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# Trade Wars and Trade Talks with Data†

*By* Ralph Ossa*

*How large are optimal tariffs? What tariffs would prevail in a worldwide trade war? How costly would a breakdown of international trade policy cooperation be? And what is the scope for future multilateral trade negotiations? I address these and other questions using a unified framework which nests traditional, new trade, and political economy motives for protection. I find that optimal tariffs average 62 percent, world trade war tariffs average 63 percent, the government welfare losses from a breakdown of international trade policy cooperation average 2.9 percent, and the possible government welfare gains from future multilateral trade negotiations average 0.5 percent.* (*JEL* F12, F13, O19)

I propose a flexible framework for the quantitative analysis of noncooperative and cooperative trade policy. It is based on a multi-country multi-industry general equilibrium model of international trade featuring inter-industry trade as in Ricardo (1817), intra-industry trade as in Krugman (1980), and special interest politics as in Grossman and Helpman (1994). By combining these elements, it takes a unified view of trade policy which nests traditional, new trade, and political economy motives for protection. Specifically, it features import tariffs which serve to manipulate the terms-of-trade, shift profits away from other countries, and protect politically influential industries. It can be easily calibrated to match industry-level tariffs and trade.

I use this framework to provide a first comprehensive quantitative analysis of noncooperative and cooperative trade policy, focusing on the main players in recent GATT/WTO negotiations. I begin by considering optimal tariffs, i.e., the tariffs countries would impose if they did not have to fear any retaliation. I find that each country can gain considerably at the expense of other countries by unilaterally imposing optimal tariffs. In the complete version with lobbying, the mean welfare gain of the tariff imposing government is 1.9 percent, the mean welfare loss of the other governments is −0.7 percent, and the average optimal tariff is 62.4 percent.

* Booth School of Business, University of Chicago, 5807 South Woodlawn Avenue, Chicago, IL 60637 (e-mail: ralph.ossa@chicagobooth.edu). I would like to thank two anonymous referees as well as Kyle Bagwell, Kerem Cosar, Chang-Tai Hsieh, Giovanni Maggi, Andres Rodríguez-Clare, Bob Staiger, Jon Vogel, and seminar participants at various universities and conferences for very helpful comments and suggestions. Seyed Ali Madanizadeh provided excellent research assistance. This work is supported by the Business and Public Policy Faculty Research Fund at the University of Chicago Booth School of Business. The author declares that he has no relevant or material financial interests that relate to the research described in this paper.

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These averages are of a comparable magnitude in the baseline version in which political economy forces are not taken into account.

I then turn to an analysis of Nash tariffs, i.e., the tariffs countries would impose in a worldwide trade war in which their trading partners retaliated optimally. I find that countries can then no longer benefit at the expense of one another and welfare falls across the board so that nobody is winning the trade war. Intuitively, each country is imposing import tariffs in an attempt to induce favorable terms-of-trade and profit shifting effects. The end result is a large drop in trade volumes which is leaving everybody worse off. In the complete version with lobbying, the mean government welfare loss is $-2.9$ percent and the average Nash tariff is 63.4 percent. These averages are again quite similar in the baseline version in which political economy forces are not taken into account.

I finally investigate cooperative tariffs, i.e., the tariffs countries would negotiate to in efficient trade negotiations. I consider trade negotiations starting at Nash tariffs, factual tariffs, and zero tariffs following a Nash bargaining protocol. I find that trade negotiations yield significant welfare gains, that a large share of these gains has been reaped during past trade negotiations, and that free trade is close to the efficiency frontier. In the complete version with lobbying, trade negotiations starting at Nash tariffs, factual tariff, and zero tariffs yield average government welfare gains of 3.6 percent, 0.5 percent, and 0.2 percent, respectively. These averages are again quite similar in the baseline version in which political economy forces are not taken into account.

I am unaware of any quantitative analysis of noncooperative and cooperative trade policy which is comparable in terms of its scope. I believe that this is the first quantitative framework which nests traditional, new trade, and political economy motives for protection. Likewise, there is no precedent for estimating noncooperative and cooperative tariffs at the industry level for the major players in recent GATT/WTO negotiations. The surprising lack of comparable work is most likely rooted in long-binding methodological and computational constraints. In particular, the calibration of general equilibrium trade models has only been widely embraced quite recently following the seminal work of Eaton and Kortum (2002). Also, the calculation of disaggregated noncooperative and cooperative tariffs is very demanding computationally and was simply not feasible without present-day algorithms and computers.

The most immediate predecessors are Perroni and Whalley (2000); Broda, Limao, and Weinstein (2008); and Ossa (2011). Perroni and Whalley (2000) provide quantitative estimates of noncooperative tariffs in a simple Armington model which features only traditional terms-of-trade effects. Ossa (2011) provides such estimates in a simple Krugman (1980) model which features only new trade production relocation effects. Both contributions allow trade policy to operate only at the most aggregate level so that a single tariff is assumed to apply against all imports from any given country.[1] Broda, Limao, and Weinstein (2008) provide detailed statistical estimates of the inverse export supply elasticities faced by a number of non-WTO member countries. The idea is to test the traditional optimal tariff formula which

[1] Neither contribution computes cooperative tariffs. The work of Perroni and Whalley (2000) is in the computable general equilibrium tradition and extends an earlier contribution by Hamilton and Whalley (1983). It predicts implausibly high noncooperative tariffs of up to 1,000 percent. See also Markusen and Wigle (1989) and Ossa (2012a).

states that a country's optimal tariff is equal to the inverse export supply elasticity it faces in equilibrium.[2]

The paper further relates to an extensive body of theoretical and quantitative work. The individual motives for protection are taken from the theoretical trade policy literature including Johnson (1953–1954); Venables (1987); and Grossman and Helpman (1994).[3] The analysis of trade negotiations builds on a line of research synthesized by Bagwell and Staiger (2002). My calibration technique is similar to the one used in recent quantitative work based on the Eaton and Kortum (2002) model such as Caliendo and Parro (forthcoming). However, my analysis differs from this work in terms of question and framework. In particular, I go beyond an investigation of exogenous trade policy changes by emphasizing noncooperative and cooperative tariffs.[4] Also, I take a unified view of trade policy by nesting traditional, new trade, and political economy effects.

My application focuses on 7 regions and 33 industries in the year 2007. The regions are Brazil, China, the European Union, India, Japan, the United States, and a residual Rest of the World and are chosen to comprise the main players in recent GATT/WTO negotiations. The industries span the agricultural and manufacturing sectors of the economy. My main data source is the most recent Global Trade Analysis Project database (GTAP 8) from which I take industry-level trade, production, and tariff data. In addition, I use the United Nations' (UN) Comtrade trade data for the time period 1994–2008 for my estimation of demand elasticities, and the International Trade Centre's Market Access Map tariff data as well as the UN's TRAINS tariff data for my calibration of political economy weights. A detailed discussion of the data including the applied aggregation and matching procedures can be found in the Appendix.

To set the stage for a transparent presentation of the theory, it is useful to discuss the elasticity estimation up-front. As will become clear shortly, I need industry-level estimates of CES demand elasticities which do not vary by country. I obtain such estimates by applying the well-known Feenstra (1994) method to the UN trade data pooled across the main importers considered in my analysis. The results are listed in Table 1. As can be seen, the variation in the elasticities appears plausible with homogeneous goods such as wheat and rice having the largest values. Moreover, the mean elasticity of 3.4 is within the range of previous findings in the literature, and I will also consider various scalings as sensitivity checks. The interested reader can find a more detailed discussion of the elasticity estimation in the Appendix.

The remainder of the paper is organized as follows. I first lay out the basic setup, characterize the equilibrium for given tariffs, demonstrate how to compute the

[2] This approach is not suitable for estimating the optimal tariffs of WTO member countries. This is because such countries impose cooperative tariffs so that the factual inverse export supply elasticities they face are not informative of the counterfactual inverse export supply elasticities they would face if they imposed optimal tariffs under all but the most restrictive assumptions.

[3] Mathematically, the analyzed profit shifting effect is more closely related to the production relocation effect in Venables (1987) than the classic profit shifting effect in Brander and Spencer (1981). This is explained in more detail in footnote 12. See Mrazova (2011) for a recent treatment of profit shifting effects in the context of GATT/WTO negotiations.

[4] Existing work typically focuses on quantifying the effects of exogenous tariff changes. Caliendo and Parro (forthcoming), for example, analyze the effects of the North American Free Trade Agreement. One exception can be found in the work of Alvarez and Lucas (2007) which includes a short discussion of optimal tariffs in small open economies.

Table 1—Parameter Estimates

| | $\sigma_s$ | $\lambda_{BRA}$ | $\lambda_{CHN}$ | $\lambda_{EU}$ | $\lambda_{IND}$ | $\lambda_{JPN}$ | $\lambda_{ROW}$ | $\lambda_{US}$ |
|---|---|---|---|---|---|---|---|---|
| Wheat | 10.07 | 1.29 | 1.68 | 1.66 | 1.67 | 1.91 | 1.27 | 1.24 |
| Rice | 7.01 | 1.23 | 1.64 | 1.51 | 1.38 | 1.91 | 1.23 | 1.19 |
| Dairy | 5.89 | 1.24 | 1.29 | 1.56 | 1.29 | 1.46 | 1.25 | 1.34 |
| Wearing apparel | 5.39 | 1.29 | 1.46 | 1.22 | 1.13 | 1.03 | 1.22 | 1.48 |
| Other metals | 4.47 | 1.11 | 0.80 | 1.06 | 1.05 | 0.94 | 1.08 | 1.16 |
| Vegetable oils, etc. | 4.03 | 1.13 | 1.19 | 1.09 | 1.50 | 0.96 | 1.08 | 1.03 |
| Bovine meat products | 3.89 | 1.05 | 1.16 | 1.44 | 1.05 | 0.95 | 1.11 | 1.07 |
| Leather products | 3.67 | 1.18 | 1.13 | 1.06 | 0.97 | 1.17 | 1.08 | 1.22 |
| Ferrous metals | 3.67 | 1.10 | 0.73 | 1.04 | 1.04 | 0.90 | 1.03 | 1.09 |
| Other manufactures | 3.53 | 1.15 | 1.22 | 1.06 | 1.00 | 0.86 | 1.04 | 1.23 |
| Other cereal grains | 3.32 | 0.98 | 1.22 | 1.26 | 1.04 | 1.72 | 1.41 | 0.91 |
| Oil seeds | 3.21 | 0.97 | 1.01 | 0.87 | 1.20 | 1.79 | 1.20 | 1.04 |
| Other meat products | 3.20 | 1.03 | 1.09 | 1.12 | 1.04 | 0.91 | 1.11 | 0.96 |
| Beverages and tobacco products | 2.92 | 1.01 | 1.45 | 1.28 | 1.51 | 0.93 | 1.09 | 1.24 |
| Bovine cattle, etc. | 2.91 | 0.92 | 0.56 | 1.07 | 0.92 | 0.94 | 0.91 | 0.81 |
| Textiles | 2.87 | 1.04 | 1.19 | 0.96 | 0.91 | 0.82 | 0.99 | 1.26 |
| Other transport equipment | 2.84 | 0.91 | 0.76 | 0.94 | 0.74 | 0.73 | 0.90 | 1.03 |
| Plant-based fibers | 2.80 | 0.96 | 0.58 | 0.77 | 0.82 | 0.73 | 0.90 | 0.81 |
| Wool, etc. | 2.76 | 0.91 | 0.85 | 0.00 | 0.86 | 1.37 | 0.91 | 0.64 |
| Motor vehicles, etc. | 2.75 | 0.99 | 1.18 | 0.99 | 0.96 | 0.73 | 0.92 | 0.90 |
| Metal products | 2.70 | 1.01 | 0.96 | 0.94 | 0.84 | 0.75 | 0.91 | 1.06 |
| Sugar | 2.69 | 0.92 | 1.22 | 1.10 | 1.34 | 1.27 | 1.00 | 0.85 |
| Other food products | 2.62 | 0.90 | 1.01 | 0.98 | 1.05 | 0.93 | 0.96 | 0.89 |
| Paper products, etc. | 2.56 | 0.93 | 0.67 | 0.88 | 0.81 | 0.73 | 0.86 | 0.91 |
| Other crops | 2.53 | 0.92 | 0.64 | 0.87 | 1.12 | 0.74 | 0.93 | 0.80 |
| Electronic equipment | 2.49 | 0.91 | 0.82 | 0.87 | 0.61 | 0.66 | 0.84 | 1.00 |
| Other mineral products | 2.47 | 0.92 | 0.87 | 0.87 | 0.80 | 0.72 | 0.89 | 1.02 |
| Other machinery, etc. | 2.46 | 0.94 | 0.76 | 0.86 | 0.79 | 0.73 | 0.83 | 1.00 |
| Vegetables, etc. | 2.42 | 0.82 | 0.96 | 0.83 | 1.01 | 0.90 | 0.90 | 0.80 |
| Chemical products, etc. | 2.34 | 0.85 | 0.74 | 0.84 | 0.73 | 0.71 | 0.81 | 0.96 |
| Wood products | 2.32 | 0.90 | 0.77 | 0.79 | 0.72 | 0.71 | 0.83 | 0.90 |
| Forestry | 2.20 | 0.77 | 0.78 | 0.66 | 0.61 | 0.70 | 0.76 | 0.61 |
| Other animal products | 1.91 | 0.68 | 0.59 | 0.56 | 0.50 | 0.72 | 0.73 | 0.53 |
| Mean | 3.42 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

*Notes:* The entries under "$\sigma_s$" are the estimated elasticities of substitution. The entries under "$\lambda_{BRA}$" until "$\lambda_{US}$" are the estimated political economy weights for each country which are scaled to have a mean of one. The boxes highlight the industries with the five highest values of $\lambda$ for each country.

general equilibrium effects of tariff changes, and discuss the welfare effects of tariff changes. I then turn to optimal tariffs, world trade wars, and world trade talks.

## I. Basic Setup

There are $N$ countries indexed by $i$ or $j$ and $S$ industries indexed by $s$. Consumers have access to a continuum of differentiated varieties. Preferences over these varieties are given by the following utility functions:

$$(1) \qquad U_j = \prod_s \left( \sum_i \int_0^{M_{is}} x_{ijs}(\nu_{is})^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1}\mu_{js}},$$

where $x_{ijs}$ is the quantity of an industry $s$ variety from country $i$ consumed in country $j$, $M_{is}$ is the mass of industry $s$ varieties produced in country $i$, $\sigma_s > 1$ is the elasticity of substitution between industry $s$ varieties, and $\mu_{js}$ is the fraction of country $j$ income spent on industry $s$ varieties.

Each variety is uniquely associated with an individual firm. Firms are homogeneous within industries and their technologies are summarized by the following inverse production functions:

$$l_{is} = \sum_j \frac{\theta_{ijs} x_{ijs}}{\varphi_{is}}, \tag{2}$$

where $l_{is}$ is the labor requirement of an industry $s$ firm in country $i$ featuring iceberg trade barriers $\theta_{ijs}$ and a productivity parameter $\varphi_{is}$. Each firm has monopoly power with respect to its own variety and the number of firms is given exogenously.[5]

Governments can impose import tariffs but do not have access to other policy instruments.[6] I denote the ad valorem tariff imposed by country $j$ against imports from country $i$ in industry $s$ by $t_{ijs}$ and make frequent use of the shorthand $\tau_{ijs} \equiv t_{ijs} + 1$ throughout. Government preferences are given by the following objective functions:

$$G_j = \sum_s \lambda_{js} W_{js}, \tag{3}$$

where $W_{js}$ is the welfare of industry $s$ in country $j$ and $\lambda_{js} \geq 0$ is the political economy weight of industry $s$ in country $j$ which is scaled such that $\frac{1}{S}\sum_s \lambda_{js} = 1$. Welfare is given by real income in this setup which can be defined at the industry level, $W_{js} \equiv \frac{X_{js}}{P_j}$, and at the aggregate level, $W_j \equiv \frac{X_j}{P_j}$, where $X_{js}$ is the nominal income in industry $s$ of country $j$, $P_j$ is the ideal price index in country $j$, and $X_j = \sum_s X_{js}$. $X_{js}$ consists of industry labor income, industry profits, and a share of aggregate tariff revenue, which I assume to be allocated to industries based on employment shares.[7]

Notice that governments simply maximize welfare if the political economy weights are set equal to one since $W_j = \sum_s W_{js}$. The interpretation of the political economy weights is that one dollar of income accruing to industry $s$ of country $j$ counts $\lambda_{js}$ as much in the government's objective function as one dollar of income accruing to an industry which receives average political support. This formulation of government preferences can be viewed as a reduced form representation of the

[5] The model can also be solved and calibrated with free entry and fixed costs of production. I focus on a version without free entry for two main reasons. First, because it features positive profits and therefore lends itself more naturally to an analysis of political economy considerations. Second, because it rules out corner solutions with zero production in some sectors so that it can be implemented using a much simpler algorithm. See footnote 12 for a further discussion of the model with free entry.

[6] This restriction is motivated by the fact that import tariffs have always been by far the most important trade policy instruments in practice. However, it would be easy to extend the framework to also include export subsidies, import quotas, or voluntary export restraints. See Bagwell and Staiger (2009, 2012) for a discussion of the importance of this restriction for the theory of trade agreements in a range of simple new trade models.

[7] To be clear, $X_{js} = w_j L_{js} + \pi_{js} + \frac{L_{js}}{L_j} TR_j$, where $w_j$ is the wage rate in country $j$, $L_{js}$ is employment in industry $s$ of country $j$, $\pi_{js}$ are the profits in industry $s$ of country $j$, $L_j$ is total employment in country $j$, and $TR_j$ is the tariff revenue of country $j$.

