Tariff Reciprocity*

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Abstract

'Effective' tariff index comparisons are spotlighted in media reports on trade wars and trade talks. Deficiency in the index used for comparisons misleads public opinion and policy makers. We offer an import volume equivalent uniform tariff index to replace the import-weighted average 'effective' tariff. Its share weights embody their general equilibrium dependence on *all* country and product tariffs. Reciprocal reductions in the indexes are: (i) consistent with the objective of reciprocal exchange of market access, and (ii) decompose into the product of buyer and seller incidences of tariffs that reflect domestic political economy objectives.

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1 Introduction

Media reports on tariff policy changes and trade negotiations put the 'effective' tariff index under the same spotlight as the consumer cost-of-living index. The observed buyer share weights that adequately approximate price weights in cost-of-living index comparisons across time are deficient for 'effective' tariff index comparisons of tariff heights across countries. Tariffs have large indirect effects on buyer share weights due to trade diversion to third parties that ripples outward and rebounds back within the world trade system. The 'effective' (trade-weighted average) tariff index thus misinforms public opinion and policy makers. We offer a tariff index appropriate for international comparison purposes.

Our new tariff index is based on weights that incorporate multilateral interaction effects on buyer trade shares. Equal exchange of tariff changes measured by the index - tariff reciprocity – satisfies a simple notion of fairness.[1] Local changes can be chosen that satisfy the trade volume reciprocity principle expressed by "equal exchange of market access". The index by construction satisfies equivalence to the non-discrimination or Most-Favored Nation (MFN) principle. These principles in the U.S. Trade Agreements Act of 1934 remain as relevant in the more protectionist era of bilateral threats and negotiations that followed 2016 as they were in the more protectionist 1930s. We think our index can inform and facilitate trade relations management in the likely future of sequential bilateral negotiations.

The difference in weights between the two indexes is illustrated by an example. U.S. tariff increases on China's exports to the U.S. not only lower China's share of U.S. imports, they raise other countries' U.S. import shares. Third party effects also matter. Expanding the example, U.S. tariff increases on Chinese exports divert some of China's exports to Japan, raising Japan's share weight on its tariff on China's manufactures. Some crowded-out Japanese home market sales may go to the U.S., raising the Japan-US trade share.

[1] Fairness considerations in public policy are prominent domestically in the U.S. in form of state and city level minimum wage laws that offset cost-of-living differentials. Internationally, fairness considerations in the U.S. are visible in fair trade provisions in trade agreements and in non-profit institutions that establish and monitor voluntary fair trade agreements.

Ripples continue *ad infinitum*.

Our proposed tariff index embeds systemic interaction of interest group protection and its negative externalities. Domestic political economy implications are embedded because the import volume equivalent uniform tariff factor index is equal to the product of each country's buyers' incidence of its own plus the rest of the world's tariffs and its sellers' incidence of sales costs due to its own plus the rest of the world's tariffs. The indexes are thus interdependent, since a small rise in one country's tariff index raises its buyers' incidence and also raises other countries' seller incidences. Consequently, the other sellers' tariff indexes rise. (Proof is in Section 3.2.) The True Cost of Protection (TCP) is the index's name, in homage to the True Cost of Living index.[2]

The WTO reciprocal exchange of market access principle is locally equivalent to TCP tariff reciprocity because equal percentage TCP tariff changes produce equal percentage trade volume changes. Bagwell and Staiger (2002) show that reciprocity offsets the tendency for tariffs to be over-used by governments because foreign sellers pay part of the tariff as its incidence falls partly on them. Decomposition of TCP changes measures the negative externality, useful information for present and subsequent negotiations.

The constant trade elasticity gravity representation of spatial equilibrium is the economic structure basis for calculation of the tariff index.[3] Tariff average indexes for each importing country are calculated as the uniform tariff on all goods from all origins that yields the same value of imports at world prices that is observed with the actual highly heterogeneous tariffs.

The TCP is calculated with 2019 data for 99 countries and 107 manufacturing industries. (2019 is the latest year for which the necessary trade and production data is concorded with

[2]The homage also nods to their common linkage to index number theory. The distance between two vectors of prices or costs can be summarized with a weighted average of the component changes. Economically meaningful indexes require weights appropriate for the purpose of comparison. For the True Cost of Living it is the cost variation of maintaining the base level of utility. The 'effective' tariff approximates the cost-of-living rationale for the set of imported goods. The TCP index purpose is the cost variation that maintains the world price value of imports for each country.

[3]Efficient spatial arbitrage equilibrium determines the distribution of given supplies of goods to multiple destinations. Thus buyers' willingness-to-pay is equal to the product of the origin seller's net payment times a markup factor comprised of 'iceberg trade frictions' times the bilateral tariff factors. The Constant Elasticity of Substitution demand system is assumed to generate the buyers' willingness-to-pay at all destinations.

bilateral tariffs.) TCP tariff indexes diverge substantially from import-weighted average tariffs. The overall correlation is 0.65, varying above and below for some countries and sectors. TCP decomposition into buyer and seller incidence varies significantly by country and also by sector. Interest group pressure and partial equilibrium intuition might suggest that seller incidence below 1 (raising seller prices) would be common. Alternatively, the importance of imported inputs suggests the opposite. The results show that manufacturing sectors in rich countries mostly have seller incidence greater than 1, led by the U.S. at 85% of sectors. The proportion across all sectors and countries is 40%.

Section 2 relates the TCP to alternative tariff indexes. Section 3 derives it and Section 4 applies it.

2 Relation to the Literature

The received tariff index literature applies index number theory to generate tariff indexes with different objectives and thus differing weights. Anderson and Neary (2005) collects a body of work aimed at tariff indexes appropriate to measuring changes in trade policy restrictiveness for the 1990s globalization of developing economies. The analysis assumed constant world prices to focus on internal effects of tariff changes. Welfare improvement as an objective for tariff reform suggested the Trade Restrictiveness Index (TRI) Anderson and Neary (1996), the uniform tariff equivalent in welfare to the observed tariff vector. Tariff reform under the WTO commitment of preserving market access suggested the Mercantilist Trade Restrictiveness Index (MTRI) Anderson and Neary (2003), the uniform tariff equivalent in trade volume to the observed tariff vector.

