Backward-Engineering Trade Protection: How to Estimate Worldwide Industry-Level Trade Barriers

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Abstract

In this paper, I present an approach to estimate worldwide industry-level non-tariff-barriers to trade (NTBs). The resulting data cover 160 countries and more than 200 industries. Expressed in terms of *ad valorem* tariff-equivalents, the data provide a comprehensive overview of the pattern of applied trade protection around the world. This is timely and important a) because NTBs make up the bulk of applied trade protection given that tariff-policies are increasingly regulated by international obligations; and b) because systematic and reliable data on NTBs is not available due to the complexity of existing regulations and the largely non-mandatory international reporting standards for these measures. Instead of relying on official data sources that may contain biased reporting, I therefore estimate the size of trade barriers from observable trade frictions. Specifically, I exploit observed trade frictions along with data on trade elasticities to identify the size of unobserved trade barriers. As a consequence of this indirect estimation method, my data are not affected by the self-selection and coverage problems prevalent in existing data sources on NTBs. My data are valuable for research in the areas of trade and trade policy and have broad implications for policy-making.

Keywords: trade protection, non-tariff barriers to trade, gravity estimation, protection data

JEL: C82, F02, F13, F14, F15, F53

1 Introduction

Trade barriers, both physical and manmade, strongly shape global trade and production patterns and, ultimately, affect the domestic economic, social, and political realities in globalized modern societies.

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In recent decades, reductions in shipping costs resulting from progress in transportation technology and logistics have accelerated the trend toward the international division of labor, outsourcing, and global supply chains. The decline in transport costs has gone in tandem with political efforts toward a liberalization of international trade. A series of multilateral trade rounds in the post-World War II era has resulted in significant reductions of tariff rates. These developments have resulted in substantial increases in global trade volumes and a deeper integration of the world economy.

Crucially, however, the decline in physical transport costs and tariffs has also greatly increased the use and importance of non-tariff barriers to trade (NTBs). These non-tariff barriers to trade take the form of quotas, licenses, requirements, or various other regulations. With tariff-levels largely bound by international obligations, governments increasingly resort to this more diffuse set of measures to regulate international trade. Such efforts may well be aimed at accepted objectives such as enforcing labor standards, ensuring public health, or guaranteeing safety and security. There are widespread concerns, however, that NTBs are used to reintroduce protectionism through the backdoor and thus to freeride on previous trade agreements. A recent World Bank study, for instance, refers to NTBs as "Trade Policy's New Frontier" (Cadot and Malouche 2012, also see: WTO 2012a).

Given the importance of NTBs for contemporary trade relations, reliable data on these measures and their and price-effects are of interest in many contexts. In particular, valid data on trade barriers are required for any trade policy analyses (Hertel 1997, Piermartini and The 2005, WTO 2012b). First, assessments of export growth opportunities and market potentials by countries and firms require valid information on trade barriers. Second, in the run-up to trade talks, the identification of negotiation priorities requires information on currently imposed trade barriers. Third, information on trade protection can also reduce political frictions and economic costs associated with trade disputes because increased transparency reduces to need for fact-finding through costly arbitration. Finally, data on NTBs can help to monitor compliance with international agreements and thus even deter the implementation of discriminatory measures in the first place.

Moreover, data on NTBs are required to comprehensively assess the domestic welfare effects of trade policies. Using data on tariffs, transport costs, or aggregate trade openness indicators, a host of studies has shown that trade barriers not only affect production patterns (Díez 2014, Lee and Swagel 1997), investment and innovation decisions (Bloom, Draca, and Van Reenen 2016, Bustos 2011), economic growth (Yanikkaya 2003, Wacziarg and Welch 2008), and productivity (Amiti and Konings 2007, Luong 2011). Trade barriers have also been shown to affect employment and wages (Galiani and Sanguinetti 2003, Gaston and Trefler 1994) as well as income and income inequality (Baier and Bergstrand 2001, Nicita 2004, Slaughter 2001). Without accounting for the bulk of applied trade protection in the form of NTBs, however, these results necessarily remain selective and cannot reflect an accurate picture of the economic and social consequences of current policies.

The key challenge for carrying out the above analyses in a comprehensive manner is that systematic and reliable data on NTBs is very difficult to obtain. This has to do in part with the reluctance of governments to give up their remaining wiggle room for setting trade policy. As a result, reporting standards have remained weak and the quality of existing data collections is poor. An additional complication arises because NTBs are such a non-homogeneous set of measures. Like tariffs, NTBs raise the trade costs for foreign exporters and thereby discourage trade. Unlike tariffs, however, NTBs are not simply a tax on the value of imported goods, but affect prices in a more indirect manner. As a result of these factors, taking stock of applied levels of trade protection has become more difficult in recent decades.

This is directly reflected in the nature of existing collections of information on NTBs. All these collections rely on 'bottom-up' efforts to compile individual government regulations. Such collections, however, are likely (and in some case obviously) incomplete and biased due to selective government reporting, limited human resources, and the immense complexity of the subject matter. There is furthermore no way to systematically assess the stringency of individual regulations in these collections. As a result, it is neither clear whether, and, if yes, to what degree, a given regulation affects trade, nor how these effects can be assessed. Consequently, it is also not clear how any two regulations are comparable or whether regulations concerning specific issues, industries, or countries systematically differ from each other.

In this paper, I present an alternative 'top-down' approach to systematically compile data on applied product-level trade protection for a large number of countries. To do so, I use an statistical method to indirectly infer the levels of applied trade protection by individual countries across a wide range of products. The procedure uses information on the price-sensitivities of domestic consumers (that are reflected in trade elasticities) and information on observed trade frictions (that are assessed by comparing the value of imports to the value of domestically produced and consumed goods) to estimate the size of trade barriers. The underlying logic is that, when holding constant the price-sensitivity of consumers and a host of other trade cost factors, low levels of imports compared to domestically produced and consumed goods imply high trade barriers.

My approach has two significant advantages over existing collections of information on NTBs. First, it does not rely on government reporting of trade barriers that may be incomplete and biased. Rather, the method focuses on the observable *effects* of these trade barriers, which necessarily ensue if a barrier effectively reduces trade flows. Second, my approach naturally results in a standardized estimate of the economic effects of applied barriers. This allows me to report the size of all trade barriers that affect a given industry-level trade flow into a given country in terms of *ad valorem* tariff-equivalents (AVEs), i.e., as a percentage tax on the import price. My results therefore conveniently summarize and quantify the effects of a potentially diverse set of different measures in a simple, comparable, and easy to interpret manner.

The rest of the paper proceeds as follows. Section 2 discusses the existing data on non-tariff barriers and their limitations in greater detail. Section 3 presents the theoretical and conceptual considerations underlying my estimation strategy. The section introduces the gravity model of trade and discusses the underlying theory and assumptions. Section 4 describes the estimation strategy in detail and illustrates how a gravity approach can be used to estimate the size of NTBs given information on trade, domestic production, trade elasticities, and relevant trade-cost factors other than NTBs. Section 5 describes presents the results and discusses their validity. Section 6 provides a number of concluding remarks.

2 Background: Currently Available Information on Trade Barriers

Given the increasingly important role of non-tariff barriers as trade policy instruments, the lack of reliable information on these measures has been a source of growing unease among trade researchers and practitioners alike. Two recent book-length reports published by the WTO and the World Bank, respectively, are devoted to the problem of non-tariff measures in modern trade relations and treat the issues of lacking transparency and insufficient documentation at length (Cadot and Malouche 2012, WTO 2012a; also see: Bacchetta et al. 2012).

A number of factors contribute to the poor quality of data on NTBs compared to tariffs. First, there is a longer tradition of recording tariffs and governments have incentives to do so. Historically, tariffs were the primary instrument of trade policy while NTBs have come into focus much later than tariffs and efforts to classify and try and record these measures systematically have only started to pick up in the mid-1990s. Moreover, these efforts have been slow-moving not only because governments have little interest in documenting potential violations to international trade rules, but also because doing so is costly. This is different in the case of tariffs, where governments always had an incentive to record transactions to collect tariff revenues. Yet because NTBs do not result in government revenue, no comparable incentives to document these measures exist.

Second, NTBs are more difficult to record than tariffs. Whereas tariffs are clearly defined import taxes, NTBs are heterogeneous policies comprising technical standards, quarantine restrictions, various kinds of quotas, licensing requirements, and so forth. Moreover, non-tariff barriers are not only more diffuse than tariffs in the form they take but also in how they create costs. Tariffs are straightforward costs that are paid at the port of landing and there are established and comparatively regulated customs procedures involved in the process. In contrast, non-tariff barriers may affect imports not only at the border, but at various stages of the 'trade route' (including search and adaption costs, costs involved in complying with regulations during production, or restrictions on distribution and post-sales services). Given these considerations it is not surprising that the stiffness of NTBs is difficult to systematically assess.

Third, various policies that adversely affect trade serve legitimate purposes such as ensuring environmental protection, worker's rights, or consumer health. It is, however, often difficult to distinguish valid concerns from protectionist intentions. In theory, the distinction is clear: As long as such regulations do not discriminate against imports but are equally binding for domestic producers, such policies are in conformity with WTO rules.[1] The problem in practice is, of course, that the two variants are very difficult to tell apart. This problem does not arise with respect to tariffs, which are discriminatory by definition. On the one hand, this ambiguity makes NTBs particularly attractive policy tools for governments wishing to shield domestic industries. On the other hand, this means that observed regulations may very well be completely non-discriminatory and apply to domestic as well as foreign producers. Such measures would have no effect on trade.

Despite these difficulties in observing and assessing non-tariff barriers, various attempts have

[1] In this regard, a distinction is sometimes made between non-tariff measures (NTMs), which are non-discriminatory, and non-tariff barriers (NTBs), which are discriminatory.

been made to collect information on these measures. One of the earliest of these attempts was undertaken by UNCTAD with the non-tariff branch of the TRAINS database. The database is large in terms of observations, but has long been known to suffer from severe inconsistencies (Rau and Vogt 2017). It is also extremely unbalanced both cross-sectionally and over time. The project has been lying more or less dormant since the late 1990s as a result of these problems. Only in 2012 has UNCTAD published a new classification of NTMs and revamped its data collection efforts. The new data (mostly for the years 2012, 2013, and 2014) continue to be highly unbalanced however (for instance, there are over 40.000 entries for Argentina and close to zero for South Korea), and only come in binary form per HS 6-digit product (indicating whether a product is covered by some regulation or not).