"protection for sale" theory of Grossman and Helpman (1994). However, it takes a somewhat broader approach by taking producer interests and worker interests into account. As will become clear shortly, industry profits and industry labor income are proportional to industry sales so that this is the margin special interest groups seek to affect.

## II. Equilibrium for Given Tariffs

Utility maximization implies that firms in industry $s$ of country $i$ face demands

$$x_{ijs} = \frac{(p_{is}\theta_{ijs}\tau_{ijs})^{-\sigma_s}}{P_{js}^{1-\sigma_s}}\mu_{js}X_j, \tag{4}$$

where $p_{is}$ is the ex-factory price of an industry $s$ variety from country $i$ and $P_{js}$ is the ideal price index of industry $s$ varieties in country $j$. Also, profit maximization requires that firms in industry $s$ of country $i$ charge a constant markup over marginal costs

$$p_{is} = \frac{\sigma_s}{\sigma_s - 1}\frac{w_i}{\varphi_{is}}, \tag{5}$$

where $w_i$ is the wage rate in country $i$.

The equilibrium for given tariffs can be characterized with four condensed equilibrium conditions. The first condition follows from substituting equations (2), (4), and (5) into the relationship defining industry profits $\pi_{is} = M_{is}\left(\sum_j p_{is}\theta_{ijs}x_{ijs} - w_i l_{is}\right)$:

$$\pi_{is} = \frac{1}{\sigma_s}\sum_j M_{is}\tau_{ijs}^{-\sigma_s}\left(\frac{\sigma_s}{\sigma_s - 1}\frac{\theta_{ijs}}{\varphi_{is}}\frac{w_i}{P_{js}}\right)^{1-\sigma_s}\mu_{js}X_j. \tag{6}$$

The second condition combines equations (2), (4), and (5) with the requirement for labor market clearing $L_i = \sum_s M_{is} l_{is}$:

$$w_i L_i = \sum_s \pi_{is}(\sigma_s - 1). \tag{7}$$

The third condition results from substituting equation (5) into the formula for the ideal price index $P_{js} = \left(\sum_i M_{is}(p_{is}\theta_{ijs}\tau_{ijs})^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}}$:

$$P_{js} = \left(\sum_i M_{is}\left(\frac{\sigma_s}{\sigma_s - 1}\frac{w_i\theta_{ijs}\tau_{ijs}}{\varphi_{is}}\right)^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}}. \tag{8}$$

And the final condition combines equations (4) and (5) with the budget constraint equating total expenditure to labor income, plus tariff revenue, plus aggregate profits:

$$X_j = w_j L_j + \sum_i\sum_s t_{ijs}M_{is}\tau_{ijs}^{-\sigma_s}\left(\frac{\sigma_s}{\sigma_s - 1}\frac{\theta_{ijs}}{\varphi_{is}}\frac{w_i}{P_{js}}\right)^{1-\sigma_s}\mu_{js}X_j + \sum_s \pi_{js}. \tag{9}$$

Conditions (6)–(9) represent a system of $2N(S+1)$ equations in the $2N(S+1)$ unknowns $w_i$, $X_i$, $P_{is}$, and $\pi_{is}$ which can be solved given a numeraire. An obvious problem, however, is that this system depends on the set of unknown parameters $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ which are all difficult to estimate empirically.

## III. General Equilibrium Effects of Tariff Changes

I avoid this problem by computing the general equilibrium effects of counterfactual tariff changes using a method inspired by Dekle, Eaton, and Kortum (2007). In particular, conditions (6)–(9) can be rewritten in changes as

$$(10)\quad \hat{\pi}_{is} = \sum_j \alpha_{ijs} (\hat{\tau}_{ijs})^{-\sigma_s} \left(\frac{\hat{w}_i}{\hat{P}_{js}}\right)^{1-\sigma_s} \hat{X}_j$$

$$(11)\quad \hat{w}_i = \sum_s \delta_{is} \hat{\pi}_{is}$$

$$(12)\quad \hat{P}_{js} = \left(\sum_i \gamma_{ijs} (\hat{w}_i \hat{\tau}_{ijs})^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}}$$

$$(13)\quad \hat{X}_j = \frac{w_j L_j}{X_j} \hat{w}_j + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \hat{t}_{ijs} (\hat{\tau}_{ijs})^{-\sigma_s} \left(\frac{\hat{w}_i}{\hat{P}_{js}}\right)^{1-\sigma_s} \hat{X}_j + \sum_s \frac{\pi_{js}}{X_j} \hat{\pi}_{js},$$

where a "hat" denotes the ratio between the counterfactual and the factual value, $\alpha_{ijs} \equiv T_{ijs} / \sum_n T_{ins}$, $\gamma_{ijs} \equiv (\tau_{ijs} T_{ijs}) / \left(\sum_m \tau_{mjs} T_{mjs}\right)$, $\delta_{is} \equiv \left(\sum_j \frac{\sigma_s - 1}{\sigma_s} T_{ijs}\right) / \left(\sum_t \sum_n \frac{\sigma_t - 1}{\sigma_t} T_{int}\right)$, and $T_{ijs} \equiv M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}}\right)^{1-\sigma_s} \tau_{ijs}^{-\sigma_s} \mu_{js} X_j$ is the factual value of industry $s$ trade flowing from country $i$ to country $j$ evaluated at world prices.

Equations (10)–(13) represent a system of $2N(S+1)$ equations in the $2N(S+1)$ unknowns $\hat{w}_i$, $\hat{X}_i$, $\hat{P}_{is}$, $\hat{\pi}_{is}$. Crucially, their coefficients depend on $\sigma_s$ and observables only so that the full general equilibrium response to counterfactual tariff changes can be computed without further information on any of the remaining model parameters. Moreover, all required observables can be inferred directly from widely available trade and tariff data since the model requires $X_j = \sum_i \sum_s \tau_{ijs} T_{ijs}$ and $w_j L_j = X_j - \sum_i \sum_s t_{ijs} T_{ijs} - \sum_s \pi_{js}$, where $\pi_{is} = \frac{1}{\sigma_s} \sum_j T_{ijs}$ in this constant markup environment.[8]

Notice that this procedure also ensures that the counterfactual effects of tariff changes are computed from a reference point which perfectly matches industry-level trade and tariffs. Essentially, it imposes a restriction on the set of unknown parameters $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ such that the predicted $T_{ijs}$ perfectly match the observed $T_{ijs}$ given the observed $\tau_{ijs}$ and the estimated $\sigma_s$. It is important to emphasize that the restriction on $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ does not deliver estimates of $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ given the high dimensionality of the parameter space. To obtain estimates of $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$, one would

[8] Notice that this system can be reduced to $2N$ equations in the $2N$ unknowns $\hat{w}_i$ and $\hat{X}_i$, by substituting for $\hat{\pi}_{is}$ and $\hat{P}_{js}$ in conditions (11) and (13) using conditions (10) and (12). I work with this condensed system in my numerical analysis to improve computational efficiency.

have to reduce this dimensionality, for example, by imposing some structure on the matrix of iceberg trade barriers.[9]

One issue with equations (10)–(13) is that they are based on a static model which does not allow for aggregate trade imbalances thereby violating the data. The standard way of addressing this issue is to introduce aggregate trade imbalances as constant nominal transfers into the budget constraints. However, this approach has two serious limitations which have gone largely unnoticed by the literature. First, the assumption of constant aggregate trade imbalances leads to extreme general equilibrium adjustments in response to high tariffs and cannot be true in the limit as tariffs approach infinity. Second, the assumption of constant nominal transfers implies that it matters what nominal units they are measured in since this affects how real transfers change in counterfactuals.[10]

To circumvent these limitations, I first purge the original data from aggregate trade imbalances using my model and then conduct all subsequent analyses using this purged dataset. The first step is essentially a replication of the original Dekle, Eaton, and Kortum (2007) exercise using my setup. In particular, I introduce aggregate trade imbalances as nominal transfers into the budget constraint and calculate the general equilibrium responses of setting those transfers equal to zero which allows me to construct a matrix of trade flows featuring no aggregate trade imbalances. I discuss this procedure and its advantages as well as the first-stage results in more detail in the Appendix.

As an illustration of the key general equilibrium effects of trade policy, panel A of Table 2 summarizes the effects of a counterfactual 50 percentage point increase in the US tariff on chemicals or apparel. Chemical products have a relatively low elasticity of substitution of 2.34 while apparel products have a relatively high elasticity of substitution of 5.39. The first column gives the predicted percentage change in the US wage relative to the numeraire. As can be seen, the US wage is predicted to increase by 1.45 percent if the tariff increase occurs in chemicals and is predicted to increase by 0.67 percent if the tariff increase occurs in apparel.

The second column presents the predicted percentage change in the quantity of US output in the protected industry and the third column the simple average of the predicted percentage changes in the quantity of US output in the other industries. Hence, US output is predicted to increase by 5.73 percent in chemicals and decrease by an average 1.40 percent in all other industries if the tariff increase occurs in chemicals. Similarly, US output is predicted to increase by 33.35 percent in apparel and decrease by an average 0.97 percent in all other industries if the tariff increase occurs in apparel.

Intuitively, a US import tariff makes imported goods relatively more expensive in the US market so that US consumers shift expenditure toward US goods. This then incentivizes US firms in the protected industry to expand, which bids up US wages and thereby forces US firms in other industries to contract. Even though it is not directly implied by Table 2, it should be clear that mirroring adjustments occur in other countries. In particular, firms in the industry in which the United States imposes import tariffs contract, which depresses wages and allows firms in other industries to expand.

[9] I do not further pursue an estimation of $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ in this paper, since the model relates $T_{ijs}$ and $\{M_{is}, \theta_{ijs}, \varphi_{is}\}$ with a standard gravity equation whose empirical success is widely known.

[10] This is explained in more detail in the Appendix.

TABLE 2—EFFECTS OF 50 PERCENTAGE POINT INCREASE IN US TARIFF

| | Δ US wage | Δ US production (protected) | Δ US production (other) |
|---|---|---|---|
| *Panel A. General equilibrium effects* | | | |
| Chemicals | 1.45 | 5.73 | −1.40 |
| Apparel | 0.67 | 33.35 | −0.97 |
| | Δ US welfare | Terms-of-trade effect | Profit shifting effect |
| *Panel B. Welfare effects* | | | |
| Chemicals | 0.17 | 0.34 | 0.12 |
| Apparel | −0.14 | 0.16 | −0.15 |

*Notes:* The entries in panel A are the percentage change in the US wage normalized such that the average wage change across all countries is zero (column 1), the percentage change in the quantity of output in the US chemicals or apparel industry (column 2), and the average of the percentage changes in the quantity of output in the other US industries (column 3). The entries in panel B are the percentage change in US welfare (column 1), the component due to terms-of-trade effects (column 2), and the component due to profit shifting effects (column 3). The values in column 2 and 3 do not add up to the value in column 1 because they are computed using equation (14) which is a linear approximation. Here, all changes are computed relative to factual tariffs.

## IV. Welfare Effects of Tariff Changes

Given the general equilibrium effects of tariff changes, the implied welfare effects can be computed from $\hat{W}_j = \hat{X}_j/\hat{P}_j$, where $\hat{P}_j = \Pi_s\left(\hat{P}_{js}\right)^{\mu_{js}}$ is the change in the aggregate price index. This framework features both traditional as well as new trade welfare effects of trade policy. This can be seen most clearly from a log-linear approximation around factuals. As I explain in detail in the Appendix, it yields the following relationship for the welfare change induced by tariff changes, where $\frac{\Delta W_j}{W_j}$ is the percentage change in country $j$'s welfare and so on:[11]

$$\frac{\Delta W_j}{W_j} \approx \sum_i \sum_s \frac{T_{ijs}}{X_j}\left(\frac{\Delta p_{js}}{p_{js}} - \frac{\Delta p_{is}}{p_{is}}\right) + \sum_s \frac{\pi_{js}}{X_j}\left(\frac{\Delta \pi_{js}}{\pi_{js}} - \frac{\Delta p_{js}}{p_{js}}\right) + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j}\left(\frac{\Delta T_{ijs}}{T_{ijs}} - \frac{\Delta p_{is}}{p_{is}}\right). \tag{14}$$

The first term is a traditional terms-of-trade effect which captures changes in country $j$'s real income due to differential changes in the world prices of country $j$'s production and consumption bundles. Country $j$ benefits from an increase in the world prices of its production bundle relative to the world prices of its consumption

[11] As will become clear shortly, this welfare decomposition emphasizes international trade policy externalities by focusing on terms-of-trade effects and profit shifting effects. While this seems most useful for the purpose of this paper, one can also derive an alternative decomposition which highlights the distributional effects of trade policy. In particular, since nominal income consists of wage income $(w_j L_j)$, industry profits $(\pi_{js})$, and tariff revenue $(R_j)$, changes in real income can be decomposed as $\hat{W}_j = \frac{w_j L_j}{X_j}\frac{\hat{w}_j}{\hat{P}_j} + \sum_s \frac{\pi_{js}}{X_j}\frac{\hat{\pi}_{js}}{\hat{P}_j} + \frac{R_j}{X_j}\frac{\hat{R}_j}{\hat{P}_j}$. If one equates the notion of "consumer" with the notion of "worker," the first term can be interpreted as a weighted change in consumer surplus, the second as a weighted change in producer surplus, and the third as a weighted change in government surplus.

bundle because its exports then command more imports in world markets. The terms-of-trade effect can also be viewed as a relative wage effect since world prices are proportional to wages given the constant markup pricing captured by formula (5).

Notice that this equivalence between terms-of-trade effects and relative wage effects implies that changes in tariffs always change the terms-of-trade in all industries at the same time. This is because a tariff in a particular industry can only affect the terms-of-trade in that industry if it changes relative wages in which case it then also alters the terms-of-trade in all other industries. This would no longer be true if the tight connection between prices across industries within countries was broken by allowing for variable markups, changing marginal costs, or more than one perfectly mobile factor of production.

The second term is a new trade profit shifting effect which captures changes in country $j$'s real income due to changes in country $j$'s aggregate profits originating from changes in industry output. It takes changes in industry profits, nets out changes in industry prices, and then aggregates the remaining changes over all industries using profit shares as weights. These remaining changes are changes in industry profits originating from changes in industry output since industry profits are proportional to industry sales in this constant markup environment.[12]

The last term is a combined trade volume effect which captures changes in country $j$'s real income due to changes in country $j$'s tariff revenue originating from changes in import volumes. It takes changes in import values, nets out changes in import prices, and then aggregates the remaining changes over all countries and industries using tariff revenue shares as weights. These remaining changes are changes in import volumes since changes in import values can be decomposed into changes in import prices and import volumes.[13]

As an illustration, panel B of Table 2 reports the welfare effects of the counterfactual 50 percentage point increase in the US tariff on chemicals or apparel and decomposes them into terms-of-trade and profit shifting components following equation (14). As can be seen, US welfare increases by 0.17 percent if the tariff increase occurs in chemicals but decreases by 0.14 percent if the tariff increase occurs in apparel. The differential welfare effects are due to differential profit shifting effects. While the terms-of-trade effect is positive in both cases, the profit shifting effect is positive if the tariff increase occurs in chemicals and negative if the profit increase occurs in apparel.

[12] While this effect is similar to the classic profit shifting effect from Brander and Spencer (1981), there is also a close mathematical connection to the production relocation effect from Venables (1987). It can be shown that in a version of the model with free entry and fixed costs of production, the equivalent of equation (14) would be $\frac{\Delta V_j}{V_j} \approx \sum_i \sum_s \frac{T_{ijs}}{X_j}\left(\frac{\Delta p_{js}}{p_{js}} - \frac{\Delta p_{is}}{p_{is}}\right) + \sum_i \sum_s \frac{\tau_{ijs} T_{ijs}}{X_j} \frac{1}{\sigma_s - 1} \frac{\Delta M_{is}}{M_{is}} + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j}\left(\frac{\Delta T_{ijs}}{T_{ijs}} - \frac{\Delta p_{is}}{p_{is}}\right)$, where the second term can now be interpreted as a production relocation effect. Essentially, tariffs lead to changes in industry output at the intensive margin without free entry and at the extensive margin with free entry.

[13] Readers familiar with the analysis of Flam and Helpman (1987) may wonder why decomposition (14) does not reveal that tariffs can also be used to partially correct for a domestic distortion brought about by cross-industry differences in markups. The reason is simply that this decomposition only captures first-order effects, while the Flam and Helpman (1987) corrections operate through second-order adjustments in expenditure shares. As will become clear in the discussion of efficient tariffs, they always push governments to impose somewhat higher tariffs on higher elasticity goods in an attempt to counteract distortions in relative prices. While I take this force into account in all my calculations, I only emphasize it in the discussion of efficient tariffs, as the key channels through which countries can gain at the expense of one another are terms-of-trade and profit shifting effects.

