Quantitative Analysis of Multi-Party Tariff Negotiations

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Abstract

This paper develops a model of international tariff negotiations to study the design of the institutional rules of the GATT/WTO. We embed a multi-sector model of trade between multiple countries into a model of inter-connected bilateral negotiations over tariffs. Using 1990 trade flows and tariff outcomes from the Uruguay Round of GATT/WTO negotiations, we estimate country-sector productivity levels, sector-level productivity dispersion, iceberg trade costs, and country-pair bargaining parameters. We use the estimated model to simulate an alternative institutional setting for multilateral tariff negotiations in which the most-favored-nation requirement is abandoned. We find that abandonment of the most-favored-nation requirement would result in inefficient over-liberalization of tariffs and a deterioration in world-wide welfare relative to the negotiated outcomes in the presence of the most-favored-nation requirement.

Keywords: multilateral bargaining, tariff determination, quantitative trade

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1 Introduction

Multilateral tariff bargaining is complicated. According to the terms-of-trade theory of trade agreements, the central problem for a trade agreement to solve arises only when foreign exporters bear some of the incidence of a country's unilateral decision to raise its tariffs. When the country's tariffs induce these external effects, the consequences of any negotiated changes in its tariffs will in general spill over to all its trading partners. In this environment, a multilateral bargain, whereby all the trading countries of the world bargain without restrictions over all the tariffs that affect them, would be fraught with difficulty. But so too would be attempts to decentralize the bargaining into a collection of bilateral negotiations: owing to the spillovers on third-parties typically implied by the tariff changes negotiated within a given bilateral bargain, such a collection of bilateral tariff bargains would amount to an environment of bilateral bargaining with externalities.

Within the World Trade Organization (WTO) and its predecessor GATT, orchestrating a single multilateral bargain for all of the tariffs of the 164 current WTO members poses obvious challenges, and this would have been challenging even for the original 23 members of GATT. Perhaps for this reason, over its 70-year history the GATT/WTO has made extensive use of a decentralized approach to tariff bargaining that relies on simultaneous bilateral bargains. This approach was featured in the first five GATT rounds of multilateral tariff negotiations. It was used as a complement to multilateral bargaining methods in the last three GATT rounds, as well as in the now-suspended WTO Doha Round.[1] A number of GATT's key principles and norms – such as its non-discrimination principle embodied in the most-favored-nation (MFN) rule, and its principal supplier and reciprocity norms – are included in the GATT/WTO arguably in part to create a bargaining protocol that shapes and mitigates the externalities that stem from bilateral tariff bargains in this environment.

In this paper we analyze bilateral tariff bargaining in a multi-country quantitative trade model. Bagwell et al. (2017b) develop an equilibrium analysis of bilateral tariff bargaining in a three-country trade model and show that, due to the distinct nature of the externalities associated with non-discriminatory versus discriminatory tariffs, in the presence of an MFN rule tariff bargaining typically leads to inefficient outcomes that can

[1] As Bagwell et al. (2017a) explain, early GATT rounds allowed as well for a multilateral element, in that negotiated offers could be re-balanced at the end of the round as necessary for multilateral reciprocity. Among the last three GATT rounds, the Uruguay Round, for example, employed multilateral bargaining methods that included "zero-for-zero" tariff commitments in specific sectors.

exhibit either over- or under-liberalization, while in the absence of an MFN rule tariff bargaining always results in inefficient over-liberalization. Bagwell and Staiger (2005) show that when each party in a bilateral bargain is restricted to making offers that satisfy MFN and that also adhere to a strict form of reciprocity, the externalities associated with bilateral tariff bargaining are eliminated. As Bagwell and Staiger (1999, 2017) show for multilateral tariff bargaining settings, however, the strict adherence to MFN and reciprocity that eliminates these externalities will itself impose constraints that lead to under-liberalization and thus prevent countries from reaching the efficiency frontier, provided that countries are asymmetric in either their economic size or in the underlying objectives of their governments.[2] Bagwell et al. (2017a) examine in detail the bargaining records associated with the GATT Torquay Round (1950-51). They unveil a set of stylized facts from this bargaining data, and they argue that a number of these stylized facts can be interpreted through the lens of the theoretical findings of Bagwell and Staiger (2017) for tariff bargaining under MFN and reciprocity.

As these papers illustrate, theory can provide a useful guide to the implications of different sets of rules for the outcomes of tariff bargaining, but theory alone cannot provide a ranking across bargaining protocols. Ossa (2014) and Ossa (2016) initiates the examination of trade policy in a multi-country quantitative trade model. Ossa's papers compute Nash equilibrium tariffs and fully cooperative tariffs. Our paper models the specific structure of the bargaining system as a nexus of bilateral negotiations with extensions to third parties via MFN.

