NOR**	-1.93	-1.06
COL	-1.81	-1.13	**NZL**	-1.56	-1.11
COM	-1.04	-1.17	**OMN**	-1.23	-1.05
CRI	-1.23	-1.03	**PAN**	-1.24	-1.05
CYP	-1.17	-1.03	**PER**	-1.74	-1.18
CZE	-1.36	-1.03	**PHL**	-1.61	-1.08
DEU	-2.01	-1.06	**POL**	-1.51	-1.08
DNK	-1.69	-1.09	**PRT**	-1.47	-1.05
DZA	-1.59	-1.13	**PRY**	-1.19	-1.06
EGY	-1.78	-1.14	**ROM**	-1.37	-1.04
ESP	-1.95	-1.06	**RWA**	-1.12	-1.13
EST	-1.09	-1.03	**SAU**	-1.86	-1.04
ETH	-1.17	-1.09	**SDN**	-1.32	-1.15
FIN	-1.84	-1.07	**SEN**	-1.16	-1.08
FRA	-1.93	-1.05	**SGP**	-1.30	-1.06
GAB	-1.15	-1.11	**SLV**	-1.25	-1.06
GBR	-1.91	-1.07	**SUR**	-1.02	-1.05
GEO	-1.15	-1.13	**SVK**	-1.22	-1.03
GHA	-1.15	-1.05	**SVN**	-1.24	-1.03
GIN	-1.19	-1.12	**SWE**	-2.01	-1.06
GMB	-1.04	-1.05	**TGO**	-1.08	-1.05
GRC	-1.71	-1.04	**THA**	-1.83	-1.15
GTM	-1.38	-1.09	**TTO**	-1.15	-1.07
GUY	-1.03	-1.04	**TUN**	-1.24	-1.04
HKG	-1.57	-1.04	**TUR**	-1.97	-1.11
HND	-1.11	-1.05	**TZA**	-1.28	-1.09
HRV	-1.22	-1.04	**UGA**	-1.22	-1.08
HUN	-1.32	-1.06	**UKR**	-1.46	-1.05
IDN	-2.09	-1.12	**URY**	-1.40	-1.08
IND	-3.26	-1.31	**USA**	-3.39	-1.10
IRL	-1.51	-1.04	**VEN**	-1.85	-1.09
IRN	-1.87	-1.13	**ZAF**	-2.04	-1.14
ISL	-1.20	-1.04	**ZMB**	-1.12	-1.06
ISR	-1.13	-1.06			

[a]The same pattern is obtained with the median elasticities by country.