The positive terms-of-trade effects are a direct consequence of the increase in the US relative wage identified above. The differential profit shifting effects are the result of cross-industry differences in markups which are brought about by cross-industry differences in the elasticity of substitution. Since the quantity of US output always increases in the protected industry but decreases in other industries, the change in profits which is due to changes in industry output is always positive in the protected industry but negative in other industries. The overall profit shifting effect depends on the net effect which is positive if the tariff increase occurs in a high profitability industry such as chemicals and negative if it occurs in a low profitability industry such as apparel.[14]

Notice that the overall welfare effects are smaller than the sum of the terms-of-trade and profit shifting effects in both examples. One missing factor is, of course, the trade volume effect from equation (14). However, this effect is close to zero in both examples since the loss in tariff revenue due to a decrease in import volumes in the protected industry is approximately offset by the gain in tariff revenue due to an increase in import volumes in other industries. The discrepancy therefore largely reflects the fact that equation (14) only provides a rough approximation if tariff changes are as large as 50 percentage points since it is obtained from a linearization around factuals.[15]

To put these and all following welfare statements into perspective, it seems useful to provide a sense of the magnitude of the gains from trade. As I explain in detail in Ossa (2012b), the gains from trade are typically larger in multi-sector models than in their single-sector equivalents because they avoid an aggregation bias stemming from cross-industry heterogeneity in the trade elasticities. This model is no exception and predicts welfare losses of moving from factual tariffs to autarky of $-9.9$ percent for Brazil, $-12.9$ percent for China, $-12.3$ percent for the European Union, $-10.8$ percent for India, $-13.0$ percent for Japan, $-20.8$ percent for the Rest of the World, and $-13.5$ percent for the United States.[16]

## V. Optimal Tariffs

The above discussion suggests that governments have incentives to use import tariffs to increase relative wages generating a positive terms-of-trade effect and expand high-profitability industries generating a positive profit shifting effect. However, these incentives combine with political economy considerations as governments also seek to favor politically influential industries. In particular, governments grant extra protection to high $\lambda_{is}$ industries as this increases industry revenue by increasing industry sales. Recall from above that producers and workers simply split industry revenue using the constant shares $\frac{1}{\sigma_s}$ and $1 - \frac{1}{\sigma_s}$. As a result, there is

[14] As is easy to verify, equations (5) and (11) imply that $\sum_s \frac{\pi_{js}}{X_j}\left(\frac{\Delta \pi_{js}}{\pi_{js}} - \frac{\Delta p_{js}}{p_{js}}\right) = 0$ if $\sigma_s = \sigma$ for all $s$ so that there is then no profit shifting effect.

[15] In particular, the overall reduction in imports associated with the increase in tariffs also reduces the import shares which leverage the improvement in relative world prices. This effect does not appear in equation (14) since changes in import shares are second order effects.

[16] The welfare losses of moving from free trade to autarky are $-10.0$ percent for Brazil, $-13.1$ percent for China, $-12.6$ percent for the European Union, $-11.2$ percent for India, $-15.4$ percent for Japan, $-20.8$ percent for the Rest of the World, and $-14.2$ percent for the United States. Most of the variation in the gains from trade is due to variation in trade openness, just as in Ossa (2012b).

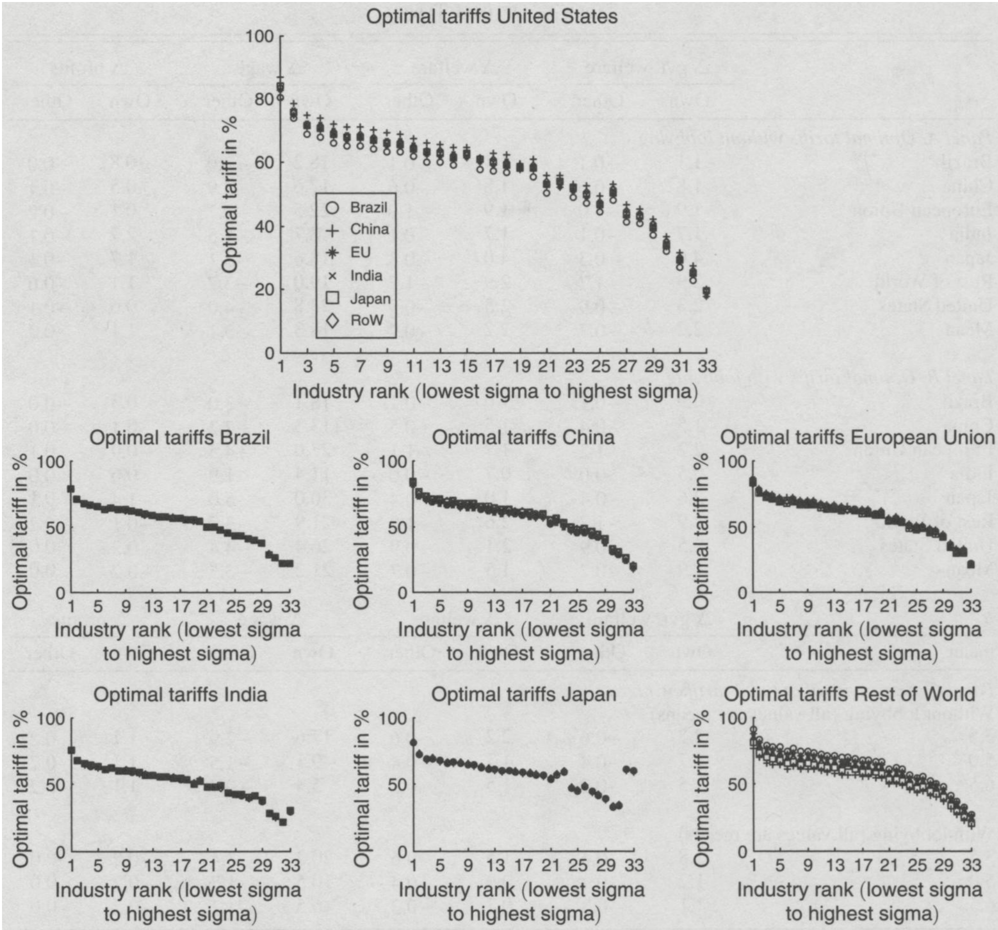


FIGURE 1. OPTIMAL TARIFFS WITHOUT LOBBYING

*Note:* The median optimal tariffs are 60.3 percent for the United States, 56.1 percent for Brazil, 59.3 percent for China, 61.3 percent for the European Union, 54.0 percent for India, 59.6 percent for Japan, and 61.5 percent for the Rest of the World.

no conflict of interest between producers and workers with respect to trade policy in this environment.

I compute optimal tariffs using the Su and Judd (2012) method of mathematical programming with equilibrium constraints, as I explain in detail in the Appendix. Essentially, it involves maximizing the government's objective function (3) subject to the equilibrium conditions (10)–(13), which ensures relatively fast convergence despite the high dimensionality of the optimization problem. I begin by discussing optimal tariffs for the baseline version in which $\lambda_{is} = 1 \; \forall \; i$ and $s$. I then describe how I calibrate the political economy weights and present the political economy results. To be clear, optimal tariffs refer to tariffs countries would choose given all other countries' factual tariffs. They are regarded as an important benchmark in the trade policy literature.

Figure 1 summarizes the optimal tariffs of each country for the baseline version in which $\lambda_{is} = 1 \; \forall \; i$ and $s$. It ranks all industries by elasticity of substitution and

TABLE 3—OPTIMAL TARIFFS

| | Δ gvt. welfare | | Δ welfare | | Δ wage | | Δ profits | |
|---|---|---|---|---|---|---|---|---|
| | Own | Other | Own | Other | Own | Other | Own | Other |
| *Panel A. Optimal tariffs without lobbying* | | | | | | | | |
| Brazil | 1.1 | −0.1 | 1.1 | −0.1 | 18.2 | −3.0 | 0.8 | −0.0 |
| China | 1.8 | −0.6 | 1.8 | −0.6 | 17.6 | −2.9 | 0.5 | −0.1 |
| European Union | 1.9 | −1.0 | 1.9 | −1.0 | 22.5 | −3.7 | 0.1 | −0.2 |
| India | 1.7 | −0.1 | 1.7 | −0.1 | 8.7 | −1.5 | 2.7 | −0.1 |
| Japan | 4.0 | −0.3 | 4.0 | −0.3 | 18.6 | −3.1 | 1.7 | −0.1 |
| Rest of World | 2.9 | −1.7 | 2.9 | −1.7 | 19.0 | −3.2 | 1.1 | −0.6 |
| United States | 2.3 | −0.9 | 2.3 | −0.9 | 23.8 | −4.0 | 0.6 | −0.1 |
| Mean | 2.2 | −0.7 | 2.2 | −0.7 | 18.3 | −3.1 | 1.1 | −0.2 |
| *Panel B. Optimal tariffs with lobbying* | | | | | | | | |
| Brazil | 0.9 | −0.1 | 1.0 | −0.1 | 18.1 | −3.0 | 0.3 | −0.0 |
| China | 1.5 | −0.4 | 1.5 | −0.5 | 13.3 | −2.2 | 0.1 | −0.0 |
| European Union | 2.2 | −1.2 | 1.7 | −1.1 | 27.0 | −4.5 | −0.9 | 0.1 |
| India | 0.5 | −0.0 | 0.7 | −0.0 | 11.4 | −1.9 | 0.6 | −0.0 |
| Japan | 2.6 | −0.4 | 1.0 | −0.4 | 30.0 | −5.0 | −1.4 | 0.1 |
| Rest of World | 2.9 | −1.7 | 2.6 | −1.8 | 21.9 | −3.7 | −0.1 | −0.2 |
| United States | 2.5 | −0.9 | 2.1 | −0.9 | 26.4 | −4.4 | −0.2 | 0.0 |
| Mean | 1.9 | −0.7 | 1.5 | −0.7 | 21.2 | −3.5 | −0.2 | 0.0 |

| $\sigma$ | Δ gvt. welfare | | Δ welfare | | Δ wage | | Δ profits | |
|---|---|---|---|---|---|---|---|---|
| mean | Own | Other | Own | Other | Own | Other | Own | Other |
| *Panel C. Sensitivity of optimal tariffs w.r.t.* $\sigma_s$ | | | | | | | | |
| Without lobbying (all values are means) | | | | | | | | |
| 3.5 | 2.2 | −0.6 | 2.2 | −0.6 | 17.6 | −2.9 | 1.1 | −0.2 |
| 5.0 | 1.7 | −0.4 | 1.7 | −0.4 | 9.1 | −1.5 | 1.1 | −0.2 |
| 6.5 | 1.5 | −0.2 | 1.5 | −0.2 | 5.4 | −0.9 | 1.1 | −0.2 |
| With lobbying (all values are means) | | | | | | | | |
| 3.5 | 1.8 | −0.6 | 1.5 | −0.6 | 20.2 | −3.4 | −0.2 | 0.0 |
| 5.0 | 1.2 | −0.4 | 0.9 | −0.4 | 10.5 | −1.7 | −0.2 | 0.0 |
| 6.5 | 1.1 | −0.3 | 0.7 | −0.3 | 6.5 | −1.1 | −0.2 | 0.0 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The entries under "own" are the effects on the tariff imposing country while the entries under "other" are the averages of the effects on all other countries. The last rows of panels A and B report averages. Panel C reports only such averages.

plots the optimal tariffs of each country with respect to all trading partners against the industry rank. As can be seen, optimal tariffs vary widely across industries and are strongly decreasing in the elasticity of substitution, as one would expect given the profit shifting motive for protection.[17] There is also some variation across countries and trading partners even though it is much less pronounced. Optimal tariffs are highly correlated across countries with the mean pairwise correlation coefficient being 91.2 percent. The median optimal tariff across all countries combined is 58.9 percent.[18]

Panel A of Table 3 lists the effects of imposing the optimal tariffs from Figure 1 individually for each country, always showing the effects on the tariff imposing

[17] Loosely speaking, governments choose the level of tariffs to optimally manipulate the terms-of-trade and the distribution of tariffs to optimally shift profits.

[18] To be precise, this is the average of the median optimal tariffs reported in the note to Figure 1.

country ("own") as well as the averages of the effects on all other countries ("other"). Recall that $G_j = W_j$ if $\lambda_{is} = 1 \; \forall \; i$ and $s$ so that the changes in government welfare and overall welfare are identical here. As can be seen from the first to fourth column, each country can gain considerably at the expense of other countries by unilaterally imposing optimal tariffs. The average welfare gain of the tariff imposing country is 2.2 percent. The average welfare loss of the other countries is 0.7 percent. The reason each country can gain at the expense of other countries is that the terms-of-trade and profit shifting effects have a beggar-thy-neighbor character, as can be seen from the fifth to eighth column.[19]

Country sizes vary significantly in my sample, with the largest countries (European Union and Rest of World) being around eight times larger than the smallest countries (Brazil and India) in nominal income terms. This variation in country size matters for optimal tariffs just as one would expect. In particular, median optimal tariffs are positively related to country size, as one can see from Figure 1. Also, the trade policy externalities associated with optimal tariffs are positively related to country size, as one can see from columns two, four, six, and eight of panel A of Table 3. Japan is an outlier because of its extreme factual trade policy. Most notably, Japan imposes factual tariffs of up to 513 percent on rice which implies that factual tariffs are highly distortive so that a move to optimal tariffs also brings about sizeable efficiency gains.

The extreme protection of the Japanese rice industry is the result of the political influence this industry enjoys as a key constituent of the Japanese Liberal Democratic Party.[20] And political economy forces also provide a plausible explanation for the cross-industry variation in factual tariffs in other countries. For example, the five most protected US industries in the sample are sugar, dairy, leather products, wearing apparel, and textiles which are all perceived as having political clout. Interestingly, the most protected industries also tend to be associated with the highest elasticities as one might suspect from inspecting the industry ranking in Table 1. As a result, the cross-industry variation in factual tariffs differs from the cross-industry variation in optimal tariffs in the baseline case in which $\lambda_{is} = 1 \; \forall \; i$ and $s$ with the rank correlation coefficient averaging $-16$ percent.

A natural approach to identifying the political economy weights would therefore be to match the cross-industry distribution of optimal tariffs to the cross-industry distribution of factual tariffs after controlling for their respective means. However, factual tariffs are the result of complex and unfinished trade negotiations so that their relationship to optimal tariffs is far from clear. I therefore instead match the cross-industry distribution of optimal tariffs to the cross-industry distribution of noncooperative tariffs whenever measures of noncooperative tariffs are available from the MAcMap or TRAINS database.[21] The MAcMap database is the source of GTAP's

[19] I have also computed the effects of optimal tariffs on trade flows. On average, trade flows are predicted to fall by 30.8 percent for the tariff imposing country and by 7 percent for all other countries.

[20] See, for example, a *Japan Times* article from February 20, 2011 entitled "The sticky subject of Japan's rice protection."

[21] I refer to these tariffs as noncooperative tariffs because it is unclear whether they should be thought of as measures of *optimal* tariffs or *Nash* tariffs. Similarly, it is also unclear whether I should match the cross-industry distribution of optimal tariffs or the cross-industry distribution of Nash tariffs to the cross-industry distribution of noncooperative tariffs. While I choose optimal tariffs for simplicity, I also show below that the results would have looked very similar if I had chosen Nash tariffs instead.

applied tariffs which I use as factual tariffs throughout. However, it also separately lists the components of applied tariffs including noncooperative tariffs whenever noncooperative tariffs are imposed. The TRAINS database is an additional source of tariff data which I consult only when noncooperative tariffs are unavailable from the MAcMap database.

The MAcMap database contains direct measures of noncooperative tariffs for China, Japan, and the United States. These are tariffs applied nondiscriminatorily against a number of non-WTO member countries with which China, Japan, or the United States do not have normal trade relations.[22] They are known as "general rate" tariffs in the case of China and Japan, and as "column 2 tariffs" in the case of the United States. They are significantly higher than factual tariffs with the simple averages being 69 percent as opposed to 10 percent for China, 76 percent as opposed to 21 percent for Japan, and 23 percent as opposed to 3 percent for the United States.[23] However, their ranking is highly correlated with the ranking of factual tariffs with the rank correlation coefficients being 49 percent for China, 80 percent for Japan, and 28 percent for the United States.

Moreover, the TRAINS database provides direct measures of noncooperative tariffs for the European Union. They are known as "autonomous rate" tariffs and are obtained from Annex I of the EU's Combined Nomenclature Regulation. Just like the abovementioned measures of noncooperative tariffs, these "autonomous rate" tariffs used to apply to non-WTO member countries with which the European Union did not have normal trade relations. However, the European Union no longer makes use of them and now simply applies its most-favored nation tariffs by default.[24] The "autonomous rate" tariffs are again significantly higher than factual tariffs with the simple average being 25 percent as opposed to 8 percent. They are also again highly correlated with factual tariffs with the rank correlation coefficient being 78 percent.

Finally, it might be argued that the factual tariffs of Brazil and India reflect their noncooperative tariffs to some extent. This is because Brazil and India choose to set their factual tariffs well below the bound tariffs they have committed to in the WTO. In particular, the MAcMap database suggests that the average "water in the tariff," i.e., the difference between bound and factual tariffs, is around 20 percentage points for Brazil and around 30 percentage points for India. Needless to say, these and the other measures of noncooperative tariffs have to be taken with a large grain of salt. However, it will turn out that all aggregate results are quite robust to the choice of political economy weights which will considerably mitigate this concern.

Figure 2 shows the result of matching the distribution of optimal tariffs to the distribution of noncooperative tariffs for the European Union, China, Japan, and the United States, and to the distribution of factual tariffs for Brazil, India, and the Rest

[22] The particular countries are Andorra, Bahamas, Bermuda, Bhutan, British Virgin Islands, British Cayman Islands, French Guiana, Occupied Palestinian Territory, Gibraltar, Monserrat, Nauru, Aruba, New Caledonia, Norfolk Island, Palau, Timor-Leste, San Marino, Seychelles, Western Sahara, and Turks and Caicos Islands for China; Andorra, Equatorial Guinea, Eritrea, Democratic People's Republic of Korea, Lebanon, and Timor-Leste for Japan; and Cuba and Democratic People's Republic of Korea for the United States.

[23] The average reported for the United States column 2 tariffs might seem too low to readers closely familiar with US tariff data. Notice, however, that the average is taken over GTAP sectors which gives a lot of weight to agricultural industries. The simple average over all HS 6-digit United States column 2 tariffs in my dataset is 32 percent.

[24] In the rare instances in which the "autonomous rate" is lower than the bound most-favored nation rate, the European Union actually still applies the "autonomous rate," albeit on a most-favored nation basis.