We specify and estimate a quantitative trade model building from Eaton and Kortum (2002) and Costinot et al. (2011). We use the estimated model to explore the properties of changes to the tariff bargaining protocol for the GATT Uruguay Round (1986-1994), the last completed GATT/WTO multilateral negotiating round. To this end, we extend the model of Costinot et al. (2011) to include tariffs and to allow the parameter governing the dispersion of productivity across varieties within a sector to vary by sector. Introducing tariffs to the model is straightforward and of course necessary if we are to use the model to explore alternative tariff bargaining protocols. Allowing for sector-specific productivity-dispersion parameters in the model is important because, as is well-known in this model (and in the Eaton and Kortum (2002) model from which it builds), trade elasticities – and

[2] Bagwell and Staiger (2017) analyze a model of multilateral tariff bargaining in which each country's multilateral tariff proposal must satisfy MFN and multilateral reciprocity, and in this context they identify bargaining outcomes that can be implemented using dominant strategy proposals for all countries.

with them the magnitude of the externalities imposed on trading partners by a country's unilateral tariff decisions – are governed by this parameter, and we wish to allow for the possibility that these elasticities vary by sector.

To model bilateral tariff bargaining in this environment, we follow Bagwell et al. (2017b) and adopt the solution concept of Horn and Wolinsky (1988). This solution concept, which is commonly employed by the Industrial Organization literature to characterize the division of surplus in bilateral oligopoly settings where externalities exist across firms and agreements, is sometimes referred to as a "Nash-in-Nash" solution, because it can be thought of as a Nash equilibrium between separate bilateral Nash bargaining problems.[3] According to this solution, each bilateral negotiation results in the Nash bargaining solution taking as given the outcomes of the other negotiations. As Bagwell et al. discuss, the Nash-in-Nash approach is not without limitations when applied to tariff bargaining, but it offers a simple means of characterizing simultaneous bilateral bargaining outcomes in settings with interdependent payoffs, and thereby makes the analysis of bilateral tariff bargaining in the GATT/WTO context tractable in a quantitative trade model.[4]

[3]The Nash-in-Nash solution concept has been used by Crawford and Yurukoglu (2012) and by Crawford et al. (2017) to explore negotiations between cable television distributors and content creators, and by Grennan (2013), Gowrisankaran et al. (2015), and Ho and Lee (2017) to consider negotiations between hospitals and medical device manufacturers with health insurers. It is broadly related to the pairwise-proof requirements that are indirectly implied under the requirement of passive beliefs in vertical contracting models (McAfee and Schwartz (1994) and Hart and Tirole (1990)) and directly imposed in contracting equilibria (Cremer and Riordan, 1987). See McAfee and Schwartz (1994) for further discussion. Micro-foundations for the Nash-in-Nash approach are developed by Collard-Wexler et al. (2016) in the context of negotiations that concern bilateral surplus division. The trade application considered by Bagwell et al. (2017b) and that we consider here is different, however, in that the negotiations focus on tariffs (rather than lump-sum transfers) which have direct efficiency consequences.

[4]As Bagwell et al. (2017b) observe, the most direct interpretation of the Nash-in-Nash approach is in terms of a delegated agent model, where a player is involved in multiple bilateral negotiations while relying on separate agents for each negotiation, and where agents are unable to communicate with one another during the negotiation process. This interpretation has some obvious drawbacks in settings such as tariff negotiations where within-negotiation communication between agents (trade negotiators) associated with the same player (government) across different bilaterals are clearly feasible. Agents may also coordinate at the end of a negotiation round, in order to ensure that the overall "package" is balanced. These drawbacks are arguably mitigated, however, to the extent that opportunities for communication and coordination across bilaterals are limited by bargaining frictions and arise only after bilateral bargaining positions have hardened. On balance, we believe that the tractability advantages of the Nash-in-Nash approach make it a potentially valuable tool, albeit only one such tool, for examining bilateral tariff

We first use data on trade flows, production, and tariffs at the country-sector level – aggregated into 49 sectors and for the 25 largest countries by GDP in 1990, with the rest of the world aggregated into five additional regions – together with data on a set of gravity variables, to estimate the taste, productivity, and iceberg cost parameters that according to the model would best match the data. More specifically, we estimate the parameters to match trade shares by country-sector, value added by country, and inequality conditions implied by the bargaining model. Given these estimates, we use the model to generate a series of benchmark counterfactual outcomes, including welfare under autarky and in the absence of any trade frictions.

We then use the model to calculate the Horn-Wolinsky bargaining solution beginning from the 1990 tariffs under three institutional constraints reflected in the tariff-bargaining environment of the Uruguay Round, namely, that countries (i) are restricted to bargain over MFN tariffs, (ii) must respect existing GATT tariff commitments and not raise their tariffs above these commitments, and (iii) abide by the principal supplier rule, which guides each importing country to limit its negotiations on a given product to the exporting country that is the largest supplier of that product to its market. We use our trade model to identify viable pairs of negotiating countries under this bargaining protocol through the principal supplier patterns that the model predicts.[5] To account for important dimensions of the Uruguay Round negotiations that went beyond tariff bargaining (to issues such as agricultural subsidies, intellectual property, services, and possibly even national security concerns and geopolitical affairs), we allow countries to make costly transfers as part of their tariff negotiations. Using the tariff changes between 1990 and 2000 as our measure of the tariff bargaining outcomes of the Uruguay Round, we solve our model for the Horn-Wolinsky solution under different values of the cost of transfers and the bargaining powers for each country in each of its bilaterals, and we select as our estimates of the cost-of-transfers and bargaining parameters the set of parameters that generates the Horn-Wolinsky solution within our model that best matches the tariff bargaining outcomes of the Uruguay Round.