Table 4: *Tariffs and trade restrictiveness indices*

Country	Unweighted Tariff		Import-weighted Tariff		TRI[a]	Country	Unweighted Tariff		Import-weighted Tariff		TRI[a]
code	Average	Variance	Average	Variance		code	Average	Variance	Average	Variance	
ALB	11.96	44.06	12.05	41.72	13.56	**KOR**	8.52	41.87	6.31	34.04	8.35*
ARG	14.49	31.13	12.02	31.41	15.35*	**LBN**	6.37	91.82	6.56	85.11	12.14**
AUS	4.80	42.43	5.41	32.38	7.19*	**LKA**	7.72	71.02	7.63	140.05	14.86**
AUT	4.58	18.90	3.92	19.34	6.52**	**LTU**	3.80	62.44	3.09	46.76	7.84**
BEL	4.60	19.28	3.88	19.33	7.17**	**LVA**	3.32	45.85	2.76	41.35	6.48**
BFA	12.42	46.26	10.82	51.94	13.56*	**MAR**	28.82	514.29	27.45	346.07	32.61
BGD	20.07	180.55	21.67	208.92	23.91	**MDG**	4.43	16.65	3.97	16.35	6.09*
BLR	10.76	35.65	9.91	35.49	11.52	**MEX**	17.55	143.42	16.18	145.35	21.29*
BOL	8.94	7.30	8.23	12.30	8.82	**MLI**	12.09	44.06	10.51	51.13	12.29
BRA	14.27	35.51	11.76	54.36	15.30*	**MUS**	18.97	690.61	11.85	428.56	25.67**
CAF	17.81	91.13	16.62	104.87	19.74	**MWI**	13.08	92.57	11.88	97.49	13.99
CAN	4.60	35.91	4.04	18.15	6.42*	**MYS**	8.66	131.45	5.47	175.01	17.41***
CHL	6.98	0.10	6.95	0.28	6.96	**NGA**	24.16	457.70	16.32	263.25	27.87*
CHN	15.94	135.70	13.40	120.25	24.38**	**NIC**	4.98	41.88	5.62	40.44	14.12**
CIV	12.00	46.92	10.40	43.95	11.73	**NLD**	4.59	19.31	3.89	19.34	6.86*
CMR	16.35	80.48	14.64	75.02	16.55	**NOR**	2.21	157.49	1.62	73.82	9.59***
COL	12.42	38.56	11.65	64.38	14.01	**NZL**	3.04	15.26	3.72	15.17	5.08*
CRI	5.52	50.17	5.31	42.71	8.38*	**OMN**	7.64	88.13	18.72	1070.60	28.55*
CZE	5.06	46.19	4.77	30.17	7.95**	**PER**	13.59	13.05	13.01	8.38	13.70
DEU	4.56	19.84	3.89	19.34	7.22**	**PHL**	5.43	29.79	3.28	38.96	8.51**
DNK	4.60	19.29	3.93	19.46	6.86**	**POL**	11.20	204.45	7.83	90.81	14.46**
DZA	18.45	97.57	13.46	98.83	17.67*	**PRT**	4.64	20.14	3.91	19.44	7.04**
EGY	18.59	192.69	13.97	208.20	20.17*	**PRY**	13.35	34.13	12.68	31.30	14.04
ESP	4.58	19.93	3.87	19.30	7.10**	**ROM**	17.14	137.93	16.48	151.90	21.84*
EST	0.07	0.88	0.47	4.55	2.37***	**RWA**	9.66	47.49	10.13	48.88	12.40*
ETH	17.88	159.17	14.69	136.61	19.56*	**SAU**	11.30	12.60	9.93	22.45	11.04
FIN	4.61	19.04	3.92	19.32	6.58**	**SDN**	4.98	125.30	5.12	110.31	20.10***
FRA	4.57	19.91	3.87	19.30	7.51**	**SEN**	12.36	47.42	10.47	39.41	12.40
GAB	18.40	90.55	15.01	84.09	18.53*	**SGP**	0.00	0.00	0.00	0.00	0.00
GBR	4.58	20.01	3.98	19.81	7.00**	**SLV**	7.35	79.44	7.44	62.26	11.02*
GHA	12.95	103.30	10.35	79.32	13.65*	**SVN**	10.22	39.78	10.51	43.17	12.98*
GRC	4.69	20.18	3.93	19.46	7.15**	**SWE**	4.60	19.22	3.99	19.46	6.36*
GTM	6.69	62.39	6.97	48.58	9.57*	**THA**	15.41	177.33	10.58	153.32	19.74**
HKG	0.00	0.00	0.00	0.00	0.00	**TTO**	8.20	102.01	5.98	82.28	12.55**
HND	7.12	50.44	7.25	44.21	11.04*	**TUN**	28.86	175.13	27.33	177.21	30.42
HUN	9.24	95.50	8.67	61.11	12.92*	**TUR**	9.25	345.43	5.57	82.10	15.99***
IDN	6.76	99.35	5.23	57.18	10.02**	**TZA**	16.39	75.97	14.36	70.99	16.97
IND	31.87	178.20	31.17	281.55	36.62	**UGA**	7.95	32.44	7.14	31.02	9.55*
IRL	4.64	20.27	3.94	19.41	6.89**	**UKR**	6.57	47.86	4.34	50.06	8.43**
ISL	4.15	51.86	3.48	41.59	8.03**	**URY**	14.64	36.74	14.35	35.73	15.37
ITA	4.58	19.93	3.91	19.40	7.31**	**USA**	4.17	134.81	4.02	39.60	15.52***
JOR	15.58	192.14	14.18	153.88	18.88*	**VEN**	12.69	37.22	13.98	66.58	15.84
JPN	3.29	22.99	2.94	30.74	6.30**	**ZAF**	8.02	127.64	6.30	94.96	11.92*
KEN	17.96	176.69	13.55	217.06	23.05**	**ZMB**	11.71	87.50	9.12	71.07	13.28*

[a]This is Feenstra's (1995) linear approximation of Anderson and Neary's (1992, 1994) trade restrictiveness index. *, **, and *** indicate that, in log difference, TRI is larger than the import-weighted tariff by at least 20, 50 and 100 percent respectively.