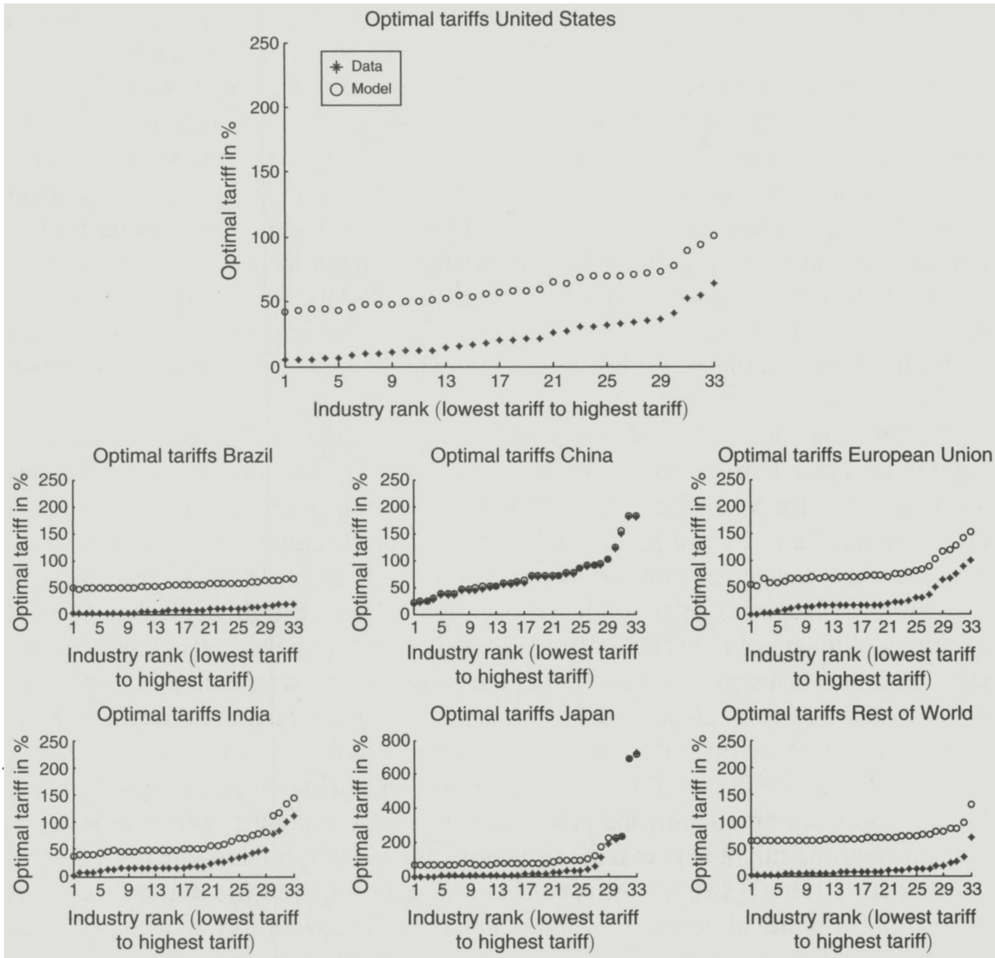


FIGURE 2. OPTIMAL TARIFFS WITH LOBBYING

*Note:* The median optimal tariffs are 56.4 percent for the United States, 54.2 percent for Brazil, 60.7 percent for China, 69.0 percent for the European Union, 49.9 percent for India, 77.5 percent for Japan, and 68.9 percent for the Rest of the World.

of the World. The matching is conducted by minimizing the residual sum of squares between the optimal tariffs and the noncooperative or factual tariffs after controlling for their respective means.[25] Since noncooperative tariffs are applied nondiscriminatorily I also restrict the optimal tariffs to be applied nondiscriminatorily for the purpose of this exercise. As can be seen, the model is largely able to replicate the distributions of noncooperative and factual tariffs as one would expect given the number of free political economy parameters.[26] However, it also overpredicts the

[25] A more detailed discussion of the algorithm can be found in the Appendix.

[26] Given that there are as many free parameters as data points, one might expect the distributions of predicted optimal tariffs to be identical to the distributions of observed noncooperative and factual tariffs except for their means. Recall, however, that the political economy weights are constrained to be nonnegative so that this does not always have to be the case. In my application, this constraint only binds in the case of the EU's wool industry which explains the slight outlier in the corresponding graph (industry rank 3). This occurs because the European Union imports the vast majority of its wool which makes the optimal tariff very inelastic with respect to the political economy weight.

levels of noncooperative tariffs for all countries other than China, an issue which can be addressed by adjusting the elasticities of substitution, as I explain below.

Japan's most extreme noncooperative tariffs are too close to prohibitive to be exactly matched by my method of computing optimal tariffs without imposing extreme convergence tolerances. For example, Japan's noncooperative tariff on rice is 721 percent which is virtually indistinguishable from a tariff of, say, 800 percent as far as its quantitative implications are concerned. I therefore restrict each optimal tariff corresponding to a noncooperative tariff higher than 225 percent to be at most as high as the noncooperative tariff itself and find the lowest possible political economy weight which makes the optimal tariff hit that upper bound. As can be seen from Figure 2, this procedure applies only to the most extreme noncooperative tariffs of Japan.

The resulting political economy weights are reported in the second to eighth column of Table 1 in which I have marked the five highest values for each country with boxes for better legibility. Overall, the estimates appear highly plausible. For example, the five most favored US industries are found to be wearing apparel, dairy, textiles, beverages and tobacco products, and wheat. With an average rank correlation of 70 percent, the political economy weights are highly correlated across countries. With an average rank correlation of 78 percent, they are also highly correlated with the elasticities. To understand the latter correlation, recall that politically unmotivated governments impose lower tariffs in higher elasticity industries. As a result, even a completely flat schedule of observed noncooperative tariffs could only be rationalized with higher political economy weights in higher elasticity industries. What is more, observed noncooperative tariffs tend to be higher in higher elasticity industries as one might expect from inspecting the industry ranking in Table 1.[27]

Panel B of Table 3 lists the effects of unilaterally imposed optimal tariffs given the estimated political economy weights in exactly the same format as panel A. A comparison of the last rows of panels A and B as well as the medians reported in the notes to Figure 1 and Figure 2 reveals that the aggregate implications of optimal tariffs with lobbying are quite similar to the aggregate implications of optimal tariffs without lobbying. The unweighted welfare gains are now a bit smaller given that governments now maximize weighted welfare. Also, the median optimal tariffs are now a bit higher given that the optimal tariff distribution is now more extreme (the average of the median optimal tariffs reported in the note to Figure 2 is 62.4 percent). The main difference is that profit shifting effects are now all but eliminated given that the cross-industry distribution of tariffs is now driven primarily by political considerations.

Panel C of Table 3 explores the sensitivity of the results in panels A and B to alternative assumptions on the elasticity of substitution. In particular, it recalculates the averages reported in the last rows of panels A and B using scaled versions of the original elasticity estimates reported in Table 1, where the scaling is such that

[27] For a number of reasons, it is hard to compare these estimates to the ones obtained by Goldberg and Maggi (1999). First, Goldberg and Maggi (1999) estimate a dummy variable indicating whether or not an industry is politically organized, whereas I allow the political economy weights to vary continuously by industry. Also, Goldberg and Maggi (1999) restrict attention to US manufacturing industries only, whereas I consider agricultural and manufacturing industries around the world. Finally, Goldberg and Maggi (1999) use an SIC 3-digit industry classification which is hard to match to the GTAP sectors considered here.

the elasticities average to the values displayed in the first column of panel C (recall that the original elasticity estimates reported in Table 1 average to 3.4 percent). The specific range is chosen to correspond to the range of aggregate trade elasticities suggested by Simonovska and Waugh (2014).[28] As can be seen, the welfare effects of optimal tariffs are strongly decreasing in the elasticities which is a reflection of the fact that the optimal tariffs themselves are strongly decreasing in the elasticities. Intuitively, lower elasticities give countries more monopoly power in world markets which they optimally exploit through higher tariffs. In the case without lobbying, the average of the median optimal tariffs is equal to 56.8 percent if the mean elasticity is 3.5, 34.3 percent if the mean elasticity is equal to 5.0, and 24.6 percent if the mean elasticity is equal to 6.5. In the case with lobbying, the average of the median optimal tariffs is equal to 60.1 percent if the mean elasticity is 3.5, 35.5 percent if the mean elasticity is equal to 5.0, and 25.6 percent if the mean elasticity is equal to 6.5.

Recalculating the last row of panel B involves recalibrating the political economy weights to ensure that the distribution of optimal tariffs continues to match the distribution of noncooperative or factual tariffs. The main effect of increasing the elasticities is to decrease the variance of the political economy weights as it makes the optimal tariffs more sensitive to changes in the political economy weights. At the same time, the ranking of the political economy weights stays largely unchanged with the average rank correlation coefficient across specifications being 97 percent. Moreover, recalculating the last rows of panels A and B also involves repurging the original data from aggregate trade imbalances following the same procedure explained above.

Since optimal tariffs are strongly decreasing in the elasticities, increasing the elasticities also reduces the differences between optimal tariffs and noncooperative or factual tariffs for all countries other than China for which the levels were already closely matched in Figure 2. For example, the optimal tariffs of the United States almost perfectly match the noncooperative tariffs of the United States in a version of Figure 2 drawn for the case in which the elasticities average to 6.5. In light of this, it is tempting to calibrate the average elasticity to minimize the differences between optimal tariffs and noncooperative or factual tariffs. Recall, however, that the measured noncooperative or factual tariffs are highly imperfect proxies for the actual noncooperative tariffs so that I do not pursue this here.[29,30]

[28]The trade elasticities are the partial equilibrium elasticities of trade flows with respect to trade costs and equal $1 - \sigma_s$ here. Simonovska and Waugh (2014) obtain their results in the context of an Eaton and Kortum (2002) model, which means that their results do not exactly apply here. However, it is now well-understood that different gravity models share similar aggregate behaviors so that I still use their numbers as rough bounds.

[29]By giving an extra weight to real profits in the government objective functions (3), one could also control the level of optimal tariffs from the political economy side. However, this would work in a highly implausible fashion which is why I refrain from it here. In particular, the level of optimal tariffs could then be *decreased* by *increasing* the weights on real profits in all industries. To see this, consider a tariff reduction which is such that it leaves the scale of all industries unchanged. Such a tariff reduction would then increase real profits in all industries by reducing the aggregate price index while leaving nominal profits in all industries unchanged as nominal profits are directly proportional to industry scale. Essentially, governments would then cater to producer interests by subsidizing consumption since they cannot boost production in all industries at the same time.

[30]To get a sense of how a version of the model without profit shifting effects behaves, I have also computed optimal tariffs in the baseline case without lobbying under the assumption that the elasticity of substitution is equal to 3.42 in all industries which is the average of my elasticity estimates from Table 1. In this case, optimal tariffs would be uniform across industries and have a median of 44 percent. They would increase welfare in the tariff imposing country by 1.5 percent on average and decrease welfare in all other countries by 0.5 percent on average. Of course, the prediction that optimal tariffs are uniform across industries should not be expected to generalize to richer terms-of-trade only environments in which relative prices and relative wages are less closely linked.

## VI. Trade Wars

The above discussion of each country's optimal tariffs assumes that the other countries do not retaliate which allows each country to benefit considerably at the other countries' expense. I now turn to an analysis of the Nash equilibrium in which all countries retaliate optimally. The Nash tariffs are such that each government chooses its tariffs to maximize its objective function (3) given the tariffs of all other governments as well as conditions (10)–(13). They can be computed by iterating over the algorithm used to compute optimal tariffs, as I discuss in detail in the Appendix. I refer to optimal tariffs without retaliation as optimal tariffs and optimal tariffs with retaliation as Nash tariffs throughout.[31]

Figure 3 summarizes the Nash tariffs of each country for the baseline version in which $\lambda_{is} = 1 \ \forall \ i$ and $s$. It ranks all industries by elasticity of substitution and plots the Nash tariffs of each country with respect to all trading partners against the industry rank. As can be seen, these Nash tariffs are very similar to the optimal tariffs from Figure 1. The median Nash tariff across all countries is 58.1 percent which is remarkably close to the average tariff of 50 percent typically reported for the trade war following the Smoot-Hawley Tariff Act of 1930.[32] This trade war is the only full-fledged trade war in economic history and therefore an interesting benchmark for me. Of course, it can only serve as a rough reference point given the differences in the set of players and the timing of the experiment. I will therefore also contrast the predicted Nash tariffs with the abovementioned measures of noncooperative tariffs when I discuss the political economy case below.

Panel A of Table 4 lists the welfare effects of Nash tariffs in a similar format as panel A of Table 3. The main difference is that there is now only a single multilateral tariff scenario under consideration in contrast to the seven unilateral ones from Table 3. As can be seen, countries can no longer benefit at one another's expense and welfare falls across the board with the average loss equaling −2.4 percent. This loss is much higher than the average loss from unilaterally imposed optimal tariffs since all countries now impose noncooperative tariffs at the same time. Intuitively, each country now increases its import tariffs in an attempt to induce favorable terms-of-trade and profit shifting effects. The end result is a large drop in trade volumes which leaves all countries worse off.[33]

Notice that the welfare losses resulting from Nash tariffs are quite similar across countries with only Japan and the Rest of the World standing out. The relatively small welfare loss of Japan is again mainly due to Japan's highly distortive factual tariffs which imply that Japan's Nash tariffs are well below Japan's factual tariffs in agricultural industries such as rice. The relatively large welfare loss of the Rest of the World is mainly due to the fact that the Rest of the World is by far the most open economy in the sample with an overall import share of 27 percent (the average across all other countries is 16 percent). Variation in openness is also the reason why

[31] I have experimented with many different starting values without finding any differences in the results which makes me believe that the identified Nash equilibrium is unique. This is, of course, subject to the well-known qualification that complete autarky is also always a Nash equilibrium.

[32] See, for example, Bagwell and Staiger (2002, p. 43). The reported number is again the average of the median Nash tariffs reported in the note to Figure 3.

[33] On average, trade flows are predicted to fall by 57.7 percent due to Nash tariffs.

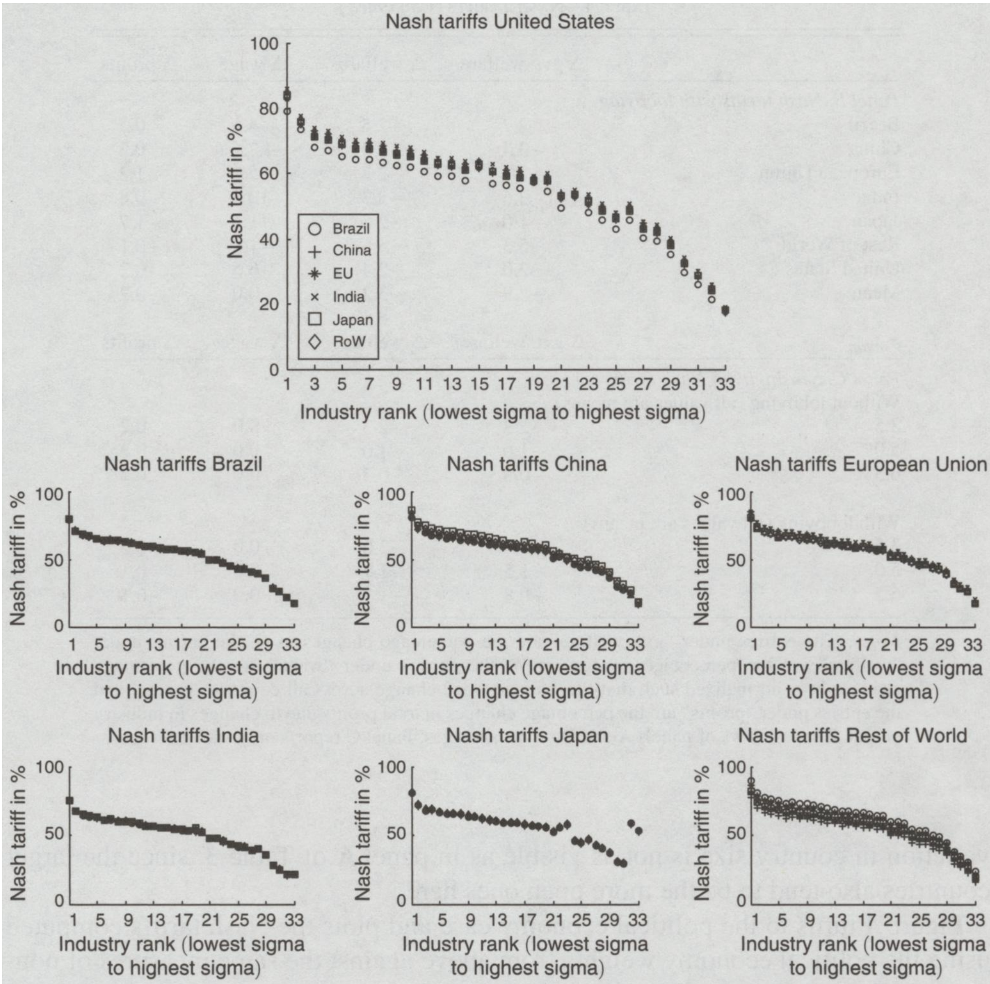


FIGURE 3. NASH TARIFFS WITHOUT LOBBYING

*Note:* The median Nash tariffs are 59.6 percent for the United States, 56.4 percent for Brazil, 58.6 percent for China, 59.1 percent for the European Union, 54.5 percent for India, 58.5 percent for Japan, and 59.7 percent for the Rest of the World.