The second large database on NTMs comes from the WTO (accessible through the WTO's new I-TIP portal) and contains measures that member states have notified to the WTO in accordance with their notification 'requirements'. Because there is no enforcement mechanism aimed at ensuring compliance with these requirements, however, these data, too, are problematic at best. The WTO itself points out that "[n]otifications provide an incomplete and sometimes misleading account of the incidence of non-tariff measures" (WTO 2012a, p. 98). The quasi-voluntary nature of these requirements allows governments to report innocent measures while withholding information on their more discriminatory policies. Bacchetta et al. (2012), for instance, state that "compliance appears to be generally low, except where Members have an own interest in complying" (p. 42).

In addition to the I-TIP portal, two further sources of information on NTBs have recently been made available by the WTO. The first concerns so-called specific trade concerns (STCs) voiced by member states. These are 'reverse notification' and may therefore be seen as more credible. The main problem of these datasets is that they are extremely limited in scope – on average containing only a handful of concerns per importer and relating only to sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT). Furthermore, because there are many other channels through which governments can raise such concerns, these data, too, "may provide a distorted picture of the trade-restrictive or trade-distortive effects of TBT and SPS measures" (WTO 2012a, p. 100).

Another WTO source of information on NTMs/NTBs is the recently published WTO Trade Monitoring database, which is coded from qualitative information taken from the WTO's Trade Monitoring Reports since 2008. The database covers a somewhat larger number of measures than the STCs data but, as with the STCs data, its overall coverage is far from comprehensive.

Two additional concerns with all of the above sources are that considerable difficulties exist in a) assigning the correct HS product codes to qualitative information drawn from regulations, notifications, and reports, and b) identifying whether measures that used to be in force at some point have been terminated or not (also see: Bacchetta et al. 2012). These difficulties are understandable and perhaps inevitable given the size and complexity of the task. But they nonetheless raise additional doubts about the quality of the data thus obtained. Moreover, these difficulties often prohibit the use of these data in quantitative analyses, because the NTBs data cannot be matched with relevant data on trade flows and other relevant factors.

In combination, the above issues lead to a situation in which the available "data on NTMs is very fragmentary" (Cadot and Malouche 2012, p. 3). Similarly, Anderson and van Wincoop (2004) note that "[t]he grossly incomplete and inaccurate information on policy barriers available to researchers is a scandal and a puzzle" (p. 693). These problems are also reflected in gravity estimates in which the above data (insofar as HS industry codes are available) are included as a predictor for trade flows. One would expect a clear negative association between NTBs and trade volumes as is the case with tariff data. Instead, coefficient estimates are generally small, overwhelmingly statistically insignificant and occasionally even positive (see: Appendix A, which provides a complete list of empirical results for existing data sources).

In light of the above discussion – and given that NTBs are a) widely recognized as important impediments to trade, and b) the subject of the vast majority of WTO disputes – this is unlikely to accurately reflect the true significance of these measures in the context of modern trade relations.

3 Quantifying Observable Trade Frictions: The Gravity Model of Trade

Given the lack of suitable direct data on non-tariff barriers, I indirectly infer the size and pattern of NTBs from observable trade frictions using a gravity approach. Conceptually, the idea is to deduce the size of these barriers for any given importer and product from the ratio of international to domestic trade – net of the effect of other trade cost factors such as distance or tariffs and of the effect of the elasticity of substitution. Put differently, if X_{ij} are exports from i to j in a given product category and X_{ii} are 'exports' from i to itself (i.e., domestically produced varieties that are also sold domestically), then – after accounting for other trade cost factors – the ratio of X_{ij} to X_{ii} will reflect any additional trade frictions associated with exports to destination j. From these observed frictions and knowledge of the price-sensitivity of consumers, it is then possible to 'reverse engineer' the size of NTBs in country j. The gravity equation makes it possible to implement this intuition econometrically and to re-express implied non-tariff barriers in *ad valorem* equivalents (AVEs) – i.e., as percentage increases in price.

Gravity models have traditionally been used to quantify the effects of observed trade cost factors on trade flows (typically using on data on international trade). However, the reverse use of inferring unobserved trade costs from trade flows, so-called 'border effects', has become wide-spread practice since the pioneering work of McCallum (1995). McCallum's goal was to assess the effect of the U.S.-Canada border on trade flows by comparing trade among only U.S. States or only Canadian Provinces to cross-border trade flows. While McCallum (1995) used subnational data on inter-state and inter-provincial trade, it has subsequently become common practice to calculate domestic trade as production minus total exports following Wei (1996). This is the approach I employ as well, as is discussed in more detail in the data section below.

It is useful to consider the theoretical underpinnings of the gravity model before dealing with the implementation and estimation details (for a useful discussion of both the theoretical and empirical aspects of the gravity model, see: Head and Mayer 2014). The gravity model makes it possible to estimate the effect of trade frictions, because it provides a "frictionless benchmark" (Anderson 2010,

p. 4) against which observed data can be compared. To see this, consider equation (1a) of the theoretical formulation of the gravity model due to Anderson and van Wincoop (2003):

$$X_{ij} = \frac{Y_i E_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i \text{P}_j}\right)^{1-\sigma}, \tag{1a}$$

where

$$\Pi_i = \left(\sum_j \frac{E_j}{Y_w} \left(\frac{t_{ij}}{\text{P}_j}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{1b}$$

and

$$\text{P}_j = \left(\sum_i \frac{Y_i}{Y_w} \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{1c}$$

Without product and time subscripts, which are omitted for simplicity, the model can be thought of as representing total trade in a given year. Then X_{ij} are aggregate trade flows from country i, the exporter, to country j, the importer. Y_i is total exporter production, E_j is total importer production proxying total expenditure, and Y_w is world total production. Next, t_{ij} is the sum of all bilateral trade costs (to be separated out below) expressed as a multiplicative factor. That is, if the sum of all trade costs amounted to 25 percent of the factory gate export price, then $t_{ij} = 1.25$. The parameter σ is the elasticity of substitution (see: Appendix B for a detailed description of my approach to estimate this parameter). Lastly, the terms Π_i and P_j in equations (1b) and (1c) are 'multilateral resistance' (MR) price indices that relate bilateral trade costs t_{ij} for and given dyad ij to the (expenditure) weighted average of *all* other trade costs that i (Π_i) and j (P_j) face when trading with other partners. These indices thus capture *relative* gravity effects and are discussed in some more detail below.

To see where the 'frictionless benchmark' comes in, consider the model only with the first term on the right-hand side of equation (1a), $Y_i E_j / Y_w$, and ignore the second term. Further assume that country i and country j were the only countries in the world and that each country's total production was equal to 50 units in some currency. So, $X_{ij} = Y_i E_j / Y_w = 50 \times 50/100 = 2500/100 = 25$. The model would predict exports of 25 currency units from country i to country j. Because in this setup the model is symmetric, the reverse prediction would equal 25 currency units as well. Thus, the two countries consume half of their production at home and exchange the other half – just as if they were one large country and goods would be shipped back and forth at random. This logic extends to worlds populated with larger numbers of differently sized countries.[2]

[2] Note that the model also makes convincing predictions concerning the relationship between trade openness and economic size. It is well known that small countries tend to be more open to trade than large countries trade because the latter trade more domestically simply as a result of their size. Consider a situation with two asymmetrically sized countries: $X_{ij} = Y_i E_j / Y_w = 80 \times 20/100 = 1600/100 = 16$. In the absence of trade costs the reverse prediction remains identical. So, the large country is predicted to export and import much less ($16/80 = 20\%$) relative to its overall production, compared to the small country ($16/20 = 80\%$). Naturally, in a parameterized regression framework these relationships are more flexible and there is no need for the coefficients on the production variables to equal one, as implied by the theoretical model. It is all the more

Next, consider the full model including the second term. The second term captures to what degree trade costs lead to deviations from the frictionless scenario just discussed. The first thing to note is the prominent role played by the elasticity of substitution. Because the elasticity of substitution is restricted to be strictly greater than one (to rule out complementary relationships between varieties), the exponent as a whole is always negative, i.e., $(1-\sigma)<0$. Because the ratio in brackets – the 'network-adjusted' trade costs – will typically be greater than one, the second term as a whole will be bounded between zero and one. Due to the multiplicative relationship between the two, the second term revises downward the frictionless benchmark prediction of the first term as a function of σ and the sum of all trade costs.

For concreteness, consider some numerical examples. Suppose relative trade costs, the fraction inside the brackets of the second term, were equal to 2. This implies that factory gate export prices of country i producers double as a result of trade costs. The degree to which this increase in price dampens demand on the side of country j consumers crucially depends on the elasticity of substitution. Supposing σ was equal to 3 so that $(1-\sigma)=-2$. Thus, the second term would equal $2^{-2}=1/2^2$. The trade cost term would therefore be equal .25 and predicted trade flows would equal one quarter of the frictionless benchmark. Now suppose, consumers were much more price-sensitive and the elasticity of substation was 6 instead of 3. Then, $(1-\sigma)=-5$, and because trade costs still equal 2, the second term becomes $2^{-5}=1/2^5=1/32\approx\ .03$. Consequently, predicted trade flows amount to merely three percent of the frictionless benchmark scenario. Thus, identical trade costs can have varying effects depending on the price-sensitivity of consumers.

Note that the second term approaches one – and the frictionless benchmark is recovered – under two different circumstances. First, if the fraction inside the brackets approaches one, then the entire term approaches one because one to the power of anything is always one. This is not surprising, and indicates that trade costs that are absent should have no influence on trade flows (although the correct interpretation is a little more subtle given the ratio formulation of the bilateral and multilateral trade cost components). Second, if the elasticity of substitution approaches one, then the exponent approaches zero and anything raised to the power of zero also equals one. Put differently, if consumers are highly price-insensitive and are willing to pay any price for a given variety of a product, then trade costs have no effect on trade flows either.