Our estimated bargaining parameters are of interest in their own right, as they reflect the interplay of a number of forces in the model that together determine the slope of the

negotiations under various institutional constraints.

[5] As we later discuss, while the main tariff bargains in the Uruguay Round proceeded according to the tariff-line bilateral request-offer protocol that characterized the first five GATT rounds (see, e.g., Croome (1995), pp. 185), there were also a number of sectoral bargains that proceeded under distinct protocols (see, e.g., Preeg (1995), p. 191).

bargaining frontier and the disagreement point for each bilateral. Regarding the slope of the bargaining frontier, our estimate of the cost of transfers implies that lump-sum international transfers were not available to governments in the context of the Uruguay Round. Hence, in our tariff-bargaining setting, utility is not transferable across countries, as the countries in any bilateral use both costly transfers and tariff changes to transfer utility between them, and the relative degree to which the incidence of each country's tariff changes falls on, and only on, its bilateral bargaining partner will have implications for the slope of the bargaining frontier in that bilateral. We use our model to characterize the slopes of the bilateral bargaining frontiers between pairs of bargaining countries in the Uruguay Round, and we discuss how these slopes reflect features of the underlying economic environment and factor into our estimated bargaining power parameters. Moreover, the disagreement point for each bilateral is endogenously determined under the Horn-Wolinsky bargaining solution: a country could have strong bargaining power in each of its bilaterals and nevertheless fare relatively poorly in the Uruguay Round when judged from its 1990 status quo payoff, if the outcomes from all other bilaterals have served to disproportionately worsen this country's disagreement payoff in each of its bilaterals. We find that this possibility accords with the broad experience of Japan in the Uruguay Round. According to our estimates, of all the countries engaged in tariff bargaining in the Uruguay Round Japan had the greatest bargaining power; yet, its gains from the outcome of the Uruguay Round relative to the 1990 status quo were only modestly higher than the average gains that countries experienced from the Round.

Comparing the Horn-Wolinsky model solution under our representation of the Uruguay Round bargaining protocol to the actual Uruguay Round tariff bargaining outcomes, we can explain 57.86% of the variation in 190 country-sector tariff reductions. Also of interest is how the Horn-Wolinsky solution of our model compares to a tariff bargain that reached the efficiency frontier. Our model has no market imperfections and no political economy forces, and so achieving free trade in all tariffs would place the world on the efficiency frontier. But a comparison of our model outcomes to global free trade is not particularly meaningful, both because our bargaining analysis is limited to tariffs on non-agricultural products, and because according to our model under the principal supplier rule not all countries engaged in tariff bargaining in the Uruguay Round. A more meaningful free-trade benchmark with which to compare the Horn-Wolinsky solution of our model is a bargain that sets to zero just the non-agricultural tariffs under negotiation in the Uruguay Round according to our model. Compared to this free-trade benchmark, and solving also for the non-cooperative Nash tariff equilibrium over the same set of tariffs, our model indicates that the GATT rounds leading up to the Uruguay Round had achieved roughly 40% of the potential aggregate world-wide welfare gains in moving from the non-cooperative Nash to this free-trade benchmark, while our Horn-Wolinsky model solution indicates that the Uruguay Round itself achieved roughly an additional 40% of the potential world-wide welfare gains from the elimination of these tariffs. And compared to a benchmark that sets these same tariffs equal to the levels that would maximize world welfare in light of the existing distortions implied by the fixed levels of all other tariffs in the world, our model indicates that the GATT rounds leading up to the Uruguay Round and the Uruguay Round itself each achieved roughly a third of the potential aggregate world-wide welfare gains in moving from the non-cooperative Nash to this world-welfare maximizing benchmark, leaving roughly a third of the potential gains from negotiating over this set of tariffs as "unfinished business."

