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ABSTRACT

The theoretical debate over whether countries can and should set tariffs in response to export elasticities goes back over a century to the writings of Edgeworth (1894) and Bickerdike (1907). Despite the optimal tariff argument's centrality in debates over trade policy, there exists no evidence about whether countries actually apply it when setting tariffs. We estimate disaggregate export elasticities and find evidence that countries that are not members of the World Trade Organization systematically set higher tariffs on goods that are supplied inelastically. The result is robust to the inclusion of political economy variables and a variety of model specifications. Moreover, we find that countries with higher aggregate market power have on average higher tariffs. In short, we find strong evidence in favor of the optimal tariff argument.

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Introduction

The idea that countries set tariffs in response to their market power in international markets is the single most controversial result in international trade policy. It is not hard to find examples of first class theorists arguing that it provides the underlying motive for the world trading system (Bagwell and Staiger, 1999) while others argue that it is little more than an intellectual curiosity with no practical value in all but the largest countries (Krugman and Obstfeld, 1997). Given that the theoretical debate over optimal tariffs goes back almost two centuries, one might well ask, "What evidence is there in favor or against the notion that tariffs vary inversely with export supply elasticities?" The answer is none.

In this paper we provide evidence that countries who are not members of the World Trade Organization systematically set higher import tariffs on goods that are supplied inelastically. The result is robust to the inclusion of political economy variables and a variety of model specifications. Moreover, we find that countries that have more aggregate market power have on average higher tariffs. In short, we find strong evidence that countries follow the optimal tariff argument in setting tariffs.

The theory that a country might gain from protection has a long history (c.f. Irwin, 1996).[1] The intuition for why countries might gain from tariffs through an improvement in their "terms-of-trade" stems from two key insights. The first, from Torrens (1833) and Mill (1844), is that while free trade raises national income relative to autarky, there are many possible prices at which countries would be willing to trade. The imposition of a tariff creates a welfare loss due to consumption and production distortions, but it can also produce a gain if foreign suppliers reduce

[1] Much of our discussion of the history of thought on optimal tariffs is drawn from Irwin's comprehensive book on the subject. All of our quotes from Edgeworth are drawn from this work.

their prices in order to maintain market access. If the losses due to the domestic distortion are less than the gains from the price or terms-of-trade effect, a country can gain from a tariff.

The key insight regarding when a country should impose a tariff was developed by Edgeworth (1894). He showed that as long as a foreign country's offer curve was not perfectly elastic, a country could gain from a tariff. If a country's tariff caused exporters not to change the quantity supplied much because they lower their price in order to maintain some of their market access, then there would be gains from imposing a tariff. Bickerdike (1907) extended Edgeworth's framework and developed, in a two-good world, the formula equating the welfare maximizing (or optimal) tariff and the inverse of the export supply elasticity. His ability to derive a closed-form solution to the optimal tariff problem was praised by Edgeworth as having "accomplished a wonderful feat." Indeed, Bickerdike's equation serves as the basic theoretical equation we will examine in this paper. Although Bickerdike framed his derivation with one import good, it can also be derived in a many good setting (e.g. Grossman and Helpman, 1995) under the assumption of quasilinear utility.

Despite its long and distinguished history, trade economists have long been uncomfortable with the optimal tariff argument (Irwin, 1996). Edgeworth (1908, p. 554), himself, expressed worry that although the theory seemed "to justify the imposition of small customs duties, say from 2 ½ to 5 percent on a great number of articles… it is to be feared that its abuse will be considerable." Over the years, economists have developed several other objections. Many have argued that "small countries have very little ability to affect the world prices of either their imports or other exports, so that the terms-of-trade argument is of little practical importance" (p. 226) as Krugman and Obstfeld (1997) write in their undergraduate textbook. Other economists have argued that even if this argument is true in theory, it is too hard or complex to implement. For example, Feenstra (2004) in his graduate textbook argues “the formula is not very helpful because there is little that we know empirically about the elasticity of foreign export supply.” Finally, economists have argued that countries may not impose optimal tariffs if they will trigger retaliation.[2]

Despite the skepticism regarding the practical importance of the optimal tariff argument, it continues to feature prominently in the leading theoretical trade policy models. Grossman and Helpman (1995) extend their endogenous trade policy model to the “large country case” – where the elasticity of the export supply curves a country faces are not infinite. Although not stressed in their paper, there would be no motive for trade talks in their model in the absence of a terms-of-trade use of the tariff. This is a key point made by Bagwell and Staiger (1999) who provide an economic theory of the General Agreement on Trade and Tariffs (GATT). In this and in subsequent work, Bagwell and Staiger have strongly argued that the use of tariffs to explore the terms-of-trade effect can explain many of the key features of the current multilateral trading system. Their work has been quite influential despite the fact that there is no direct evidence that countries use, or indeed possess, market power in trade prior to entering into reciprocal liberalization in the GATT or its successor, the WTO.

There is some evidence that changes in countries’ trade policy affect the prices of their imports.[3] This evidence generally focuses on relatively large countries and on imperfect competition in specific industries as the source of the effects. More importantly, these studies do not argue or estimate whether countries changed their trade policies to affect their terms-of-trade and

[2] Johnson (1953) shows that certain countries may actually gain from using optimal tariffs despite retaliation.
[3] Kreinin (1961) estimates that more than two-thirds of US tariff reductions in the Geneva trade Round were passed on as higher prices to countries exporting to the US. Chang and Winters (2002) estimate that the elimination of internal tariffs between Argentina and Brazil caused prices of exports into Brazil to fall. There is also evidence of imperfect pass-through from exchange rates and that the effect is symmetric to that of tariff changes for the US auto sector (Feenstra, 1989).

much less if they did so taking the export supply elasticity into account simply because little was known empirically about these elasticities.

The measurement of foreign export supply elasticities and importers' implied market power constitutes one of the contributions of this paper. Since the optimal tariff argument hinges directly on the magnitudes of these elasticities, they are a prominent feature of our analysis. We rely on the methodology of Feenstra (1994) and Broda and Weinstein (2006) to estimate these elasticities for each 4-digit Harmonized System (HS) category during the period 1994-2003 for the 15 non-WTO members for which this and the relevant tariff data is available for a large fraction of products.

We find that the inverse export supply elasticity for the typical 4-digit HS good to be between 1 and 3. We also show that several conjectures about the behavior of these elasticities across goods and countries are supported in the data. For example, we find that larger countries face less elastic export supply curves, which indicates that, on average, they have more market power than small countries. We also find that the higher a country's share in world imports in a particular good, the smaller the export supply elasticity it faces. Moreover, the export supply elasticities for the same good across importing countries are similar, and, as we would expect, they are higher for commodities than for differentiated products.

The estimation of these elasticities enables us to identify the key finding of our empirical work: the strong positive correlation between observed tariffs of non-WTO members and the inverse export supply elasticity (i.e., market power). This relationship is present both when we compare median tariff rates across countries and when we compare actual tariff rates across Harmonized Tariff System (HS) 4-digit sectors within countries. In particular, if we classify goods in each country according to their inverse export supply elasticity, we find that the tariff is about 14 percent higher in those goods for which a country has medium or high market power relative to those in which it has the least market power. This figure more than doubles for the subset of countries in which we can also control for political economy determinants of tariffs. For instance, the average Chinese tariff for products with low inverse elasticities is 21 percent, while it is 29 percent for products where it is high: a 38 percent increase.

The relationship is robust to many different specifications, e.g. using continuous and discontinuous versions of the export supply elasticity measure, and across many different samples. In particular, it is robust to the inclusion of political economy variables. We construct a variable that is common across various types of political economy models: the inverse import penetration weighted by the import demand elasticity (Helpman, 1997). As is common in recent tests of the political economy models (e.g., Goldberg and Maggi, 1999), we find that the effect of import penetration variables is strong and significant, but nonetheless, the positive relationship between tariffs and the inverse export elasticity remains strong. In short, we conclude that the evidence is consistent with the tariff setting policy postulated by Edgeworth over 100 years ago.

The paper is organized as follows. We first present the basic theory that we test. In section 3 we describe the estimation methodology we use for the elasticities. In section 4 we describe the data and assess the validity of the elasticity estimates. In section 5 we present the estimation results.

2. Theory

The basic theory underlying the optimal tariff argument is well established. Therefore in this section, we provide the basic intuition for the result and show how it is robust to the inclusion of political economy considerations.

Suppose each individual has a utility defined over a numeraire good, c_0 , and a vector of non-numeraire goods **c**:

(1) $$U = c_0 + u(\mathbf{c}).$$

The elements in **c** can represent either a homogenous good, as is standard, or a consumption aggregate, as we also use later.

Each individual h with income I^h chooses expenditure on each good c_g to maximize U such that $c_0^h + \sum_g p_g c_g^h \leq I^h$, where p_g is the domestic price for c_g. Given the quasilinearity, the demand for each non-numeraire good is independent of income. If we also assume that the utility is separable over goods, i.e. $\partial^2 u / \partial c_g \partial c_k = 0$ for all $g \neq k$, then demand for each good is also independent of prices of other goods and can be written as $c_g = c_g(p_g)$.

An individual's indirect utility can be written as $v^h = I^h + \psi(\mathbf{p})$, where the last term represents a measure of consumer surplus.[4] Social welfare is then the sum of the individual indirect utilities over all individuals:

(2) $$W = \sum_h \left[I^h + \psi(\mathbf{p}) \right].$$

The standard assumption in some of the leading endogenous trade policy models, e.g. Grossman and Helpman (1994, 1995), is that the numeraire is freely traded and produced using only labor according to a constant returns production. The equilibrium wage is then determined by the marginal product in this sector, which we normalize to one. The non-numeraire goods are produced using a constant returns production with labor and one factor specific to the good, k_g. All H individuals own a unit of labor and a fraction of them also own up to one unit of specific capital. Therefore, the sources of income are wages, quasi-rents, π_g, and tariff revenues, r_g, which are redistributed uniformly to all individuals. Thus, we can rewrite social welfare as

(3) $$W = H + \sum_g \left[r_g(p_g) + H\psi_g(p_g) + \pi_g(p_g) \right].$$

[4] More specifically, with separable utility, $\psi(p) = \sum_g \psi_g(p_g) = \sum_g \left[u_g\left(c_g(p_g)\right) - p_g c_g(p_g) \right]$.

Note that since the wage is determined in the numeraire sector and capital is specific, the quasi-rent in the production of g can be written as a function of the producer price, which in the absence of production taxes equals the consumer price.

Most endogenous trade policy models focus on homogenous goods. In that case, the world price for each traded good $g \in G_m$ is determined by the market clearing conditions

(4) $$Hm_g\left(\left(1+\tau_g\right)p_g^*\right) = m_g^*\left(p_g^*\right) \quad \forall g \in G_m$$

where Hm_g represents home's import demand written as a function of the domestic price, $p_g = \left(1+\tau_g\right)p_g^*$, and m_g^* is the rest of the world's export supply. From this we obtain prices as functions of the trade policy: $p_g\left(\tau_g\right),\ p_g^*\left(\tau_g\right)$.[5]

A government choosing the optimal tariff to maximize welfare in equation (3) will then set the tariff for each good g according to the following first order condition for each good:[6]

(5) $$\tau_g p_g^* \frac{dm_g}{d\tau_g} - m_g \frac{dp_g^*}{d\tau_g} = 0 \quad \forall g \in G_m.$$

If there is no domestic production in this good, the expression is the same with imports equal to consumption. The first term represents the domestic distortion caused by the tariff. The second term represents the terms-of-trade effect. If the country has no market power in trade, i.e. if the export supply elasticity is infinite, then $dp_g^*/d\tau_g = 0$ and the optimal tariff is zero. Otherwise the optimal tariff is positive and can be shown to equal the inverse export supply elasticity,[7]

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[5] In a setting with many importers the equilibrium prices also depend on other importers' tariffs. This does not affect the results here because the optimal tariff prediction takes the other countries' policies as given *and* we will focus on the case where there is a constant foreign export supply elasticity, which is independent of prices.