To conclude the discussion, a brief consideration of the multilateral resistance indices, Π_i and P_j is in order (equations 1b and 1c). Essentially, these terms reflect the larger network effects of international trade relations that go beyond the ij link. Intuitively, if the sum of bilateral trade costs t_{ij} takes on some intermediate value, but both countries face considerably higher trade costs with all their remaining trade partners – for instance, because they are neighboring remote island states – then their multilateral resistance terms are large. As a result, the fraction $t_{ij}/\Pi_i\mathrm{P}_j$ becomes smaller, implying higher predicted trade flows X_{ij} than would be expected by considering t_{ij} in isolation. The same logic applies in reverse, for instance, when both countries have strong economic integration

interesting in this context that estimated coefficients in gravity models are well known to converge to values close to one.

agreements with other partners but not with each other. The MR terms thus capture part of the 'general-equilibrium' component of international trade. They reflect the insight that, on a global scale, *relative* trade costs shape empirically observed trade patterns.

4 Estimation Strategy: 'Reverse Engineering' the Size of Non-Tariff Barriers

The above considerations carry over directly into the empirical specification of the model. Since the theoretical gravity equation is in multiplicative form, it needs to be transformed into a setup more suitable for estimation. Taking the logarithm of both sides of equation (1a) makes it possible to re-express the theoretical model in linear-additive form. I further add time-subscripts and convert the trade and production variables to lower case (to reflect the fact that estimation is done on the disaggregated level and separately for each product). The resulting product-level equation takes the following form:

$$\ln x_{ijt} = -\ln y_{wt} + \ln y_{it} + \ln y_{jt} + (1-\sigma)\ln t_{ijt} - (1-\sigma)\ln \Pi_{it} - (1-\sigma)\ln \mathrm{P}_{jt}, \qquad (2)$$

where now x_{ijt} are product-level exports from country i to j at time t, y_{it} and y_{jt} are industry-level production in i to j at time t, Π_{it} and P_{jt} are the multilateral resistance indices as above. The trade cost term, $\ln t_{ijt}$, can be further specified as the combined effect of n individual trade cost factors:

$$\ln t_{ijt} = \sum_{n} \ln t_{ijtn} = \ln dist_{ij} + contig_{ij} + lang_{ij} + \ln tar_{ijt} + b_{ij\neq m} + b_{ij=m}. \qquad (3)$$

These are the dyadic trade cost factors that will be explicitly included in the empirical model presented below. The first three terms of equation (3) capture physical trade cost factors. In particular, $dist_{ij}$ is the distance between countries i and j in kilometers, $contig_{ij}$ is a dummy variable taking on a value of one if the countries share a common border and zero otherwise, and $lang_{ij}$ is a dummy indicating whether i and j share an official language. These factors only vary across country pairs but not over time. Next, tar_{ijt} is the bilateral tariff rate in a given year. The exact nature of these variables and the data sources are discussed in more detail below.

The primary variables of interest in the present context are the two border indicators $b_{ij\neq m}$ and $b_{ij=}$. Because the data contain observations of domestic trade in which $i = j$, not all recorded trade flows cross international borders. If collapsed into a single variable, b_{ij}, would take on a value of one if the recorded flow pertains to cross-border trade between two countries and zero if the recorded flow pertains to domestic trade within a single country. The split version of b_{ij} as contained in the trade cost equation (3) simply separates the international component into two parts: $b_{ij\neq m}$ takes on a value of one if the recorded flow pertains to any cross-border trade between two countries – except for exports to country $j = m$. Similarly, $b_{ij=m}$ takes on a value of one *only* if the recorded flow pertains to cross-border trade that involves country m as a destination (i.e., importer). That is, the variable $b_{ij=m}$ separates out all trade flows that are vulnerable to country m's import policies concerning the product under consideration; $b_{ij=m}$ can, therefore, be used to obtain an estimate of the stringency of these policies. Specifically, this can be done by estimating

$$\ln x_{ijt} = \alpha + \sum_{n-1} \varphi_{n-1}(1-\sigma)\ln t_{ijtn-1} + \beta(1-\sigma)b_{ij=} \quad + \gamma_{it} + \gamma_{jt} + \varepsilon_{ijt}, \tag{4a}$$

where α is an intercept, β is the regression coefficient on the primary variable of interest and φ_1 through φ_5 are the regression coefficients on the remaining $n-1$ trade costs variables, γ_{it} and γ_{jt} are time-varying exporter and importer fixed effects and ε_{ijt} is an error term that is assumed to be log-normal. With an eye to the further discussion also define

$$\tilde{\beta} \equiv \beta(1-\sigma). \tag{4b}$$

Equation (4a) follows directly from (2) and (3). To see this, note that the production variables and the multilateral resistance terms are monadic country-year level predictors and are therefore contained within the two time-varying country fixed effects. As a result, only the dyadic trade cost factors from (3) remain as explicit variables in the model. This is fortunate, in particular, because the fixed effects specification is by far the most convenient way around a host of observational and modeling problems related to treatment of the multilateral resistance indices (as well as other forms of unobserved heterogeneity).

The fixed effects specification I use has the additional advantage of accounting for other forms of unobserved heterogeneity that is clustered at the country-year level. Several of the trade cost factors listed in the introduction – such as the state of transport infrastructure, the quality of the legal system, or the political stability in the importing country – are appropriately dealt with in this way. The same is true for importer-specific shocks to tastes or income, and exporter-specific production shocks. The explicitly included dyadic variables capture further important aspects. Apart from accounting for physical trade cost determinants, the distance, contiguity, and language variables are expected to account for important cultural differences as well because both physical and linguistic proximity are likely to be related to cultural proximity.

With tariffs as an observable policy barrier component also accounted for, it is therefore reasonable to expect that a considerable share of any remaining international trade frictions is attributable to non-tariff policy barriers (one limitation of the method is that the separate product-by-product estimation setup makes it impossible to account for characteristics that only vary *between* products – in particular, the relative transportability of products. I come back to this point below). The size of these NTBs then can be inferred from the estimated coefficients on the border indicator $b_{ij=m}$. Conceptually, the coefficient on the border indicator picks up the residual deviation from the theoretical baseline prediction of the gravity model as discussed above after accounting for a host of other trade cost factors.

To see how this works in detail, first consider once more the case when the two border dummies are collapsed into a single variable b_{ij}. Because this variable is equal to one if trade flows cross an international border and zero otherwise, the estimated coefficient is equal to $\ln x_{b_{ij}=1} - \ln x_{b_{ij}=0}$, which is equivalent to $\ln(x_{b_{ij}=1}/x_{b_{ij}=0})$. Exponentiating thus provides the time- and importer-averaged ratio of the size of international to domestic trade flows of a given product after accounting for the other factors discussed above. The coefficient, therefore, can be interpreted as a conditional average reflecting how large international trade is relative to domestic trade for a given product, all else equal. It can be seen as a measure of the general restrictiveness of the international trade network to trade in the given product.

The same logic applies to the importer-specific variable $b_{ij=m}$ only that in this case the coefficient reflects the specific trade restrictiveness of importer m – while the average restrictiveness of all remaining countries is reflected by the coefficient on $b_{ij\neq m}$. For instance, if the estimated coefficient on $b_{ij=m}$ was equal to –2, then because $\exp(-2) \approx 0.13$, this would imply that the amount of goods other countries export to country m is on average equal to 13 percent of what these countries trade domestically.

The important point to note, however, is that empirically observed trade frictions cannot be directly used to infer the size of non-tariff barriers in a given country m. The reason is that observed trade frictions are not only determined by policy barriers, but also by the price-sensitivity of consumers. Intuitively, if country m imposes high NTBs on a given product but consumers in country m are willing to pay high prices for different imported varieties of that product, then observed trade frictions should be moderate. Conversely, if country m maintains only very moderate NTBs but consumers are extremely price-sensitive, then observed trade frictions should be large despite the moderately-sized policy barriers. Thus, observed trade frictions alone do not provide sufficient information to assess the intrinsic severity of policy barriers because the effectiveness of policy barriers depends not only on the barriers themselves but also on the substitutability between domestic and foreign product varieties.

This problem is readily apparent from equation (4a) and directly follows from the theoretical formulation of the gravity model discussed in section 3. In this setup, the parameter of interest is β, but the parameter resulting from the actual estimation is $\tilde{\beta} = \beta(1-\sigma)$ as defined in equation (4b) because observed trade frictions depend on both the underlying NTBs and the price-sensitivity of consumers. In a certain sense, therefore, the coefficient estimates on $b_{ij=m}$ are 'theoretically contaminated' because the estimates reflect the combined influence of two factors – the actual trade barrier and the elasticity of substitution. Given information on the elasticity of substitution, however, it is straightforward to obtain the parameter of interest (i.e., Anderson and van Wincoop 2003). In particular, the *ad valorem* equivalent of the underlying policy barrier can be calculated as

$$NTB\ \widehat{AVE_{j=m}}/100 \;=\; \exp(\beta) - 1 \;=\; \exp\left(\frac{\tilde{\beta}}{1-\sigma}\right) - 1. \tag{5}$$

The logic is as follows: if $\tilde{\beta} = -2$, as in the above example, and $\sigma = 4$, then $-2/(1-4) \approx 0.67$. This implies a trade cost factor of $\exp(0.67) \approx 1.95$. That is, the factory gate export price of a given product variety is in effect multiplied by 1.95 as a consequence of the non-tariff barrier and therefore results in an import price that is $1.95 - 1 = .95 = 95\%$ higher than the original export price. The implied *ad valorem* equivalent of the underlying trade barrier is therefore estimated to be 95 percent.

It is worth noting that, for a given level of observed trade frictions, $\tilde{\beta}$, *higher* values of the elasticity of substitution result in *lower* estimated NTBs, and vice versa. The intuition is that if consumers are extremely price-sensitive (i.e., high σ), then even a very moderate policy barrier will have a considerable effect on observed trade flows. On the other hand, if consumers are willing to pay almost any price (low σ) for foreign varieties of a product, then very stiff barriers are required to achieve the same level of observable trade frictions. It follows that for any given level of trade frictions, the higher the value of σ, the lower the implied NTBs.