Not all countries gained from the Uruguay Round according to our model predictions, with Switzerland and Turkey suffering small losses.[6] As these two countries were not among our bargaining pairs and hence in our model do not alter their own tariffs from 1990 levels as a result of commitments made in the Uruguay Round, the losses they suffer as a result of the Uruguay Round reflect adverse terms-of-trade movements that were generated according to our model by the negotiated MFN tariff cuts of others. There is also an important possibility in Nash-in-Nash bargains that did *not* occur under the Uruguay Round protocol according to our results: while according to the Nash-in-Nash concept each bilateral negotiation must lead to an agreement over tariffs which, with the outcomes of all other negotiations taken as given, benefits both negotiating parties, the externalities across bargaining pairs raise the possibility that a country engaged in bargaining could be made worse off as a result of the web of bilateral tariff bargains

[6]Decision-making in the GATT/WTO system operates on a consensus basis, although provisions for voting may apply when consensus fails. From this perspective, it may be expected that a country would attempt to veto an agreement were it to anticipate a loss. As Posner and Sykes (2014) argue, related concerns arose with the creation of the WTO in the Uruguay Round and a novel strategy was adopted in response: "Holdout issues were significant, and some GATT members balked at some of the proposed new commitments. In response, the major players agreed on a novel strategy – they would formally withdraw from the GATT, and enter a new treaty creating the WTO. Any GATT member who wished to retain the benefits of GATT membership in relation to the major players had to do the same even if they did not like aspects of the new WTO regime. Some members complained that the process was coercive, but they had little choice but to capitulate."

negotiated in the multilateral round than it would have been if the round had never taken place.[7] Our results imply that this possibility did not arise in the Uruguay Round.

Armed with our trade-model, cost-of-transfers and bargaining-power parameters, we then turn to the consideration of counterfactual bargaining protocols. As we have described, under our representation of the Uruguay Round bargaining protocol, our results point to the existence of unfinished business with respect to the tariffs under negotiation in the Uruguay Round; and we find that further reductions in average tariffs are required to achieve the world-welfare maximizing benchmark, in line with the under-liberalization possibility identified by Bagwell et al. (2017b) when negotiations proceed over MFN tariffs. This raises the possibility that changes to the protocol that stimulate further negotiated tariff liberalization could be attractive from the perspective of world welfare. To evaluate this possibility, we consider an alternative bargaining protocol under which the MFN requirement and the principal supplier rule are abandoned, and we solve for the Horn-Wolinsky solution when countries can bargain over discriminatory tariff changes. Our primary interest here is in how abandonment of the MFN requirement impacts tariff bargaining; and as the principal supplier rule was introduced into the GATT bargaining protocols in order to facilitate bilateral tariff bargaining in the presence of MFN, it is natural to remove these two constraints at the same time.

We find that average tariffs drop further under discriminatory negotiations than under MFN negotiations, as expected; but MFN negotiations are better for world welfare than discriminatory negotiations.[8] More specifically, we would expect from the findings of Bagwell et al. (2017b) that in the absence of an MFN rule Nash-in-Nash tariff bargaining always results in inefficient over-liberalization. But our findings indicate further that, together with the costs of the trade diversion implied by discriminatory tariffs, the degree of inefficient over-liberalization of these tariffs is quantitatively sufficiently important to outweigh the inefficient under-liberalization that arises according to the model under MFN, resulting in lower world welfare under discriminatory tariff bargaining than under

[7] As we discuss further in the Conclusion, this possibility would not be expected to arise in a setting where each party in a bilateral bargain is restricted to making offers that satisfy MFN and that also adhere to a strict form of reciprocity, because as Bagwell and Staiger (2017) and Bagwell et al. (2017a) argue in a two good general equilibrium model the externalities associated with bilateral tariff bargaining are then eliminated.

[8] Our analysis focuses on the economic benefits of the MFN rule and does not include other potential benefits, including improved international relations (see, e.g., Hull (1948), and the discussion in Culbert (1987)) and the enhanced participation by smaller countries that a rules-based system may encourage.

MFN tariff bargaining. Moreover, developing and emerging countries are among the biggest losers from the abandonment of MFN, in some cases (e.g. China, India) faring substantially worse than under the 1990 status quo. Among industrialized countries, South Korea suffers the largest losses from the abandonment of MFN, experiencing a large reduction in welfare relative to the 1990 status quo level, and the EU and Canada also lose. By contrast, our results indicate that Japan would be the biggest gainer from abandonment of MFN in the Uruguay round, due largely to its enhanced ability to exploit its strong bargaining power when unconstrained by MFN, with the US and some of the EU-member countries also enjoying small gains.

These findings are driven by and highlight an important difference across MFN and discriminatory tariff bargaining that is quantified by our model: while we find that the spillovers to third parties from tariff reductions negotiated in a bilateral are often large in both the MFN and the discriminatory tariff bargaining settings, they are usually of opposite signs, positive for MFN tariff bargaining and negative for discriminatory tariff bargaining. As we show, the negative third-party externality associated with discriminatory tariff reductions and the implied transfer of surplus from third parties to bargaining parties drives down the levels of the negotiated tariffs in the absence of the MFN constraint from what these levels would be under MFN; and this force is sufficiently strong to result in substantial over-liberalization of these tariffs. Put differently, while the free-rider issue and associated drag on tariff liberalization created by the positive third-party externality from the GATT/WTO's MFN requirement is widely emphasized as a shortcoming of the GATT/WTO approach, we find that the abandonment of MFN in tariff bargaining would create negative third-party externalities that are even more powerful, and that would ultimately lead to tariff bargaining outcomes that are worse from the perspective of world welfare.