[6] Taking $dW/d\tau_g$ using the envelope theorem, $\frac{d\psi(p)}{d\tau_g} = -c_g \frac{dp_g}{d\tau_g}$ and $\frac{dp_g}{d\tau_g} = \frac{dp_g^*}{d\tau_g}\left(1+\tau_g\right) + p_g^*$, we can obtain (5).

[7] To obtain this we use the market clearing condition and the implicit function theorem to derive the expressions for $dp^*/d\tau$, $dp/d\tau$.

(6) $$\tau_g^{opt} = \omega_g \equiv \left[\left(dm_g^* / dp_g^* \right) \left(p_g^* / m_g^* \right) \right]^{-1}.$$

A common objection to the use of this expression to explain trade policy is that governments do not choose tariffs to maximize social welfare. However, equation (6) can also describe the equilibrium policy even when the government has other objectives, such as redistribution of income to particular specific factor owners. A key insight in the trade policy literature is that of targeting (e.g. Bhagwati and Ramaswami, 1963), which states that if a government has domestic objectives they can be met more efficiently using an instrument other than tariffs, and that when these instruments target the distortion at the source, the optimal tariff is zero in a small economy. The counterpart to this insight for a large economy is that when the government's objective function includes some positive weight on social welfare, we obtain the optimal tariff expression in equation (6) provided that the government also uses other policy instruments (e.g. subsidies or transfers).[8]

Another potential objection is that we are ignoring incentives to impose tariffs because of monopoly power in the export sector. The original Bickerdike formulation allowed for both market power in the import and export sectors. He showed in a two good world that if a country could not impose an export tax, the optimal tariff was linearly related to the inverse export elasticity (although not with a coefficient of unity) plus another term that was related to the inverse demand elasticity of the country's exports. Graaf (1949-50) extended this result in a model with many goods and showed that if countries can impose both export taxes and import tariffs, then if the cross-price elasticities are all zero, the optimal policy is to impose an export tax equal to the inverse demand elasticity and import tariff equal to the inverse export elasticity. The bottom line from these more complex policy experiments is that even if countries have monopoly power in the export sectors, this may create an

[8] Most trade policy models that provide a political economy motive for a tariff must in fact rule out these other instruments; otherwise in those models the tariff's only role would be to affect the terms-of-trade. This is an example of the puzzle of the use of inefficient policies for redistribution. Rodrik (1995) points out it is particularly problematic for trade policy, Drazen and Limão (2004) provide one explanation for it.

additional motive for the use of import tariffs (c.f. Gros, 1987 and Alvarez and Lucas, 2005), but it does not eliminate the incentive to impose higher tariffs in sectors in which imports are supplied less elastically.

It is also worth noting that equation (6) still represents the optimal tariff in a number of special but interesting cases of political economy models. Grossman and Helpman (1995) extend their political contributions trade model to the large country case. The non-cooperative tariff that the government chooses in that model maximizes a weighted sum of social welfare and contributions, C_g, from the L organized lobbies representing specific factor owners, i.e. $aW+\sum_{g\in L}C_g$. In this case, the optimal tariff is

$$\tau_g^{GH} = \omega_g + L_g \tag{7}$$

where L_g reflects the lobbying motive for tariffs and is given by

$$L_g = \frac{\pi'_g / Hm_g}{\sigma_g}\frac{I_g - \alpha}{a+\alpha},$$

where σ_g is the import demand elasticity. If a, the government's marginal rate of substitution between contributions and social welfare, is infinite then we obtain the optimal tariff. Even if it is finite, the optimal tariff in equation (6) is still the solution for all goods if all voters own specific factors, i.e. $\alpha = 1$ *and* all industries are organized into lobbies $I_g = 1$. That is also the solution for unorganized industries, $I_g = 0$, when factor ownership is highly concentrated, $\alpha = 0$. Otherwise the tariff for an organized group is increasing in π'_g / Hm_g, the inverse import penetration ratio, because a given tariff generates larger benefits for a factor owner if it applies to more units sold. The tariff depends negatively on the import demand elasticity, σ_g, reflecting the basic Ramsey taxation intuition that, once the terms-of-trade effect is accounted for, the tariff's distortion is increasing in this elasticity. Helpman (1997) shows that the size and elasticity effect captured in the first term of

L_g also arises in the context of other political economy models, so we will construct and use it as one of the controls in the estimation.

The key obstacle in estimating equation (6) is obtaining elasticity estimates for a broad set of countries and goods. In order to achieve this we must impose some structure on the data. We now briefly describe how the standard approach above can be extended in a way that is both compatible with our estimation of the elasticities *and* delivers the relationship in equation (6).

In the next section, we describe the system of import demand and export supply equations that we use to estimate the elasticities. This system can be derived in a setting where any foreign variety (i.e. a good imported from a particular exporter) is valued according to a CES utility function, and supply is perfectly competitive. In the appendix, we show that the optimal tariff in a model with CES utility over foreign varieties of a given good is identical to equation (6), i.e. the inverse export elasticity. This occurs when utility is separable across goods (but not varieties); the tariffs do not affect the relative demand of varieties within any given good; and hence the only distortion that is addressed by the tariff is the terms-of-trade externality. As we prove in the appendix, there are three assumptions that imply the tariff in a good does not affect the relative demand of varieties within it, all of which driven by the constraints imposed by the data and estimation. First, consumption and export supply elasticities within any given good are constant. Second they are identical across varieties, i.e. exporters of that good. Third, tariffs are equal across exporters of the same good.[9]

[9] If we took the optimal tariff argument to an extreme, we may expect countries to optimally discriminate and choose different tariffs for different exporters of the same good. However, in practice, we do not observe this. In fact, even in the set of countries that we examine, which are not bound by the WTO to set identical tariffs on a given good from different countries, we find that tariffs are generally defined on the basis of a good and not origin (unless of course the country has a preferential trade agreement). One reason is that the administrative cost of optimal discrimination may be too high since that would require preventing international arbitrage and very strict enforcement of rules of origin.

3. Estimating Foreign Export Supply and Import Demand Elasticities

As we have just seen, there is good theoretical justification for why we should expect to see a relationship between tariffs imposed on a good and the inverse export elasticity of that good. The main reason why this relationship has not been examined before is the difficulty of obtaining reliable measures of market power. In this section we explain how to obtain the elasticities of export supply (and import demand) for each good in each importing country, which can then be used to estimate the relationship implied by (6) and (7).

We rely closely on the methodology derived by Feenstra (1994) as extended by Broda and Weinstein (2006).[10] Their basic approach is to estimate the inverse export supply and import demand elasticities (ω_{ig} and σ_{ig}, respectively), using the following system of import demand and export supply equations:

(8) $$\Delta^{k_{ig}} \ln s_{igvt} = -\left(\sigma_{ig} - 1\right)\Delta^{k_{ig}} \ln p_{igvt} + \varepsilon_{igvt}^{k_{ig}}$$

(9) $$\Delta^{k_{ig}} \ln p_{igvt} = \frac{\omega_{ig}}{1+\omega_{ig}}\Delta^{k_{ig}} \ln s_{igvt} + \delta_{igvt}^{k_{ig}}$$

Equation (8) represents the optimal demand of country *i* for a given variety *v* of a good *g* – derived from a CES utility function – and (9) represents the export supply of that variety. Both are expressed in terms of shares, where s_{igvt} is the share of variety *v* of good *g* in country *i*. The equation for each variety imported by country *i* is differenced with respect to time and a benchmark variety of the same good imported by *i*. More specifically the difference operator we use for the shares and domestic prices is defined as $\Delta^{k_{ig}} x_{igvt} = \Delta x_{igvt} - \Delta x_{igk_{ig}t}$. The parameter ε_{igvt} represents a taste, quality

[10] Broda and Weinstein (2006) estimate elasticities of substitution for 10-digit HS goods in the US. They could also have computed export supply elasticities but did not do so.

or exchange rate shock to a variety in i and δ_{igvt} represents shocks to its export supply. Both enter the expressions above in differenced form: $\varepsilon_{igvt}^{k_{ig}} = \varepsilon_{igvt} - \varepsilon_{igk_{ig}t}$ and $\delta_{igvt}^{k_{ig}} = \delta_{igvt} - \delta_{igk_{ig}t}$.

An important feature of the method used is that it requires double log-differencing the data. This implies that the level of tariffs on varieties or goods will not affect our estimated elasticities, which eliminates the possibility of reverse causality when we estimate (6) and (7). More generally, changes in trade costs at the good level will also not affect the estimates. Similarly, our estimates will not be biased in the presence of any fixed costs of exporting that cause some set of countries to have no exports of a variety over time whereas others have positive exports. Finally, our estimates will be unbiased if there are quality differentials across countries for a given variety or if there are good specific trends in these differentials.[11]

There are two important assumptions needed to identify the elasticities. First, ω_{ig} and σ_{ig} are restricted to be the same over time and for all varieties of a good imported by a country, but they are allowed to vary over importers and goods. Second, once good-time specific effects are controlled for, demand and supply shocks at the variety level are assumed to be uncorrelated, that is, $E\left(\varepsilon_{igvt}^{k_{ig}}\delta_{igvt}^{k_{ig}}\right) = 0$.

To derive the key moment conditions for identification that take advantage of the independence condition of errors, $E\left(\varepsilon_{igvt}^{k_{ig}}\delta_{igvt}^{k_{ig}}\right) = 0$, it is convenient to solve (8) and (9) in terms of those errors and multiply them together to obtain:

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[11] Generally the foreign export supply is written as a function of the price received by the exporter, p_{igvt}^{*}. In the presence of some ad valorem trading cost, τ_{igvt}, the domestic price is $p_{igvt} = p_{igvt}^{*}\left(1+\tau_{igvt}\right)$, which implies that $\Delta^{k_{ig}} \ln p_{igvt} = \Delta^{k_{ig}} \ln p_{igvt}^{*} + \Delta \ln\left(1+\tau_{igvt}\right) - \Delta \ln\left(1+\tau_{igk_{ig}t}\right)$. In the implementation, we define a variety as an HS-6-digit good exported from a specific country. Many countries set their tariffs at the HS-6 level and equal across exporting partners, i.e. $\tau_{igvt} = \tau_{igk_{ig}t}$, in that case the term is exactly zero.

(10) $$\left(\Delta^{k_{ig}} \ln p_{igvt}\right)^2 = \theta_{i1}\left(\Delta^{k_{ig}} \ln s_{igvt}\right)^2 + \theta_{i2}\left(\Delta^{k_{ig}} \ln p_{igvt}\Delta^{k_{ig}} \ln s_{igvt}\right) + u_{igvt}$$

where $\theta_{ig1} = \frac{\omega_{ig}}{\left(1+\omega_{ig}\right)\left(\sigma_{ig}-1\right)}$, $\theta_{ig2} = \frac{1-\omega_{ig}\left(\sigma_{ig}-2\right)}{\left(1+\omega_{ig}\right)\left(\sigma_{ig}-1\right)}$ and $u_{igvt} = \varepsilon_{igvt}^{k_{ig}}\ \delta_{igvt}^{k_{ig}}$. Note that the error term, u_{igvt}, is correlated with the regressands that depend on prices and expenditure shares. Therefore to consistently estimate $\boldsymbol{\beta}_{\mathbf{ig}} = \begin{pmatrix} \theta_{1ig} \\ \theta_{2ig} \end{pmatrix}$ we must exploit the panel nature of the dataset and use the assumption that demand and supply elasticities are constant over varieties of the same good. In particular, we can define a set of moment conditions for each good *g* and each importing country *i*, by using the independence of the unobserved demand and supply disturbances for each variety over time, that is,

(11) $$G(\boldsymbol{\beta}_{\mathbf{ig}}) = E_t\left(\mathrm{u}_{\mathrm{igv}}\left(\boldsymbol{\beta}_{\mathbf{ig}}\right)\right) = 0 \quad \forall v, g \text{ and } i.$$

For each good *g* and importer *i*, all the moment conditions that enter the GMM objective function can be stacked and combined to obtain Hansen's (1982) estimator:

(12) $$\hat{\beta}_{ig} = \arg\min_{\beta_{ig} \in \mathrm{B}} \mathrm{G}^*\left(\beta_{\mathrm{ig}}\right)' W \mathrm{G}^*\left(\beta_{\mathrm{ig}}\right) \quad \forall g \text{ and } i.$$

where $\mathrm{G}^*\left(\boldsymbol{\beta}_{\mathbf{ig}}\right)$ is the sample analog of $G\left(\boldsymbol{\beta}_{\mathbf{ig}}\right)$ stacked over all varieties *v* of a good *g*, *W* is a positive definite weighting matrix to be defined below, and B is the set of economically feasible $\boldsymbol{\beta}_{\mathbf{ig}}$ which is common across importers and goods (i.e., $\sigma_{ig} > 1$ and $\omega_{ig} > 0 \quad \forall i, g$). We follow Broda and Weinstein (2006) in the way we implement this optimization. We first approximate (12) by estimating the "between" version of (10) to obtain estimates of θ_{i1} and θ_{i2} and then solving for $\boldsymbol{\beta}_{\mathbf{ig}}$ as in Feenstra (1994). If this produces imaginary estimates or estimates of the wrong sign we use a grid search of $\boldsymbol{\beta}$'s over the space defined by B. In particular, we evaluate the GMM objective function for values of $\sigma_{ig} > 1$ and $\omega_{ig} > 0$ at intervals that are approximately 5 percent apart.[12] Standard errors were obtained by bootstrapping.