The TCP differs from the TRI and the MTRI because its objective is a tariff index suitable for comparison of tariff levels in the context of managing interdependence. This objective necessarily requires endogenous world prices, violating the fixed world prices assumption of the TRI and MTRI. The TCP admits the complexity of world price effects of tariffs and restores simplicity by assuming that given supplies of goods are distributed globally by efficient spatial arbitrage. Like the MTRI, the TCP is the uniform-across-sectors tariff equivalent in volume to the observed tariffs. Unlike the MTRI, the TCP is the vector of such uniform tariffs such that the observed vector of aggregate trade volumes valued at world prices is maintained for every country. Its calculation includes solving for the trade volume effects of all the national tariff eliminations simultaneously. Despite its underlying computational complexity, TCP tariff interpretation for public opinion is reasonably simple. Actual applied tariffs are hypothetically replaced by nationally uniform tariffs that maintain the each country's observed value of imports at world prices. Tariff heterogeneity across countries and products is dissolved in the set of border wall height measures for each country.

TCP calculation assumes an all-else-equal equilibrium where expenditures and national production vectors are held constant.[4] Like the True Cost of Living index, it compares the existing price (tariff) vector with a hypothetical price (tariff) vector that holds real income (trade volume at world prices) constant.

The implicit all-else-equal comparison of effective tariff rates across countries closely resembles the comparison of real effective exchange rates. Differentiated bilateral tariffs resemble the multiple financial frictions treated in the international finance literature as bilateral exchange rate deviations from Purchasing Power Parity. In principle, the trade weights used to calculate real effective exchange rates could be adjusted for interdependence and trade frictions following the methods used here to generate the TCP.

In contrast to the all-else-equal assumption, a large academic literature calculates the full general equilibrium comparative static effects of tariff changes (including from zero) on the trade and welfare of the countries. For example, suppose the objective is to compare welfare changes from trade policy. The projection model may be used to compare the percentage welfare losses of countries from existing tariffs relative to the universal zero tariff equilibrium.

[4]Head and Mayer (2014) call this "modular trade impact" analysis to distinguish it from full general equilibrium comparative static analysis where the impact of a set of tariff changes on real incomes and resource reallocation are included. Thus in comparative statics it accounts for first order general equilibrium trade diversion effects.

A more ambitious example is Ossa (2012), where changes in equilibrium welfare of a set of countries are calculated for the change between observed tariffs and the tariffs associated with a trade war equilibrium.[5] General equilibrium comparative statics require the model to project the effect of the hypothetical tariff changes on changes in incomes, expenditures and trade imbalances.

The results are less transparent than tariff averages to non-specialist audiences and thus less informative to public and policy maker opinion.[6] Another disadvantage in the context of public opinion influence is that changes in production and income variables induced by the change in tariffs widen the lens of the model and suggest focus on domestic policies along with trade policy. The TCP hypothetically changes only tariffs in its all-else equal measurement of the tariff wall's height.

The TCP index is developed and applied in the context of the CES (Constant Elasticity of Substitution) structural gravity model of bilateral trade (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Arkolakis et al., 2012; Allen et al., 2020). It also appears to closely approximate more general demand models, Anderson (forthcoming). Gravity is the current workhorse model of trade policy analysis because it fits the data extremely well, and its use in projections is remarkably more successful than most economic models. The application focuses on tariffs only for simplicity. Tariff equivalents of non-tariff barriers and protectionist aspects of domestic policies like subsidies can be incorporated into the TCP; see Anderson and Neary (2005).

3 The True Cost of Protection Index

The TCP is derived here based on the gravity model of spatial arbitrage. The CES version[7] simplifies gravity such that equilibrium bilateral trade flows are a decreasing constant

[5]Ossa (2012) also calculates the changes in welfare associated with a cooperative tariff equilibrium.

[6]Even the restrictive production technologies described by Arkolakis et al. (2012) appear at once too complex (to appreciate their power) and too simple (to avoid suspicion that excluded economic forces might change results). Trade imbalances are particularly problematic.

[7]The CES structure represents a reasonably wide class of models, Arkolakis et al. (2012).

elasticity function of relative resistance, explained below. The CES is chosen for familiarity but the method for measuring TCP extends to any fully parameterized demand system that represents buyers preferences or technologies.

We begin with the simple case where each country exports a single bundle of goods also sold at home and imports goods from each other country. The multiple sectors case is developed later when needed. We abstract throughout from a time dimension, as the extension to a sequence of static equilibria and their TCPs is straightforward.

Each country potentially exports to all others and imports from all others. Spatial arbitrage drives reallocation profits to zero in equilibrium. The trade flow effects of the complete bilateral system of trade frictions are reduced by arbitrage to a simple bilateral relative resistance. Relative resistance is the ratio of bilateral resistance (tariffs and all other trade frictions) to the product of buyer (inward) and seller (outward) multilateral resistances. The multilateral resistances are also the buyer and seller incidences of trade frictions on *all* sales, domestic and foreign.

The CES demand model implies that sales $X_{ij} = p_{ij}x_{ij}$ at buyer prices (p_{ij}) of goods from origin i to destination j (x_{ij}) are given by:

$$X_{ij} = E_j \left(\frac{\beta_{ij} p_{ij}}{P_j} \right)^{-\theta}, \ \theta > 0.$$

Here, E_j is the total expenditure in destination j on goods from all origins i including $i = j$, $\beta_{ij} > 0$ is a taste parameter and $P_j = [\sum_i (\beta_{ij} p_{ij})^{-\theta}]^{-1/\theta}$ is the CES price index. The trade elasticity θ is equal to one plus the constant elasticity of substitution parameter.

Arbitrageurs choose the spatial distribution of the national endowment y_i of goods for each origin country i. The quantity shipped from i to destination country j is denoted x_{ij}. The various frictions (transportation costs, search costs, delay costs, insurance from loss, advertisement, taste differences, tariffs and other trade barriers, sellers' pricing-to-market markups) are combined in exogenous (to the efficient marginal shipment choices of arbitrageurs) 'iceberg' trade frictions $f_{ij} > 1$. Thus the amount x_{ij} that arrives at j requires shipment from origin i equal to $f_{ij}x_{ij}$. Efficient spatial arbitrage (with zero profits) implies that the observed shipments satisfy

$$\max_{\{x_{ij}\}} \sum_j p_{ij}x_{ij} | \sum_j f_{ij}x_{ij} \leq y_i, \ \forall i. \tag{1}$$

The solution implies $p_{ij} = \lambda_i f_{ij}, \ \forall x_{ij} > 0$. The Lagrange multiplier is the opportunity cost of serving any destination j and is interpreted as $\lambda_i = c_i\Pi_i$ where c_i is the net price to the seller i and Π_i is the average efficient distribution cost facing seller i.