5 Non-Tariff Barriers: Data, Estimation, and Results

In order to implement the above estimation procedure, data on trade, tariffs and production are required – all at the product level and over time – as well as dyadic data on distances, contiguity, and official languages. The following paragraphs briefly describe these data and their sources.

Trade data come from different sources. First, the bulk of the data on trade in the agricultural and manufacturing sectors is taken from the UN Comtrade database. Depending on data availability, Comtrade provides up to two reports for each trade flow – the export flow x_{ij} as reported by exporter i, and the mirror import flow m_{ji} as reported by importer j. Second, the UNCTAD Trains database – from which the data on tariffs is taken – also reports import trade values for these sectors. While most of this data is taken from Comtrade and thus identical with the m_{ji} report, UNCTAD also occasionally reports data from the WTO IBD database. Third, data on trade in services is taken from the UN Service Trade database as well as from the OECD's 'Statistics on International Trade in Services' database.

As a result of the multiple data sources, there may be up to three different entries per trade flow. This is helpful to alleviate missing data concerns. At the same time, it raises the question of how to combine multiple reports into a single figure. I follow the simple strategy of using the maximum value in cases where several entries for a single flow are available. The reasoning is that under-reporting seems likely to be a much more severe problem in trade statistics than over-reporting. Potential reasons for under-reporting include capacity constraints on the side of customs authorities as well as incentives of buyer and sellers to evade tariff and tax collection. In contrast, systematic reasons for over-reporting are much less evident.

Production data is required to derive the volume of domestic trade, which is calculated as the value of production minus the value of total exports in each product category, following Wei (1996) as noted above. Production data also come from different sources. Data on agricultural production is taken from the Food and Agricultural Organization's (FOA) 'Value of Agricultural Production' database. Data on manufacturing production comes from the INDSTAT4 2013 database compiled by the United Nations Industrial Development Organization (UNIDO). Finally, data on production in services comes from the OECD's 'Structural Analysis Statistics (STAN)' database.

The need for production data constrains the level of granularity at which the analysis can be carried out. Production data is simply not available at a level of aggregation similar to the HS 6-digit categories in which trade and tariff data is reported (i.e., more than five thousand product categories). To be more specific, data on agricultural production is on the HS 4-digit level, data on production in the manufacturing sector is on the ISIC Rev. 3 4-digit level, and data on service sector production is on the ISIC Rev. 3 2-digit level.[3]

The time coverage of the data ranges in theory from 1988 to 2012. However, as a result of a large share of missingness in the earlier years and sparse data coverage in the UNIDO data after 2010, the vast majority of observations span the second half of the 1990s and the 2000s.

Finally, the data on distances, geographic contiguities, and official languages come from the gravity datasets provided by CEPII (Head et al. 2010, Mayer and Zignago 2011). Because the estimation setup includes domestic trade, that is observations with $i = j$, it is necessary to have domestic analogues for all trade cost variables that are explicitly included in the model. This requires, in particular, a measure of distance that is comparable for domestic distances *within* countries and international distances *between* countries. This rules out the use of standard distance measures such as the distances between capital cities, if one does not want to implicitly assume that domestic trade costs related to distance are zero.

Fortunately, CEPII provide an appropriate measure that allows for consistent comparisons between domestic and international distances. Specifically, the measure is calculated as the population-weighted distance between major cities, where these cities serve as proxies for the economic centers between which goods are traded both domestically and internationally. This approach makes it possible to directly compare the average weighted distance between cities within a country to the average weighted distance between cities across countries (for a detailed description see: Head and Mayer 2002). The adaption of the contiguity and language variables is straightforward. A country is necessarily contiguous with itself, so the contiguity variable takes on a value of one for observations in which $i = j$. The same logic holds for official languages. Finally, domestic tariffs are equal to zero.[4]

The estimation is done separately by product k to obtain product-specific results. Within each product category, I then iterate through countries j in order to get importer-product specific estimates for each importer. Thus, the estimation is repeated j times with changing constellations of the variables $b_{ij=m}$ and $b_{ij\neq m}$, where j is the number of importers in the product-specific subset of the data. Overall, the data contains information on 160 importing countries and 211 different products k in the mixed HS-ISIC classification. Naturally, not all $j \times k$ theoretically possible combinations are contained in the data, both because not all countries import all products and because the data is incomplete due to missingness. Nonetheless, the procedure results in a total of 11,563 estimated

[3] Data on services is generally only available at a relatively coarse aggregation level. This is also true for data on trade in services.

[4] Tariffs on service trade are equally set to zero. Tariffs do not apply to trade in services primarily because services do not pass through customs. Service barriers typically come in the form of investment restrictions and various domestic regulations. A detailed classification of service barriers can be found in: Borchert et al. (2012).

NTB *ad valorem* equivalents.

The estimated NTBs can be seen as over-time averages of importing countries' most-favored nation (MFN) non-tariff import policies.[5] In other words, the estimates reflect the general openness or restrictiveness of a country's product-specific import policies that affect all exporters alike (see: Gowa and Hicks (2012) for a discussion of possible limitations of this assumption).

Table 6.1 exemplarily shows the results of two of 11,563 analyses run to obtain these estimates. These results relate to Brazil's imports of pork (H_0203, with 0203 being the 4-digit HS code for pork) and photographic equipment (I_3320, with 3320 being the 4-digit ISIC Rev. 3 code for optical instruments and photographic equipment). The first column for each product category shows the global results with $b_{ij=m}$ and $b_{ij\neq m}$ collapsed into a single indicator b_{ij}, as indicated by the heading 'WLD' (for 'world'). The second set of columns shows the results for Brazil as country m.

The coefficient estimates of $b_{ij=m}$ that are of primary interest are reported at the bottom of the table. As one would expect, the overall pattern of the estimates changes only slightly with the change in the border indicator from the WLD to the BRA setting. As indicated by the much larger negative coefficients on the border indicators, pork trade (with pork being a typical agricultural product) appears to be considerably more restricted than trade in optical and photographic products (which are sophisticated manufactures), both on the world scale and with respect to Brazil. This result is in line with expectations and also reflected in the coefficient estimates on the tariff variable.[6]

From the estimated coefficients, the implied Brazilian non-tariff barriers can be calculated as described above. The elasticities of substitution – as obtained from the procedure described in Appendix B – for pork and photographic equipment are 5.34 and 2.78, respectively. Consequently, for pork the estimate is $\exp(-5.78/(1-5.43))-1=2.79=\ 279\%$, and for photographic equipment the estimate is $\exp(-0.83/(1-2.78))-1=0.56\ =56\%$.[7]

The figures presented in Table 1 are representative of the overall results. The average R-squared across all analyses is slightly below 0.78 (which is no unusual value for gravity-type regressions). The average number of observations per product sub-dataset is 12,925 including the time-series, with the average number of years covered being 21.5 (although, as noted above, the early years are underrepresented, so there is no even coverage across these years).

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[5] In WTO parlance, MFN is the tariff rate that members grant to all other members equally (leaving aside preferential trade agreements). The concept is based on the idea of non-discrimination so that all WTO members are equally 'most-favored' by each other.

[6] One thing to note in this context is that the coefficients on the global estimates for b_{ij} and $b_{ij\neq k}$ in the photographic equipment category are not statistically significant. However, the purpose here is not the test *whether* international trade volumes are different from domestic ones but to assess *how* the two relate and to use this information to infer trade frictions. For this reason, the p-value is not necessarily the relevant statistic to consider with respect to the border indicators. Basically, a precise coefficient estimate of exactly 0 would be highly informative (although not statistically significant) because it implies that international trade in the given product is just as open as domestic trade and therefore that implied NTBs are equal to zero – conditional on all other trade cost factors.

[7] As noted above, because higher elasticities imply lower barriers, these results would diverge more strongly if they were calculated using, say, the mean of the two elasticities.

Table 1: Exemplary Gravity Estimates for Brazil's Pork and Photographic Equipment Imports

	H_0203: Pork meat		I_3320: Opt. & photogr. equipment	
	WLD	BRA	WLD	BRA
$\ln dist_{ij}$	–0.326***	–0.325***	–0.955***	–0.951***
	(0.040)	(0.041)	(0.032)	(0.032)
$\ln(1 + tar_{ijt})$	–0.305***	–0.306***	0.007	0.013
	(0.041)	(0.041)	(0.031)	(0.031)
$contig_{ij}$	1.845***	1.846***	0.908***	0.894***
	(0.116)	(0.116)	(0.097)	(0.097)
$lang_{ij}$	0.458***	0.457***	0.973***	0.964***
	(0.079)	(0.079)	(0.056)	(0.056)
b_{ij}	–5.735***	–	–0.346	–
	(0.176)		(0.203)	
$b_{ij\neq m}$	–	–5.734***	–	–0.320
		(0.177)		(0.209)
$b_{ij=m}$	–	–5.780***	–	–0.831**
		(0.445)		(0.270)
$Fixed\ effects$	it, jt	it, jt	it, jt	it, jt
$N * T$	12,365	12,365	16,800	16,800
R^2	0.724	0.799	0.791	0.810

Notes: The dependent variable is $\ln(1 + x_{ijt})$. The constant of 1 is added to avoid taking logarithms of zeros of which some are reported in the data; similarly for tariffs, where the prevalence of zeros is considerably more pronounced. The fixed effects are directional, i.e., there are two fixed effects per dyad-year; the intercept and fixed effects coefficients are not reported. Huber-White robust standard errors are in parentheses; ***, **, and * indicate significance at the .001, .01 and .05 levels, respectively.

Overall, some 86 percent of estimated coefficients are statistically significant at the 5 percent level. When only considering the coefficients on the $b_{ij=m}$ indicator, this number drops to 64 percent. As noted in footnote 5, however, p-values may not be the most informative statistic in the present context. As the further discussion highlights, it is far from uncommon (at least in the manufacturing sector) that international and domestic trade are comparably open.