The problem of measurement error in unit values motivates our weighting scheme. In particular, there is good reason to believe that unit values calculated based on large volumes are much better measured than those based on small volumes of imports.[13] The use of the between estimate coupled with our need to estimate σ_g, ω_g, and a constant means that we need data from at least four exporting countries for each importer in each good and at least two time differences to identify β.

4. Data, Descriptive Statistics and Assessment of Elasticity Estimates

4.1 Data

In order to estimate equations (6) and (7) we need data on tariffs and domestic production as well as estimates of the elasticities. The first decision is what set of countries to include in our sample. Here we face both theoretical and empirical constraints. Since a, if not *the*, major function of the GATT/WTO is to allow countries to reciprocally lower their tariffs in order to internalize the terms-of trade effects, we should focus the test on non-GATT/WTO members.[14]

[12] For computational easiness, we performed the grid search over values of σ_{ig} and ρ_{ig} where ρ_{ig} is related to ω_{ig} in the following way: $\omega_{ig} = \frac{\rho_{ig}}{\sigma_{ig}(1-\rho_{ig})-1}$. The objective function was evaluated at values for $\sigma_{ig} \in [1.05, 131.5]$ at intervals that are 5 percent apart, and for $\rho_{ig} \in [0.01, 1]$ at intervals 0.01 apart. Only combinations of σ_{ig} and ρ_{ig} that imply $\sigma_{ig} > 1$ and $\omega_{ig} > 0$ are used. To ensure we used a sufficiently tight grid, we cross-checked these grid-searched parameters with estimates obtained by non-linear least squares as well as those obtained through Feenstra's original methodology. Using our grid spacing, the difference between the parameters estimated using Feenstra's methodology and ours differed only by a few percent for those σ_{ig} and ω_{ig} for which we could apply Feenstra's "between" approach.

[13] In the appendix of Broda and Weinstein (2006), they show that this requires us to add one additional term inversely related to the quantity of imports from the country and weight the data so that the variances are more sensitive to price movements based on large shipments than small ones.

[14] Whether entering into the WTO really does lead countries to lower their tariffs in a way that no longer reflects the terms-of-trade motive, as predicted by Bagwell and Staiger (1999), is obviously an important and interesting question that will have to be addressed in another paper.

Our tariff data comes from the TRAINS database, which provides data at the 6-digit HS level. Unfortunately, some non-WTO countries report this data for only a small share of goods making it impossible to make meaningful comparisons across goods or compute country averages. Therefore we focus only on the fifteen non-WTO countries that report tariffs in at least one third of all 6-digit goods. The set of countries and the years we use are reported in Table 1.[15]

The trade data is obtained from the United Nations Commodity Trade Statistics Database (COMTRADE). This database provides quantity and value data at 6-digit 1992 HS classification for bilateral flows between all exporting countries in the world. As we can see from Table 1, the import data for most countries in our sample covers the period 1994-2003. COMTRADE does not report trade statistics for Taiwan, so for this country we use the bilateral trade flows reported in the UNCTAD's TRAINS database.[16]

4.2 Descriptive Statistics

The choice of what constitutes a good is somewhat arbitrary. Ideally we would like to define goods at the most disaggregate level possible, but the practical problem of doing so is that we would have so few varieties per good that our elasticity estimates would not be precise. Therefore in estimating (8) and (9) we define a good, g, as a 4-digit HS category and a variety, v, as an import of a particular 6-digit good from a particular exporter. Table 2 shows that this provides 1100 goods for the typical country, i.e. the typical country has 1100 4-digit categories with positive imports between 1994 and 2003. The typical good in the sample is imported from 17 different countries. We define varieties of a good as pairs of 6-digit exporting country flows. There are between 15,000 and 66,000 varieties of goods per year being imported by each of the non-WTO members in our sample.

[15] This criteria was binding for only four countries: Bahamas, Brunei, Seychelles and Sudan.
[16] TRAINS has a cutoff "value" point for including a bilateral trade flow that is higher than Comtrade. This limits the number of "varieties" in TRAINS and is the main reason why we focus on COMTRADE data. In the case of Taiwan however there are still over 30,000 6-digit-exporting-country pairs and 900 4-digit sub-headings.

For instance, there were 40 different varieties of live fish (4-digit HS 0301) imported by China in 2001, among them were "trout" (HS 030191) from Australia and "eels" (HS 030192) from Thailand. The high degree of specialization of exports suggests that one should be cautious about assuming that the share of a country in world GDP is a sufficient proxy for the ability of a country to gain from a tariff. If China places a tariff on live fish, it is not clear that Thai eel producers can easily export their eels elsewhere.

Table 2 also shows the means and medians of our tariff data. There are several important features to note. First, while there is a lot of variation across countries and industries, the average and median tariffs stand at 13 and 10 percent respectively. Moreover, 99 percent of all tariffs are below 82 percent and 95 percent of tariffs are below 42 percent. There is also a fair amount of cross country variation in median and average tariff rates, ranging from around 31 and 38 percent in China to 1 and 7 percent in Latvia.

If one takes size, as measured by GDP, as a good proxy for market power then the data on tariff levels suggests that the skepticism regarding the optimal tariff argument is not entirely unwarranted. First, as we can see in Table 2, although China is both the largest country in our sample and has the highest tariff, Taiwan, the second largest country has a below average tariff. The correlation between median tariff and the log of GDP is 0.48 and that between average tariffs and GDP is 0.53 However, if we drop China, those correlations fall to 0.05 and 0.10, respectively.

Data on the within-country variation also suggests that the tariff setting policies are likely to be more complex than a simple application of the optimal tariff calculus. Figure 1 portrays the within-country frequency distribution of tariffs at the 4-digit level. The results are quite striking. Although most countries have large dispersion across goods there are a few with almost no dispersion such as Bolivia, Oman, and Saudi Arabia. Bolivia is most extreme in this regard with 95 percent of its tariffs in the range of 9.4 to 10 percent. While some countries have a smooth distribution of tariffs, some countries like Algeria, Bolivia, Belarus and Ecuador have a large number of tariffs that take only a few discrete values. So even though tariffs are generally set as a continuous variable, there are some countries, typically ones that reformed their policies and perhaps followed the common advice of economists to minimize tariff dispersion, where these tariffs take on only a few different values. Moreover we observe truncation and some bunching at the lower end of distribution, where about 9% of all tariffs are zero.

There are a couple of important implications of the stylized facts above. First, even though there are some interesting insights from considering cross-country results, it may be more reasonable to focus on the effect of market power in determining tariffs across goods within countries. Second, the data seems to militate against a simple relationship in which policymakers equate the tariff level with a continuous variable such as export elasticities or degrees of political power. One can imagine many reasons for this. Perhaps policy makers are uncertain of inverse elasticities or political connectedness and therefore divide their tariff schedule in various categories rather continuous levels; maybe policymakers employ other means of protection at their disposal when they want to achieve high levels of protection; maybe countries are averse to setting tariffs too high out of fear of retaliation; or maybe once tariffs hit prohibitive levels, there is no reason to raise them further.

Regardless of the reason, the preceding paragraph suggests that it may be too much to ask the data to reproduce the precise functional form of Bickerdike's (1907) optimal tariff formula, i.e. the tariff in a good exactly equals the inverse of the export supply elasticity. We can, however, contemplate alternative versions of the optimal tariff formula which maintain the essential insight of Edgeworth (1894). Namely, we should expect to see countries apply higher tariffs on goods that are less elastically supplied. If we observe a positive relationship between the two variables, we can conclude that the basic intuition that countries apply higher tariffs on inelastically supplied goods is correct. Thus we will take a flexible approach in terms of the functional form in the following sections.

4.3 Assessment of Elasticity Estimates

Our estimation strategy requires two phases. First we obtain estimates of import demand and supply elasticities, and second we use these to explain observed tariff levels. We use equation (12) to obtain our estimates of the elasticities of export supply of every imported good with more than four varieties in each of the 15 countries in our sample.

Since we are conducting this analysis at the 4-digit level, we generated over 12,000 elasticity of supply estimates. This is far too many parameters to present individually. Therefore in Table 3A we report summary statistics of these elasticities. From the 10^{th} and 90^{th} percentile columns we can see that there is a lot of variance and potential outliers in our estimated parameters, suggesting that we will need to be careful about measurement error in subsequent analysis. However, the medians, which give less weight to outliers than the means, seem sensible. The median inverse elasticity is 1.6, implying a median elasticity of supply of 0.6, indicating that 1 percent increase in prices elicits a 0.6 percent increase in the volume of exports for the typical good. The following column reports the standard deviations of the median elasticities. The small standard deviations indicate that our estimate of the median market power in each of these countries is relatively tight suggesting that there are, in many cases, significant differences in our estimates of the typical inverse elasticity across countries.

Another way to look at the data is to ask how confident we are in any particular elasticity estimate for a particular country-good . Obviously, with over 12,000 elasticities, some parameters will be imprecisely estimated. Still, we would like to get some sense of precision for the typical elasticity. One problem in doing this is that our standard errors are non-spherical, and so we must resort to bootstrapping. In order to do this, we resampled the data and computed estimates of each of the elasticities 50 times.[17] One of the results of this procedure is that we found that larger point estimates tended to have larger confidence intervals than smaller point estimates, e.g. point estimates of 100 tended to have wider confidence bands than point estimates of 1. One way to have a comparable metric for the precision of these point estimates is to normalize each confidence band by the magnitude of the point estimate. We therefore computed the ratio of the 10^{th} and 90^{th} percentile estimates of each inverse elasticity relative to the corresponding median point estimate. Table 3B reports the median of these ratios as well as the median of all point estimates by country.

For the typical point estimate, the 10^{th} and 90^{th} percentiles were 0.4 times the size of the estimate and 3.5 times the size of the estimate respectively. This gives us some sense of how much of the dispersion in Table 3A is driven by measurement error. If this range tends to be constant for most point estimates, then differences between point estimates of 0.2 and point estimates of 2 or more are often going to be significant, but we typically won't have sufficient precision to distinguish point estimates that are closer together. Thus, as we move towards our econometric analysis of tariffs and inverse elasticities, we should recognize that we have reasonable confidence that our methodology can statistically distinguish between high, medium, and low elasticities and that the dispersion in Table 3A is not just due to imprecise parameter estimates.