Efficient arbitrage implies that world sales of each country i's goods at buyer prices p_{ij} to each destination j can be modeled as if to a world buyer at a world price $c_i\Pi_i$. World sales from i must equal world expenditure so

$$\sum_j X_{ij} = Y_i = Y\left(\frac{c_i\Pi_i}{P^*}\right)^{-\theta}.$$

Here P^* is the "world" price index, equal to $[\sum_i (c_i\Pi_i)^{-\theta}]^{-1/\theta}$ from $\sum_i Y_i/Y = 1$. The normalization $P^* = 1$ is applied for simplicity. Apply the same normalization to the actual price indexes, $1 = \sum E_j P_j/Y$, so that the two equilibria are comparable. Country j's benchmark hypothetical expenditure on goods from i at "world" prices is $E_j Y_i/Y = E_j(c_i\Pi_i)^{-\theta}$. Country j's actual expenditure on goods from i reduces the benchmark hypothetical expenditure by the ratio

$$\left(\frac{\beta_{ij}p_{ij}/P_j}{c_i\Pi_i}\right)^{-\theta}.$$

Simplify the ratio to $\tau_{ij}t_{ij}/\Pi_i P_j$ where τ_{ij} is the tariff factor that j places on i's goods and $t_{ij} = \beta_{ij}p_{ij}/c_i$, the friction factor due to all other price and non-price frictions in the efficient arbitrage equilibrium. $c_i\Pi_i$ is the opportunity cost of sending a unit of good i to destination j. The effective willingness-to-pay $\beta_{ij}p_{ij}$ at the arbitrage equilibrium volume of trade must cover the extra friction cost represented by the ratio.

The resulting arbitrage equilibrium expenditure X_{ij} is given by the CES gravity equation:

$$X_{ij} = \frac{E_j Y_i}{Y} \left(\frac{\tau_{ij} t_{ij}}{\Pi_i P_j} \right)^{-\theta}. \tag{2}$$

The first ratio on the right hand side is the benchmark as-if-frictionless bilateral trade flow. The second term in brackets represents the effect of trade frictions f_{ij}. The frictions reduce trade by the power of the trade elasticity $\theta > 0$.[8] τ_{ij} in the numerator is the tariff factor placed on origin i by destination j ($\tau_{jj} = 1$ for domestic sales), while t_{ij} in the numerator is the effect of all other trade frictions, absorbing the β_{ij} taste differences.

The denominator of the frictions ratio is the product of the inward (P_j) and outward (Π_i) multilateral resistances of Anderson and van Wincoop (2003). These are general equilibrium trade cost indexes that consistently aggregate bilateral trade costs and decompose their incidence on the buyers (the inward multilateral resistance, P_j) and the sellers (the outward multilateral resistance, Π_i) in each country as if they buy from and sell to, respectively, a unified world market.

Two properties of the multilateral resistances (MRs) will be crucial for the construction and implications of the TCP index. First, MRs consistently aggregate bilateral buyer and seller incidences of trade frictions to the country level, so the TCP is a general equilibrium index that takes into account interaction of all active spatial links in the complete bilateral trade system. Second, the product of the MRs relative to their free trade values comprises the TCP, which implies its interpretation as the product of the buyer and seller incidences of tariffs.

Imports M_j are given by $M_j = \sum_{i \neq j} X_{ij}$. Then, protected M_j and free trade M_j^F imports are:

$$M_j = \sum_{i \neq j} \frac{Y_j E_j}{Y} \left(\frac{\tau_{ij} t_{ij}}{\Pi_i P_j} \right)^{-\theta}, \quad M_j^F = \sum_{i \neq j} \frac{Y_j E_j}{Y} \left(\frac{t_{ij}}{\Pi_i^F P_j^F} \right)^{-\theta}. \tag{3}$$

[8] The trade elasticity is a reduced form 'parameter' that represents a combination of demand and supply responses to price variation. The gravity literature has several special cases in which the trade elasticity is a parametric function of more basic supply and demand parameters.

An alternative expression for import expenditure isolates the effect of tariffs to their effect on the multilateral resistances. Imports are the difference between total expenditure and expenditure on the domestic good: $M_j = E_j - X_{jj}$ and $M_j^F = E_j - X_{jj}^F$. Thus

$$M_j = E_j \left[1 - \frac{Y_j}{Y}\left(\frac{t_{jj}}{\Pi_j P_j}\right)^{-\theta}\right],\ M_j^F = E_j \left[1 - \frac{Y_j}{Y}\left(\frac{t_{jj}}{\Pi_j^F P_j^F}\right)^{-\theta}\right].$$

The TCP for country j is the uniform tariff factor τ_j^μ that maintains the same level M_j when applied to replace the observed tariff factors. This has the effect of raising expenditure on the domestic good at rate $(\tau^\mu)^\theta$, as if the domestic relative friction t_{jj} were falling proportionally to τ^μ. Thus τ_j^μ is implicit in:

$$M_j = E_j \left[1 - \frac{Y_j}{Y}\left(\frac{t_{jj}}{\Pi_j P_j}\right)^{-\theta}\right] = E_j \left[1 - \frac{Y_j}{Y}\left(\frac{t_{jj}}{\Pi_j^F P_j^F}\right)^{-\theta}(\tau_j^\mu)^\theta\right]. \tag{4}$$

The true cost of protection index (the uniform tariff factor) is solved from equation (4) as:

$$TCP_j \equiv \tau_j^\mu = \frac{\Pi_j P_j}{\Pi_j^F P_j^F} = \frac{\Pi_j}{\Pi_j^F}\frac{P_j}{P_j^F},\ \forall j. \tag{5}$$

Equation (5) is operational when applied with standard gravity model methods.

TCPs are reciprocal in the sense that their construction maintains constant aggregate international trade volumes for all countries. As a general spatial equilibrium index, the TCP takes into account the effects of tariffs on all links in the complete bilateral trade system. The size of each country's tariff or tariff changes depends on the full spatial equilibrium effects of all tariffs captured in the product of ratios on the right hand side of equation (5).