Our work is related to other studies of trade policy in multi-country quantitative trade models. Work of this kind includes Ossa (2014) and Ossa (2016), as mentioned previously, and also Caliendo et al. (2017), Caliendo and Parro (2015), and Spearot (2016). By comparison, a key distinguishing feature of our work is that we explicitly model the bargaining process. We are thereby able to use our quantitative model of trade and tariff bargaining to compare outcomes under MFN and counterfactual discriminatory negotiations.

The remainder of the paper proceeds as follows. The next section sets out our quantitative model of trade and tariff bargaining. Section 3 describes the data we use to estimate the model, while section 4 describes our approach to estimation. Section 5 presents our model estimates and computes a number of model benchmarks. Section 6 presents our counterfactual. Section 7 concludes.

2 Model

Our model world economy consists of the multi-sector version of Eaton and Kortum (2002) from Costinot et al. (2011), extended to include tariffs and to allow the parameter governing the dispersion of productivity across varieties within a sector to vary by sector, as in Caliendo and Parro (2015). The model world economy is then embedded into an equilibrium model of tariff bargaining. In the next subsection, we describe the model world economy, and in the following subsection we describe our approach to modeling tariff bargaining.

2.1 Model World Economy

We consider a world economy with $i = 1, ..., N$ countries and $k = 1, ..., K$ sectors. Within each sector k, there is a countably infinite number of varieties indexed by ω. We allow each country to impose an import tariff (possibly discriminatory across trading partners) in each sector k. Because our model world economy is a straightforward variant of the models in Costinot et al. (2011) and Caliendo and Parro (2015), we provide only a minimal description here, and refer readers to those papers for additional model details.

We begin by describing the supply side of the model. Each country has an immobile-across-countries labor endowment L_i. Production of each variety in each sector is governed by a constant-returns-to-scale technology requiring only labor. Furthermore, an infinite number of firms, all with the same productivity parameter, exist to produce each variety in each sector, ensuring perfect competition.

The production technology for each variety is drawn from a Frèchet distribution with CDF given by

$$F_i^k(z) \quad = \quad \exp\left(-(\frac{z}{z_i^k})^{-\theta_k}\right),$$

where z_i^k is country i's sector-k level productivity parameter and θ_k is a sector-specific productivity shape parameter. We will reference specific draws from these distributions as

$z_i^k(\omega)$, that is, country i's productivity in variety ω in sector k. While the first and second moments of the distribution of productivity depend on both the z and the θ parameters, the ratio of expected variety productivity for the same sector between two countries is equal to the ratio of their z_k parameters in sector k. Higher values of θ_k imply lower heterogeneity in within-sector productivity, and more responsiveness of trade flows with respect to changes in fundamentals (and hence higher trade elasticities) as a result.

Producers face iceberg trading costs and potentially tariffs when serving other countries. We parameterize iceberg costs to depend on an origin effect, a destination effect, a sector-specific border effect, a sector-specific distance effect, and whether the origin and destination share a common language, a physical border, or have a preferential trade agreement (PTA). It is often noted that the so-called "Quad" countries of the US, the (at the time) 10 member-countries of the EU, Canada and Japan had an outsized impact on the shape of the Uruguay Round due to their status as major traders and special trading relationships with each other. We attempt to capture this with inclusion of an effect, common across sectors, for shipments between each of the Quad-country pairs. Our parameterization of iceberg trade costs is then given by:

$$\log d_{ji}^k = \alpha_j + \gamma_i + \beta_{0k} + \beta_{1k} dist_{ji} + \beta_{2k} PTA_{ji} + \beta_3 lang_{ji} + \beta_4 border_{ji} + \sum_{n \in Q} \beta_{5n} Quad_{n,ji}$$

with d_{ji}^k denoting the iceberg trade costs for country j's sector-k exports to country i, and with $d_{ii}^k = 1 \forall k$. The variable $dist_{ji}$ is the distance between countries j and i, PTA_{ji} is an indicator variable that takes the value 1 if countries j and i are members of a common PTA and 0 otherwise, $lang_{ji}$ is an indicator variable that takes the value 1 if countries j and i share a common language and 0 otherwise, $border_{ji}$ is an indicator variable that takes the value 1 if countries j and i share a common physical border and 0 otherwise, and Q is the set of pairs of the members of the "Quad," i.e., the US, the EU, Canada and Japan, and $Quad_{n,ji}$ is equal to one whenever countries j and i make up the pair n. With perfect competition in each country-sector-variety, the price of each variety in each country is equal to:

$$p_i^k(\omega) = \min_{j \in 1,\ldots,N} \frac{w_j}{z_j^k(\omega)} d_{ji}^k (1 + t_{ji}^k)$$

where w_j is the wage of labor in country j and t_{ji}^k is equal to the ad valorem tariff levied by country i on sector-k imports from country j.[9]