We now turn to the question of whether our estimates themselves seem plausible. There are several ways that we can explore this. First, we can look at the magnitudes. One interesting finding in our estimates is that even small countries have significant market power in their typical good. This may seem surprising if one assumes the world is composed of homogeneous goods that are

[17] This is extremely computationally intensive – it implies calculating more than 600,000 bootstrapped parameters.

traded at no cost. However, this may not be the right framework for thinking about trade since it is also well-known that trade costs can strongly segment markets. Empirically, we know that these trade costs have enormous impact on trade patterns as trade falls off quite rapidly with distance. According to Anderson and van Wincoop's review of the literature, "the tax equivalent of 'representative' trade costs for industrialized countries is 170 percent" (2004, p. 692). One implication of this is that even countries that are small from the world's perspective may have considerable amounts of *regional* market power. For example, gravity equations imply that trade with a partner who shares a border is typically over 14 times larger than with an identically sized non-bordering country if one considers the decay due to distance alone. If one controls for other forces, the differential can easily rise to a factor of 100. These gravity results suggest that while small countries may not have market power in the world as a whole, this may not be a meaningful comparison, and they may have significant market power regionally.[18] For example, even though China is only 3 percent of world GDP, the fact that it is Japan's largest trading partner means that it is not obvious that a rise in Chinese protection could easily be accommodated by a switch in Japanese exports to the US or Europe.

These concerns notwithstanding, it is important to also remember that our estimation of the optimal tariff equation will not rely on the level of market power but rather on how market power is distributed across countries and goods. To explore how reasonable our estimated elasticities are in these dimensions we proceed in three ways. First, we assess whether they fit our priors about what they should be for particular goods. Second, we check whether elasticities for the same good

[18] Average distance between bordering countries is about 706 miles versus 4853 for non-bordering countries. The estimate of 14 is calculated as the ratio of the predicted trade between bordering and non-bordering countries in a gravity framework $(\exp[-1.37*\ln 7))^{-1}$, where the distance elasticity of -1.37 is from Limão and Venables, 2001). This effect does not even take into account the fact that trade between neighboring countries is often found to be several times larger for reasons other than distance, e.g. according to the estimates in Limão and Venables the ratio goes up to 100!

estimated using data from two different countries are correlated. Third, since the trade literature has made much of the fact that elasticities of foreign export supply should be correlated with country size, we ask whether this intuition is correct.

It is hard to have strong priors about what elasticities of export supply should be in particular industries without knowing much about the world's production structure. However, we conjecture that differentiated goods are likely to be supplied less elastically than non-differentiated goods since it is unlikely that a country can have a large impact on the world price of a good traded on an organized exchange. Rauch (1999) divided goods into three categories – commodities, reference priced goods, and differentiated goods – based on whether they were traded on organized exchanges, were listed as having a reference price, or could not be priced by either of these means. Table 4A uses this classification and confirms the prediction by testing the differences of the median and mean inverse elasticities across each group of goods as classified by Rauch. The most striking feature of the table is that both the median and the mean *inverse* elasticities are much higher for differentiated products than for commodity or reference priced goods. In all but one case, we can strongly reject the hypothesis that differentiated products have the same average and median elasticity as reference priced goods and differentiated goods.[19]

Table 4B also reveals a similar pattern among the 15 goods that constitute the largest share of imports in the sample of countries studied. In particular, the three goods supplied most elastically (i.e. with the lowest median inverse elasticity) are soybeans, barley and natural gas. All of these goods constitute commodities for which it would be hard for a small importer to affect the price. By contrast, the three goods supplied most inelastically are integrated circuits, aircraft, and nuclear

[19] Although the difference in means between differentiated and reference products is large (94 vs. 77) it is is not statistically significant because of the influence of large outliers, which affect the mean but not the median. When we address this by using the log of the inverse elasticity we find that the predicted mean *level* is significantly higher for the differentiated relative to the reference products.

reactors. These goods seem more likely to be ones for which a country might have some market power. Thus, when we look at the biggest import categories our methodology seems to generate a reasonable ordering.

A second criterion for evaluating these estimates is to examine the similarities in estimates obtained from different datasets. While it is possible for elasticities of export supply for a given good to vary across importers, it would be disturbing if we could not identify some goods that were more or less elastically supplied. The motive is simple, the export supply curve faced by all importers of a given variety, i.e. from a given exporter, share one common term, the value of the exporter's production minus its domestic consumption. In order to test whether there is some pattern in the supply elasticities we obtain, we tested whether the supply elasticity we estimated in one country is related to the supply elasticity estimated using import data from other countries. To test this we regress the log of the estimated inverse elasticity in a good for a country against the log of the mean inverse elasticity in the same good computed using the data of the remaining 14 countries. We report these result in the last columns of Table 3A. The point estimates are all positive and significant, which indicates a very strong positive statistical relationship – 0.7 for the typical country – between the estimates of the export elasticity in a sector obtained using any one importer's data and the mean export elasticity obtained using the data from the other countries. Since the datasets are completely different, these results suggest that the elasticities we estimate are not random; they contain information about systematic variation across goods.[20]

As a third check for the "reasonableness" of the elasticities, we examine whether they reflect the common intuition that market power is related to country size. Given that the largest country in

[20] We use a log specification to minimize the influence of the outliers – a problem that the bootstraping identified. The other motive for using the log specification is that the estimation procedure for the elasticities cannot yield non-positive estimates. Thus the distribution of estimates is skewed with positive deviations from the median vastly exceeding negative ones in magnitude. However, the density function of the log of the inverse export elasticity estimates has a pattern quite similar to a normal density plot.

our sample, China, represents only 3 percent of world GDP, it is entirely possible that the relationship between GDP and country size is weak in our data. Nevertheless, the intuition that country size should positively vary with the inverse elasticity is so ingrained in our intuition that it seems reasonable to look for it in our data. Again we have to face one estimation issue. Since some of our countries report tariffs in only a fraction of their goods computing simple means and medians across different sets of goods may be misleading. We therefore include HS 4-digit industry dummies in the regression so our results should be interpreted as comparing market power for different countries within each import good.

Table 5 reports the results from the regression of log inverse export elasticities on log GDP. The results indicate a very strong positive relationship, which supports the notion that market power rises as GDP rises.[21] This is true even after controlling for the clustering of the standard errors. We also obtain a positive relationship when we use the log of an importer's market share in each good instead of its GDP. Moreover, it remains strong even if we drop China or if we focus on the set of five countries for which we have both elasticity and political economy data. Hence our estimated elasticities also pass our third "reasonableness" check – larger countries have more market power.[22]

In sum, the analysis above suggests that our elasticity estimates are "reasonable" by a number of criteria. First, when we look at the largest import sectors, we find that goods that we think of as commodities tend to be supplied more elastically than differentiated goods. Second, there is a high correlation between elasticities estimated in different datasets. And third, larger importers tend to have more market power than smaller importers. The bootstrapping shows that the

[21] This is consistent with the results in Markusen and Wigle (1989) who find larger optimal tariffs for United States than for Canada.

[22] When we include both the GDP and import share measure we obtain positive coefficients for both but the import share variable is not significant in the sample using the 15 countries. This and the small amount of variation explained by the import share (shown by the R-square within) implies that one must be careful about using these shares as a measure of market power. The R-square within for GDP is also small, which explains why tariffs and GDP in our sample do not have a robust positive correlation (e.g. it disappears once we drop China) but tariffs and inverse elasticities do, as we show in the next section.

estimates are reasonably tight with the exception of some large outliers, which is something we will correct for in the econometric analysis.

5. Testing Optimal Tariff Theory

5.1 Preview

We can now answer whether there is some relationship between the tariffs and export supply elasticities. Before turning to regression evidence, we will examine a data plot: the median tariff in each country against the median inverse export elasticity. There are many reasons to be skeptical that we can obtain a relationship in the cross section. We only have fifteen countries to work with so one may worry that any one country can dominate the results. In addition, the countries in our sample have very different political systems, economic conditions, and mix of other protectionist tools – all of which are reasons to abandon all hope that a relationship will be visible.

However, since the cross-sectional story of market power and tariffs has such prominence, we think it is worthwhile to see if we can detect a relationship. Figure 2 presents median average tariff in a country against the median inverse elasticity. There is a remarkably strong positive relationship. The pattern seems to be driven by no one country or even set of countries on a particular continent or with a particular income level. The positive relationship between median tariffs and median elasticities is also statistically significant.[23] Of course, there are many reasons to be wary of this relationship, as we just pointed out. Fortunately, we have a vast quantity of country-good data underlying this plot that can be exploited to examine the relationship more carefully.

Before plowing forward into the econometrics, it is worth reconsidering one important element of the data. At the upper extreme, the inverse export supply elasticity takes on very large values, which may reflect measurement error: an issue we will return to later. However, these high

[23] If we regress the median tariff on the median inverse elasticity we obtain a positive slope (b=5.9; s.e. = 2.9; R^2 = 0. 21). The positive relationship is still present if we exclude China, (b=4.2; s.e. = 2.36).

inverse elasticities (from Table 3A, the typical 90th percentile is around 150) are clearly not compatible with a theory predicting a one-to-one relationship between inverse elasticities and tariffs. Of course, as we highlighted above, there are many good reasons, to suspect that the relationship between tariffs and inverse elasticities might be positive over some region and then level off.[24] Therefore we report not only linear regressions analogous to the functional form derived by Bickerdike (1907) but also other specifications, which are more in the spirit of Edgeworth and that may better capture the tariff setting behavior for elasticities at different values.

In Table 6, we report the results of regressing average tariffs on the inverse export elasticity controlling for HS-4 digit industry effects. These estimates can be thought of as the regression analog of Figure 2, where we use the variation within a product and across countries to identify the relationship between inverse elasticities and tariffs. In columns 1, 2, 4, and 5 of Table 6, we can see that in both OLS and Tobit specifications there is a strong statistical relationship between inverse elasticities and tariff levels. In the linear specification, the coefficient is tiny (for reasons we will discuss shortly), but in the log specification the coefficient has a reasonable magnitude, 0.44.

Our inverse elasticities are estimates and thus they capture the true values plus some error, which the bootstrapping results suggest is larger at higher inverse elasticities. As is well known this can cause attenuation bias in the OLS estimates and make it less likely that we find a relationship between tariffs and inverse elasticities. We correct for this attenuation bias by employing an IV approach. We use as an instrument the mean inverse elasticity over the other countries, which is correlated with the inverse export elasticities but not with any country specific error. In columns 3 and 6 we report instrumental variables estimates based on such an instrument. The coefficient and

[24] One alternative is that countries may know what goods are supplied elastically and which are not, but they may not know the precise level of the elasticity. Another is that when goods have high inverse elasticities the tariff becomes prohibitive and so after a certain level it no longer affects the tariff. Also at high inverse elasticities countries may introduce other forms of protection such as licenses to extract rents.

standard errors hardly change either case. Therefore in this specification we do not find evidence of attenuation bias caused by measurement error.

The results we have presented thus far are suggestive of a relationship but are still far from convincing. In particular, we have already seen that China for example has high tariffs and high inverse elasticities. It is possible that our regressions are being driven by one or a handful of countries. Moreover, expressing the optimal tariff in terms of a country's size and market power may be natural in a two-good model, but is not very useful from an empirical perspective because of the many cross-country differences that may affect average tariff levels. Furthermore, as we have seen, the theory also provides important predictions for tariff variation within a country. Since there is generally much more variation in tariffs and elasticities within countries and fewer potential omitted variables we believe this is the more promising route. This is our focus in the next section.

5.2 The Classical Approach

Our approach to testing the optimal tariff theory is two-pronged. In this section we focus on the classical approach, i.e. on testing a simple model where the inverse export supply elasticity is the key determinant. There are potentially several other factors highlighted by several political economy models that influence tariff setting behavior. Thus, in the next section we estimate a political economy augmented model. The main motive for this approach is a data constraint: we have tariff and elasticity data for 15 non-WTO countries but only 5 of these have the required data for the political economy augmented test.