A key property of TCPs is the close relationship between tariff reciprocity and the GATT/WTO interpretation of trade negotiations as reciprocal exchange of market access. This property follows from equation (4), which implies that imports are monotonically decreasing in τ_j^μ.[9]

[9] The all-countries multilateral free trade calculation is natural in the international policy relations context,

The TCP decomposes into the product of the incidence of tariffs on buyers (via P_j/P_j^F) and sellers (via Π_j/Π_j^F) in each country. This property is a structural general equilibrium version of the tariff pass-through literature, which is based on high-frequency price responses and mainly relies on reduced-form and partial equilibrium analysis. It differs significantly because the TCP barrier to imports is reduced by the domestic product price increase enabled by the tariff-induced fall in j's seller incidence as sales are diverted into the domestic market by the tariff.

3.1 TCP Measurement

TCP measurement requires determination of the multilateral resistances Π_j, P_j at the observed and free trade (F) equilibria. Equation (4) may be applied either to one country at a time (unilateral free trade) or to all countries together. In the international policy relations context the all countries multilateral free trade calculation is natural. Measurement requires a more realistic model with multiple sectors, denoted by subscript k. For all situations of tariff change, including the switch to uniform tariff factors, the multilateral resistances are the solutions to

$$\Pi_{i,k}^{-\theta_k} = \sum_j \frac{E_{j,k}}{Y_k} \left(\frac{\tau_{ij,k} t_{ij,k}}{P_{j,k}} \right)^{-\theta_k}, \ \forall i, k \tag{6}$$

and

$$P_{j,k}^{-\theta_k} = \sum_i \frac{Y_{i,k}}{Y_k} \left(\frac{\tau_{ij,k} t_{ij,k}}{\Pi_{j,k}} \right)^{-\theta_k}, \forall j, k. \tag{7}$$

Note that a number of variables are kept fixed in these calculations: $\{E_j, Y_i, t_{ij,k}\}$ as well as the trade elasticities. System (6)-(7) solves only up to a normalization (as is obvious from dividing through both sides by the left hand side variables).

System (6)-(7) is simple enough in form to be easily solved computationally for tariff changes, but it is complex enough to eliminate simple rules such as cutting all tariffs τ_{ij}

but the TCP can be applied to negotiations over changes either to one country at a time or to subsets or all countries at once.

by the same proportion. More importantly, political economy reasons lie behind the highly differentiated tariff structures of countries, suggesting the impossibility of broad uniform reduction rules. Solutions of system (6)-(7) for various proposed tariff factor sets $\{\tau'_{ij}\}$ combine with (4) to yield the resulting vector of τ^{μ}_{j}s. These are the basis for evaluating the various tariff changes for reciprocity and progress toward lower trade barriers.

For the many sectors case, the set of sectoral CES gravity equations nests within an upper level aggregator. For simplicity the aggregator is Cobb-Douglas (the limit case where the trade elasticity $\theta \to 0$). For each sector k there is an equation (4) that defines a sector-specific $\tau^{\mu}_{j,k}$. The Cobb-Douglas aggregator implies that $E_{j,k}/E_j = \alpha_{j,k},\ \alpha_{j,k} \in (0,1),\ \sum_k \alpha_{j,k} = 1$. Then the country j uniform tariff factor replaces the vector of $\tau^{\mu}_{j,k}$s with the scalar τ^{μ}_{j} that satisfies the constant M_j constraint (hence $\sum_k \alpha_{j,k} b_{jj,k}$ is constant):

$$\sum_k \alpha_{j,k} \frac{Y_{j,k}}{Y_k} \left(\frac{\tau^{\mu}_{j,k} t_{jj,k}}{(\Pi^{\mu}_{j,k})^F (P^{\mu}_{j,k})^F} \right)^{-\theta_k} = \sum_k \alpha_{j,k} \frac{Y_{j,k}}{Y_k} \left(\frac{\tau^{\mu}_{j} t_{jj,k}}{(\Pi^{\mu}_{j,k})^F (P^{\mu}_{j,k})^F} \right)^{-\theta_k},\ \forall j. \tag{8}$$

τ^{μ}_{j} does not have a closed form solution except in the case where $\theta_k = \theta,\ \forall k$. Equation (8) is operational given the set of solutions $\{\tau^{\mu}_{j,k}\}$. Solve (8) for τ^{μ}_{j} to obtain:

$$\tau^{\mu}_{j} = \left(\sum_k \frac{X^F_{jj,k}}{\sum_k X^F_{jj,k}} \left(\tau^{\mu}_{j,k}\right)^{-\theta} \right)^{-\frac{1}{\theta}}. \tag{9}$$

3.2 Local TCP Changes

Local tariff changes are analyzed for three reasons. First, the analysis illustrates the interdependence of TCPs. Change in one TCP changes all others in the same direction – tariff reciprocity. Second, TCP change is related to market access change. Third, bilateral marginal tariff reform is characterized that satisfies reciprocity and marginal MFN.

It eases notation in what follows to denote expenditure shares as

$$b_{ij} = \frac{X_{ij}}{E_j} = \frac{Y_i}{Y}\left(\frac{\tau_{ij}t_{ij}}{\Pi_i P_j}\right)^{-\theta}, \ \forall i, j.$$

Log-differentiate the right hand side of the first equation in (4) to yield

$$\hat{M}_j = -\frac{b_{jj}}{1-b_{jj}}\theta(\hat{\Pi}_j + \hat{P}_j).$$

A small equiproportionate rise in j's national tariff (a marginal MFN tariff change) implies $\hat{\tau}^{\mu}_j = \hat{\Pi}_j + \hat{P}_j > 0$. Efficient arbitrage due to (1) combines with exogenous seller costs c_j to imply that $\hat{\Pi}_j = 0$, due to the envelope theorem. In important contrast, $\hat{\Pi}_i \geq 0;\ \forall i \neq j$ due to the direct effect of j's tariff. Country j's tariff increase imposes a negative externality on all foreign sellers that raises their TCP's, reciprocity prior to any retaliation. The TCP rises need not be uniform, despite the marginal MFN property of $\hat{\tau}^{\mu}_j$.

The analysis also illustrates the local close relationship between the tariff index and trade volume. $\hat{\tau}^{\mu}_j \Rightarrow \hat{P}_j = (1-b_{jj})\hat{\tau}^{\mu}_j$. Thus the local comparative statics reduce to:

$$\hat{M}_j = -\theta b_{jj}\hat{\tau}^{\mu}_j. \tag{10}$$

Trade volume is proportional to τ^{μ}_j in rates of change. b_{jj} is the proportion of total expenditure that is domestic, the mass capable of being diverted to imports upon proportional reduction of tariffs $\hat{\tau}^{\mu}_j$. Equation (10) quantifies the close relationship between tariff reciprocity and market access reciprocity combined with the marginal MFN no-discrimination principle.