We now turn to the demand side of the model and describe the consumer demand system. A representative consumer in each country chooses consumption levels of each variety in each sector to maximize the following utility function that is CES across varieties within a sector with a Cobb-Douglas aggregator across sectors:

$$\begin{aligned} u_i &= \Pi_{k=1}^{K} (C_i^k)^{\alpha_i^k} \\ C_i^k &= (\sum_{\omega=1}^{\infty} c^k(\omega)^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}, \end{aligned}$$

where α_i^k are country i's taste parameters for sector k, and σ is a within-sector constant elasticity of substitution across varieties. Consumers take prices for each variety as given. They choose consumption to maximize this utility function subject to their budget constraint that total expenditure must be weakly less than their country's labor income plus tariff revenue.

We can now describe the equilibrium of the model given a set of tariffs. An equilibrium consists of a vector of wages w_i and a vector of national incomes E_i (wage income plus tariff revenue) such that labor markets clear, trade is balanced, and consumers and firms are behaving optimally.[10]

2.2 Tariff Bargaining

We assume that in a multilateral round of tariff negotiations, countries negotiate bilaterally and simultaneously over tariff vectors. As we discussed in the Introduction, this bargaining structure was featured in the first five GATT rounds of multilateral tariff negotiations, and it was used as a complement to multilateral bargaining methods in the last three GATT rounds, including the Uruguay Round, as well as in the now-suspended

[9] With this specification we are assuming that the ad valorem tariff is applied to the delivered price of the import good at the importing country's border.

[10] Countries do run trade deficits in the data which we can not rationalize in our static model. As discussed in Ossa (2016), an ideal solution would involve a dynamic model of saving and borrowing which is outside the scope of this paper. Ossa (2016) also discusses an alternative approach which partially accounts for trade deficits by considering the trade surplus as fixed additional income to a country. We instead simply abstract away from the issue of trade deficits and work in a setting of balanced trade.

WTO Doha Round. Moreover, as we also discussed in the Introduction, we will allow countries to make use of costly transfers in their bargains, in order to capture the broader set of issues beyond tariff bargaining that the Uruguay Round negotiations encompassed. But for the moment we assume that bargaining takes place only over tariffs, and we postpone our description of the introduction of transfers into the model until after we have described the basic tariffs-only bargaining structure.

As all tariffs affect all countries through the trade equilibrium in our model, the payoffs from each bilateral negotiation depend on the outcomes of the other bilateral negotiations. We follow Bagwell et al. (2017b) and apply the solution concept of Horn and Wolinsky (1988) to this tariff bargaining problem. According to this solution, each pair of negotiating countries maximizes its Nash product given the actions of the other pairs.

Let $\pi_i(\mathbf{t})$ be the welfare of country i when the world vector of tariffs is given by $\mathbf{t}$. We measure a country's welfare by its real national income level. When country i negotiates with county j, they select the tariffs τ that they negotiate so as to maximize their Nash product:

$$np_{ij}(\tau, \mathbf{t}_{-ij}) = (\pi_i(\tau, \mathbf{t}_{-ij}) - \pi_i(\tau_\mathbf{0}, \mathbf{t}_{-ij}))^{\zeta_{ij}} (\pi_j(\tau, \mathbf{t}_{-ij}) - \pi_j(\tau_\mathbf{0}, \mathbf{t}_{-ij}))^{1-\zeta_{ij}}$$

where ζ_{ij} is the bargaining power parameter of country i in its bilateral bargain with country j and where we have partitioned the set of tariffs into those being negotiated by i and j and all other tariffs as $(\tau, \mathbf{t}_{-ij})$. $\tau_\mathbf{0}$ represents the level for the tariffs under negotiation between i and j that will prevail if i and j fail to reach an agreement. We set these to be the levels of these tariffs in place when the negotiating parties entered the round.

We further parameterize the pairwise bargaining powers. Specifically, each country has a bargaining ability parameter a_i. When countries i and j meet, the pairwise bargaining parameter is equal to

$$\zeta_{ij} = \frac{\exp(a_i)}{\exp(a_i) + \exp(a_j)}.$$

We now define the Horn and Wolinsky (1988) tariff bargaining equilibrium for our model:

Definition 1 (Tariff Bargaining Equilibrium) *An equilibrium in tariffs consists of a vector of tariffs such that for each pair ij the tariffs negotiated by this pair maximizes np_{ij} given the other tariffs in the vector.*

The key assumption in the Horn and Wolinsky (1988) bargaining equilibrium is that, when evaluating a candidate τ, the pair ij holds the vector $\mathbf{t}_{-ij}$ fixed. In other words, if ij were to not reach agreement, or were to deviate from a tariff vector specified by the equilibrium, then the other tariffs do not adjust. As we discussed in the Introduction, this equilibrium notion is sometimes referred to as "Nash-in-Nash," because it is the Nash equilibrium to the synthetic game where each pair constitutes a player, the payoff function is the pair's Nash bargaining product, and the strategies of each player are the tariffs being negotiated by the pair associated with that player.