Although the estimates in this section may not control for all relevant determinants, they may still be quite valuable in testing the optimal tariff theory. First, as we described in the theory section, there are several special but important cases under which the tariff may be explained by focusing on the terms-of-trade effect alone. Second, in all subsequent regressions we will include country-level fixed effects, so that all of the variation we explore in HS 4-digit tariff rates is within countries. Finally, given the way we estimated the elasticities, they are unlikely to be correlated with a variety of omitted variables that vary across goods within a country. We will also discuss some results where we introduce additional controls.

We have two strategies to deal with the skewness and measurement error in our inverse export elasticity variable. As before, we can run regressions using the log of the variable or we can transform the variable into indicator variables that correspond to low versus medium or high values. We will also explicitly estimate whether the effect of the inverse elasticity on the tariff levels off after some value.

Table 7 reports our first set of results with country fixed effects. When we run the regression in a linear specification for the full sample, in column 3, we obtain a positive and significant coefficient on the inverse elasticity as predicted by theory, but the coefficient is tiny. The reason for this is that some of our estimates of the inverse elasticity are very large and imply implausibly large tariffs in a linear specification with a coefficient of any larger magnitude. In columns 2 and 1 we use the observations with inverse export supply in the lowest 66th, and 33rd percentile respectively. The coefficient on the inverse elasticity remains significant and rises by a factor of 12,000 when we focus only on the goods with the lowest inverse export supply elasticities! This suggests that while there is a strong positive relationship between these two variables, there is a tapering off of the magnitude of the association as the optimal tariff implied by the elasticity crosses some level. In column 4 we allow for different marginal effects for market power. According to the data the optimal breakpoint is at the 33rd percentile of the inverse elasticity. For products below it the marginal effect is 4.3 whereas above it the effect is close to 0. Despite the low marginal effect at high inverse elasticity those goods do have a higher average tariff.

An alternative way to address the functional form issue is by using the log of the inverse elasticity. We do so and find that the coefficient on this variable is positive and significant in both the OLS and Tobit specifications, in columns 6 and 7 of Table 7 respectively. In column 8 we use IV to address the possibility of country specific errors in the measurement of the elasticities and potential concerns with endogeneity. In the same vein as in table 6, the instrument for the elasticity in a given country-good pair is the mean elasticity of that good for the remaining countries. The estimate remains significant and it increases nearly three-fold indicating that measurement error may be causing attenuation in the OLS estimates. These OLS and IV results are robust to including two potentially important regressors (not reported in table). First, industry dummies that account for any unobserved heterogeneity that could simultaneously determine the export elasticity and tariffs. Second, import demand elasticity, which captures any differential motive to impose higher tariffs on goods with lower import elasticity to collect tariff revenue due to a standard Ramsey motive.[25]

Finally, in column 5 we address the measurement error and, to some extent, the functional form issue, by sorting each country's data by the inverse elasticity and creating dummies corresponding to whether the inverse elasticity in an industry is in the lowest third of the data or not. Tariffs are significantly lower –1.24 percentage points– when goods are supplied elastically, i.e. have low inverse elasticities. To better understand the relative importance of the terms-of-trade motive we can compare this increase to the average tariff in the country. This calculation reveals that for the representative country the terms-of-trade motive increases the tariff by 14 percent.

In sum, just as Edgeworth postulated over a century ago, all of our specifications indicate that elastically supplied imports have significantly lower tariffs than those supplied inelastically.

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[25] The industry dummies that we use represent the 20 sections in the HS tariff code, e.g. live animals, chemicals, textiles, etc. The import demand elasticity is estimated as described previously. Its coefficient has the predicted sign but it is not statistically significant.

This is the first time anyone has ever documented a positive relationship between tariffs and inverse export supply elasticities.

5.3 The Political Economy Augmented Model

The preceding analysis established that there is an unmistakable positive relationship between estimated inverse export supply elasticities and tariff levels for countries outside of the WTO. However, there are many good reasons to believe that commercial policy is also strongly influenced by domestic political interests that may be completely independent of terms-of-trade considerations. One issue that we face is whether there may be some correlation between our estimates of the inverse elasticities and political economy variables. It is hard to see why there might be a systematic correlation between our estimates of export supply elasticities and political economy variables because all importer-industry-time variation has been purged from the elasticity data before estimation. Moreover, lobbies tend to form at the industry level and, as we reported above, our results continue to hold when we include industry dummies that account for unobserved industry heterogeneity. Nonetheless, our prior results could still reflect some type of omitted variables bias in the estimates, which we now try to address.

The specifics of the political economy that are relevant for the tariff structure are quite likely to differ across these countries. So, our approach is to ask if our results are robust to the inclusion of a political economy variable that is central in an important model, Grossman and Helpman's, and that also plays a role in alternative political economy models. If we assume that all sectors are politically organized, the Grossman-Helpman model of tariff setting can be used to provide a particularly parsimonious characterization of the effects of both market power and domestic lobbying. In this model, tariffs are given by equation (7) with I_g=1, the sum of the inverse elasticity and a political economy variable, which we will refer to as the "inverse import penetration ratio."

The variable that captures the political economy motive equals the domestic production divided by the level of imports and the import demand elasticity. We can only obtain production data for 5 of the 15 countries in our sample – Bolivia, China, Ecuador, Latvia, and Taiwan. The most disaggregate level at which this is available for all these countries is the ISIC 3-digit data from UNIDO's industrial database. Thus we divide production by imports at this level, which can be interpreted as the average penetration for the goods in that ISIC 3-digit. However, we then divide this by the import demand elasticity that we estimate at the HS-4 digit level. Thus, the political economy variable still varies at the 4-digit level.

We present a cross-tabulation of our 4-digit tariff data for these countries using the inverse export elasticity and the inverse import penetration variables in Table 8. Each element of Table 8 consists of the average percentage deviation of a tariff from the country mean for a given combination of inverse export elasticities and inverse import penetration ratios. For example, the element of the upper left corner of the table indicates that average tariffs in 4-digit sectors with inverse export elasticities in the lowest 33 percent of the distribution of inverse elasticities *and* inverse import penetration ratios in the lowest 33 percent of the distribution of inverse import penetration typically had tariffs 37 percent below the country average. As we move down the columns we see that the effect on the tariff differential in a sector of increasing the inverse export supply elasticity while holding the inverse import penetration variable fixed. As we move right along a row, we see the effect on the tariff differential in a sector of increasing the inverse import penetration variable.

There are a number of important features of Table 8. First, there is a very strong rise in tariffs relative to country averages as the inverse import penetration rises. This is clearly predicted by the Grossman-Helpman model and more generally it is consistent with the importance of domestic political economy effects in tariff-setting. Shifting from a sector with a low inverse import penetration ratio to a high one is associated with a 40-66 percent increase in tariff rates relative to the country average. Second, tariffs also rise as the inverse export elasticity rises as long as the inverse import penetration is not high. This suggests that at some point domestic political economy factors may swamp the optimal tariff argument of Edgeworth, but as long as these forces are not too strong, there is a strong positive association between inverse export elasticities and tariffs.

In the first column of Table 9 we present the regression analog of Table 8. Here we regress tariffs on country dummies and dummies corresponding to whether the inverse export elasticity and inverse import penetration variables are in the lowest, middle, or highest third of their ranges. The excluded categories are low import penetration and inverse export elasticities, which are captured by each of the country intercepts. The coefficients on the medium and high dummies are then interpreted as the additional effect on tariff values in these countries for goods in such categories. Column 2 deals with the endogeneity of production over imports by instrumenting it using the average for the other four countries.[26]

Both specifications confirm that importers impose lower tariffs in sectors with lower inverse export elasticities. There is not much difference between medium and high, as suggested by our previous results with the full sample. The political economy variables have the predicted sign, and their inclusion does not eliminate the effect of market power on tariffs. Moreover, the magnitudes of this impact seem quite large relative to average tariffs in countries.

[26] There are two potential sources of endogeneity that the IV addresses here. First, tariffs affect domestic prices and production and imports so there is reverse causation. Second, there is an omited variable bias caused by measurement error since the true variable that we want according to the model should be measured at the HS-4 digit level and include an indicator for whether the sector is organized into a lobby. A suitable instrument must be correlated with inverse import penetration but not with tariffs in the country. Given that the tariffs of our non-WTO sample of countries are not set jointly the average production to import ratio over any four countries is unlikely to be determined by the tariffs of the fifth. On the other hand, inverse import penetration variables in other countries are likely to be correlated with those in a particular country if there is some commonality in the tradability of certain ISIC 3 industries.

The last four columns of Table 9 report results using continuous variables instead of dummies. The specifications address various econometric issues and all of them confirm the positive and significant effect of market power on tariffs. They also verify the positive and significant effect of the political economy variable. The OLS and Tobit estimates, which correct for biases due to truncation of the dependent variable, are similar. The median regression addresses any problem with outliers. The IV specification in column 6 instruments the import penetration and the one in column 7 instruments the export elasticity and the import penetration ratio.

The IV results in column 7 indicate that controlling for political economy variables and instrumenting strengthen the coefficient on the inverse export elasticity that we reported earlier. Clearly, adding a variable to account for domestic political interests does not alter the relationship between inverse export elasticities and tariffs. A two standard deviation increase in the inverse elasticity leads to an increase in tariffs of about 9 percentage points, which is a substantial effect.

Up until this point we have been assuming that the relationship between inverse export elasticities and tariffs is common across countries. The reason for this is that by pooling our dataset we can obtain our estimates based on thousands of observations, which increases their precision. However, a reasonable objection to this approach is that there may exist different tariff setting processes across our sample of countries, and thus the relationship between tariffs and our explanatory variables may vary substantially across countries.

In order to assess how important the optimal tariff argument is for individual countries we reran our regressions at the country level. We report these results in Table 10. Not surprisingly, moving from thousands to hundreds of observations per regression results in higher standard errors. However, in the IV regressions we can reject the hypothesis that sectors with medium and high inverse elasticities are not higher than those with low inverse levels in most cases. Similarly, sectors with high inverse import penetration ratios have a significantly higher tariff than the ones where this ratio is low.[27] The quantitative importance of the effect is clear if we compare the difference in tariffs between low and high inverse elasticity goods. It ranges from 1% for Bolivia to 53% for Latvia. The values are 17% for Ecuador, 30% for Taiwan and 37% for China. The median is 30%.

The weakest results arise when we use the dummies for Bolivia. As we saw in Figure 1, Bolivian tariffs hardly vary – about 90% of its tariff lines in our sample take a value of 10 percent, 5 observations have a tariff of 5 percent and the remainder are in between. Clearly, this tariff structure does not fit the stylized optimal tariff models we have been discussing so far. Is there anything we can say about the sectors in which Bolivia deviates from the common tariff of 10 percent? We can answer this question by running a censored normal regression with two censoring points: a lower bound of 5 percent and an upper bound of 10 percent. The estimated coefficients on both the export and political economy variables then come in strongly with the right sign. In other words, Bolivia is the exception that proves the rule – even when a country has a tariff structure that hardly varies; the sectors where the tariffs tend to be higher correspond to sectors with higher inverse export elasticities and/or higher political power.

6. Conclusion

The idea that a country could improve its terms-of-trade through the imposition of tariffs has been in the economics literature for close to two centuries. Economists have known for over one century that the optimal tariff in sectors where goods are not supplied elastically is positive. However, thus far, perhaps due to data and computational issues, no one has tested whether countries do so. This paper is the first to provide evidence that importers who are not members of the GATT/WTO do impose higher tariffs on goods with lower export supply elasticities. This result

[27] In the OLS regressions, we observe the same sign pattern although the attenuation of the coefficient estimates arising from the measurement error means that the probability value in testing the differences are typically higher. However, given the endogeneity of the import penetration variable we believe that the IV estimates are the correct ones.

is present when looking at tariffs across countries, across sectors within countries, and even after controlling for political economy considerations.

We also find evidence that political economy forces also matter for tariff setting behavior. This suggests that both political economy and international market power are important forces in the determination of protection.