Finally, consider a bilateral agreement to reciprocally reduce tariffs by a small amount between countries j and l only. The envelope theorem for arbitrage implies $\hat{\Pi}_l = \hat{\Pi}_j = 0$. Their imports rise by $\widehat{M_j} = -\theta b_{lj}\hat{\tau}_{lj}$ and $\widehat{M_l} = -\theta b_{jl}\hat{\tau}_{jl}$. Equal market access change from bilateral tariff reciprocity requires symmetry, $b_{lj} = b_{jl}$, and thus may condition the choice of potential partners. (Symmetry and reciprocity could also suggest combinations of jointly compatible partners.) Trade diversion from non-partners implies that $\hat{\Pi}_i \geq 0, \ \forall i \neq j, l$. The negative externality incentivizes subsequent bilateral agreements between relatively symmetric partners. Agreements sequences guided by gradual reduction in TCPs thus may flexibly achieve much liberalization.

For finite tariff changes, the full system of interaction of tariffs given by (6)-(7) generates the multilateral resistance changes and thus the TCP discrete changes. TCP tariffs are monotonically decreasing in trade volumes but proportionality need not hold.

4 Empirical Application

The TCP requires the availability of domestic trade flows (hence production data matched with trade data). We use two datasets constructed and maintained by the United States International Trade Commission (USITC). Specifically, we use the *International Trade and Production Database for Estimation* (ITPD-E) of Borchert et al. (2022) and the *International Trade and Production Database for Simulation* (ITPD-S) of Borchert et al. (2024). Both datasets include trade and production data for many countries (more than 200) and 170 industries over a long period of time (1988-2019 for goods and 2000-2019 for services). The ITPD-E uses only raw administrative data, which renders it suitable for estimation. The ITPD-S is based on the ITPD-E but fills any missing trade values and it is perfectly balanced. Thus it is suitable for counterfactual analysis, including the construction of the TCP.

In addition to the two trade and production datasets of the USITC, we use a new (not yet released) USITC dataset on tariffs that consistently aggregates product-level tariffs to match the dimensions of the ITPD-E and the ITPD-S datasets. Finally, we also employ various datasets to construct proxies for bilateral trade costs, which are used in our gravity estimations. Specifically, we rely on the *Dynamic Gravity Dataset* (DGD) of the USITC (Gurevich and Herman, 2018)[10] for data on European Union (EU) and World Trade Organi-

[10] https://www.usitc.gov/data/gravity/dgd.htm

zation (WTO) membership, and all standard time-invariant gravity variables, e.g., distance, contiguity, common official language, and colonial relationships. An indicator variable for Euro membership is based on data from the European Union,[11] while data on other currency unions are from Jose de Sousa's database.[12] Data on membership in Regional Trade Agreements (RTAs) are from Egger and Larch (2008).[13] Finally, data on sanctions are from the latest edition of the *Global Sanctions Database* (Syropoulos et al., 2024).[14]

The application focuses on the manufacturing industries in the ITPDs. Services industries are excluded since there are no tariffs for services, and we also exclude agriculture and mining. Due to availability of tariff data and convergence issues, we are unable to obtain uniform tariff estimates for 11 of the 118 manufacturing industries in the ITPD. Thus we report and analyze results for 107 industries, which are listed in Table 1.

We proceed in two steps. First, we use the ITPD-E to estimate gravity for each of the industries to obtain the trade cost estimates for the base case. Then we use the ITPD-S to construct the TCP by solving the gravity system with and without tariffs for each industry. We use the most recent year available in the ITPDs - 2019. We use a common trade elasticity of 4. Finally, to mitigate/avoid convergence issues, e.g., due to some very small countries, we select the 99 largest exporters. These account for more than 99% of exports.

Since the number of TCP tariffs is large ($99 \times 107 = 10,593$), we report in four steps. First, we report summary statistics based on the full set of TCPs. Second, we report U.S. industry-specific TCP tariffs. Third, we discuss the cross-country variation of aggregate TCP tariffs compared to the corresponding import-weighted tariffs. Finally, we decompose the TCP index into the incidences of tariffs on buyers and sellers in each country and industry.

First, the TCP tariffs and the import-weighted tariffs in the full set of 10,593 tariffs are positively but far from perfectly correlated. The average correlation across all industries is 0.65, but it varies between 0.10 (for 'Distilling rectifying and blending of spirits') and 0.86 (for

[11]https://european-union.europa.eu/institutions-law-budget/euro/countries-using-euro_en
[12]http://jdesousa.univ.free.fr/data.htm
[13]https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html
[14]https://www.globalsanctionsdatabase.com/

'Starches and starch products'). The industries with the highest correlation are "Starches and starch products" and "Medical surgical and orthopedic equipment". Interestingly, the lowest correlations are for "Distilling rectifying and blending of spirits", "Wines", and "Malt liquors and malt".

The results show that uniform tariffs are predominantly smaller but can be larger than the import-weighted tariffs. The predominance of smaller TCPs is due to concavity of the CES price index function and Jensen's inequality, which holds when sectoral trade balance prevails. Instead, revealed comparative advantage (sectoral exports larger than sectoral imports) is negatively associated with domestic expenditure share $b_{jj,k}$. The combination of revealed comparative advantage and its likely effect on reducing sectoral tariff uniform measures τ_k^μ would reduce the TCP below the import-weighted average tariff even in the linear case $\theta = -1$.

Overall TCPs are larger than import-weighted tariffs for some countries, potentially explained by *overall* trade deficits. The international borrowing implied by a trade deficit enables more spending on its imports while its partners' lending implies them spending less on its exports. All else equal, this raises its TCP relative to its balanced trade level.

Formally, j's sellers' incidence is increased by its external borrowing. In equation (6), replace $E_{j,k}$ with $\phi_j Y_j \alpha_{j,k}$ where $E_j = \phi_j Y_j$ and $\phi_j > 1$ is associated with external borrowing. World balanced budget equilibrium requires $\sum_i \phi_i Y_i / \sum_i Y_i = 1$, which implies that the lending countries have $\phi_i < 1$. Turn to the impact on j's seller incidence:

$$\Pi_{i,k}^{-\theta_k} = \sum_j \frac{\phi_j Y_j \alpha_{j,k}}{Y_k} \left(\frac{\tau_{ij,k} t_{ij,k}}{P_{j,k}} \right)^{-\theta_k}, \ \forall i, k.$$

Country j's borrowing ($\phi_j > 1$) raises the weight on its (lower friction) domestic sales while the lending of other countries ($\phi_i \leq 1,\ i \neq j$) reduces their spending on j's exports to higher friction destinations. This reallocation lowers the right hand side of the equation and thus raises Π_j. Notably in Figure 2, Turkey's TCP is relatively far above its import-weighted average due to its relatively high merchandise trade deficit.