Table 5: *Decomposition of deadweight loss in GDP due to the current tariff regime.*[a]

Country code	Total (Million of $)	Import-weighted Tariff Average	Variance	Covariance	per capita ($)	Country code	Total (Million of $)	Import-weighted Tariff Average	Variance	Covariance	per capita ($)
ALB	7.93	6.24	1.79	-0.13	2.53	**KOR**	365.19	208.55	178.30	-21.65	7.71
ARG	115.81	71.01	15.44	29.36	3.20	**LBN**	42.12	12.29	24.31	5.49	9.61
AUS	99.20	56.16	62.13	-19.10	5.11	**LKA**	35.94	9.46	22.77	3.67	1.92
AUT	113.82	41.14	51.77	20.89	14.17	**LTU**	15.64	2.42	11.87	1.31	4.49
BEL	279.57	81.88	105.13	92.59	27.18	**LVA**	5.77	1.05	5.71	-0.96	2.45
BFA	6.10	3.88	1.72	0.49	0.53	**MAR**	443.74	314.39	144.39	-15.09	15.21
BGD	133.61	109.74	48.82	-24.96	1.00	**MDG**	1.23	0.51	0.53	0.16	0.08
BLR	33.93	25.09	9.07	-0.25	3.40	**MEX**	3125.93	1805.43	1002.40	318.07	31.46
BOL	6.48	5.66	1.03	-0.19	0.75	**MLI**	2.89	2.12	0.98	-0.20	0.26
BRA	407.99	241.04	94.75	72.21	2.37	**MUS**	61.32	13.06	39.87	8.37	51.10
CAF	2.67	1.91	0.73	0.06	0.71	**MWI**	3.69	2.67	1.84	-0.81	0.35
CAN	235.01	93.06	103.48	38.46	7.56	**MYS**	771.54	76.16	445.45	249.89	32.41
CHL	31.86	31.81	0.18	-0.09	2.07	**NGA**	237.03	81.27	80.32	75.41	1.82
CHN	5903.89	1783.53	1194.42	2925.95	4.64	**NIC**	7.69	1.22	1.56	4.91	1.43
CIV	14.39	11.32	4.60	-1.52	0.89	**NLD**	279.58	89.91	114.91	74.79	17.43
CMR	17.42	13.62	4.77	-0.98	1.13	**NOR**	188.29	5.37	151.14	31.78	41.72
COL	112.42	77.72	36.87	-2.19	2.61	**NZL**	13.46	7.24	7.94	-1.68	3.47
CRI	15.83	6.34	9.61	-0.15	4.09	**OMN**	153.55	65.99	201.62	-114.11	61.96
CZE	95.74	34.45	45.68	15.57	9.36	**PER**	65.52	59.07	2.92	3.51	2.49
DEU	850.19	246.80	315.43	287.97	10.33	**PHL**	104.24	15.48	56.06	32.66	1.33
DNK	83.24	27.31	34.40	21.49	15.53	**POL**	505.30	148.16	219.46	137.68	13.08
DZA	167.45	97.19	53.02	17.29	5.43	**PRT**	78.06	24.09	30.63	23.37	7.69
EGY	328.93	157.78	168.32	2.80	5.05	**PRY**	16.19	13.21	2.57	0.41	3.00
ESP	269.71	80.13	103.26	86.31	6.62	**ROM**	219.40	124.92	69.87	24.61	9.79
EST	0.88	0.04	0.73	0.14	0.65	**RWA**	1.42	0.93	0.45	0.02	0.18
ETH	18.60	10.49	6.64	1.47	0.28	**SAU**	215.20	174.10	39.64	1.46	10.11
FIN	49.77	17.67	22.22	9.90	9.59	**SDN**	20.84	1.35	5.68	13.77	0.65
FRA	666.05	176.88	227.94	261.28	11.25	**SEN**	10.29	7.34	2.64	0.32	1.05
GAB	14.90	9.78	3.65	1.47	11.58	**SGP**	0.00	0.00	0.00	0.00	0.00
GBR	669.71	216.50	270.75	182.45	11.34	**SLV**	18.64	8.48	9.54	0.59	2.95
GHA	12.50	7.19	5.32	-0.01	0.64	**SVN**	69.35	45.50	17.78	6.12	35.08
GRC	64.13	19.37	24.40	20.33	6.06	**SWE**	94.34	37.11	45.37	11.82	10.61
GTM	19.07	10.13	10.13	-1.16	1.63	**THA**	718.34	206.34	282.62	229.34	11.74
HKG	0.00	0.00	0.00	0.00	0.00	**TTO**	21.05	4.77	10.97	5.26	16.24
HND	13.94	5.99	5.04	2.86	2.10	**TUN**	331.71	267.74	63.52	0.44	34.29
HUN	205.50	92.54	75.23	37.73	20.17	**TUR**	418.48	50.78	134.38	233.34	6.11
IDN	125.00	34.05	71.19	19.76	0.60	**TZA**	19.14	13.68	4.71	0.72	0.56
IND	2301.76	1667.65	483.27	150.89	2.23	**UGA**	3.57	2.01	1.22	0.36	0.15
IRL	82.73	27.04	33.81	21.84	21.41	**UKR**	42.82	11.34	30.15	1.31	0.87
ISL	5.97	1.13	3.87	1.00	21.17	**URY**	32.53	28.33	4.92	-0.75	9.73
ITA	485.13	138.79	176.12	170.20	8.41	**USA**	9983.10	669.78	1641.26	7672.06	34.99
JOR	61.40	34.64	26.51	0.26	12.20	**VEN**	203.42	158.44	53.97	-9.01	8.26
JPN	521.73	113.61	404.06	4.03	4.11	**ZAF**	120.92	33.77	80.80	6.33	2.70
KEN	52.65	18.21	21.53	12.96	1.71	**ZMB**	5.12	2.41	2.06	0.64	0.51