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Appendix: Optimal tariff with CES utility for foreign varieties

Broda-Weinstein (2005) assume the existence of a utility $M^{\mu}D^{\alpha}$ where M is the subutility function for imported goods and D is a composite domestic good. Therefore we follow that approach here but rule out income effects by using the quasilinear structure outlined above with $u = u(M^{\mu}D^{\alpha})$. Moreover, we take M as a Cobb-Douglas aggregate over imported goods $g \in G_m$, so $M = \prod_g M_g^{\phi_g}$. Each M_g is in turn composed of varieties that are aggregated via a CES utility with elasticity of substitution $1/(1-\rho_g)$. So $M_g = [(\Sigma_v d_{gv}^{1-\rho_g} m_{gv}^{\rho_g})^{1/\rho_g}]$ where $d_{gv} > 0$ is a taste or quality parameter for gv. Finally, we assume that the subutility represented by u gives rise to constant expenditure. That is $u = \ln(M^{\mu}D^{\alpha})$. Thus we can rewrite the utility as

$$U = c_0 + \mu \sum_{g \in G_m} \phi_g \ln[(\Sigma_v d_{gv}^{1-\rho_g} m_{gv}^{\rho_g})^{1/\rho_g}] + \alpha \ln D \ ; \ 0 < \rho < 1 \tag{1}$$

This structure implies separability across imported goods but not its varieties. We could provide a similar treatment to the domestic composite good but since it is log separable this is not necessary in order to determine the optimal tariffs for each imported good. As shown in the standard model in the text a demand structure with quasilinear utility and separability over goods g implies that tariffs in any good g only impact welfare through the consumption of that good and the tariff revenue it generates. Thus we can focus on deriving the optimal tariff separately for each good $g \in G_m$. Furthermore we assume that $\tau_{gv} = \tau_g$ for all v in a given good.

We now want to show that the optimal tariff for each of these goods is given by the inverse export supply elasticity as we estimate it. In the estimation we must assume they are constant and identical within goods across imported varieties. Therefore we impose those conditions and write the export supply for each variety of good g as

$$m_{gv}^* = a_{gv} p_{gv}^{*1/\omega_g} \text{ all } g, v \tag{2}$$

Note that different exporters may have different a_{gv} and this variation, along with the differences in demand taste generate variation in prices across exporters that is important in identifying the elasticities empirically (we also use the time variation). The demand for each variety is obtained by minimizing expenditure subject to obtaining a given level M_g. It is

$$m_{gv} = d_{gv}(\frac{p_g}{p_{gv}})^{\sigma_g} M_g \quad (3)$$
$$= \mu\phi_g d_{gv} p_{gv}^{-\sigma_g} p_g^{\sigma_g - 1}$$

where p_g represents the standard price index, $\left(\sum_v d_{gv} {p_{gv}}^{1-\sigma_g}\right)^{1/(1-\sigma_g)}$. The second line uses the fact that $u()$ has a constant expenditure share and that the maximization of that utility will yield $p_g M_g = \mu\phi_g$. Using this and the export supply equation we obtain the market clearing price obtained by foreign exporters, $p^*_{gv} = p_{gv}/(1+\tau_{gv})$.

$$H\mu\phi_g d_{gv}(p^*_{gv}(1+\tau_g))^{-\sigma_g} p_g^{\sigma_g-1} = a_{gv} p_{gv}^{*1/\omega_g} \quad (4)$$

$$p^*_{gv} = [\eta_{gv}(1+\tau_g)^{-\sigma_g} p_g^{\sigma_g-1}]^{\frac{\omega_g}{1+\omega_g\sigma_g}} \quad (5)$$

where $\eta_{gv} \equiv \frac{H\mu\phi_g d_{gv}}{a_{gv}}$ depends on variety specific characteristics so prices of the same will vary across exporters.

The key insight to showing that the optimal tariff is simply ω_g for each good is to note that the tariff does not affect the relative demand of varieties in any given good. Therefore the only distortion that it addresses is the terms of trade externality. There are three assumptions that explain this. First, consumption and export supply elasticities within a good are constant. Second they are identical across varieties or exporters of that good. Third, tariffs are equal across exporters of the same good. To see this we can simply use the expressions for m_{gv} and p^*_{gv} and we obtain the relative demand across any two v, k of a given good as

$$\frac{m_{gv}}{m_{gk}} = \frac{d_{gv}}{d_{gk}}(\frac{\eta_{gk}}{\eta_{gv}})^{\frac{\omega_g\sigma_g}{1+\omega_g\sigma_g}} \quad (6)$$

To obtain individual prices, p^*_{gv}, as a function of tariffs we first solve for the aggregate price index of each good and then replace it in the expression for p^*_{gv}. To do so we first note that $p_g = (1+\tau_g)\left(\sum_v d_{gv} {p^*_{gv}}^{1-\sigma_g}\right)^{1/(1-\sigma_g)}$ and then aggregate the individual prices from the market clearing conditions to obtain an expression similar to this one, which can be solved to obtain

$$p_g(\tau_g) = (1+\tau_g)^{\frac{1}{1+\omega_g}} \Phi \quad (7)$$

where $\Phi \equiv \left(\sum_v d_{gv}[\eta_{gv}]^{\frac{\omega_g(1-\sigma_g)}{(1+\omega_g\sigma_g)}}\right)^{(1+\sigma_g\omega_g)/(1+\omega_g)(1-\sigma_g)}$. We can verify that if $\omega_g = 0$ there is complete pass-through from tariffs to the aggregate price of g and as ω_g increases the effect of tariffs to domestic prices is attenuated. Replacing this in the market clearing condition for each variety we obtain $p^*_{gv}(\tau_g)$.

$$p^*_{gv} = (1+\tau_g)^{-\frac{\omega_g}{1+\omega_g}}[\eta_{gv}\Phi^{\sigma_g-1}]^{\frac{\omega_g}{(1+\omega_g\sigma_g)}} \tag{8}$$

The equilibrium level of imports as a function of tariffs is then $Hm_{gv} = m^*_{gv}$, for each variety of g given by

$$m^*_{gv}(\tau_g) = (1+\tau_g)^{-\frac{1}{1+\omega_g}}\Gamma_{gv} \tag{9}$$

$\Gamma_{gv} \equiv a_{gv}[\eta_{gv}\Phi^{\sigma_g-1}]^{\frac{1}{1+\omega_g\sigma_g}}$

The government will then choose τ_g for each good to maximize the following social welfare expression

$$\max_{\tau_{gg}} W = H + \sum_g HW_g + \pi_d + Hs_d \tag{10}$$

where for each good g we have that W_g is given by $\tau_g\Sigma_v p^*_{gv}(\tau_g)m_{gv}(\tau_g) + \mu\phi_g \ln[(\Sigma_{gv}d^{1-\rho}_{gv}m_{gv}(\tau_g)^\rho)^{1/\rho}] - \Sigma_{gv}p_{gv}(\tau_g)m_{gv}(\tau_g)$ (recall that all of these variables and parameters, except μ, vary across goods but we omit the subscripts). The foc for each good g can then be derived and simplified to obtain

$$\Sigma_v\left(\tau_g p^*_{gv}\frac{dm_{gv}}{d\tau_g} - m_{gv}\frac{dp^*_{gv}}{d\tau_g}\right) = 0 \tag{11}$$

Therefore we obtain an expression similar to the one under the standard model. However now it is defined over the sum of the varieties. To see that the elasticity we estimate is exactly the solution we can rewrite the expression above in terms of elasticities of m_{gv} and p^*_{gv} wrt τ_g. Using the equilibrium level of imports and prices derived it is simple to see that these are constant across varieties in a good and thus we obtain the inverse elasticity solution.

$$\begin{aligned} H\Sigma_v p^*_{gv}m_{gv}\left(\frac{dm_{gv}}{d\tau_g}\frac{\tau_g}{m_{gv}} - \frac{dp^*_{gv}}{d\tau_g}\frac{\tau_g}{p^*_{gv}}\frac{1}{\tau_g}\right) &= 0 \\ \Sigma_v p^*_{gv}m_{gv}\left(-\frac{1}{1+\omega_g}\frac{\tau_g}{1+\tau_g} - (-\frac{\omega_g}{1+\omega_g}\frac{\tau_g}{1+\tau_g})\frac{1}{\tau_g}\right) &= 0 \\ \tau_g &= \omega_g \text{ all } g \end{aligned} \tag{12}$$