Second, we report on sectoral variation of TCPs as a measure of relative protection offered by a country. The sectoral TCP tariffs for the U.S. are reported in Table 1.[15] All but one of the U.S. TCP tariffs are positive. The single negative value is for "Publishing of books and other publications", but it is essentially zero (-0.0003). Some other country-sector TCPs (not shown) are also negative. Negative sectoral TCPs are explained by trade diversion as the observed tariffs divert the sectoral trade into low or zero tariff destinations. The switch to uniform tariffs in the hypothetical equilibrium implies that import subsidies are required to maintain the observed import totals for the low sector-country destinations.

Returning to the variation of U.S. sectoral TCPs, the smallest positive uniform tariff (0.0004) is for "Publishing of newspapers journals etc.". The largest uniform tariffs of about 7% are for industries marked by large Chinese imports, e.g., "Industry Luggage handbags etc.", "Wearing apparel except fur apparel", "Pottery china and earthenware", "Textile fibre preparation; textile weaving", and "Refractory ceramic products". The correlation between the TCP and import-weighted tariffs for U.S. is 0.6 - high but far from perfect. Figure 1 visualizes the indexes from Table 1 and shows that most of the import-weighted tariffs for the U.S. are actually lower than the corresponding TCP tariffs. This reflects the overall trade deficit, as previously noted.

Tariff change reciprocity with sectoral trade imbalances should be used with care. Reciprocity applied to eliminating sectoral imbalances negates comparative advantage and thus eliminates the specialization gains from trade. In contrast, tariff reciprocity applied to *negotiations over tariff policy changes* can increase gains from trade for all countries while allowing for tariff changes due to protectionist pressures and domestic externalities in the individual countries. Thus its application may be consistent with effective management of international relations and the WTO principles.

[15] For brevity, Table 1 reports the U.S. TCP and import-weighted tariffs for half of the manufacturing industries from the ITPD-E data. The full set of estimates are available by request and they are visualized in Figure 1.

Third, we examine the cross-country variation of TCP indexes relative to import-weighted average tariffs. Table 2 reports the uniform TCP tariffs per country, which are aggregated according to equation (9).[16] The lowest uniform TCP tariffs, i.e., subsidies, are about -3% for Peru, Iraq, and Chile, and the largest TCP tariffs vary between 5% and 13% for BGD (5%), PAK (5%), BMU (6%), LKA (6%), BRA (7%), IND (9%), MNG (12%), and KEN (13%). Notably some of the largest tariffs are for Asian economies other than China. The correlation between the TCP and the import-weighted country tariffs is 0.53 - high but far from perfect. Figure 2 visualizes the indexes from Table 2 and shows that most of the import-weighted tariffs are higher than the corresponding TCP tariffs. Consistent with Figure 1, the U.S. is one of the countries whose TCP index is larger than the corresponding import-weighted average tariff. Interestingly, some of the other countries whose TCP tariffs are larger than their import-weighted tariffs are countries that are peripheral but not members of the EU, e.g., Norway, Switzerland, and Turkey.

Finally, we report buyer and seller incidence variation of the TCP tariffs decomposition as implied by equation (5). The results for each United States industry are reported in Table 1. Four patterns emerge, depending on the direction and magnitudes of effects on the sellers (i.e., the percentage changes in the OMRs in column (5)) and the buyers (i.e., the percentage changes in the IMRs in column (6)).[17] First, for 85 percent of the industries (91 out of 107), both buyers and sellers in the U.S. have tariff incidence above 1. Second, in more than two-thirds of cases with tariff incidence above 1 for both sellers and buyers, the buyers incidence is larger, i.e., U.S. buyers pay most of the tariff. Third, in 11 industries, most of which are in the Food sector, U.S. sellers suffer tariff incidence above 1, while U.S. buyers enjoy incidence below 1. Finally, for 5 industries, seller incidence is below 1. In four

[16]For brevity, Table 2 reports the TCP and import-weighted tariffs for half of the countries in our sample. The full set of estimates are available by request and they are visualized in Figure 2.

[17]The TCP effects for each country-industry combination are due to three forces: (i) higher tariffs on imports; (ii) higher tariffs on exports; and (iii) general equilibrium forces due to own tariffs and tariffs in other countries. Therefore, unlike the simple case of unilateral protection, where the direction of the impact on the producers and the consumers is clear (i.e., producers in the protecting country will gain, while the consumers will suffer higher prices), the effects that we report in Table 1 are composite indexes that are hard to decompose.

of these cases, the decreases in seller incidence are very small. The only meaningful change (an increase of about 1 percent) is for "Games and toys", where buyer prices rise about 2 percent.

There is wide variation across countries in their proportions of seller incidence greater than one. Since TCP variation is small, the cross-country variation in proportions is mainly due to variation in their non-price determinants of trade "frictions" such as heterogeneity in quality and taste or technology along with standard gravity controls. But rich countries tend to have higher proportions of seller incidence greater than one. The U.S. leads, but other rich economies are similar. For example, the next 9 countries after the U.S. with significant fractions of seller incidences > 1 (i.e., more than 70%) are JPN, TUR, IND, FIN, RUS, SWE, ITA, DEU, and ESP. Almost all EU countries have shares greater than 50%. The U.S. extreme share is likely due to its larger overall trade deficit, as analyzed above. In contrast, the percentage of seller incidences greater than 1 among *all* country-sector observations is 40%. China's percentage is 31%, an outlier attributable to its large relative trade surplus (on the same reasoning applied to the U.S. trade deficit).

5 Conclusion

This paper defines and applies a tariff index that measures the height of tariff walls suitable for comparison across countries. The results demonstrate a "proof of concept". Refinements for the future include better data, sensitivity to trade elasticities, and treatment of aggregate trade imbalances.

Higher trade elasticities increase the concavity of the CES aggregator, hence increase differences between TCPs and import-weighted average tariffs. Consensus on the elasticities remains elusive. Large aggregate trade imbalances have substantial effects on the TCP. How these differences should be treated in the context of trade negotiations is a question for future research.