TABLE 4—NASH TARIFFS

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Nash tariffs without lobbying* | | | | |
| Brazil | −1.9 | −1.9 | 1.3 | 0.4 |
| China | −2.2 | −2.2 | 0.5 | −0.2 |
| European Union | −2.6 | −2.6 | 2.7 | −0.9 |
| India | −2.2 | −2.2 | −9.3 | 1.9 |
| Japan | −0.8 | −0.8 | −0.6 | 0.7 |
| Rest of World | −5.0 | −5.0 | −0.8 | −0.6 |
| United States | −2.2 | −2.2 | 6.3 | −0.3 |
| Mean | −2.4 | −2.4 | 0.0 | 0.2 |

(*Continued*)

Table 4—Nash Tariffs (*Continued*)

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel B. Nash tariffs with lobbying* | | | | |
| Brazil | −2.7 | −2.5 | −4.6 | 0.5 |
| China | −3.4 | −2.9 | −7.1 | 0.3 |
| European Union | −2.2 | −2.7 | 5.6 | −1.2 |
| India | −3.6 | −3.3 | −10.5 | 0.8 |
| Japan | −1.0 | −2.8 | 11.4 | −1.7 |
| Rest of World | −5.3 | −5.6 | −1.3 | −0.1 |
| United States | −2.0 | −2.4 | 6.5 | −0.2 |
| Mean | −2.9 | −3.2 | 0.0 | −0.2 |

| $\sigma_{mean}$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel C. Sensitivity of Nash tariffs w.r.t.* $\sigma_s$ | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | −2.3 | −2.3 | 0.0 | 0.2 |
| 5.0 | −1.0 | −1.0 | 0.0 | 0.3 |
| 6.5 | −0.3 | −0.3 | 0.0 | 0.2 |
| With lobbying (all values are means) | | | | |
| 3.5 | −2.8 | −3.0 | 0.0 | −0.2 |
| 5.0 | −1.5 | −1.7 | 0.0 | −0.1 |
| 6.5 | −0.8 | −1.1 | 0.0 | −0.1 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

variation in country size is not as visible as in panel A of Table 3, since the larger countries also tend to be the more open ones here.

Figure 4 turns to the political economy case and plots the Nash tariffs computed using the political economy weights from above against the same measures of noncooperative and factual tariffs shown in Figure 2. As can be seen, the distribution of Nash tariffs is also quite closely in line with the distribution of noncooperative and factual tariffs even though they have not been directly matched.[34] This suggests that the political economy weights would have been very similar if they had been chosen to match the distribution of Nash tariffs rather than the distribution of optimal tariffs to the distribution of noncooperative and factual tariffs. This is comforting since it is not entirely clear which point on the tariff reaction curves the measures of noncooperative and factual tariffs best represent.

Panel B of Table 4 summarizes the welfare effects of Nash tariffs in the political economy case. A comparison of the last rows of panels A and B, as well as the medians reported in the notes to Figures 3 and 4, reveals that the aggregate implications of Nash tariffs are also quite similar with and without political economy forces. Similar to what we observed with respect to optimal tariffs, the unweighted welfare losses are a bit larger in the political economy case given that governments now maximize weighted welfare. Also, the median Nash tariffs are a bit higher in the political economy case given that the tariff distribution is now more extreme (the

[34] Just like the optimal tariffs, the Nash tariffs also overpredict the levels of noncooperative tariffs for all countries other than China. See the section on optimal tariffs for a discussion of how this issue can be addressed.

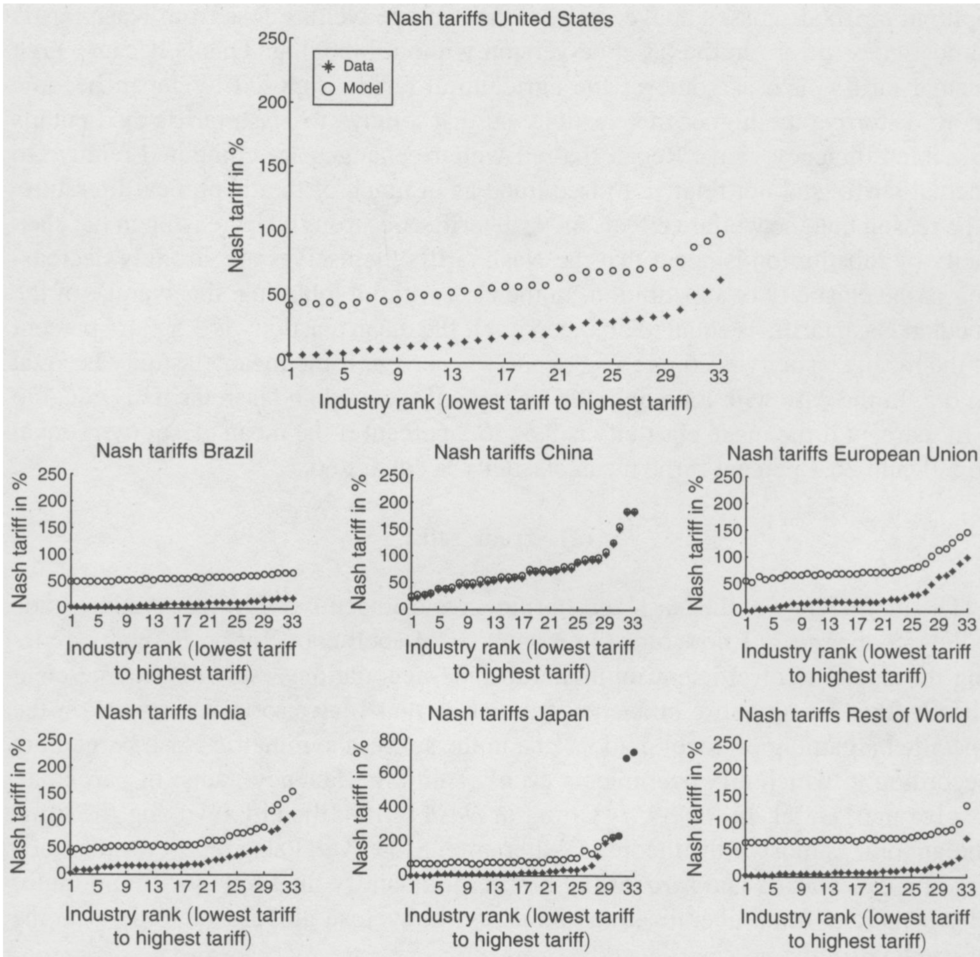


FIGURE 4. NASH TARIFFS WITH LOBBYING

*Note:* The median Nash tariffs are 56.6 percent for the United States, 54.7 percent for Brazil, 62.9 percent for China, 69.4 percent for the European Union, 54.1 percent for India, 77.6 percent for Japan, and 68.5 percent for the Rest of the World.

average of the median Nash tariffs reported in Figure 4 is 63.4 percent). Notice that the average profit shifting effects are very small even without lobbying which is the case because all governments attempt to boost their most profitable industries at the same time.[35]

Panel C of Table 4 explores the sensitivity of the results in panels A and B to alternative assumptions on the elasticity of substitution exactly in the same fashion as explained earlier for Table 3. As can be seen, the welfare effects of Nash tariffs are strongly decreasing in the elasticity of substitution just like the welfare effects of

[35] While the relatively high government welfare loss in the Rest of the World is again the result of its relatively high trade exposure, the relatively low government welfare loss of Japan is now driven by its relatively extreme political economy. In particular, Japan is effectively banning imports in its politically best connected industries which limits the losses in government welfare but significantly harms overall welfare.

optimal tariffs discussed above. Indeed, the average welfare loss from Nash tariffs almost goes to zero in the baseline version without lobbying. This is because high factual tariffs such as some of the agricultural tariffs imposed by Japan become more distortive the higher the elasticity so that a move to Nash tariffs also entails sizeable efficiency gains. Recall that all welfare changes are computed relative to factual tariffs and not relative to free trade as in much of the theoretical literature. The reason that the welfare effects of Nash tariffs are strongly decreasing in the elasticity of substitution is again that the Nash tariffs themselves are strongly decreasing in the elasticity of substitution. In the case without lobbying, the average of the median Nash tariffs is equal to 56.0 percent if the mean elasticity is 3.5, 34.4 percent if the mean elasticity is equal to 5.0, and 25.4 percent if the mean elasticity is equal to 6.5. In the case with lobbying, the average of the median Nash tariffs is equal to 61.2 percent if the mean elasticity is 3.5, 36.2 percent if the mean elasticity is equal to 5.0, and 26.4 percent if the mean elasticity is equal to 6.5.[36]

## VII. Trade Talks

The inefficiency of the Nash equilibrium creates incentives for international trade policy cooperation. I now turn to an analysis of such cooperation by characterizing the outcome of efficient multilateral trade negotiations. As will become clear shortly, there is an entire efficiency frontier so that I have to take a stance on the specific bargaining protocol. I adopt one in the spirit of symmetric Nash bargaining according to which all governments evenly split all efficiency gains. In particular, I solve max $\hat{G}_1$ s.t. $\hat{G}_j = \hat{G}_1\ \forall\, j$ starting at *Nash* tariffs, thereby invoking the same threat point as most of the theoretical literature. Moreover, I also report results starting at *factual* tariffs and *zero* tariffs in order to quantify the scope for future mutually beneficial trade liberalization and assess how close global free trade is to the efficiency frontier.

Figures 5, 6, and 7 show the world cooperative tariffs under these three regimes for the baseline version in which $\lambda_{is} = 1\ \forall\, i$ and $s$. They rank all industries by the elasticity of substitution and plot the cooperative tariffs of each country with respect to all trading partners against the industry rank. As can be seen, the cross-industry variation in the cooperative tariffs is very similar across the three figures while the cross-country variation is changing quite a bit. The cross-industry variation in the cooperative tariffs counteracts distortions in relative prices originating from cross-industry variation in markups. The cross-country variation in the cooperative tariffs induces terms-of-trade effects which replicate international side payments and ensure that all efficiency gains are split equally as required by the bargaining protocol.

To better understand the cross-industry variation in cooperative tariffs, notice that the equilibrium in this economy is efficient as long as relative prices equal relative

[36] To get a sense of how a version of the model without profit shifting effects behaves, I have again also computed Nash tariffs in the baseline case without lobbying under the assumption that the elasticity of substitution is equal to 3.42 in all industries which is the average of my elasticity estimates from Table 1. In this case, Nash tariffs would be uniform across industries and have a median of 43 percent. They would decrease welfare by 1.8 percent on average. Just like before, the prediction that Nash tariffs are uniform across industries should not be expected to generalize to richer terms-of-trade only environments in which relative prices and relative wages are less closely linked.

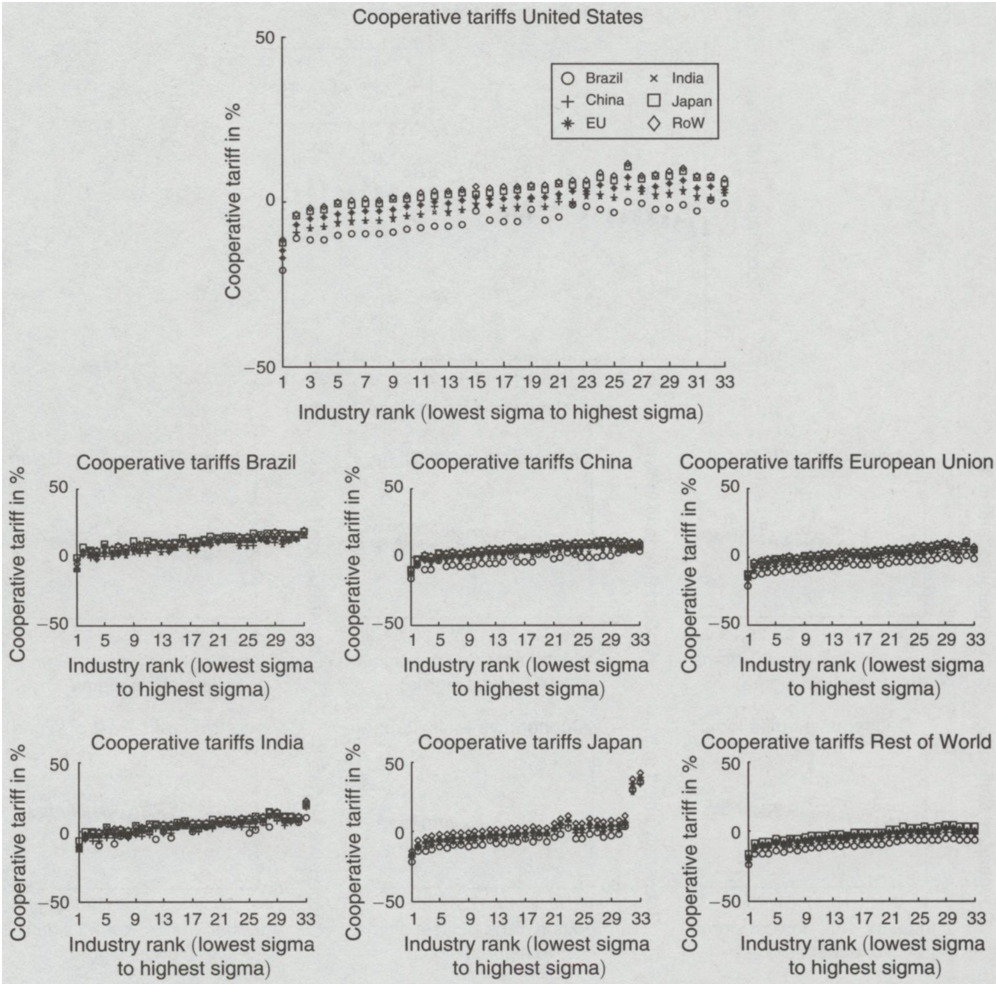


FIGURE 5. COOPERATIVE TARIFFS WITHOUT LOBBYING STARTING AT NASH TARIFFS

marginal costs.[37] If markups are the same across industries, this is the case without policy intervention so that free trade is then first-best. If markups differ across industries, however, relative prices are distorted without policy intervention but can be fully corrected by taxing imports and domestic sales in the high elasticity industries and subsidizing imports and domestic sales in the low elasticity industries. This is also what governments attempt in the cooperative equilibrium with the important difference that they are given no access to domestic policy instruments. This is similar to the point of Flam and Helpman (1987).[38]

[37] To see this, consider the effects of a fully symmetric increase in markups starting at the efficient benchmark where prices equal marginal costs. On the demand side, consumption would be unchanged for all varieties since relative prices would be unchanged and profits would be fully redistributed to consumers. On the supply side, output would be unchanged for all varieties since there is a fixed number of firms, a fixed supply of workers, and wages adjust to ensure full employment.

[38] In the baseline version in which $\lambda_{is} = 1 \; \forall \; i$ and $s$, moving from Nash tariffs to cooperative tariffs therefore implies moving from a tariff schedule which is decreasing in the elasticity of substitution (governments attempt

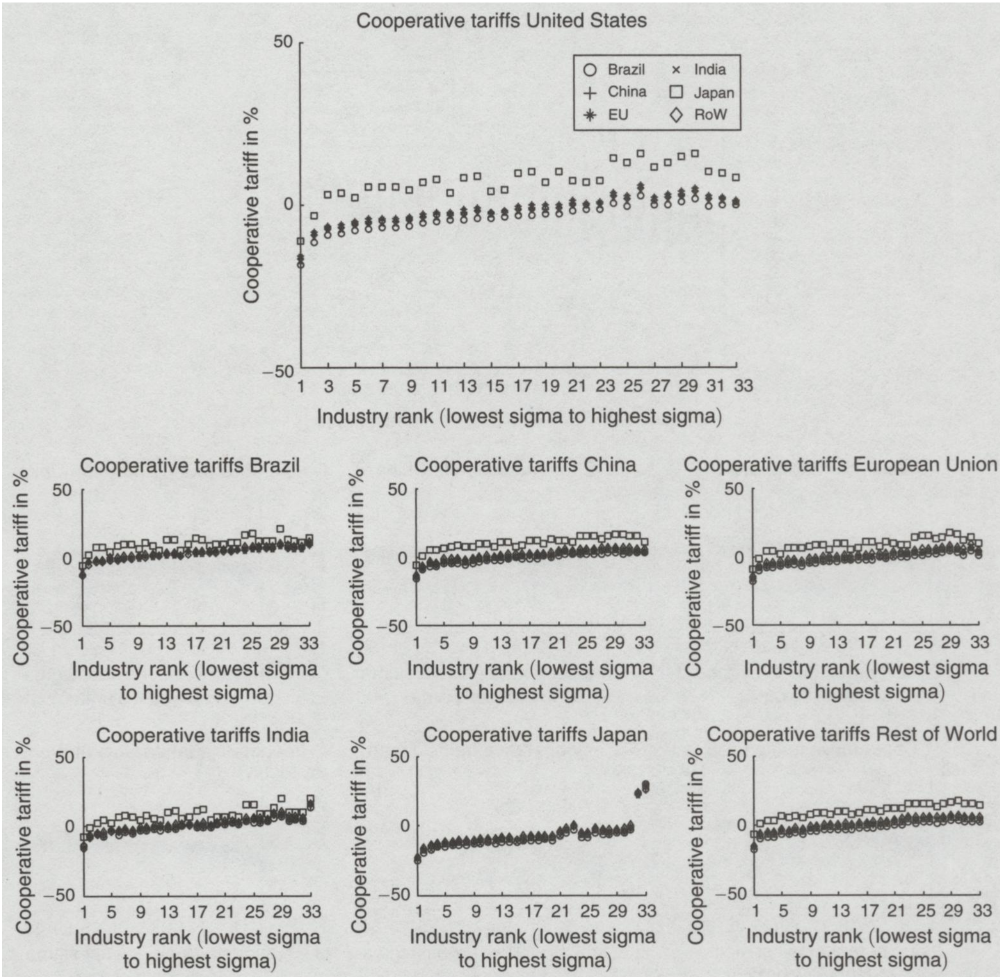


Figure 6. Cooperative Tariffs without Lobbying Starting at Factual Tariffs

To better understand the cross-country variation in cooperative tariffs, notice that a combination of import tariffs and import subsidies can induce terms-of-trade effects which replicate international side payments. As an illustration, consider the case of the United States and Japan. If the United States imposes an across-the-board import tariff, this improves the US terms-of-trade but also increases the prices of Japanese goods relative to US goods in the US market with the opposite occurring in Japan. If Japan now responds with the right across-the-board import subsidy, it is possible to further improve the US terms-of-trade but now decrease the prices of Japanese goods relative to US goods in the US market back to their original level with the opposite occurring in Japan. In this situation, Japan would then effectively make a side payment to the United States. This is essentially the point of Mayer (1981).

to shift profits) to one which is increasing in the elasticity of substitution (governments attempt to correct markup distortions).