Figure 1: Histogram of Tariffs by Country

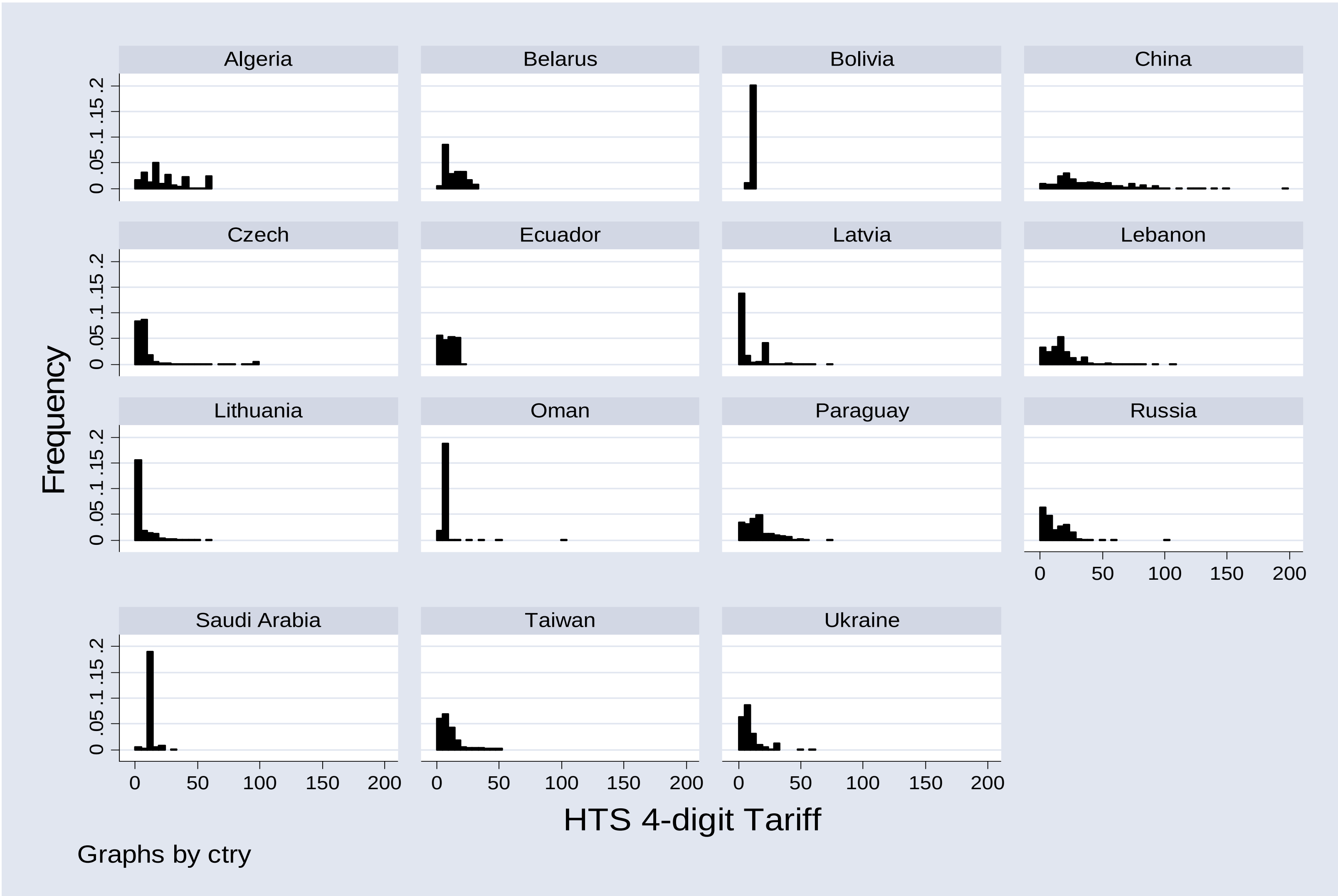

Figure 2

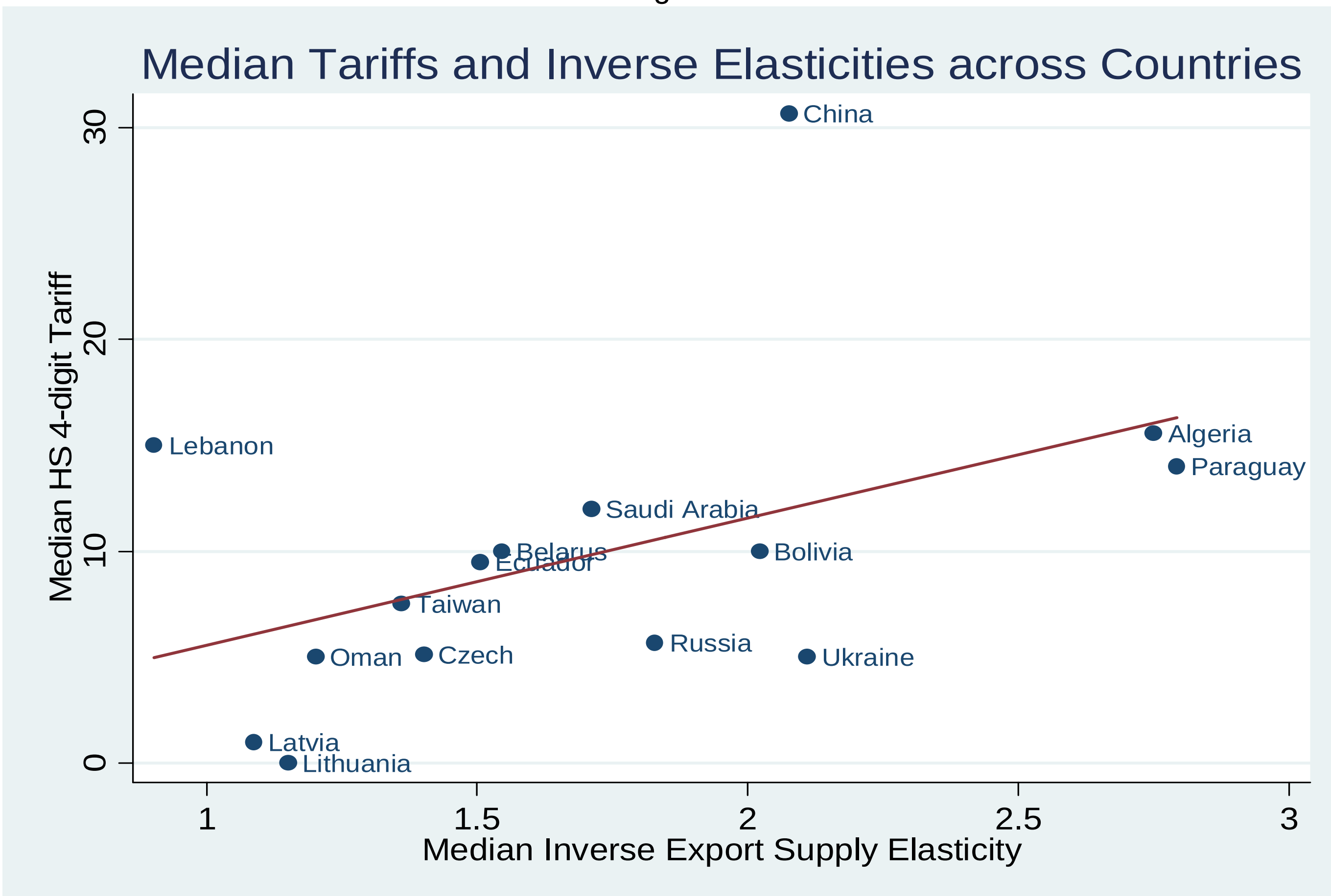
Median Tariffs and Inverse Elasticities across Countries
Median HS 4-digit Tariff
0
10
20
30
1
1.5
2
2.5
3
Median Inverse Export Supply Elasticity
China
Lebanon
Algeria
Paraguay
Saudi Arabia
Belarus
Ecuador
Bolivia
Taiwan
Oman
Czech
Russia
Ukraine
Latvia
Lithuania

Table 1: Data Sources and Years used

	WTO Accession Date	GATT Accession Date	Production Data Source	Production Data Years	Tariff Data*	Trade Data**
Algeria					93	94-03
Belarus					97	98-03
Bolivia***	1-Jan-1995	8-Sep-1990	UNIDO	93	93	94-03
China			UNIDO	93	93	94-03
Taiwan	1-Jan-2002		UNIDO	96	96	94-03
Czech	1-Jan-1995	15-Apr-1993			92	94-03
Ecuador	21-Jan-1996		UNIDO	93	93	94-03
Latvia	10-Feb-1999		UNIDO	96	97	94-03
Lebanon					00	97-02
Lithuania	31-May-2001				97	95-03
Oman					92	94-03
Paraguay	1-Jan-1995	6-Jan-1994			91	94-03
Russian					94	96-03
Saudi Arabia					91	94-03
Ukraine					97	96-02

Notes: * All tariff data is from TRAINS. Countries are included if we have tariff data for at least one year before accession (GATT/WTO). ** Except for Taiwan, all trade data is from COMTRADE. For Taiwan data if from TRAINS. *** The date of the tariffs for Bolivia is post-GATT accession but those tariffs were set before GATT accession and unchanged between 1990-93.

Table 2: Trade and Tariff Data Description

	Number of Varieties*	Number of 4-digit HS	Median # of Var per HS4	Tariff Rate per 4-digit HS code			
				Mean	Median	10th Percentile	90th Percentile
Algeria	26466	1100	13	23.8	15.6	6.2	60.0
Belarus	24440	1172	12	12.4	10.0	5.0	25.0
Bolivia	18592	1064	9	9.9	10.0	10.0	10.0
China	63764	1217	33	37.9	30.7	12.0	75.0
Taiwan	38397	1215	19	9.6	7.5	0.0	20.0
Czech	61781	1219	30	9.5	5.1	0.0	14.6
Ecuador	22979	1101	11	9.4	9.5	2.0	17.0
Latvia	33790	1128	17	7.0	1.0	1.0	20.0
Lebanon	34187	1109	15	17.1	15.0	3.0	35.0
Lithuania	34825	1159	17	3.6	0.0	0.0	15.0
Oman	20482	1107	10	5.7	5.0	5.0	5.0
Paraguay	15430	1049	7	16.1	14.0	3.0	32.5
Russian	66731	1187	34	10.7	5.7	0.5	24.7
Saudi Arabia	62525	1202	32	12.1	12.0	12.0	12.0
Ukraine	37693	1128	18	7.4	5.0	0.0	15.0

Notes: * Varieties are defined as (6-digit HS, exporting country) pairs

Table 3A: Inverse Export Supply Elasticity Statistics

	Inverse Export Supply Elasticity							Logs Regression**		
	Nobs	Vars per HS-4*	Median	St.Dev (Median)	Mean	10th Perc	90th Perc	Beta	St. Error	R^2
Algeria	739	26	2.8	0.25	118	0.2	217	0.80	(0.07)	0.13
Belarus	704	20	1.5	0.14	85	0.1	153	0.80	(0.07)	0.14
Bolivia	639	21	2.0	0.22	103	0.1	217	0.82	(0.09)	0.13
China	1106	46	2.1	0.15	93	0.3	153	0.54	(0.06)	0.11
Czech Rep.	1075	42	1.4	0.08	63	0.1	91	0.61	(0.05)	0.12
Ecuador	747	25	1.5	0.10	77	0.1	149	0.73	(0.08)	0.12
Latvia	829	32	1.1	0.07	50	0.1	50	0.57	(0.07)	0.09
Lebanon	788	27	0.9	0.08	58	0.0	91	0.71	(0.08)	0.11
Lithuania	811	33	1.2	0.08	65	0.1	91	0.70	(0.07)	0.13
Oman	629	24	1.2	0.09	209	0.2	131	0.39	(0.08)	0.04
Paraguay	511	20	2.8	0.45	132	0.2	752	0.94	(0.11)	0.14
Russia	1032	54	1.8	0.10	48	0.2	91	0.53	(0.05)	0.11
Saudi Arabia	1036	53	1.7	0.11	71	0.2	131	0.48	(0.06)	0.08
Taiwan	869	25	1.6	0.17	104	0.0	217	0.31	(0.08)	0.02
Ukraine	861	32	2.1	0.14	84	0.2	153	0.83	(0.07)	0.17
Median	811	27	1.6	0.11	84	0.1	149	0.70	(0.07)	0.12

Notes: * Median number of varieties per 4-digit HS code. ** Univariate regression of log inverse export supply elasticities in each country on the average of the log inverse elasticities in that good for the available remaining 14 countries.

Table 3B: Bootstrapping Descriptive Statistics

	Median	10th Percentile Relative to Median Point Estimate*	90th Percentile Relative to Median Point Estimate*
Algeria	1.8	0.4	3.8
Belarus	1.3	0.3	3.5
Bolivia	2.7	0.2	6.6
China	1.8	0.4	3.4
Czech Rep.	1.4	0.4	3.6
Ecuador	1.2	0.3	3.8
Latvia	1.0	0.4	3.3
Lebanon	0.9	0.4	3.6
Lithuania	1.1	0.4	3.3
Oman	1.3	0.4	3.5
Paraguay	1.7	0.3	4.3
Russia	1.8	0.4	3.3
Saudi Arabia	1.7	0.4	3.2
Taiwan	0.9	0.3	3.9
Ukraine	1.5	0.4	3.5
Median	1.4	0.4	3.5

* The elements of these columns were computed by first dividing the 10th (or 90th) percentile confidence band of a given inverse elasticity by the median point estimate of the inverse elasticity, and then computing the median of these ratios. They indicate the magnitude of the confidence interval relative to size of the typical point estimate.

Table 4A: Inverse Elasticities by Rauch Classification

	Differentiated	Reference Priced	Commodity
Median Inv Elasticity	2.38	0.70	0.45
Standard errors	(0.04)	(0.06)	(0.14)
p-value*		0.00	0.00
Mean Inv Elasticity	93	87	20
Standard errors	(3.50)	(39.6)	(4.47)
p-value*		0.89	0.00

Notes: * p-values for test of difference of mean or median relative to differentiated goods

Table 4B: Inverse Elasticities of Export Supply for the largest 15 4-digit HS sectors*

4-digit HS code	Inverse Elasticity (Median)	Import share	Description HS code
1201	0.01	0.023	SOYBEANS, WHETHER OR NOT BROKEN
1003	0.01	0.009	BARLEY
2711	0.08	0.032	PETROLEUM GASES & OTHER GASEOUS HYDROCARBONS
1001	0.10	0.013	WHEAT AND MESLIN
2304	0.17	0.006	SOYBEAN OILCAKE & OTH SOLID RESIDUE, WH/NOT GROUND
2710	0.31	0.013	OIL (NOT CRUDE) FROM PETROL & BITUM MINERAL ETC.
1511	0.34	0.006	PALM OIL & ITS FRACTIONS, NOT CHEMICALLY MODIFIED
2601	0.54	0.028	IRON ORES & CONCENTRATES, INCLUDING ROAST PYRITES
2709	0.62	0.309	CRUDE OIL FROM PETROLEUM AND BITUMINOUS MINERALS
1205	0.89	0.007	RAPE OR COLZA SEEDS, WHETHER OR NOT BROKEN
7108	1.26	0.009	GOLD (INCL PLAT PLATED), UNWR, SEMIMFR OR POWDER
8703	1.35	0.007	MOTOR CARS & VEHICLES FOR TRANSPORTING PERSONS
8401	2.83	0.010	NUCLEAR REACTORS; FUEL ELEM (N-I); MACH ISOTOP SEP
8802	46.5	0.020	AIRCRAFT, POWERED; SPACECRAFT & LAUNCH VEHICLES
8542	63.8	0.006	ELECTRONIC INTEGRATED CIRCUITS & MICROASSEMBL, PTS

Notes: * Import share is defined as the ratio of total imports for the 15 countries in an HS4 good relative to their total imports

Table 5: Inverse Export Supply Elasticities, GDP and World Import Shares

Dependent Variable	Log Inverse Export Supply			
Sample:	All 15 non-WTO countries		5 countries w/ production data	
Log GDP	0.145		0.151	
	(0.05)		(0.06)	
Share of World HS-4 Imports		7.19		13.48
		(1.48)		(1.55)
Observations	12343	12343	4294	4294
R-square	0.25	0.25	0.38	0.38
R-square within	0.01	0.00	0.02	0.01

Notes: All regressions include 4-digit HS fixed effects (1201 categories in full sample and 1168 in the subsample of 5 countries, the difference is due to the unbalanced panel). Robust standard errors in parentheses. In the log GDP regressions, standard errors are clustered by country. The share of world imports is calculated in 2000.