5.1 A Descriptive Overview of the Estimated Non-Tariff-Barriers

To give a more systematic overview of the results, Table 4 (which, due to its length, is appended at the end of this paper) presents the trade-weighted average NTB *ad valorem* equivalents (based on import values) across all importers for an extended selection of products.[8] The complete list is provided in Appendix C. Figure 1, graphically summarizes the complete set of results as contained in the appendix and provides some general insights.

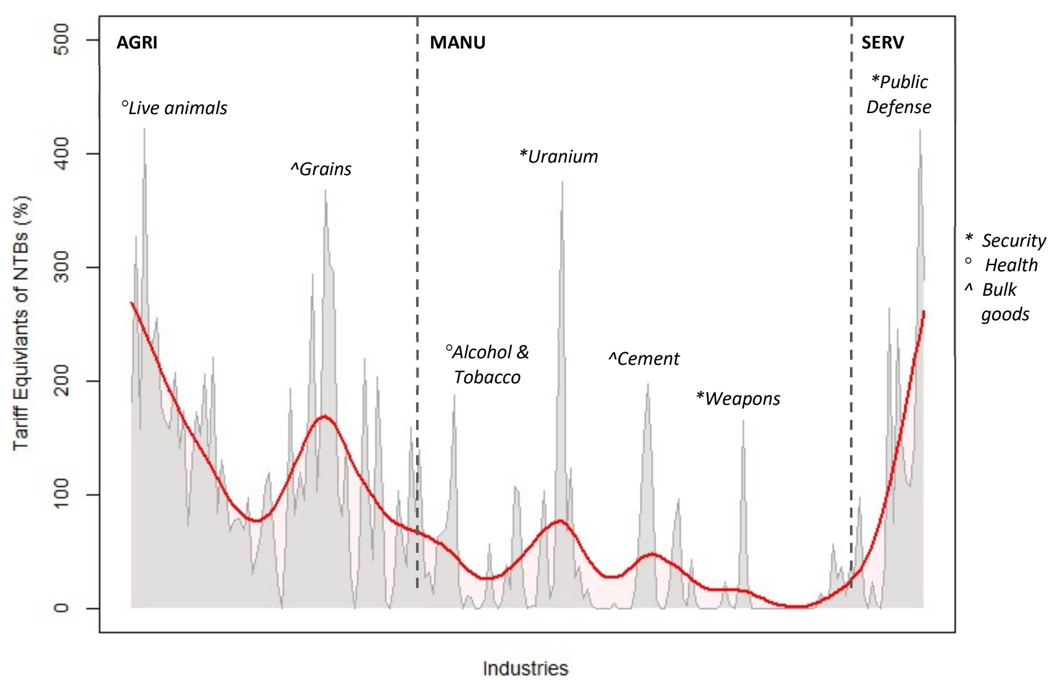
Figure 1 and Table 4 allow an assessment of the plausibility of the results by comparing the estimated NTBs to prior expectations about the restrictiveness of trade relations for different products.

[8] In the calculation of these averages, I discard a handful of estimates that are larger than 3000 percent. These estimates concern almost exclusively developing countries and appear to be mostly the result of reporting error in the production data.

Both the figure and the table are split in three broad segments relating to agricultural products, manufactures, and services. In the table, two different versions of the estimates are provided. The first column gives the raw estimates as calculated following the procedure described above (this series that is also displayed in Figure 1). However, it is fairly common in the manufacturing sector that goods are traded more intensively across international borders than domestically (conditional on trade costs). For this reason, I truncate these estimates at zero because not doing so would imply that countries actively subsidize imports. The interpretation therefore is that trade relations that are at least as open as domestic trade are considered free of policy barriers.

The second column provides an alternative measure, which simply rescales the raw estimates to a different benchmark. In doing so, I select for each product the importer with the lowest estimated NTBs and define this importer as the free-trader. I then rescale the estimates so that the free-trader has NTBs of zero and all other countries have NTBs larger than zero. This rescaling preserves the relative differences between the estimates and only leads to slight shifts in the overall weighted-average depending on how large the trade share of the free-trader is. The interpretation here is that the free-trader defines the product-specific standard of when trade is considered to be free. I refer to the first version as 'domestic-trade benchmarked' and to the second as 'free-trade benchmarked'.

Figure 1: Estimated NTB Ad Valorem Equivalents – Trade-weighted Averages



The overall pattern of results is clear. It is readily apparent that the estimated NTBs in the manufacturing sector tend to be much lower than those in both the agricultural and services sectors. This is fully in line with prior expectations given that the agricultural sector is well-known to be strongly protected across countries and trade liberalization efforts in the services sector have only picked up speed comparatively recently. With respect to individual products, the results align with intuition as well. The only estimates that are unexpected concern coke oven products (I_2310), and cement and stone (I_2694, I_2695, I_2696). The estimates for these products appear overly high. This is a direct consequence of the very low weight-to-value ratios of these products, which drastically reduce their transportability. As noted above, the product-wise estimation procedure cannot account for these product-level characteristics. For products with more representative weight-to-value ratios, however, this issue appears to be of less concern.

In the transport sector, for instance, the estimated NTBs suggest that both shipbuilding (I_3511) and the railway industry (I_3520) are relatively closed. This mirrors prior knowledge suggesting that these industries (and the large national wharfs in particular) are much less internationally integrated than, for instance, the auto and aviation sectors. High NTBs are also estimated for nuclear fuel (I_2330) and weapons and ammunition (I_2927), which are clearly among the most strongly regulated manufacturing industries. Publishing and printing (I_2211, I_2221), both of which are strongly nationally-oriented industries, attain high estimates as well.

The implied levels of protection in the textile and apparel sector are potentially lower than one would expect. It should be kept in mind, however, that these products are already shielded by some of the highest tariffs among all manufacturing goods. In the services sector, the pattern of results conforms very well with intuition: By far the lowest estimates relate to air transport (I_6200), followed by research and development (I_7300), while the highest estimates concern construction (I_4500), and public administration and defense (I_7500). This is close to what one would expect.

When turning to importer-specific estimates, an intuitive pattern emerges as well. Japan, for instance, is known for its stringent rice (H_1006) import policies. The country's NTBs for rice are estimated at 318 percent (using the domestic-trade benchmark). Similar figures are obtained for other large rice producers such as India (260 percent), or Indonesia (268 percent). This compares to estimates of 149 percent for Mexico, 25 percent for Italy, 20 percent for Spain, or 7 percent for Argentina. The picture looks much different for corn (H_1005). Here Japan's estimated NTBs are zero percent (truncated), while Mexico's are 270 percent. Similarly, Argentina's NTB estimate for soy beans (H_1201) is at 361 percent, while the estimate for the European Union is 156 percent. Conversely, when considering rape seed (H_1205), the oilseed variant dominant in Europe, the reverse result is found with an estimated 266 percent for Argentina and 443 percent for the EU.[9]

The overall pattern that emerges from these comparisons is that in the agricultural sector, large producers tend to have high estimated NTBs. In contrast, the opposite pattern is discernable in manufacturing trade. Here, large producers tend to be most open to trade. This general picture corresponds directly with theoretical expectations and prior knowledge about the dynamics of agricultural and manufacturing trade: In the agricultural sector, where producers face direct competition from very similar imported product varieties, lobbying for protection is strong. On contrast, in the

[9] Estimates for the European Union are obtained by calculating the trade-weighted averages for all member states. Imports are summed over time before transforming them into weights. This makes it possible to take into account the changing composition of the EU. Members that joined the EU later receive lower weights because their imports are summed over shorter time-periods.

manufacturing sector, where producers sell differentiated products in segmented markets and global supply chains are of major importance, calls for protection are much less frequent.

It is worth pointing out that the data resulting from the above estimation results constitute the most comprehensive and detailed information on NTBs that is currently available. This is true for the amount of detail on the product level as well as for the country coverage.

5.2 Systematically Assessing the Estimated Non-Tariff-Barriers

This subsection presents two more systematic sets of checks to substantiate the validity of the paper's results. First, it presents additional gravity estimates that demonstrate the trade depressing effect captured by the estimated NTBs. Secondly, it briefly presents some evidence that the estimated non-tariff barrier estimates vary systematically and in intuitive ways with a country's industry-level import tariffs, its competitiveness, and the number of WTO filings brought against it.

Concerning the first part of the section, the following analysis presents results for gravity estimates that directly include the acquired NTBs as a predictor, rather than as a result of the estimation procedure. This serves as a primary check that the method actually picks up on trade depressing variation in the data.

Prior to presenting the estimation results, I discuss the data structure used in the analysis and explain the rationale behind the data setup and research design choices made. The most far-reaching of these choices is to collapse the twenty-five year time-series data, ranging from 1988 to 2012, into a cross-section. This is done because the data on NTBs come as a cross-section as a result of the above estimation strategy. Since the over-time variation, along with the variation across exporters, has been used to estimate the NTBs, the resulting data are on the importer-industry level. Consequently, the NTB estimates do not vary over time. Therefore, they cannot be adequately matched with the U.S. trade enforcement data or the trade data to be used in a time-series cross-sectional analysis unless one is willing to repeat the same barrier estimate for each year and then perform a pooled analysis.

The following briefly presents the more technical details of the aggregation procedure. The data that need to be aggregated for the analysis below are the time-varying economic data on trade and GDP. A feature of economic data is that these data are measured in monetary units (i.e., in U.S. dollars). Such data are customarily reported in *current* rather than *constant* U.S. dollars and thus reflect the nominal currency values of the respective reporting year. As a result, current U.S. dollar time-series data include the effect of price inflation. The data shows an increasing trend that is due not only to economic growth but also to inflation. It is therefore necessary to inflation-adjust the data prior to calculating time-averages in order to translate all data in comparable *constant* U.S. dollar terms.

To do so, I use GDP deflators taken from the World Bank's World Development Indicators database to inflation-adjust the current data value series. Thus, all price-adjustments are made using general economy-wide inflation-measures for each country, irrespective of whether the series concern aggregated data (such as total trade or production) or disaggregated data (such as industry-level trade or production). Ideally, one would want to adjust all data-series with disaggregated deflators because prices for different products do not necessarily move in parallel within an economy. Possible alternatives to GDP deflators that allow more disaggregated price-adjustments are consumer and producer price indices (CPIs and PPIs) and trade unit values (UVs). However, both of these options have considerable disadvantages compared to GDP deflators.