To reflect the tariff bargaining environment of the Uruguay Round, we introduce three institutional constraints to our tariff bargaining solution[11] First, we assume that countries are restricted to bargain over MFN tariffs and cannot engage in bilateral bargains over discriminatory tariffs.[12] Second, we assume that countries are not allowed to make tariff offers in any bilateral that would violate their existing GATT tariff bindings by exceeding their bound (legal maximum) levels.[13] And third, in line with the principal supplier rule of GATT/WTO tariff negotiations, we assume that only the largest supplier of good k into country i prior to the round can negotiate with country i over country i's MFN tariff in sector k, t_{ik}^{mfn}.[14]

[11]Omitted from the institutional constraints that we impose on tariff bargaining is the GATT/WTO norm of reciprocity. In the Conclusion, we discuss the possibility of augmenting our representation of the Uruguay Round tariff bargaining protocol with the addition of a reciprocity norm.

[12]GATT members can and do engage in bilateral bargains over discriminatory tariffs when they negotiate preferential trade agreements, which under the GATT/WTO rules contained in GATT Article XXIV are permissible provided that the negotiating countries eliminate tariffs on substantially all trade between them. And as Bagwell et al. (2017a) describe, in some of the early GATT rounds, the reach of some of the bilaterals was expanded beyond negotiations over MFN tariffs to include discriminatory (preferential) tariffs as well. But in the more recent GATT multilateral rounds, including the Uruguay Round which is our focus here, negotiations were restricted to MFN tariffs.

[13]In fact, under Article XXVIII of GATT, countries can engage in the renegotiation of their existing tariff bindings and either modify in an upward direction or even withdraw these bindings. However, in the multilateral rounds that are our focus here, which occur under Article XXVIIIbis, the purpose of negotiations is to achieve reductions in the levels of tariff bindings, and tariff offers that violate existing bindings would instead have to occur in the context of an Article XXVIII renegotiation and include the bargaining partner with which the original tariff concession was negotiated.

[14]In their examination of the bargaining data from the GATT Torquay Round, Bagwell et al. (2017a)

We now describe how we augment our model of tariff bargaining to include the possibility of costly international transfers. As discussed in the Introduction, there were a number of important dimensions of the Uruguay Round negotiations that went beyond tariff bargaining to specific issues such as agricultural subsidies, intellectual property, services, and possibly even to broader non-economic issues covering national security concerns and geopolitical affairs. To allow our model to reflect some of these broader dimensions in the simplest way, we allow countries to make costly transfers as part of their tariff negotiations. Let $\Pi_i(\mathbf{t}, \mathbf{m})$ be the welfare of country i when the world vector of tariffs is given by $\mathbf{t}$ and the world vector of net transfers is given by $\mathbf{m}$. We continue to measure each country's welfare by its real national income level, but now augmented by the net international transfer it receives. We model this as a direct utility transfer rather than an income transfer, with no general equilibrium effects as a result: we think of this as capturing the non-economic issues beyond the market access concerns associated with tariff commitments that may have been at play during the negotiations.[15]

In this augmented setting, when country i negotiates with county j, the two countries select the tariffs τ that they negotiate and the net transfer μ_{ij} that country i pays to country j so as to maximize their Nash product, which we denote by $NP_{ij}(\tau, \mathbf{t}_{-ij}, \mu_{ij}, \mathbf{m}_{-ij})$, and which is given by:

$$(\Pi_i(\tau, \mathbf{t}_{-ij}, \mu_{ij}, \mathbf{m}_{-ij}) - \Pi_i(\tau_{\mathbf{0}}, \mathbf{t}_{-ij}, \mu_0, \mathbf{m}_{-ij}))^{\zeta_{ij}} (\Pi_j(\tau, \mathbf{t}_{-ij}, \mu_{ij}, \mathbf{m}_{-ij}) - \Pi_j(\tau_{\mathbf{0}}, \mathbf{t}_{-ij}, \mu_0, \mathbf{m}_{-ij}))^{1-\zeta_{ij}}$$

where, as before, ζ_{ij} is the bargaining power parameter of country i in its bilateral bargain with country j and the set of tariffs has been partitioned into those being negotiated by i and j and all other tariffs, $(\tau, \mathbf{t}_{-ij})$, and where we now similarly partition the sets of

find that the average number of exporting countries bargaining with an importing country over a given tariff was 1.25, suggesting that our assumption is a reasonable approximation. A potential caveat is that the findings of Bagwell et al. (2017a) apply at the 6-digit HS level of trade, whereas here we are operating at a more aggregate sectoral level; we return to this point in the Conclusion.