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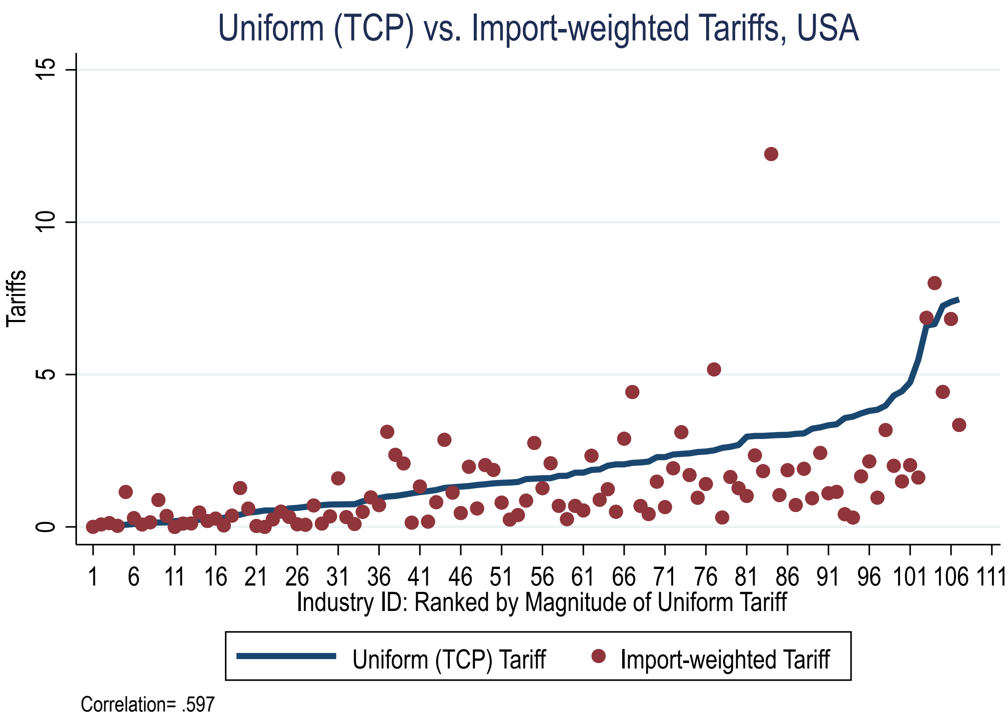
Table 1: TCP, Import-weighted Tariffs, and TCP Incidence

Industry Description	TCP	Weighted	Correlation	$\%\Delta\Pi$	$\%\Delta P$
Agricultural and forestry machinery	0.66	0.07	0.77	0.17	0.49
Articles of concrete cement and plaster	0.54	0.00	0.56	0.09	0.45
Bakery products	2.59	0.31	0.59	0.33	2.26
Basic iron and steel	1.68	0.25	0.72	0.85	0.82
Bearings gears gearing and driving elements	2.05	0.50	0.67	0.98	1.06
Builders' carpentry and joinery	1.38	0.61	0.74	-0.02	1.39
Building/repairing of pleasure/sport. boats	0.84	0.49	0.75	0.21	0.63
Cement lime and plaster	2.10	4.43	0.44	0.03	2.07
Cordage rope twine and netting	1.87	2.34	0.63	1.24	0.62
Cutlery hand tools and general hardware	1.46	0.24	0.72	1.07	0.38
Distilling rectifying and blending of spirits	0.27	0.27	0.10	0.21	0.06
Dressing and dyeing of fur; processing of fur	1.06	2.08	0.48	1.72	-0.65
Electronic valves tubes etc.	2.29	1.48	0.68	1.85	0.43
Fertilizers and nitrogen compounds	1.32	0.45	0.67	0.25	1.07
Furniture	1.58	2.76	0.72	0.32	1.26
Games and toys	1.00	3.12	0.77	-0.92	1.94
Insulated wire and cable	2.29	0.65	0.67	1.17	1.11
Lifting and handling equipment	3.02	1.86	0.78	0.50	2.51
Luggage handbags etc.; saddlery and harness	6.61	6.86	0.80	2.65	3.85
Machine tools	1.67	0.69	0.78	0.95	0.72
Machinery for mining and construction	2.63	1.64	0.72	0.83	1.78
Made-up textile articles except apparel	2.51	5.17	0.73	3.39	-0.85
Man-made fibres	3.22	0.94	0.73	1.88	1.32
Medical surgical and orthopaedic equipment	0.10	0.29	0.85	0.03	0.07
Motorcycles	2.42	1.70	0.79	1.65	0.75
Office accounting and computing machinery	0.47	0.60	0.78	0.26	0.21
Other articles of paper and paperboard	0.54	0.25	0.74	0.06	0.48
Other fabricated metal products n.e.c.	1.40	2.03	0.80	-0.04	1.45
Other general purpose machinery	0.95	0.71	0.79	0.05	0.90
Other non-metallic mineral products n.e.c.	4.74	2.03	0.50	1.01	3.69
Other rubber products	3.02	1.04	0.70	1.75	1.25
Other textiles n.e.c.	2.99	2.35	0.67	0.52	2.45
Other wood products; articles of cork/straw	0.74	1.59	0.77	0.23	0.51
Paints varnishes printing ink and mastics	2.99	1.83	0.62	0.36	2.62
Pesticides and other agro-chemical products	2.38	1.93	0.60	0.42	1.95
Plastic products	1.60	1.27	0.72	0.48	1.11
Pottery china and earthenware	7.25	4.43	0.66	2.76	4.38
Printing	0.21	0.11	0.81	0.03	0.18
Processing/preserving of fish	2.46	0.96	0.59	4.14	-1.61
Publishing of books and other publications	-0.03	0.00	0.54	-0.04	0.01
Publishing of newspapers journals etc.	0.04	0.08	0.41	0.02	0.02
Pulp paper and paperboard	0.12	0.08	0.80	0.03	0.09
Railway/tramway locomotives and rolling stock	1.10	0.14	0.67	1.65	-0.54
Refractory ceramic products	7.47	3.35	0.60	2.60	4.74
Sawmilling and planing of wood	0.06	0.04	0.56	0.00	0.05
Soap cleaning and cosmetic preparations	0.37	0.37	0.67	0.05	0.32
Sports goods	1.28	2.86	0.62	0.25	1.02
Steam generators	2.12	0.69	0.48	0.82	1.28
Structural metal products	1.89	0.89	0.78	0.11	1.77
TV and radio receivers and associated goods	0.25	0.19	0.74	0.18	0.07
Textile fibre preparation; textile weaving	7.38	6.82	0.65	1.95	5.33
Vegetable and animal oils and fats	0.14	0.88	0.69	0.12	0.02
Watches and clocks	0.40	1.28	0.79	0.08	0.32
Wearing apparel except fur apparel	6.66	8.00	0.67	5.80	0.81
Wooden containers	0.70	0.70	0.70	0.04	0.66