While national statistical offices in many developed countries provide relatively detailed consumer and producer price indices (CPIs and PPIs), such indices are typically not available for developing countries. Moreover, national price indices differ in classifications and level of detail, leading to considerable comparability issues. The OECD provides a set of harmonized CPIs and PPIs for member states based on individual national versions of these indices. However, because harmonization makes it necessary to considerably aggregate all national indices to find the 'smallest common denominator' of the respective product groupings, the resulting indices typically only include a handful of product groups. In addition, the OECD indices do not cover developing countries and are therefore not globally applicable.

Trade unit values have the advantage of being available at highly disaggregated product-levels. At the same time, however, they are an unreliable measure of price developments due to considerable measurement error. The issue of measurement errors is much more important in the context of price deflation than in the context of estimating elasticities. In the latter setting, UVs are used in a statistical context so that some of the measurement errors may cancel out or are stabilized in the statistical averaging procedure. In contrast, when used for price-deflation of, say, product-level trade data, each individual UV is matched with a single corresponding dyad-product-year observation. Thus, measurement error is fully propagated into the 'price-adjusted' trade value. This can lead to severe biases especially for developing countries for which measurement error in UVs is most pronounced.

The above considerations significantly lower the attractiveness of CPIs/PPIs and UVs relative to GDP deflators. The latter have the great advantage of being available for all countries and fully reliable on average, that is, they adequately reflect general country-specific price movements over time. This is a sufficient property for the current purpose which simply seeks to construct reasonably valid over-time averages that do not depend on getting precise annual estimates. In contrast, if one would like to investigate the details of say production growth in a given country-industry over time (for instance as function of industry investments or R&D activities, or in relation to unemployment rates), the specific year-to-year changes would be of direct interest. In the former case, individual annual changes matter much less than the general price trend, which in turn is likely to be adequately captured by GDP deflators.

Additional processing is required to construct data for the European Union. Because Brussels is responsible for EU trade policy, the European Union as such rather than individual member states is the political entity of interest. Trade, production, and GDP data, where not directly available, are aggregated by summing the individual annual figures for all member states prior to the above deflation and averaging procedure. In this context, the varying membership of the EU over time is taken into account. NTB data is calculated as the trade-weighted average of individual member state estimates as described in footnote 8.

With these aggregation procedures implemented, it is possible to proceed to the statistical analysis. This analysis serves to establish the trade depressing effect of the estimated NTB measures. The general gravity model structure is similar to the setup employed above. That is, I estimate a log-log regression of trade on a set of gravity and trade cost variables and a set of up to three fixed-effects that takes the form

$$\ln x_{ijk} = \alpha_0 + \alpha_1 \ln(1 + y_{jk}) + \tilde{\beta}_{1-4} \ln t_{ijk} + \gamma_1 + \gamma_2 + \gamma_3 + \varepsilon_{ijk}, \quad (6)$$

where x_{ijk} are deflated time-averaged exports in industry k from exporter i to importer j, y_{jk} is deflated time-averaged production in industry k in country j, α_0 is an intercept, α_1 and $\tilde{\beta}_1$ through $\tilde{\beta}_4$ are regression coefficients (as before, the tilde indicates the composite coefficient that includes the elasticity of substitution), γ_1, γ_2, and γ_3 are a differing set of fixed-effects to be specified more precisely below, and ε_{ijk} is an error term that is assumed to be log-normal. Lastly, the trade cost term, $\ln t_{ijk}$, is

$$\ln t_{ijk} = \ln(1 + barrier_{jk}) + \ln dist_{ij} + contig_{ij} + lang_{ij}. \quad (7)$$

Despite the similarity to the model in equation (4), there are a number of differences. First, data contain information on all industries. Thus, a joint model is estimated instead of estimating separate models for each industry. The industry classification remains the same as before (see: Appendix D for details). Second, unlike in the setup above, where observations relating to countries' domestic trade were included, the data now only contains information on *international* trade. Since the purpose is to estimate the effect of an (now) observed measure of trade barriers on international trade – rather than to compare domestic to international trade in order to indirectly infer the size of implied trade barriers – this choice is natural. As a direct consequence, all trade flows in the data refer to flows that cross national borders so that no border indicators are included in the model.

The trade cost term now contains a new variable, $barrier_{jk}$, which is the sum of the NTB *ad valorem* estimate for industry country j in industry k and the corresponding tariff (if available), which is in *ad valorem* terms by definition (I use the 'free-trade benchmark' version of the NTB data; this choice is inconsequential as results with the domestic benchmark data are very similar). The variable thus captures the total *ad valorem* policy barrier a country implements in any given industry. The combination of the NTBs and tariff data into a single barrier measure reflects the theoretical consideration that the two kinds of measures in tandem form the politically imposed trade cost component that matters in the context of trade disputes (this is also the measure that serves as the basis for the trade policy simulations described below). Practically, however, the NTB data by far outweigh the trade depressing effect of tariffs as discussed more extensively below.

The $dist_{ij}$, $contig_{ij}$, and $lang_{ij}$ variables that measure geographical distance, land contiguity, and common official language are defined as before. The only difference relates to the distance measure for the European Union. Because the available gravity datasets (Head et al. 2010, Mayer and

Zignago 2011) do not contain distance measures for the EU, I approximate these distances by calculating the trade-weighted distance of non-EU countries to the EU-15 member states. The EU-15 is chosen in order to capture representative distances to the 'average EU' in the time-averaged cross section.

Table 2 presents the results of the analysis in a number of different specifications. The first two columns show estimates for the entire world trade network, that is, for trade between all countries in each direction. To provide a more disaggregated picture, columns three and four show estimates only for the subset of unidirectional trade from the United States to its trade partners. The two specifications (a and b) for each of the two sets of data differ only in the form of the included fixed-effects. Because the estimated NTBs that form the basis for the $barrier_{jk}$ variable are on the importer-industry level, I cannot include industry-varying importer effects, γ_{jk} , in any of the models.

Table 2: Gravity Results Assessing Previously Estimated NTBs on World and U.S. trade

	World Trade Network		*U.S. Exports*	
	Model 1a	Model 1b	Model 2a	Model 2b
$\ln(1 + y_{jk})$	0.371***	0.102***	0.448***	0.108***
	(0.002)	(0.003)	(0.010)	(0.016)
$\ln(1 + barrier_{jk})$	–0.421***	–0.330***	–0.616***	–0.304***
	(0.004)	(0.005)	(0.024)	(0.028)
$\ln dist_{ij}$	–1.028***	–1.160***	–1.001***	–
	(0.006)	(0.006)	(0.062)	
$contig_{ij}$	0.633***	0.499***	1.017***	–
	(0.020)	(0.020)	(0.156)	
$lang_{ij}$	0.621***	0.365***	0.225***	–
	(0.012)	(0.013)	(0.056)	
$Fixed\ effects$	$ik, j_{WB}k$	ik, k, j	$j_{WB}k$	$k, j = ij$
N	222,139	222,139	4,758	4,758
R^2	0.702	0.723	0.814	0. 859

Notes: The dependent variable is logged industry-level trade, $\ln(1 + x_{ijk})$. The constant of 1 is added to avoid taking logarithms of zeros of which some are reported in the data; similarly for policy barriers. Industry (k) and importer World Bank income group (j_{WB}) or importer/dyad (ij) fixed-effects are included as indicated; the intercept and fixed-effects coefficients are not reported. Huber-White robust standard errors are in parentheses; ***, **, and * indicate significance at the .001, .01 and .05 levels, respectively.

To partially account for unobserved heterogeneity at these levels, I either specify separate industry and importer effects γ_k and γ_j , or use industry-varying importer income group effects, $\gamma_{j_{WB}k}$, where income groups are defined based on the World Bank's classification of countries according to high, upper middle, lower middle, and low income groups. The rational in the latter case is to account for product-specific unobserved heterogeneity that is related to development status and to thereby capture an important aspect of relevant importer characteristics. Also, as a result of the inability to specify industry-varying importer effects, I include industry-specific importer production, y_{jk}, as a gravity variable (while industry-specific exporter production, y_{ik}, is soaked up in the γ_{ik} in the world model and γ_k in the U.S. exports model). Because the U.S. exports model only has one exporter, namely the United States, importer effects y_j are equivalent to dyad effect y_{ij} in this context.

The estimates in Table 2 show that policy barriers are a significant hurdle to trade in general and to U.S. exports in particular. Because, unlike before, the focus is not on inferring unobserved trade barriers from observed frictions, the coefficient interpretation follows the standard logic of interpreting log-log regression models. In approximation, the coefficient estimates for continuous predictors can be interpreted as the percentage change in trade in response to a given percent change in the predictors. That is, a δ percent change in x implies a $\beta\delta$ percent change in y. Similarly, for dummy variables the coefficients are approximately interpreted as the percentage change in trade in response to a switch of the dummy from zero to one. That is, change from zero to one in x implies a β percent change in y. This approximation is intuitively graspable and sufficiently exact for small changes in the predictors of, say, ten percent or less.

For completeness, the exact interpretation follows from the functional form of the exponentiated version of the model but is less straightforward and requires additional calculations. Omitting all subscripts, a simple model with a (logged) continuous predictor x and a dummy variable D takes the form of $\ln(y) = \beta_1 \ln(x) + \beta_2 D + \varepsilon$. Exponentiation yields the unlogged model $y = x^{\beta_1} \times \exp(\beta_2\, D) \times \epsilon$. Thus, when x is multiplied by a factor $(1 + c)$, i.e., x increases by $100c$ percent, y is multiplied by $(1 + c)^{\beta_1}$. For instance, if x increases by fifty percent, y increases by 1.5^{β_1}. The change in y then is $\Delta y = (1 + c)^{\beta_1} - 1$, which, multiplied by 100, gives the corresponding percent change. Similarly when $D = 1$ y is multiplied by $\exp(\beta_2)$ with the corresponding change in y of $\Delta y = \exp(\beta_2) - 1$. Otherwise, when $D = 0$ y is multiplied by $\exp(0) = 1$ with an implied change of 0.