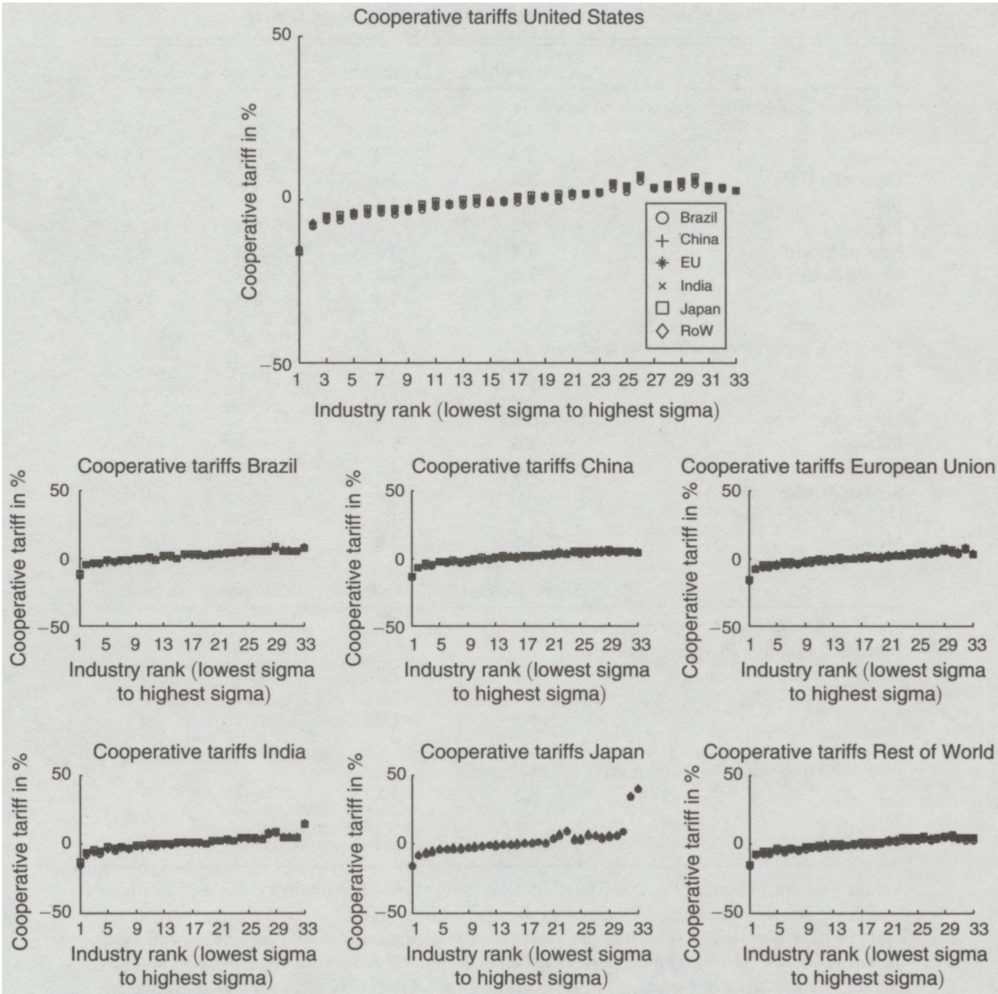


FIGURE 7. COOPERATIVE TARIFFS WITHOUT LOBBYING STARTING AT ZERO TARIFFS

An unrealistic feature of the cooperative tariffs summarized in Figures 5, 6, and 7 is that they include import subsidies which are rarely found in practice. However, ruling out import subsidies makes very little difference in terms of the quantitative results in the baseline version in which $\lambda_{is} = 1 \; \forall \; i$ and $s$. Panel A of Tables 5, 6, and 7 therefore lists the effects of cooperative tariffs under the more realistic assumption that tariffs cannot be negative. These restricted cooperative tariffs look like a raised and truncated version of the unrestricted cooperative tariffs presented in Figures 5, 6, and 7. Tables 5, 6, and 7 refer to negotiations starting at Nash tariffs, factual tariffs, and free trade, and all changes are always computed relative to these respective starting points.[39]

[39] Without ruling out import subsidies, the mean welfare effects would have been 3.5 percent, 0.6 percent, and 0.05 percent; the mean wage effects would have been 0.0 percent, 0.0 percent, and 0.0 percent; and the mean profit effects would have been 0.3 percent, 0.4 percent, and 0.2 percent, for negotiations starting at Nash tariffs, factual tariffs, and zero tariffs, respectively. Comparing those numbers to the last row of panel A of Tables 5, 6, and 7 reveals that ruling out import subsidies indeed makes very little difference here.

Table 5—Cooperative Tariffs Starting at Nash Tariffs

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying* | | | | |
| Brazil | 3.4 | 3.4 | 9.2 | −0.7 |
| China | 3.4 | 3.4 | 0.0 | −0.8 |
| European Union | 3.4 | 3.4 | −2.1 | 1.0 |
| India | 3.4 | 3.4 | 5.8 | −0.9 |
| Japan | 3.4 | 3.4 | −2.7 | 1.4 |
| Rest of World | 3.4 | 3.4 | −6.0 | 0.6 |
| United States | 3.4 | 3.4 | −4.2 | 0.4 |
| Mean | 3.4 | 3.4 | 0.0 | 0.1 |
| *Panel B. Cooperative tariffs with lobbying* | | | | |
| Brazil | 3.6 | 3.5 | 10.7 | −0.7 |
| China | 3.6 | 1.0 | −4.7 | −2.3 |
| European Union | 3.6 | 4.0 | −2.7 | 1.4 |
| India | 3.6 | 3.6 | 5.7 | −0.6 |
| Japan | 3.6 | 4.9 | −0.8 | 1.7 |
| Rest of World | 3.6 | 4.2 | −4.7 | 0.4 |
| United States | 3.6 | 4.1 | −3.5 | 1.0 |
| Mean | 3.6 | 3.6 | 0.0 | 0.1 |
| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
| *Panel C. Sensitivity of cooperative tariffs w.r.t. $\sigma_s$* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 3.3 | 3.3 | 0.0 | 0.1 |
| 5.0 | 2.2 | 2.2 | 0.0 | −0.1 |
| 6.5 | 1.7 | 1.7 | 0.0 | −0.2 |
| With lobbying (all values are means) | | | | |
| 3.5 | 3.5 | 3.5 | 0.0 | 0.1 |
| 5.0 | 2.3 | 2.2 | 0.0 | 0.0 |
| 6.5 | 1.8 | 1.7 | 0.0 | 0.1 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

As can be seen, trade negotiations starting at Nash tariffs increase each country's welfare by 3.4 percent. Since this number relates the worst-case scenario to the best-case scenario, it can be viewed as an upper bound on the value of multilateral trade policy cooperation. The results for trade negotiations starting at factual tariffs suggest that around 85 percent of these gains have already been reaped during past trade liberalizations with future trade negotiations only permitting additional welfare gains of 0.5 percent. Moreover, the results for trade negotiations starting at free trade suggest that free trade is very close to the efficiency frontier as the potential gains from such negotiations are negligibly small. This implies that tariffs are not an effective tool for correcting domestic distortions exactly as the standard targeting principle predicts.

The wage effects reported in panel A of Tables 5, 6, and 7 reflect the equilibrium side payments which ensure that all governments gain the same. For example, Brazil suffers less from the Nash equilibrium than other countries because it is relatively closed to international trade. As a result, it faces lower tariffs than other countries in the cooperative equilibrium from Figure 5 which explains the associated

TABLE 6—COOPERATIVE TARIFFS STARTING AT FACTUAL TARIFFS

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying* | | | | |
| Brazil | 0.5 | 0.5 | 6.1 | −0.7 |
| China | 0.5 | 0.5 | 0.2 | −0.9 |
| European Union | 0.5 | 0.5 | 2.7 | 0.3 |
| India | 0.5 | 0.5 | −4.0 | 1.0 |
| Japan | 0.5 | 0.5 | −9.4 | 1.8 |
| Rest of World | 0.5 | 0.5 | 1.8 | −0.2 |
| United States | 0.5 | 0.5 | 2.8 | 0.3 |
| Mean | 0.5 | 0.5 | 0.0 | 0.2 |
| *Panel B. Cooperative tariffs with lobbying* | | | | |
| Brazil | 0.5 | 0.5 | 3.3 | −0.1 |
| China | 0.5 | −1.6 | −8.0 | −2.1 |
| European Union | 0.5 | 0.3 | 0.9 | 0.0 |
| India | 0.5 | 0.8 | 0.6 | 0.2 |
| Japan | 0.5 | 0.5 | 1.5 | 0.5 |
| Rest of World | 0.5 | 0.7 | 1.1 | 0.3 |
| United States | 0.5 | 0.6 | 0.6 | 1.0 |
| Mean | 0.5 | 0.3 | 0.0 | 0.0 |
| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
| *Panel C. Sensitivity of cooperative tariffs w.r.t.* $\sigma_s$ | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 0.5 | 0.5 | 0.0 | 0.2 |
| 5.0 | 0.8 | 0.8 | 0.0 | 0.1 |
| 6.5 | 1.1 | 1.1 | 0.0 | 0.0 |
| With lobbying (all values are means) | | | | |
| 3.5 | 0.5 | 0.3 | 0.0 | 0.0 |
| 5.0 | 0.7 | 0.4 | 0.0 | 0.0 |
| 6.5 | 1.0 | 0.6 | 0.0 | 0.0 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

terms-of-trade gains apparent in panel A of Table 5. Similarly, Japan gains a lot by reducing its high factual tariffs on rice and other agricultural products. This implies that it needs to make transfers to all other countries if the Nash bargaining protocol is to be satisfied, which explains the high tariffs it faces in the cooperative equilibrium from Figure 6 as well as the associated wage decline noted in panel A of Table 6.

Panel B of Tables 5, 6, and 7 turns to the welfare effects of cooperative tariffs in the political economy case, again focusing on the realistic scenario that tariffs must be nonnegative. A comparison of the last rows of panels A and B reveals that the aggregate implications of cooperative tariffs are also quite similar with and without lobbying. The unweighted welfare gains from negotiations starting at factual tariffs or free trade are now a bit smaller since governments now maximize weighted welfare. In contrast, the unweighted welfare gains from negotiations starting at Nash tariffs are now a bit larger because Nash tariffs are now associated with lower unweighted welfare. Interestingly, trade negotiations starting at Nash tariffs make households in all countries better off even though they are conducted by politically motivated

Table 7—Cooperative Tariffs Starting at Zero Tariffs

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying* | | | | |
| Brazil | 0.03 | 0.03 | 0.1 | 0.0 |
| China | 0.03 | 0.03 | −0.2 | 0.2 |
| European Union | 0.03 | 0.03 | 0.1 | 0.0 |
| India | 0.03 | 0.03 | −0.1 | 0.2 |
| Japan | 0.03 | 0.03 | 0.6 | −0.2 |
| Rest of World | 0.03 | 0.03 | −0.2 | 0.3 |
| United States | 0.03 | 0.03 | −0.3 | 0.2 |
| Mean | 0.03 | 0.03 | 0.0 | 0.1 |
| *Panel B. Cooperative tariffs with lobbying* | | | | |
| Brazil | 0.2 | 0.28 | 1.4 | 0.6 |
| China | 0.2 | −1.25 | −3.1 | −1.4 |
| European Union | 0.2 | −0.01 | 0.8 | −0.1 |
| India | 0.2 | −0.86 | −0.7 | −0.7 |
| Japan | 0.2 | −0.44 | 1.0 | −0.5 |
| Rest of World | 0.2 | 0.28 | 1.0 | 0.5 |
| United States | 0.2 | 0.15 | −0.4 | 1.0 |
| Mean | 0.2 | −0.27 | 0.0 | −0.1 |

| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel C. Sensitivity of cooperative tariffs w.r.t. $\sigma_s$* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 0.03 | 0.03 | 0.0 | 0.1 |
| 5.0 | 0.01 | 0.01 | 0.0 | 0.1 |
| 6.5 | 0.01 | 0.01 | 0.0 | 0.1 |
| With lobbying (all values are means) | | | | |
| 3.5 | 0.2 | −0.26 | 0.0 | −0.1 |
| 5.0 | 0.3 | −0.29 | 0.0 | 0.1 |
| 6.5 | 0.4 | −0.33 | 0.0 | 0.2 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

governments. This is no longer true, however, for trade negotiations starting at factual tariffs or zero tariffs, specifically in the cases of China, India, and Japan.[40]

Panel B of Table 7 further reveals that free trade is quite close to the efficiency frontier even in the political economy case. In particular, government welfare only increases by 0.2 percent in all countries following trade negotiations starting at free trade. This suggests that a good rule of thumb for achieving efficiency in remaining trade negotiations might be to focus on tariff reductions in sectors in which factual tariffs remain high. One complication, however, is that a move to free trade does not make all governments better off relative to factual tariffs. For example, Indian government welfare would fall by 0.9 percent since Indian factual tariffs and optimal tariffs are closely aligned in the political economy case.

[40] The strong political preferences of Japan also imply that restricting tariffs to be nonnegative is not as innocuous here as it was in the benchmark case without political economy forces. Without that restriction, Japan would be able to make larger side payments to other countries thereby buying additional support for its rice and wheat industry and imposing significant distortions on its economy.

Panel C of Tables 5, 6, and 7 explores the sensitivity of the results in panels A and B to alternative assumptions on the elasticity of substitution exactly in the same fashion as explained earlier for Tables 3 and 4. As can be seen, the gains from trade negotiations starting at Nash tariffs are decreasing in the elasticity while the gains from trade negotiations starting at factual tariffs are increasing in the elasticity. The gains from trade negotiations starting at Nash tariffs are decreasing in the elasticity simply because the Nash tariffs themselves are decreasing in the elasticity. The gains from trade negotiations starting at factual tariffs are increasing in the elasticity simply because factual tariffs get more distortive the higher the elasticity.[41]

In practice, governments do not simply engage in multilateral Nash bargaining but instead follow a rules-based negotiation approach guided by the principles of the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO). The most prominent one is the most-favored nation (MFN) principle which forces countries to impose the same tariff against all trading partners for any given traded product. A comprehensive assessment of the implications of this principle is difficult in the context of this paper since MFN is enforced at the tariff-line level and therefore does not have to hold within the broad industry categories considered here. Nevertheless, it seems useful to discuss the effects of imposing MFN to get a sense of some of the broader issues involved.

Table 8 reports the effects of imposing optimal tariffs subject to the constraint of MFN in the same format as Table 3 discussed above. As can be seen, the results are virtually identical with and without MFN, as one might have suspected from the lack of cross-country variation in Figure 1.[42] Table 9 then turns to the effects of MFN versions of the Nash tariffs covered in Table 4. Again, the results are very similar with and without MFN, as one might have suspected from the lack of cross-country variation in Figure 3.[43] Overall, these results suggest that MFN by itself is hardly effective in pushing countries toward the efficiency frontier. Incidentally, this is

[41] To get a sense of how a version of the model without profit shifting effects behaves, I have again also computed cooperative tariffs in the baseline case without lobbying under the assumption that the elasticity of substitution is equal to 3.42 in all industries which is the average of my elasticity estimates from Table 1. In this case, cooperative tariffs would be uniform across industries. They would increase welfare by 2.5 percent, 0.5 percent, and 0.0 percent for trade negotiations starting at Nash tariffs, factual tariffs, and zero tariffs respectively with the latter result simply reflecting that free trade would then be on the efficiency frontier.

[42] In the case without lobbying, the median MFN optimal tariffs are 56.2 percent for Brazil, 59.9 percent for China, 60.9 percent for the European Union, 54.0 percent for India, 59.6 percent for Japan, 63.0 percent for the Rest of the World, and 60.8 percent for the United States (the mean of these medians is 59.2 percent which becomes 57.2 percent if the elasticity of substitution is scaled to average 3.5, 34.4 percent if the elasticity of substitution is scaled to average 5.0, and 24.7 percent if the elasticity of substitution is scaled to average 6.5). In the case with lobbying, the median MFN optimal tariffs are 54.2 percent for Brazil, 61.7 percent for China, 68.9 percent for the European Union, 49.9 percent for India, 77.8 percent for Japan, 68.7 percent for the Rest of the World, and 57.5 percent for the United States (the mean of these medians is 62.7 percent which becomes 60.4 percent if the elasticity of substitution is scaled to average 3.5, 35.6 percent if the elasticity of substitution is scaled to average 5.0, and 25.7 percent if the elasticity of substitution is scaled to average 6.5).