Notes: This table reports the uniform (TCP) U.S. tariffs and the corresponding import-weighted U.S. tariffs for half of the manufacturing industries from the ITPD-E data. The full set of estimates are available by request and they are visualized in Figure 1. Column (1) lists ITPD-E ID codes for each of the industries. Column (2) reports the TCP tariffs. Column (3) reports the corresponding import-weighted tariffs. Column (4) reports the correlation between the TCP and import-weighted tariffs for each industry. Finally, columns (5) and (6) report the percentage changes in the OMRs and IMRs for each industry. See text for further details.

Figure 1: Industry-level Uniform (TCP) Tariffs vs. Import-weighted Tariffs, USA



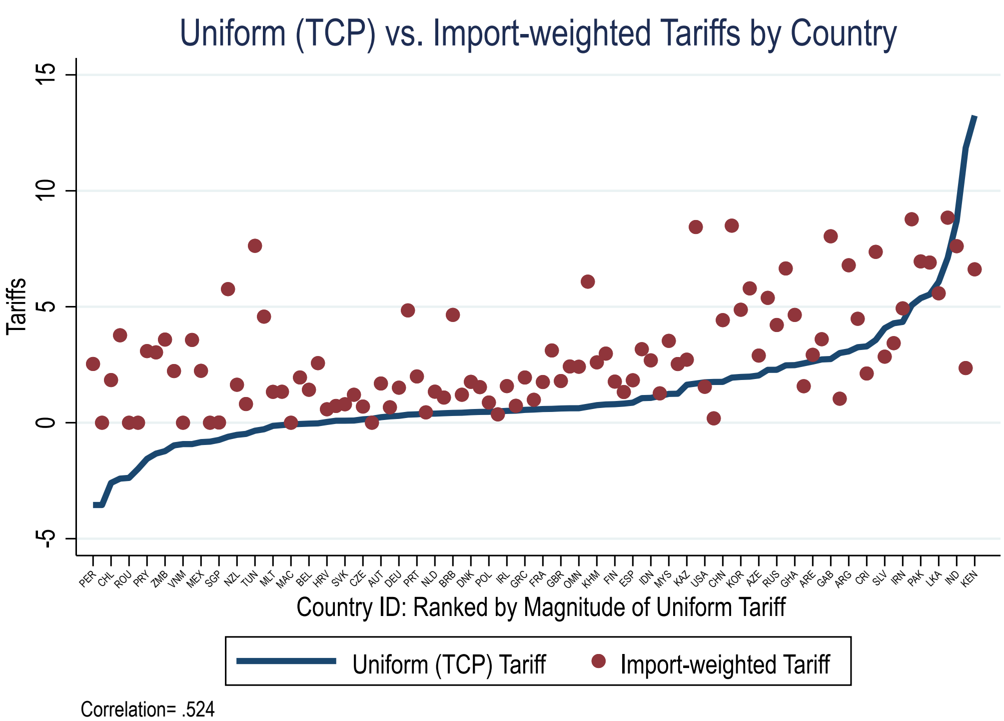
Note: This figure visualizes the uniform (TCP) U.S. tariffs and the corresponding import-weighted U.S. tariffs for 107 manufacturing industries from the ITPD-E data. The blue curve plots the uniform (TCP) tariffs in increasing order, while the red scatterplot visualizes the corresponding import-weighted U.S. tariffs. See text for further details.

Table 2: Uniform (TCP) Tariffs vs. Import-weighted Tariffs

ISO3 Country Code	Uniform (TCP) Tariffs	Import-weighted Tariffs
AGO	1.99	5.79
ARG	3.08	6.79
AUT	0.24	1.69
BEL	-0.04	1.42
BGD	5.07	8.77
BGR	0.27	0.67
BMU	5.53	6.91
BRA	7.11	8.84
CHE	0.17	0.00
CHL	-2.60	1.84
CHN	1.76	4.42
CRI	3.29	2.12
DEU	0.30	1.51
DOM	-0.92	3.57
ECU	3.25	4.48
ESP	0.86	1.83
FRA	0.59	1.76
GBR	0.61	1.80
GRC	0.55	1.95
HUN	0.41	1.08
IND	8.71	7.61
IRN	4.35	4.93
IRQ	-3.55	0.00
ITA	0.47	1.53
JPN	2.56	1.58
KEN	13.24	6.62
KOR	1.97	4.87
LBN	0.62	2.43
LKA	6.07	5.58
LVA	0.57	0.99
MEX	-0.84	2.24
MNG	11.85	2.36
MYS	1.24	3.53
NLD	0.39	1.34
NOR	1.76	0.19
NPL	2.47	6.65
PAK	5.37	6.96
PER	-3.55	2.53
POL	0.47	0.87
PRY	-1.56	3.09
ROU	-2.38	0.00
RUS	2.28	4.21
SGP	-0.74	0.01
SRB	-1.99	0.00
SVN	0.09	0.72
THA	0.69	6.08
TUN	-0.34	7.63
TUR	3.00	1.04
TWN	-0.82	0.00
USA	1.74	1.55
VEN	1.95	8.50
ZAF	4.29	3.43

Notes: This table reports the uniform (TCP) tariffs and the corresponding import-weighted tariffs for half of the 99 countries in our sample. The full set of estimates are available by request and they are visualized in Figure 2. Column (1) lists the ISO3 codes for each of the countries. Column (2) reports the uniform TCP tariffs, and column (3) reports the corresponding import-weighted tariffs. See text for further details.

Figure 2: Uniform (TCP) Tariffs vs. Import-weighted Tariffs by Country



Note: This figure visualizes the uniform (TCP) tariffs and the corresponding import-weighted tariffs for each of the 99 countries in our sample. The blue curve plots the uniform (TCP) tariffs in increasing order, while the red scatterplot visualizes the corresponding import-weighted tariffs. See text for further details.