Based on these interpretations, it is apparent from Table 2 that a given increase in policy barriers of say ten percent implies an average decrease in trade of around three to six percent depending on the model specification. Model 2b, for instance, implies that an increase in representative foreign trade barriers by ten percent depresses U.S. exports by approximately 3.04 percent (the exact value being $1.1^{-3.04} - 1 = -0.0285 = 2.85$ percent. Similarly, a decrease in foreign trade barriers by ten percent would result in an increase of U.S. exports of around 3 percent (the exact value being 3.25 percent)). These are substantial effects especially given that the data include a considerable share of trade relationships that are relatively open to trade. This implies that policy barriers in heavily protected industries can be considerably greater impediments to trade. For instance, subsetting the U.S. data to include only agricultural products results in estimates for the coefficients on the barrier variable of –0.721 (0.057) for Model 2a and –0.434 (0.057) for Model 2b.

To demonstrate that the trade depressing effect of policy barriers is driven primarily by NTBs as opposed to tariffs, I also estimate the models with the NTB data only. For these variants of the models, coefficient estimates and standard errors on the barrier variable are –0.321 (0.004) and –0.269 (0.004) for Models 1a and 1b, respectively, as well as –0.486 (0.021) and –0.234 (0.021) for Models 2a and 2b (the coefficient estimates for the other variables are substantively unchanged, which is why I do not report the results in full). Thus, coefficient estimates decrease only slightly. All estimates continue to be statistically significant at the .001 level. Very similar results are obtained for model specifications in which NTB and tariff data are both entered separately. In these cases, the estimated coefficients for tariffs turn out to be of small magnitude and much less stable then the

NTB estimates. Overall, these results help to substantiate the methodological validity and the practical importance of the estimated NTBs.

As the second part of this section, and to further tests the validity of the results, Table 3 presents some correlational and regression evidence suggesting that the non-tariff barriers estimates vary intuitively with importer-industry-specific policies and characteristics.

Table 3: Correlations and Regression Estimates – Tariffs, RCA, and WTO Dispute Filings

	Tariffs	RCA	WTO Disputes
Correlation	.24	–.15	–
Univariate regression + fixed effects	Sign: + p < .001	Sign: – p < .001	–
Poisson regression + tariffs + fixed effects	–	–	Sign: + p < .001
Interpretation	Industries protected by tariffs are also protected by NTBs	more competitive producers require *less* trade protection	higher trade barriers likely to draw *more* complaints

First, estimated non-tariff barriers are positively and significantly associated with higher tariffs. Thus, industries that are protected by higher tariffs also tend to be protected more through non-tariff barriers. This pattern makes sense, in particular, if one assumes that NTBs increasingly substitute for traditional tariffs in a world where tariff policies are increasingly regulated and governments need to resort to other less regulated – and less transparent – means to continue to shield domestic industries.

Second, the estimated non-tariff barriers are negatively and significantly associated with revealed comparative advantage (RCA), a standard measure of industry competitiveness. Again, this is in line with expectations given that domestic industries are most in need of protection if they are not internationally competitive and therefore particularly threatened by import competition. More productive domestic producers, on the other hand, have an easier time competing with foreign products and this require less protection.

Third, the estimated non-tariff barriers are positively and significantly associated with a larger number of WTO disputes being filed against the imposing country in the given industry. This result, too, conforms with expectations since foreign producers that are excluded from a given market due to trade protection are more likely to pressure their home governments to challenge the given barriers through WTO dispute settlement.

6 Conclusion

This paper has presented a method to estimate the size of applied trade protection. The paper also provides the resulting data. These data provide comprehensive information on worldwide industry-level non-tariff-barriers to trade (NTBs). This constitutes an important step forward towards systematically investigating trade policies around the world, given that reliable data on applied protection levels are currently not available. This is true, in particular, for non-tariff barriers, which make up the bulk of trade policy tools as a result of the increasingly tight regulations on tariffs through international trade agreements.

Due to the indirect method used in the estimation process, these data are not affected by the self-selection and coverage problems that plague existing data sources on NTBs. Unlike existing data on trade barriers, therefore, the data are can be used for predicting and explaining empirical trade patterns and capture substantial trade depressing effects. These trade depressing effects have been documented in a separate statistical analyses. Potential applications include assessing export growth and market potentials, conducting welfare analyses of trade policy choices, creating predictions and scenarios expected from possible policy changes, and setting of negotiation priorities.

Given its broad applicability, the presented data is likely to be of interest to scholars and practitioners alike. Furthermore, the method employed in this paper may be of interest to empirical researchers and methodologists working on international trade.

Table 4: Estimated NTB Ad Valorem Equivalents – Trade-weighted Averages (Selection)

Code	Category	Product description	AVEs.dm	AVEs.ft
H_0201	Meats	Meat of bovine animals	191.2	217.4
H_0203		Meat of swine	245.1	230.4
H_0204		Meat of sheep or goats	270.5	304.0
H_0205		Meat, of horses, asses, mules or hinnies	167.8	170.1
H_0207		Meat and edible offal of poultry	178.9	200.9
H_0701	Vegetables	Potatoes	200.4	253.5
H_0702		Tomatoes	51.1	119.9
H_0703		Onions, shallots, garlic, leeks	151.1	223.6
H_0704		abbages, cauliflowers, kohlrabi, kale	183.9	254.5
H_0705		Lettuce	131.8	220.1
H_0706		Carrots, turnips, salad beetroot, etc.	239.2	329.9
H_0707		Cucumbers and gherkins	93.4	184.0
H_0708		Leguminous vegetables	265.6	315.5
H_0801	Fruits & nuts	Coconuts, Brazil nuts, and cashew nuts	29.9	41.0
H_0802		Nuts other	70.3	143.8
H_0803		Bananas	86.8	168.9
H_0804		Dates, figs, pineapples, avocados, mangoes	116.6	170.7
H_0805		Citrus	65.2	119.5
H_0806		Grapes	112.9	190.5
H_0807		Melons and papayas	18.2	91.4
H_0808		Apples, pears, and quinces	61.5	136.9
H_0809		Apricots, cherries, peaches	63.4	108.9
H_1001	Grains	Wheat	134.2	193.1
H_1002		Rye	86.5	151.1
H_1003		Barley	161.2	176.8
H_1004		Oats	332.8	362.7
H_1005		Maize (corn)	78.2	153.6
H_1006		Rice	164.8	239.3
H_1007		Grain sorghum	388.8	480.8
H_1008		Buckwheat	303.3	388.5
H_1201	Oilseeds	Soya beans	321.7	400.2

H_1202		Ground-nuts	103.4	164.8
H_1202		Copra	102.4	140.3
H_1204		Oil seeds, linseed	76.3	122.0
H_1205		Rape or colza seeds	549.0	630.1
H_1206		Sunflower seeds	171.3	219.9
I_1711	Textiles & apparel	Textile fiber preparation, textile weaving	0.0	58.6
I_1721		Finishing of textiles	0.0	60.6
I_1722		Made-up textile articles, except apparel	13.2	108.1
I_1723		Carpets and rugs	16.2	109.5
I_1729		Cordage, rope, twine and netting	0.0	43.6
I_1730		Knitted and crocheted fabrics and articles	0.0	25.2
I_1810		Wearing apparel, except fur apparel	0.0	36.4
I_1820		Dressing & dyeing of fur, processing of fur	71.3	135.3
I_1911		Tanning and dressing of leather	0.0	72.6
I_1912		Luggage, handbags, etc.	0.0	58.1
I_1920		Footwear	0.0	55.0
I_2010	Wood & paper	Sawmilling and planning of wood	57.7	143.4
I_2021		Veneer sheets, plywood, particle board, etc.	0.0	90.4
I_2022		Builders' carpentry and joinery	118.4	175.9
I_2023		Wooden containers	109.0	174.8
I_2029		Other wood products, articles of cork/straw	18.3	100.1
I_2101		Pulp, paper and paperboard	0.0	64.1
I_2102		Corrugated paper and paperboard	6.7	103.0
I_2109		Other articles of paper and paperboard	0.0	57.3
I_2211	Printing & publishing	Publishing of books and other publications	54.2	146.4
I_2212		Publishing of newspapers, journals, etc.	119.6	186.1
I_2213		Publishing of recorded media	0.0	44.8
I_2219		Other publishing	25.3	100.9
I_2221		Printing	206.1	290.5
I_2310	Minerals & chemicals	Coke oven products	403.0	458.9
I_2320		Refined petroleum products	0.0	79.9
I_2330		Processing of nuclear fuel	171.7	165.3
I_2411		Basic chemicals, except fertilizers	0.0	44.1
I_2412		Fertilizers and nitrogen compounds	94.5	188.8
I_2413		Plastics in primary forms, synthetic rubber	0.0	68.2
I_2421		Pesticides and other agro-chemical products	21.1	101.2
I_2422		Paints, varnishes, printing ink	0.7	98.5
I_2423		Pharmaceuticals, medicinal chemicals, etc.	0.0	79.0
I_2424		Soap, cleaning & cosmetic preparations	0.0	59.5
I_2429		Other chemical products n.e.c.	0.0	47.1
I_2430		Man-made fibers	0.0	69.4
I_2511		Rubber tires and tubes	7.6	99.8
I_2519		Other rubber products	0.0	74.8
I_2520		Plastic products	0.0	54.8
I_2610		Glass and glass products	0.0	66.5
I_2691		Pottery, china and earthenware	0.0	69.8
I_2692		Refractory ceramic products	29.8	125.3
I_2693		Non-refractory clay, ceramic products	72.4	165.5
I_2694		Cement, lime, and plaster	158.3	253.7
I_2695		Articles of concrete, cement and plaster	204.0	300.3