Table 6: Industry Effects

Dependent Variable	Average Tariff at 4-digit HS (%)					
Estimation Method	OLS	Tobit	IV	OLS	Tobit	IV
Inverse Export Elasticity	0.0005	0.0004	0.0004			
	(0.0002)	(0.0002)	(0.0002)			
Log Inverse Export Elasticity				0.436	0.429	0.444
				(0.055)	(0.056)	(0.074)
Observations	12333	12333	12258	12333	12333	12258
R-squared	0.21		0.20	0.21		0.20
R-squared within	0.001		0.001	0.006		0.006

Notes: Standard errors in parenthesis. The number of HS4 categories is 1207 in all specifications except the IV where it is 1133, which is lower because the number of observations falls due to the unbalanced nature of the panel.

Table 7: Country Fixed Effects

Dependent Variable	Average Tariff at 4-digit HS (%)							
Inv Export Elasticity Sample	Smaller than 33rd percentile	Smaller than 66th percentile	All	All	All	All	All	All
Estimation Method	OLS	OLS	OLS	OLS*	OLS	OLS	Tobit	IV GMM**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inverse Export Elasticity	3.66	0.406	0.0003					
	(0.86)	(0.105)	(0.0001)					
(Inv. Exp. Elast)*(1-dummy med hi)				4.34				
				(0.845)				
(Inv. Exp. Elast)*dummy med hi				0.0003				
				(0.0001)				
Dummy med hi				2.32				
				(0.359)				
Dummy Mid and High Inv Exp Elast					1.24			
					(0.248)			
Log Inverse Export Elasticity						0.121	0.124	0.354
						(0.042)	(0.046)	(0.142)
Algeria	19.14	22.72	23.80	21.76	23.01	23.66	23.63	23.31
	(1.13)	(0.80)	(0.64)	(0.71)	(0.66)	(0.64)	(0.51)	(0.67)
Belarus	10.57	11.60	12.38	10.40	11.57	12.30	12.20	12.09
	(0.54)	(0.37)	(0.30)	(0.42)	(0.34)	(0.30)	(0.52)	(0.32)
Bolivia	8.84	9.21	9.77	7.78	8.97	9.65	9.65	9.37
	(0.27)	(0.16)	(0.03)	(0.31)	(0.17)	(0.06)	(0.54)	(0.18)
China	32.56	37.24	37.88	35.77	37.08	37.74	37.65	37.88
	(1.48)	(1.00)	(0.77)	(0.85)	(0.80)	(0.78)	(0.41)	(0.81)
Czech Rep.	6.67	8.59	9.46	7.49	8.65	9.40	8.49	9.19
	(0.71)	(0.59)	(0.54)	(0.59)	(0.54)	(0.53)	(0.43)	(0.53)
Ecuador	8.64	9.75	9.81	7.84	9.01	9.73	9.70	9.53
	(0.42)	(0.27)	(0.20)	(0.36)	(0.26)	(0.20)	(0.50)	(0.24)
Latvia	6.96	7.55	7.26	5.33	6.45	7.24	6.97	7.16
	(0.78)	(0.49)	(0.36)	(0.48)	(0.40)	(0.36)	(0.47)	(0.37)
Lebanon	15.46	16.85	17.10	15.27	16.29	17.09	17.09	17.03
	(1.06)	(0.69)	(0.53)	(0.63)	(0.56)	(0.53)	(0.49)	(0.54)
Lithuania	3.28	3.90	3.62	1.66	2.81	3.57	-5.65	3.44
	(0.58)	(0.36)	(0.26)	(0.41)	(0.32)	(0.26)	(0.59)	(0.28)
Oman	4.25	5.59	5.62	3.61	4.86	5.61	4.83	5.46
	(0.51)	(0.47)	(0.35)	(0.45)	(0.38)	(0.35)	(0.55)	(0.38)
Paraguay	13.59	15.08	16.09	14.06	15.30	15.93	15.86	15.54
	(0.93)	(0.68)	(0.50)	(0.58)	(0.53)	(0.50)	(0.61)	(0.56)
Russia	8.21	10.02	10.66	8.56	9.84	10.56	9.77	10.34
	(0.76)	(0.46)	(0.34)	(0.48)	(0.39)	(0.35)	(0.43)	(0.36)
Saudi Arabia	10.51	11.68	12.13	10.06	11.32	12.02	11.89	11.78
	(0.38)	(0.15)	(0.08)	(0.33)	(0.19)	(0.09)	(0.43)	(0.18)
Taiwan	9.29	9.24	9.69	7.85	8.89	9.61	9.09	9.60
	(0.57)	(0.36)	(0.29)	(0.41)	(0.34)	(0.29)	(0.46)	(0.33)
Ukraine	6.01	7.02	7.36	5.28	6.55	7.23	6.06	6.94
	(0.72)	(0.41)	(0.28)	(0.44)	(0.34)	(0.29)	(0.52)	(0.34)
Observations	4061	8128	12333	12333	12333	12333	12333	12258
R-squared	0.57	0.61	0.61	0.61	0.61	0.61		

Notes: Standard errors in parenthesis (all heteroshadisticity robust except Tobit). * Optimal threshold regression based on minimum RSS found using a grid search over 50 points of the distribution of inverse exp. elast (from 1st to 99th percentile in intervals of 2). Optimal threshold is 33rd percentile. Accordingly, dummy med hi=1 above the 33rd percentile and 0 otherwise. Hansen (2000) shows that the dependence of the parameters on the threshold estimate is not of "first-order" asymptotic importance, so inference on them can be done as if the threshold estimate were the true value. ** IV GMM column instruments log inverse export elasticity with the mean for that variable in whichever remaining 14 countries it is available for each HS4 product.

Table 8:
Percent deviations from mean country tariff

		Political Economy Dummy		
		Low	Medium	High
Inverse Export Elasticity	Low	-37	-19	29
		(3.5)	(3.3)	(4.7)
	Medium	-23	-4	39
		(3.1)	(3.4)	(4.2)
	High	-18	1.1	22
		(2.8)	(3.9)	(4.8)

Notes: Low<33rd percentile of variable within each country. Medium=33th - 66th; High: >66th all within each country. Average tariff in a category is the average over the countries of the percentage difference between the products in that cell and the mean in the country. Standard errors of the mean percent difference in parenthesis. Political Economy Dummy constructed by country as (Production/Imports)/Import Demand Elasticity.

Table 9: Political Economy Augmented Model

Dependent Variable	Average Tariff at 4-digit HS (%)						
Estimation Method	OLS	IV GMM	OLS	TOBIT	QREG	IV GMM	IV GMM 2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Medium Inv Export Elast	2.43	2.88					
	(0.553)	(0.567)					
High Inverse Export Elast	2.20	3.06					
	(0.568)	(0.584)					
Medium Elast * Inv Import Pen	2.82	2.48					
	(0.514)	(1.191)					
High Elast * Inv Import Pen	7.89	11.99					
	(0.553)	(0.785)					
Log (Inv Export Elast)			0.324	0.319	0.08	0.515	1.59
			(0.077)	(0.084)	(0.023)	(0.080)	(0.276)
Log (Elast * Inv Import Pen)			1.487	1.529	0.369	2.702	4.34
			(0.110)	(0.127)	(0.035)	(0.172)	(0.300)
Bolivia	4.67	2.98	12.6	12.7	8.30	14.9	17.1
	(0.506)	(0.680)	(0.271)	(0.624)	(0.210)	(0.422)	(0.796)
China	32.1	30.4	35.8	35.7	26.2	34.7	32.8
	(0.924)	(0.982)	(0.818)	(0.485)	(0.209)	(0.813)	(0.926)
Taiwan	4.36	2.67	10.3	9.94	5.87	11.1	11.5
	(0.563)	(0.709)	(0.287)	(0.504)	(0.198)	(0.319)	(0.462)
Ecuador	4.97	3.277	11.9	11.9	9.03	13.5	14.8
	(0.521)	(0.682)	(0.240)	(0.557)	(0.202)	(0.312)	(0.556)
Latvia	2.072	0.382	9.7	9.47		11.8	14.1
	(0.584)	(0.722)	(0.417)	(0.555)		(0.479)	(0.687)
Constant					2.19		
					(0.152)		
Observations	3797	3797	3791	3791	3791	3791	3653
R-squared	0.69		0.68				

Notes: Standard errors in parenthesis (all heteroshadisticity robust except Tobit)

IV GMM uses the mean inverse import penetration of other countries for each hs4 product as an instrument

IV GMM 2: instruments both variables, the instrument for each is the mean for that variable in the other countries for each hs4 product. It uses all the available data in the sample: remaining 14 countries for inverse elasticity and remaining 4 for inverse import penetration.

Table 10: Political Economy Augmented Model by Country

Dependent Variable	Average Tariff at 4-digit HS (%)									
Country	China	Ecuador	Taiwan	Latvia	Bolivia	China	Ecuador	Taiwan	Latvia	Bolivia
Estimation Method	OLS	OLS	OLS	OLS	OLS	IV GMM	IV GMM	IV GMM	IV GMM	IV GMM
Constant	25.6	5.69	7.20	3.08	9.44	21.0	6.65	6.21	2.81	9.33
	(1.77)	(0.414)	(0.713)	(0.692)	(0.101)	(2.04)	(0.55)	(0.77)	(1.22)	(0.11)
Medium Inv Exp. Elast	7.04	1.67	-0.02	1.65	-0.14	8.24	1.50	0.42	1.84	-0.11
	(1.99)	(0.426)	(0.658)	(0.834)	(0.079)	(2.03)	(0.45)	(0.67)	(0.89)	(0.07)
High Inverse Exp. Elast	5.79	1.19	1.23	1.06	0.07	7.94	1.11	1.85	1.49	0.10
	(2.02)	(0.442)	(0.766)	(0.818)	(0.065)	(2.06)	(0.47)	(0.79)	(0.91)	(0.06)
Medium Inv Imp. Pen/Imp I	6.03	3.30	1.43	1.08	0.52	6.24	0.43	0.87	-1.26	0.65
	(1.87)	(0.455)	(0.659)	(0.638)	(0.094)	(4.53)	(1.11)	(1.19)	(2.07)	(0.14)
High Inv Imp. Pen/Imp Ela:	15.7	7.01	4.20	8.51	0.59	26.1	7.25	6.65	11.1	0.73
	(1.98)	(0.420)	(0.674)	(0.855)	(0.088)	(2.72)	(0.73)	(1.05)	(1.18)	(0.12)
Observations	931	698	805	750	613	931	698	805	750	613
R-Squared	0.07	0.27	0.05	0.15	0.12					

Notes: Robust standard errors in parenthesis

IV GMM uses the mean inverse import penetration of other countries for each hs4 product as an instrument

IV GMM 2: instruments both variables, the instrument for each is the mean for that variable in the other countries for each hs4 product. It uses all the available data in the sample: remaining 14 countries for inverse elasticity and remaining 4 for inverse import penetration.