[43] In the case without lobbying, the median MFN Nash tariffs are 56.4 percent for Brazil, 59.4 percent for China, 58.7 percent for the European Union, 54.9 percent for India, 58.6 percent for Japan, 60.4 percent for the Rest of the World, and 60.0 percent for the United States (the mean of these medians is 58.3 percent which becomes 56.2 percent if the elasticity of substitution is scaled to average 3.5, 34.5 percent if the elasticity of substitution is scaled to average 5.0, and 25.4 percent if the elasticity of substitution is scaled to average 6.5). In the case with lobbying, the median MFN Nash tariffs are 54.7 percent for Brazil, 63.6 percent for China, 69.1 percent for the European Union, 54.3 percent for India, 77.9 percent for Japan, 66.9 percent for the Rest of the World, and 57.8 percent for the United States (the mean of these medians is 63.5 percent which becomes 61.2 percent if the elasticity of substitution is scaled to average 3.5, 36.4 percent if the elasticity of substitution is scaled to average 5.0, and 26.6 percent if the elasticity of substitution is scaled to average 6.5).

TABLE 8—OPTIMAL TARIFFS UNDER MFN

| | Δ gvt. welfare | | Δ welfare | | Δ wage | | Δ profits | |
|---|---|---|---|---|---|---|---|---|
| | own | other | own | other | own | other | own | other |
| *Panel A. Optimal tariffs without lobbying under MFN* | | | | | | | | |
| Brazil | 1.1 | −0.1 | 1.1 | −0.1 | 18.2 | −3.0 | 0.8 | −0.0 |
| China | 1.8 | −0.6 | 1.8 | −0.6 | 17.6 | −2.9 | 0.5 | −0.1 |
| European Union | 1.9 | −1.0 | 1.9 | −1.0 | 22.4 | −3.7 | 0.1 | −0.2 |
| India | 1.7 | −0.1 | 1.7 | −0.1 | 8.7 | −1.5 | 2.7 | −0.1 |
| Japan | 4.0 | −0.3 | 4.0 | −0.3 | 18.6 | −3.1 | 1.7 | −0.1 |
| Rest of World | 2.8 | −1.7 | 2.8 | −1.7 | 19.0 | −3.2 | 1.1 | −0.6 |
| United States | 2.3 | −0.9 | 2.3 | −0.9 | 23.8 | −4.0 | 0.6 | −0.1 |
| Mean | 2.2 | −0.7 | 2.2 | −0.7 | 18.3 | −3.1 | 1.1 | −0.2 |
| *Panel B. Optimal tariffs with lobbying under MFN* | | | | | | | | |
| Brazil | 0.9 | −0.1 | 1.0 | −0.1 | 18.1 | −3.0 | 0.3 | −0.0 |
| China | 1.5 | −0.4 | 1.5 | −0.5 | 13.3 | −2.2 | 0.1 | −0.0 |
| European Union | 2.2 | −1.2 | 1.7 | −1.1 | 27.0 | −4.5 | −0.9 | 0.1 |
| India | 0.5 | −0.0 | 0.7 | −0.0 | 11.4 | −1.9 | 0.6 | −0.0 |
| Japan | 2.6 | −0.4 | 1.0 | −0.4 | 30.0 | −5.0 | −1.4 | 0.1 |
| Rest of World | 2.9 | −1.7 | 2.5 | −1.8 | 22.0 | −3.7 | −0.1 | −0.2 |
| United States | 2.5 | −0.9 | 2.1 | −0.9 | 26.4 | −4.4 | −0.2 | 0.0 |
| Mean | 1.9 | −0.7 | 1.5 | −0.7 | 21.2 | −3.5 | −0.2 | 0.0 |
| $\sigma$ | Δ gvt. welfare | | Δ welfare | | Δ wage | | Δ profits | |
| mean | own | other | own | other | own | other | own | other |
| *Panel C. Sensitivity of optimal tariffs w.r.t. $\sigma_s$ under MFN* | | | | | | | | |
| Without lobbying (all values are means) | | | | | | | | |
| 3.5 | 2.2 | −0.6 | 2.2 | −0.6 | 17.6 | −2.9 | 1.1 | −0.2 |
| 5.0 | 1.7 | −0.4 | 1.7 | −0.4 | 9.0 | −1.5 | 1.1 | −0.2 |
| 6.5 | 1.5 | −0.2 | 1.5 | −0.2 | 5.4 | −0.9 | 1.1 | −0.2 |
| With lobbying (all values are means) | | | | | | | | |
| 3.5 | 1.8 | −0.6 | 1.5 | −0.6 | 20.3 | −3.4 | −0.2 | 0.0 |
| 5.0 | 1.2 | −0.4 | 0.9 | −0.4 | 10.5 | −1.8 | −0.2 | 0.0 |
| 6.5 | 1.1 | −0.3 | 0.7 | −0.3 | 6.5 | −1.1 | −0.2 | 0.0 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The entries under "own" are the effects on the tariff imposing country while the entries under "other" are the averages of the effects on all other countries. The last rows of panels A and B report averages. Panel C reports only such averages.

consistent with the fact that the abovementioned "autonomous rate," "general rate," and "column 2" tariffs of the European Union, China, Japan, and the United States are all imposed nondiscriminatorily.

Tables 10, 11, and 12 list the effects of trade negotiations subject to the constraint of MFN in the same format as Tables 5, 6, and 7. Recall from the above discussion of Figures 5, 6, and 7 that cross-country variation in the cooperative tariffs induces terms-of-trade effects which replicate international side payments. Imposing MFN somewhat restricts such side payments which implies slightly lower gains from trade negotiations starting at Nash tariffs or factual tariffs. The main effect of imposing MFN, however, is that it significantly reduces the difference between changes in government welfare and overall welfare for trade negotiations starting at Nash tariffs or factual tariffs in the political economy case. This is due to the fact that a restriction of side payments limits the governments' ability to coordinate their support for each other's politically influential industries.

TABLE 9—NASH TARIFFS UNDER MFN

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Nash tariffs without lobbying under MFN* | | | | |
| Brazil | −1.8 | −1.8 | 2.0 | 0.5 |
| China | −2.3 | −2.3 | 0.0 | −0.2 |
| European Union | −2.5 | −2.5 | 3.1 | −0.9 |
| India | −2.1 | −2.1 | −9.3 | 1.9 |
| Japan | −0.7 | −0.7 | −0.7 | 0.8 |
| Rest of World | −5.0 | −5.0 | −1.0 | −0.6 |
| United States | −2.2 | −2.2 | 5.8 | −0.3 |
| Mean | −2.4 | −2.4 | 0.0 | 0.2 |
| *Panel B. Nash tariffs with lobbying under MFN* | | | | |
| Brazil | −2.5 | −2.4 | −3.7 | 0.5 |
| China | −3.5 | −2.9 | −7.4 | 0.3 |
| European Union | −2.1 | −2.6 | 6.1 | −1.2 |
| India | −3.6 | −3.3 | −10.5 | 0.8 |
| Japan | −1.1 | −2.9 | 10.7 | −1.7 |
| Rest of World | −5.3 | −5.6 | −1.4 | −0.1 |
| United States | −2.1 | −2.5 | 6.1 | −0.2 |
| Mean | −2.9 | −3.2 | 0.0 | −0.2 |
| $\sigma_{mean}$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
| *Panel C. Sensitivity of Nash tariffs w.r.t. $\sigma_s$ under MFN* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | −2.3 | −2.3 | 0.0 | 0.2 |
| 5.0 | −1.0 | −1.0 | 0.0 | 0.3 |
| 6.5 | −0.2 | −0.2 | 0.0 | 0.2 |
| With lobbying (all values are means) | | | | |
| 3.5 | −2.8 | −3.0 | 0.0 | −0.2 |
| 5.0 | −1.5 | −1.7 | 0.0 | −0.1 |
| 6.5 | −0.8 | −1.1 | 0.0 | −0.1 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

An additional implication of the MFN principle is that it "multilateralizes" trade negotiations between a subset of countries by forcing them to extend all negotiated tariff concessions to nonparticipating countries as well. This implication has been discussed quite controversially in the theoretical literature. Some authors argue that it undermines multilateral trade negotiations by allowing nonparticipating countries to free ride on the bargaining outcomes of participating ones (e.g., Caplin and Krishna 1988). Other authors argue that it solves a bilateral opportunism problem resulting from a trade bloc's ability to manipulate its external terms-of-trade (e.g., Bagwell and Staiger 2005).[44] While a comprehensive quantitative analysis of these issues is beyond the scope of this paper, a simple thought experiment nevertheless sheds some interesting light on them.

In particular, consider the trade war equilibrium in the baseline version in which $\lambda_{is} = 1 \; \forall \; i$ and $s$ and suppose that the European Union, Japan, and the United States

[44] See chapter 5 of Bagwell and Staiger (2002) for a detailed review of the relevant literature.

Table 10—Cooperative Tariffs under MFN Starting at Nash Tariffs

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying under MFN* | | | | |
| Brazil | 3.3 | 3.3 | 10.5 | −0.4 |
| China | 3.3 | 3.3 | −0.3 | −0.5 |
| European Union | 3.3 | 3.3 | −2.3 | 0.9 |
| India | 3.3 | 3.3 | 5.2 | −0.4 |
| Japan | 3.3 | 3.3 | −2.9 | 1.2 |
| Rest of World | 3.3 | 3.3 | −6.0 | 0.3 |
| United States | 3.3 | 3.3 | −4.2 | 0.3 |
| Mean | 3.3 | 3.3 | 0.0 | 0.2 |
| *Panel B. Cooperative tariffs with lobbying under MFN* | | | | |
| Brazil | 3.4 | 3.3 | 10.2 | −0.6 |
| China | 3.4 | 2.2 | −1.0 | −1.1 |
| European Union | 3.4 | 3.8 | −3.6 | 1.2 |
| India | 3.4 | 3.4 | 4.2 | −0.6 |
| Japan | 3.4 | 4.5 | −0.7 | 1.3 |
| Rest of World | 3.4 | 4.0 | −5.5 | 0.5 |
| United States | 3.4 | 3.8 | −3.5 | 0.7 |
| Mean | 3.4 | 3.6 | 0.0 | 0.2 |
| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
| *Panel C. Sensitivity of cooperative tariffs w.r.t. $\sigma_s$ under MFN* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 3.2 | 3.2 | 0.0 | 0.2 |
| 5.0 | 2.1 | 2.1 | 0.0 | 0.0 |
| 6.5 | 1.6 | 1.6 | 0.0 | −0.1 |
| With lobbying (all values are means) | | | | |
| 3.5 | 3.3 | 3.5 | 0.0 | 0.2 |
| 5.0 | 2.0 | 2.1 | 0.0 | 0.1 |
| 6.5 | 1.5 | 1.7 | 0.0 | 0.1 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

reciprocally reduce their tariffs against one another by the same percentage while the other countries keep their trade war tariffs in place. Panel A of Figure 8 shows the average welfare effects of this tariff reduction under the assumption that the liberalizing countries also keep their trade war tariffs against all other countries in place. As can be seen, this non-MFN tariff reduction benefits the liberalizing countries and harms the other countries. The welfare loss of the other countries is explained by a deterioration of their terms-of-trade which can be seen from the associated relative wage effects in panel B of Figure 8. It is the result of a shift in US, EU, and Japanese consumer expenditure toward the cheaper liberalized goods.[45]

Suppose now that the European Union, Japan, and the United States undertake the same tariff reductions but extend them to the other countries according to the MFN

[45] The associated profit shifting effects are minimal since the tariff reduction occurs proportionately across industries.

TABLE 11—COOPERATIVE TARIFFS UNDER MFN STARTING AT FACTUAL TARIFFS

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying under MFN* | | | | |
| Brazil | 0.3 | 0.3 | 3.3 | −0.5 |
| China | 0.3 | 0.3 | −0.6 | −0.9 |
| European Union | 0.3 | 0.3 | 1.2 | 0.2 |
| India | 0.3 | 0.3 | −5.9 | 1.0 |
| Japan | 0.3 | 0.3 | 0.6 | 0.5 |
| Rest of World | 0.3 | 0.3 | 0.5 | −0.1 |
| United States | 0.3 | 0.3 | 0.8 | 0.5 |
| Mean | 0.3 | 0.3 | 0.0 | 0.1 |
| *Panel B. Cooperative tariffs with lobbying under MFN* | | | | |
| Brazil | 0.3 | 0.3 | 2.5 | −0.2 |
| China | 0.3 | −0.5 | −5.1 | −1.1 |
| European Union | 0.3 | 0.2 | 0.2 | 0.0 |
| India | 0.3 | 0.5 | 0.9 | 0.2 |
| Japan | 0.3 | 0.3 | 0.4 | 0.4 |
| Rest of World | 0.3 | 0.5 | 0.4 | 0.2 |
| United States | 0.3 | 0.4 | 0.7 | 0.3 |
| Mean | 0.3 | 0.2 | 0.0 | 0.0 |
| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
| *Panel C. Sensitivity of cooperative tariffs w.r.t. $\sigma_s$ under MFN* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 0.3 | 0.3 | 0.0 | 0.1 |
| 5.0 | 0.6 | 0.6 | 0.0 | 0.0 |
| 6.5 | 0.8 | 0.8 | 0.0 | −0.1 |
| With lobbying (all values are means) | | | | |
| 3.5 | 0.3 | 0.3 | 0.0 | 0.0 |
| 5.0 | 0.4 | 0.3 | 0.0 | −0.1 |
| 6.5 | 0.4 | 0.3 | 0.0 | −0.2 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

principle while the other countries still keep their trade war tariffs in place.[46] As can be seen from panel C of Figure 8, the liberalizing countries first gain and then lose from this MFN-tariff reduction while the other countries are left much better off. The welfare gain of the other countries is explained by an improvement of their terms-of-trade which can be seen from the associated relative wage effects in panel D of Figure 8. This is due to the fact that the liberalizing countries make tariff concessions to the other countries without receiving anything in return. Overall, MFN therefore seems to protect "outsider" countries from welfare losses associated with liberalizations among "insider" countries. However, it also makes "insider" liberalizations much less attractive by more than neutralizing their adverse external effects.

Readers familiar with the work of Bagwell and Staiger (2005) will recall that MFN neutralizes external terms-of-trade effects in their framework if the

[46] Recall that the trade war equilibrium is very similar with and without imposing MFN so that it does not really matter which one is taken as a staring point. For simplicity, I focus on the trade war equilibrium subject to MFN in all thought experiments captured in Figure 8.

TABLE 12—COOPERATIVE TARIFFS UNDER MFN STARTING AT ZERO TARIFFS

| | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel A. Cooperative tariffs without lobbying under MFN* | | | | |
| Brazil | 0.03 | 0.03 | 0.0 | 0.1 |
| China | 0.03 | 0.03 | −0.2 | 0.2 |
| European Union | 0.03 | 0.03 | 0.1 | 0.0 |
| India | 0.03 | 0.03 | −0.2 | 0.3 |
| Japan | 0.03 | 0.03 | 0.7 | −0.1 |
| Rest of World | 0.03 | 0.03 | −0.2 | 0.3 |
| United States | 0.03 | 0.03 | −0.2 | 0.2 |
| Mean | 0.03 | 0.03 | 0.0 | 0.1 |
| *Panel B. Cooperative tariffs with lobbying under MFN* | | | | |
| Brazil | 0.1 | 0.17 | 0.6 | 0.5 |
| China | 0.1 | −0.24 | −0.3 | −0.2 |
| European Union | 0.1 | −0.10 | 0.2 | −0.2 |
| India | 0.1 | −0.30 | −0.2 | −0.3 |
| Japan | 0.1 | −0.41 | −0.6 | −0.4 |
| Rest of World | 0.1 | 0.07 | 0.2 | 0.3 |
| United States | 0.1 | 0.08 | 0.1 | 0.4 |
| Mean | 0.1 | −0.11 | 0.0 | 0.0 |

| $\sigma$ | Δ gvt. welfare | Δ welfare | Δ wage | Δ profits |
|---|---|---|---|---|
| *Panel C. Sensitivity of cooperative tariffs w.r.t. $\sigma_S$ under MFN* | | | | |
| Without lobbying (all values are means) | | | | |
| 3.5 | 0.03 | 0.03 | 0.0 | 0.1 |
| 5.0 | 0.01 | 0.01 | 0.0 | 0.1 |
| 6.5 | 0.01 | 0.01 | 0.0 | 0.1 |
| With lobbying (all values are means) | | | | |
| 3.5 | 0.09 | −0.11 | 0.0 | 0.0 |
| 5.0 | 0.14 | −0.15 | 0.0 | 0.1 |
| 6.5 | 0.20 | −0.20 | 0.0 | 0.1 |

*Notes:* The entries under "gvt. welfare" are the percentage changes in $G$, the entries under "welfare" are the percentage changes in $W$, the entries under "wage" are the percentage changes in $w$ normalized such that the average wage change across all countries is zero, and the entries under "profits" are the percentage changes in total profits due to changes in industry output. The last rows of panels A and B report averages. Panel C reports only such averages.

liberalizing parties keep their bilateral terms-of-trade unchanged. While the thought experiment underlying Figure 8 simply considers proportional tariff cuts, the bilateral terms-of-trade of the liberalizing countries are still largely unchanged so that this does not explain why the Bagwell and Staiger (2005) result does not apply. Instead, the key is the presence of product differentiation which breaks the direct link between countries' bilateral terms-of-trade and makes MFN tariff concessions excessive to the extent that the neutralization of external terms-of-trade effects is the goal. As an illustration, consider Chinese and Japanese electronics producers competing for customers in the United States and suppose that the United States and Japan agree to a reciprocal trade liberalization which leaves the world price of Japanese electronics unchanged:

If the United States reduces its tariffs against Japan by 10 percent, the price of Japanese electronics in the US market falls by 10 percent. The repercussions this has on the world price of Chinese electronics depend on the degree of substitutability between Chinese and Japanese electronics. If they are perfect substitutes, as in Bagwell and Staiger (2005), the Chinese world price falls by 10 percent because