I_2696		Cutting, shaping & finishing of stone	132.2	202.8
I_2710	Metal & machinery	Basic iron and steel	0.0	54.3
I_2720		Basic precious and non-ferrous metals	0.0	43.9
I_2811		Structural metal products	19.2	114.1
I_2812		Tanks, reservoirs and containers of metal	74.1	165.4
I_2813		Steam generators	121.2	208.4
I_2893		Metal forging/pressing/stamping/roll-forming	0.0	91.5
I_2899		Treatment & coating of metals	0.0	37.9
I_2911		Engines & turbines (not for transport equipm.)	55.0	123.4
I_2912		Pumps, compressors, taps, and valves	0.0	35.6
I_2913		Bearings, gears, gearing & driving elements	0.0	67.2
I_2914		Ovens, furnaces and furnace burners	0.0	57.4
I_2915		Lifting and handling equipment	0.0	56.6
I_2921		Agricultural and forestry machinery	6.1	96.6
I_2922		Machine tools	0.0	47.0
I_2923		Machinery for metallurgy	23.1	100.0
I_2924		Machinery for mining & construction	0.0	44.4
I_2925		Food/beverage/tobacco processing machinery	3.4	89.6
I_2926		Machinery for textile, apparel and leather	0.0	56.7
I_2927		Weapons and ammunition	220.3	301.8
I_2930		Domestic appliances n.e.c.	0.0	70.0
I_3000	Electronics & prec. instr.	Office, accounting and computing machinery	0.0	47.2
I_3110		Electric motors, generators and transformers	0.0	64.5
I_3120		Electricity distribution & control apparatus	0.0	47.9
I_3130		Insulated wire and cable	0.0	58.2
I_3140		Accumulators, primary cells, and batteries	0.0	73.0
I_3150		Lighting equipment and electric lamps	0.0	57.8
I_3210		Electronic valves, tubes, etc.	0.0	65.4
I_3220		TV/radio transmitters, line comm. apparatus	0.0	38.5
I_3230		TV and radio receivers and associated goods	0.0	83.1
I_3311		Medical, surgical and orthopedic equipment	0.0	56.7
I_3312		Measuring/testing/navigating appliances, etc.	0.0	53.7
I_3313		Industrial process control equipment	0.9	78.9
I_3320		Optical instruments & photographic equipment	0.0	43.3
I_3330		Watches and clocks	0.0	66.4
I_3410	Transport equipment	Motor vehicles	18.4	96.9
I_3420		Automobile bodies, trailers & semi-trailers	14.8	107.8
I_3430		Parts/accessories for automobiles	0.0	83.3
I_3511		Building and repairing of ships	68.7	133.9
I_3512		Building/repairing of pleasure/sport. boats	16.4	84.9
I_3520		Railway/tramway locomotives & rolling stock	50.7	117.5
I_3530		Aircraft and spacecraft	0.0	88.3
I_3591		Motorcycles	74.0	141.5
I_3592		Bicycles and invalid carriages	18.7	68.3
I_4500	Services	Construction	334.3	263.1
I_6200		Air transport	2.1	43.3
I_6500		Financial intermediation	123.5	193.0
I_6600		Insurance and pension funding	117.1	129.6
I_7200		Computer and related activities	122.1	153.3
I_7300		Research and development	106.3	94.7

I_7500	Public administration and defense	462.7	124.8
I_9200	Recreational, cultural and sporting activities	273.7	257.8

Note: Product codes beginning with 'H' refer to the HS classification; codes beginning with 'I' refer to the ISIC Rev. 3 classification. The NTB *ad valorem* equivalents are reported in percent.

7 References

Anderson, James E. and Eric Van Wincoop. "Gravity with Gravitas: A Solution to the Border Puzzle." A*merican Economic Review* 93.1 (2003): 170-192.

Anderson, James E. and Eric Van Wincoop. "Trade Costs." *Journal of Economic literature* 42.3 (2004): 691-751.

Amiti, Mary, and Jozef Konings. "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia." *American Economic Review* 97.5 (2007): 1611-1638.

Bacchetta, Marc, Juergen Richtering, and Roy Santana. "How Much Light do WTO Notifications Shed on NTMs?" In: Cadot, O. and M. Malouche (eds.), *Non-Tariff Measures: A Fresh Look at Trade Policy's New Frontier*. The International Bank for Reconstruction and Development/The World Bank (2012).

Baier, Scott L., and Jeffrey H. Bergstrand. "The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity." *Journal of International Economics* 53.1 (2001): 1-27.

Baier, Scott L., and Jeffrey H. Bergstrand. "Bonus Vetus OLS: A Simple Method for Approximating International Trade-cost Effects using the Gravity Equation." *Journal of International Economics* 77.1 (2009): 77-85.

Baier, Scott L., and Jeffrey H. Bergstrand. "Approximating General Equilibrium Impacts of Trade Liberalizations using the Gravity Equation." In: Van Bergeijk, Peter, and Steven Brakman (eds.), *The Gravity Model in International Trade: Advances and Applications* (2010): 88-134.

Baldwin, Richard, and Daria Taglioni. *Gravity for Dummies and Dummies for Gravity Equations*. National Bureau of Economic Research. (2006).

Bloom, Nicholas, Mirko Draca, and John Van Reenen. "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity." *The Review of Economic Studies* 83.1 (2016): 87-117.

Borchert, Ingo, Batshur Gootiiz, and Aaditya Mattoo. "Guide to the Services Trade Restrictions Database." (2012).

Bustos, Paula. "Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms." *American Economic Review* 101.1 (2011): 304-40.

Cadot, O. and M. Malouche (eds.), *Non-Tariff Measures: A Fresh Look at Trade Policy's New Frontier*. The International Bank for Reconstruction and Development/The World Bank (2012).

Chen, Natalie, and Dennis Novy. "Gravity, Trade Integration, and Heterogeneity across Industries." *Journal of international Economics* 85.2 (2011): 206-221.

Chen, Natalie, and Dennis Novy. "On the Measurement of Trade Costs: Direct vs. Indirect Approaches to Quantifying Standards and Technical Regulations." *World Trade Review* 11.03 (2012): 401-414.

Díez, Federico J. "The Asymmetric Effects of Tariffs on Intra-Firm Trade and Offshoring Decisions." *Journal of International Economics* 93.1 (2014): 76-91.

Galiani, Sebastian, and Pablo Sanguinetti. "The Impact of Trade Liberalization on Wage Inequality: Evidence from Argentina." *Journal of Development Economics* 72.2 (2003): 497-513.

Gaston, Noel, and Daniel Trefler. "Protection, Trade, and Wages: Evidence from US Manufacturing." *ILR Review* 47.4 (1994): 574-593.

Gaure, Simen. "lfe: Linear Group Fixed Effects." *The R Journal* 5.2 (2013): 104-117.

Gowa, Joanne, and Raymond Hicks. "The Most-Favored Nation Rule in Principle and Practice: Discrimination in the GATT." *The Review of International Organizations* 7.3 (2012): 247-266.

Head, Keith, and Thierry Mayer. "Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade." *CEPII Working Paper* (2002).

Head, Keith, and Thierry Mayer. "The Empirics of Agglomeration and Trade." In: Henderson, Vern, and Jacques-François Thisse (eds.), *Handbook of Regional and Urban Economics: Cities and Geography*, Vol. 4. Elsevier (2004).

Head, Keith, and Thierry Mayer. "Gravity Equations: Workhorse, Toolkit, and Cookbook." In: Gopinath, Gita, Elhanan Helpman and Kenneth Rogoff (eds.), *Handbook of International Economics, Vol. 4*. Elsevier (2014): 131-195.

Head, Keith, Thierry Mayer, and John Ries. "The Erosion of Colonial Trade Linkages after Independence." *Journal of International Economics* 81.1 (2010): 1-14.

Head, Keith, and John Ries. "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of US-Canada Trade." *American Economic Review* (2001): 858-876.

Hertel, Thomas Warren. *Global Trade Analysis: Modeling and Applications*. Cambridge University Press, (1997).

Jacks, David S., Christopher M. Meissner, and Dennis Novy. "Trade Costs, 1870-2000." *American Economic Review* 98.2 (2008): 529-534.

Lee, Jong-Wha, and Phillip Swagel. "Trade Barriers and Trade Flows across Countries and Industries." *Review of Economics and Statistics* 79.3 (1997): 372-382.

Luong, Tuan Anh. "The Impact of Input and Output Tariffs on Firms' Productivity: Theory and Evidence." *Review of International Economics* 19.5 (2011): 821-835.

Mayer, Thierry, and Soledad Zignago. "Notes on CEPII's Distances Measures: The GeoDist Database." *CEPII Working Paper* (2011).

McCaffrey, Daniel F., et al. "A Review of Stata commands for Fixed-Effects Estimation in Normal Linear Models." *Stata Journal* 12.3 (2012): 406-432.

McCallum, John. "National Borders Matter: Canada-US Regional Trade Patterns." *American Economic Review* 85.3 (1995): 615-623.

Nicita, Alessandro. *Who Benefited from Trade Liberalization in Mexico? Measuring the Effects on Household Welfare*. The World Bank (2004).

Piermartini, Roberta, and Robert The. "Demystifying Modelling Methods for Trade Policy," *WTO Discussion Paper No. 10* (2005).

Rau, Marie Luise, and Achim Vogt. "Data Concepts and Sources of Non-Tariff Measures (NTMs)– an Exploratory Analysis." (2017).

Slaughter, Matthew J. "Trade Liberalization and Per Capita Income Convergence: a Difference-in-Differences Analysis." *Journal of International Economics* 55.1 (2001): 203-228.

Wacziarg, Romain, and Karen Horn Welch. "Trade Liberalization and Growth: New Evidence." *The World Bank Economic Review* 22.2 (2008): 187-231.

Wei, Shang-Jin. "Intra-national versus International Trade: How Stubborn are Nations in Global Integration?" *NBER Working Paper* (1996).

Winchester, Niven. "Is There a Dirty Little Secret? Non-Tariff Barriers and the Gains from Trade." *Journal of Policy Modeling* 31.6 (2009): 819-834.

WTO. *World Trade Report 2012 – Trade and Public Policies: A Closer Look at Non-Tariff Measures in the 21st Century*. (2012a).

WTO. "A practical guide to trade policy analysis." (2012b).

Yanikkaya, Halit. "Trade Openness and Economic Growth: a Cross-Country Empirical Investigation." *Journal of Development Economics* 72.1 (2003): 57-89.