[a] Calculation based on TRI and the estimated import demand elasticities. DWL due to tariffs can be decomposed into three parts, namely the contributions of import-weighted tariff, variance of tariff schedule, and the covariance between tariff square and import demand elasticities. Positive contribution of the covariance indicates that countries levy higher tariffs on more elastic imports.

Figure 1: Distribution of the estimated import demand elasticities at HS six digit level

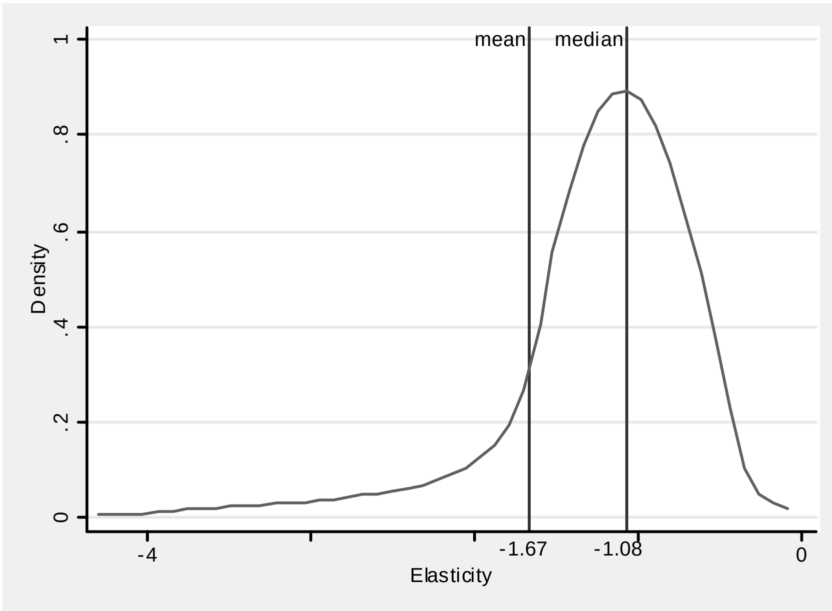

Figure 2: Import demand elasticities and Log of GDP

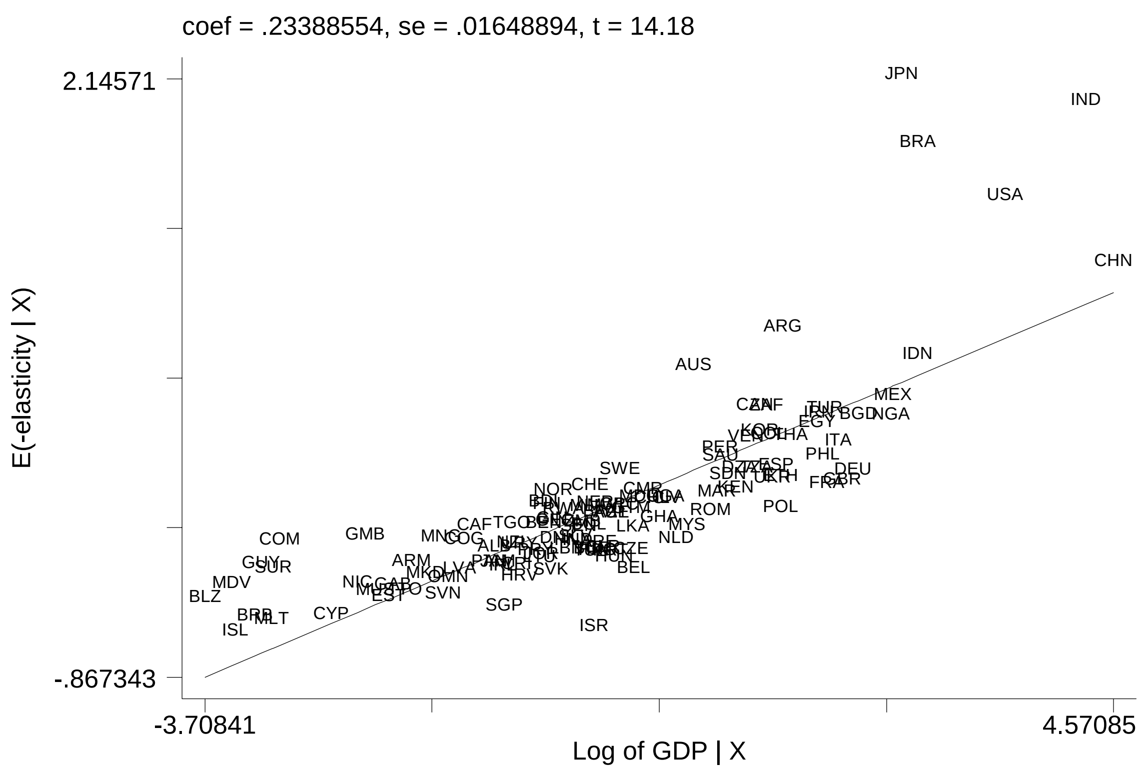

Figure 3: Import demand elasticities and Log of GDP per capita

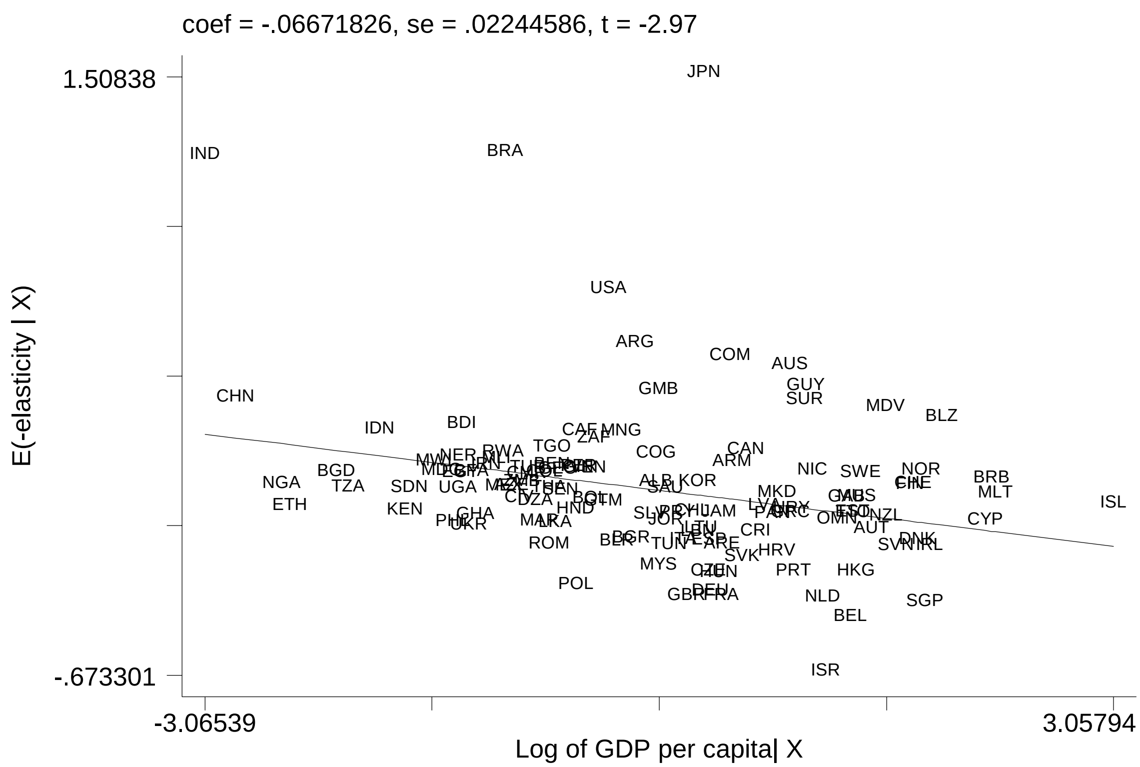

Figure 4: Trade Restrictiveness Index versus Import-weighted Tariff