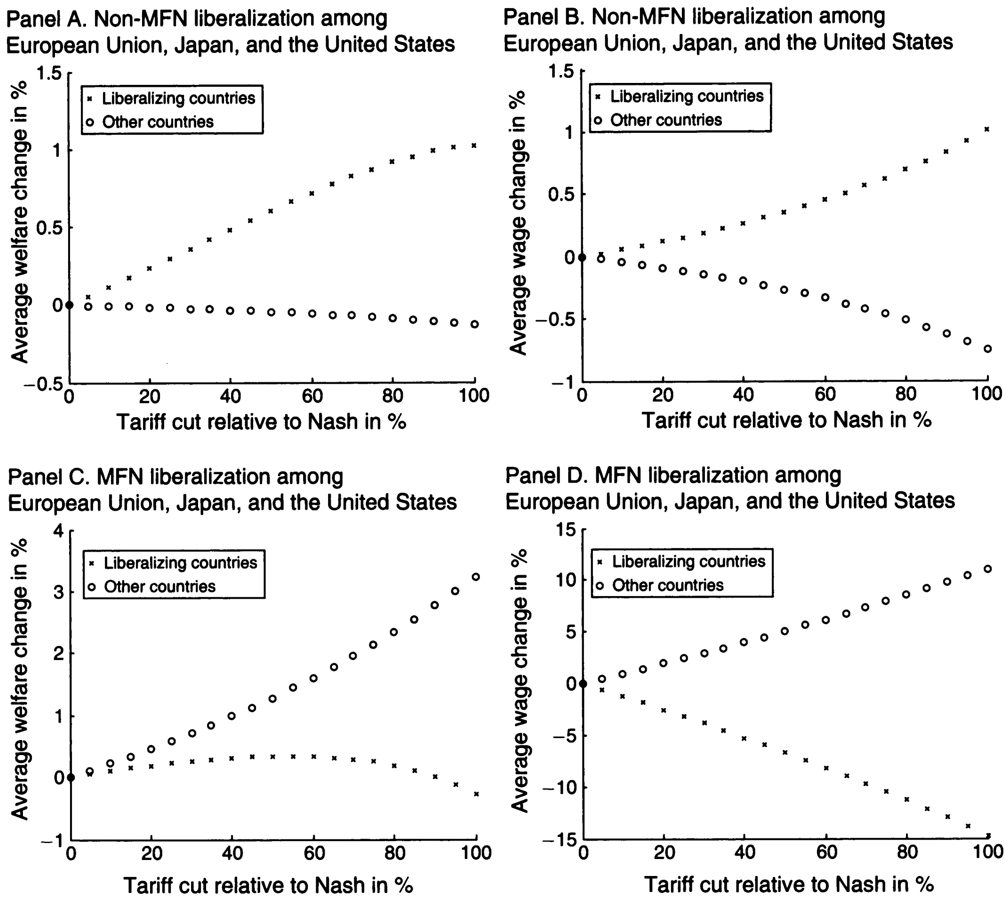


Figure 8. Discriminatory versus Nondiscriminatory Tariff Reductions

otherwise Chinese electronics become uncompetitive in the US market. If they are imperfect substitutes, as in the model developed here, the drop in the Chinese world price is less extreme because Chinese electronics are then less susceptible to Japanese competition. While a 10 percent (i.e., MFN) tariff reduction against China is therefore required to neutralize the negative effect of the US-Japanese trade liberalization on the Chinese world price with perfect substitutes, such a tariff reduction is excessive with imperfect substitutes, which explains my findings in Figure 8.[47]

## VIII. Conclusion

I proposed a flexible framework for the quantitative analysis of noncooperative and cooperative trade policy which nests traditional, new trade, and political economy motives for protection. I used this framework to provide a first comprehensive quantitative analysis of noncooperative and cooperative trade policy, addressing some natural questions emerging from the theoretical trade policy literature. I began

[47] While I only provide an intuitive discussion of this point in the interest of brevity, a formal analysis is available from me upon request.

by considering optimal tariffs, i.e., the tariffs countries would impose if they did not have to fear any retaliation. I then turned to an analysis of Nash tariffs, i.e., the tariffs countries would impose in a worldwide trade war in which their trading partners retaliated optimally. I finally investigated cooperative tariffs, i.e., the tariffs countries would negotiate to in efficient trade negotiations with and without being restricted by the GATT/WTO's most-favored nation clause.

The interpretation of my results depends on whether the framework is taken as a maintained or tested hypothesis. In the former case, they can be viewed as answers to questions of immediate policy relevance: for example, as revealing what would have happened if a trade war had broken out in the wake of the recent financial crisis; or as suggesting how much there is to gain from future multilateral trade negotiations. In the latter case, they can be interpreted as suggestive of the plausibility of some of the leading models of trade policy making: for example, as demonstrating that the predicted noncooperative tariffs can be brought in line with observed noncooperative tariffs by choosing plausible political economy weights; or as showing that the underlying trade policy externalities can be sufficiently strong to reasonably justify a lengthy process of multilateral trade negotiations.

Given the near-absence of prior quantitative analyses of noncooperative and cooperative trade policy, the framework could be extended in many ways and used to address a whole host of related questions emerging from the large qualitative trade policy literature. As one of many examples, one could elaborate on the role played by the GATT/WTO principles of reciprocity and nondiscrimination as formalized by Bagwell and Staiger (1999) and ask whether they are helpful or harmful for achieving and maintaining global efficiency. This could entail a quantitative analysis of the long-standing debate associated with Bhagwati (1991) of whether free trade agreements, which are allowed under GATT/WTO rules as an important exception to the principle of nondiscrimination, represent building-blocks or stumbling-blocks on the way toward full multilateral cooperation.

## Appendix

### A. *Data*

My main data source is the eighth version of the Global Trade Analysis Project database (GTAP 8) from which I take industry-level trade, production, and tariff data for the year 2007. The GTAP 8 database is a carefully cleaned, fully documented, publicly available, and globally consistent database covering 129 countries and 57 industries which span the agricultural, manufacturing, and service sectors of the economy. The GTAP 8 database is itself based on a number of underlying databases. In particular, its trade data is mainly drawn from the UN's Comtrade database, its production data is mainly built from national input-output tables, and its tariff data is mainly taken from the International Trade Centre's Market Access Map database. The database is documented in Narayanan, Aguiar, and McDougall (2012) which can be accessed directly from the GTAP website under https://www.gtap.agecon.purdue.edu.

For my estimation of the demand elasticities, I further make use of the UN's Comtrade trade data for the time period 1994–2008 which covers most countries in the world. The data is originally at the SITC-Rev2 4-digit level and I convert it, first, to the SITC-Rev3 4-digit level using a concordance from the Center for International Data at UC Davis and, second, to the GTAP sector level using a concordance which I manually constructed with the help of various concordances available from the GTAP website. This involved combining the original GTAP sectors "raw milk" and "dairy products" into a new GTAP sector "raw and processed dairy," the original GTAP sectors "paddy rice" and "processed rice" into a new GTAP sector "raw and processed rice," and the original GTAP sectors "raw and processed sugar" and "sugar cane, sugar beet" into a new GTAP sector "sugar."

For my calibration of the political economy weights of China, Japan, and the United States, I also make direct use of the International Trade Centre's Market Access Map database (MAcMap). The MAcMap data provides exhaustive and consistent measures of tariff protection across the world. Particular care has been taken to transform specific tariffs into ad valorem equivalents which is especially relevant for agricultural industries. While the database includes the measure of noncooperative tariffs described in the main text for China for the year 2007, I have to use data from the year 2005 for the United States and Japan. A small number of observations are missing for Japan which I replace with Japan's applied MFN rate. The data is originally at the HS 6-digit level and I convert it to the GTAP sector level using a concordance available from the GTAP website. The database is documented in Guimbard et al. (2012).

For my calibration of the political economy weights of the European Union, I make use of the UN's Trade Analysis and Information System (TRAINS) database which is made available using the World Integrated Trade Solutions (WITS) software of the World Bank. The database does not contain the measure of noncooperative tariffs described in the main text for the year 2007, so I use the next closest alternative which is from the year 2000. The data is originally at the HS 6-digit level and I convert it to the GTAP sector level using a concordance from the WITS-TRAINS website.

### B. *Elasticity Estimation*

I estimate the import demand elasticities using the method of Feenstra (1994) which identifies them from variation in the variances and covariances of demand and supply shocks across countries and over time. I base my estimation on the instructions in Feenstra (2010) in which the method is particularly clearly explained. My estimating equation is equation (2.21) in Feenstra (2010) which I estimate using weighted least squares following the code provided in Appendix 2.2 of Feenstra (2010). However, I do not focus on a single importer, but pool across the main importers considered in my analysis.

Specifically, I pool across the importers Brazil, China, India, Japan, the United States, and the EU-25 countries Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, Spain, and the United Kingdom. I use all exporters available in the data. In my estimation, all results turn out to be real numbers so that I do not need to resort to the grid search method proposed by Broda and Weinstein (2006).

Given that profit shifting effects feature prominently in my analysis, one might wonder how the cross-industry variation in markups implied by my elasticity estimates compares to the cross-industry variation in other markup estimates in the literature. To address this, I have compared the cross-country averages of the markup estimates reported in Tables 3 and 4 of Martins, Scarpetta, and Pilat (1996) to the markup estimates implied by the elasticity estimates in my Table 1. This was possible only for 23 of the 33 industries I consider since Martins, Scarpetta, and Pilat (1996) do not provide estimates for agricultural industries. Encouragingly, the estimates are positively related with only one industry clearly standing out (beverages and tobacco products). The overall correlation is 30 percent if the outlier is included and 45 percent otherwise.

## C. *Elimination of Aggregate Trade Imbalances*

To purge the trade data of aggregate trade imbalances, I essentially replicate the original Dekle, Eaton, and Kortum (2007) exercise using my model. In particular, I introduce aggregate trade imbalances as nominal transfers into the budget constraints and allow them to change exogenously so that equation (13) becomes

$$\hat{X}_j = \frac{w_j L_j}{X_j}\hat{w}_j + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j}\hat{t}_{ijs}(\hat{\tau}_{ijs})^{-\sigma_s}\left(\frac{\hat{w}_i}{\hat{P}_{js}}\right)^{1-\sigma_s}\hat{X}_j + \sum_s \frac{\pi_{js}}{X_j}\hat{\pi}_{js} - \frac{NX_j}{X_j}\widehat{NX}_j, \tag{C1}$$

where $NX_i \equiv \sum_j \sum_s (T_{ijs} - T_{jis})$ is taken from the data. I then use equations (10), (11), (12), and (C1) to solve for the general equilibrium effects $\hat{w}_i$, $\hat{X}_i$, $\hat{P}_{is}$, $\hat{\pi}_{is}$ resulting from setting $NX_j' = 0$ while keeping all tariffs unchanged. I finally use these general equilibrium effects to calculate the effects on trade flows using the relationship $\hat{T}_{ijs} = (\hat{w}_i)^{1-\sigma_s}(\hat{P}_{js})^{\sigma_s-1}\hat{X}_j$, which delivers a trade matrix without aggregate trade imbalances.

Aggregate trade imbalances are quite large in the raw data. In particular, exports minus imports as a ratio of exports plus imports equal 17 percent for Brazil, 21 percent for China, 8 percent for the European Union, −4 percent for India, 28 percent for Japan, −9 percent for the Rest of the World, and −22 percent for the United States. Given the elasticities listed in Table 1, the predicted changes in exports and imports resulting from an elimination of aggregate trade imbalances are −15 percent and 20 percent for Brazil, −17 percent and 28 percent for China, −9 percent and 6 percent for the European Union, 1 percent and −8 percent for India, −18 percent and 44 percent for Japan, 6 percent and −11 percent for the Rest of the World, and 16 percent and −26 percent for the United States.

As indicated in the main text, calculating the counterfactual effects of trade policy changes using the purged data and equations (10), (11), (12), and (13) has two main advantages over the standard approach which would call for using the raw data and equations (10), (11), (12), and (C1) with aggregate net exports kept unchanged. First, the assumption of constant aggregate trade imbalances leads to extreme general equilibrium adjustments in response to high tariffs and cannot be true in the limit as tariffs approach infinity. Second, the assumption of constant nominal transfers implies that it matters what nominal units they are measured in since this affects how real transfers change in counterfactuals.

While the first point should be obvious, the second point may not be immediately clear. To see the problem, notice that country $j$'s real income depends on $\frac{NX_j}{P_j}$ in the presence of aggregate trade imbalances if they are introduced as nominal transfers into the budget constraints. How real income changes in counterfactuals therefore depends on what units $NX_j$ is measured in. In equation (C1), I have followed the literature and simply assumed that $NX_j$ is measured in units of the numeraire in which case the problem can be detected by trying out different numeraires. Notice that $NX_j$ can generally not be held fixed in real terms since it also has to satisfy the global adding up constraint $\sum_j NX_j = 0$. Notice also that units are not an issue in the original Dekle, Eaton, and Kortum (2007) exercise since aggregate net exports are then set equal to zero anyway.

## D. *Algorithm*

As indicated in the main text, calculating disaggregated noncooperative and cooperative tariffs is very intensive computationally due to the high dimensionality of the problem which has been a major barrier to progress in the area. I overcome this barrier with a combination of modern computing power and an efficient algorithm based on the idea of mathematical programming with equilibrium constraints as formulated in Su and Judd (2012). Using a high-end desktop computer and standard MATLAB software, it takes about four days to calculate all results which are reported in the paper.

I compute US optimal tariffs by maximizing the government's objective function (3) subject to the equilibrium conditions (10)–(13) using the algorithm suggested by Su and Judd (2012). To minimize the dimensionality of the problem, I do not literally use equations (10)–(13) but substitute first for $\hat{\pi}_{is}$ using equation (10) and then for $\hat{P}_{js}$ using equation (12). As an alternative, I have also experimented with computing optimal tariffs directly from the first-order conditions which can also be manipulated in the spirit of Dekle, Eaton, and Kortum (2007). However, I eventually abandoned this approach since it did not sufficiently improve performance to justify the substantial added complication.

I compute world Nash tariffs using a similar approach as Perroni and Whalley (2000) and Ossa (2011). Starting at factual tariffs, I compute each country's optimal tariffs, then impose these optimal tariffs, and let each country reoptimize given all other countries' optimal tariffs, and so on, until the solution converges in the sense that no country has an incentive to deviate from its tariffs. I have experimented with many different starting values without finding any differences in the result which makes me believe that the identified Nash equilibrium is unique. This is, of course, subject to the well-known qualification that complete autarky is also always a Nash equilibrium.

I compute world cooperative tariffs by maximizing $\hat{G}_1$ subject to the equilibrium conditions (10)–(13) as well as the condition that $\hat{G}_j = \hat{G}_1$ for all $j$ using again the algorithm suggested by Su and Judd (2012). I either start from Nash tariffs, factual tariffs, or zero tariffs and again substitute first for $\hat{\pi}_{is}$ using equation (10) and then for $\hat{P}_{js}$ using equation (12) to reduce the dimensionality of the problem. As discussed in the main text, there is an entire frontier of efficient tariffs due to the existence of de facto side payments and restricting $\hat{G}_j = \hat{G}_1$ for all $j$ can be thought of as finding the point on that frontier which also lies on a 45 degree line from the origin.

I compute the political economy weights using a simple iterative procedure. Starting with an initial guess, I always increase the political economy weights in industries in which the predicted optimal tariff is below the targeted noncooperative tariff, and decrease the political economy weights in industries in which the predicted optimal tariff is above the targeted optimal tariff, always controlling for the cross-industry mean. I continue this procedure until the distribution of predicted optimal tariffs converges to the distribution of targeted noncooperative tariffs, as in Figure 2. For Japan's most extreme noncooperative tariffs, I follow a slightly modified procedure as explained in the main text.

## E. *Derivations*

*Derivation of Equation* (14).—Equilibrium conditions (8) and (9) can be approximated as

$$\text{(E1)} \quad \frac{\Delta P_{js}}{P_{js}} \approx \sum_i \frac{\tau_{ijs} T_{ijs}}{X_j} \left( \frac{\Delta w_i}{w_i} + \frac{\Delta \tau_{ijs}}{\tau_{ijs}} \right)$$

$$\text{(E2)} \quad \frac{\Delta X_j}{X_j} \approx \frac{w_j L_j}{X_j} \frac{\Delta w_j}{w_j} + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \left( \frac{\Delta t_{ijs}}{t_{ijs}} + \frac{\Delta T_{ijs}}{T_{ijs}} \right) + \sum_s \frac{\pi_{js}}{X_j} \frac{\Delta \pi_{js}}{\pi_{js}}.$$

These approximations imply

$$\text{(E3)} \quad \frac{\Delta P_j}{P_j} \approx \sum_i \sum_s \frac{T_{ijs}}{X_j} \frac{\Delta p_{is}}{p_{is}} + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \frac{\Delta p_{is}}{p_{is}} + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \frac{\Delta t_{ijs}}{t_{ijs}}$$

$$\text{(E4)} \quad \frac{\Delta X_j}{X_j} \approx \sum_i \sum_s \frac{T_{ijs}}{X_j} \frac{\Delta p_{js}}{p_{js}} + \sum_s \frac{\pi_{js}}{X_j} \left( \frac{\Delta \pi_{js}}{\pi_{js}} - \frac{\Delta p_{js}}{p_{js}} \right)$$
$$+ \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \frac{\Delta T_{ijs}}{T_{ijs}} + \sum_i \sum_s \frac{t_{ijs} T_{ijs}}{X_j} \frac{\Delta t_{ijs}}{t_{ijs}},$$

which immediately combines to equation (14) since $\frac{\Delta W_j}{W_j} \approx \frac{\Delta X_j}{X_j} - \frac{\Delta P_j}{P_j}$. Notice that changes in profits which are due to changes in prices are attributed to the terms-of-trade effect. Notice also that changes in the price index which directly result from changes in tariffs cancel with changes in tariff revenue which directly result from changes in tariffs.

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