[15] An alternative (and possibly complementary) approach to introducing transfers into our model would be to allow international transfers of income. Transfers of this form would enter the budget constraint of each country and have general equilibrium impacts, and this might better capture the economic issues addressed during the Uruguay Round negotiations that went beyond tariff bargaining. Our approach is simpler, and seems appropriate as a way to capture the non-economic issues described above that may also have been at play in the Round. We leave to future research a more complete exploration of the various ways that international transfers might be introduced into quantitative models of tariff bargaining.

transfers for countries i and j into those being negotiated by i and j and all other transfers, $(\mu_{\mathbf{ij}}, \mathbf{m}_{-ij})$. As before, $\tau_{\mathbf{0}}$ represents the level for the tariffs under negotiation between i and j that will prevail if i and j fail to reach an agreement, and we set these to be the levels of these tariffs in place when the negotiating parties entered the round. And similarly, μ_0 represents the level of the transfer between i and j that will prevail if they fail to reach agreement, which we set to zero.

Finally, to allow for the possibility of a non-zero cost of transfers, we assume that if country i makes a positive net transfer to its bargaining partners in total (i.e., if $\sum_j \mu_{ij} > 0$), then country i suffers an additional utility cost associated with orchestrating this level of transfer equal to $\kappa(\sum_j \mu_{ij})^2$. We treat the cost-of-transfers parameter κ as a parameter to be estimated along with the bargaining power parameters of the model, and we estimate as well the net transfers μ_{ij}.

We then define the Horn and Wolinsky (1988) tariff-and-transfer bargaining equilibrium for our model:

Definition 2 (Tariff-and-Transfer Bargaining Equilibrium) *An equilibrium in tariffs and transfers consists of a vector of tariffs and transfers such that for each pair ij the tariffs and transfer negotiated by this pair maximizes NP_{ij} given the other tariffs and transfers in the vector.*

As noted above, to reflect the principal supplier rule of GATT/WTO tariff negotiations, we assume that only the principal supplier of good k into country i prior to the round can negotiate with country i over country i's MFN tariff in sector k, t_{ik}^{mfn}. In the absence of transfers, this in turn requires that a "double coincidence of wants" exists between any viable pair of bargaining partners, in the sense that each country in the bargaining pair must be a principal supplier of at least one good to the other country in the pair. With the introduction of (costly) transfers, the requirement of a double coincidence of wants is relaxed, in principle allowing more bargaining pairs to form; for example, if country A is a principal supplier of good 1 into country B's market, and country B is not a principal supplier of any good into country A's market, there could still be a viable bilateral between countries A and B, in which country B offers to cut its tariff on good 1 in exchange for a transfer from country A. For simplicity we do not allow the introduction of transfers to expand the possible set of bilateral bargaining pairs in this way; in the Conclusion we return to discuss how this added impact of the availability of transfers might affect our results.

It is worth pausing here to consider how our estimation can pin down bargaining-power parameters and the cost of transfers. If the Uruguay Round agreed tariffs correspond closely to what according to our model would be the joint surplus maximizing tariffs for each bilateral, then bargaining powers would be reflected in the transfers (which we don't observe) rather than the agreed tariffs, and we would have large standard errors on our bargaining parameter estimates together with a low estimated cost of transfers. To the extent that the Uruguay Round agreed tariffs do not correspond to what according to our model would be the joint surplus maximizing tariffs for each bilateral, our estimation will search for the combination of positive cost-of-transfers and bargaining powers that generates predicted tariffs as close as possible to the Uruguay Round agreed tariffs.

3 Data

To operationalize our model, we require data on trade flows, production and value added, and tariffs, all at the country-sector level. To quantify iceberg trade costs, we combine these data with a set of data on gravity variables: distances between countries, whether countries share a common language, and whether countries are members of a common PTA. Details of the data cleaning and aggregation are contained in Appendix A. Table 1 provides summary statistics.

To represent the world economy, we include the twenty five largest countries by GDP in 1990, and aggregate the rest of the world into one of five "not-elsewhere-specified" (NES) regional entities: Americas, Asia-Oceania, Middle East-North Africa (MENA), Africa, and Europe. We treat each regional entity as a sovereign individual country in the estimation. We aggregate trade flows into 49 sectors. We began with SITC2 two-digit codes, and then further combine several related sectors to arrive at a total of 49 traded sectors.

3.1 Trade Flow, Production, and Value Added Data

The starting point for our data is the NBER world trade flows data from Feenstra et al. (2005) for the year 1990. We compute the gross value in 1990 dollars of each country's imports from each other country at the sector level according to our country and sector definitions. The NBER data do not provide information on a country's production or consumption. We impute each country's sector-level production by extracting the ratio

Table 1: Summary Statistics

Country	Pop(M)	Mnfctring V.A. per capita(000)	Import ratio	1990 Average Tariffs	1990 Trade Weighted Tariffs	2000 Average Tariffs	2000 Trade Weighted Tariffs	Largest Trading Partner
USA	249.6	4258.8	0.187	0.045	0.048	0.032	0.043	Canada
Argentina	32.6	768.9	0.017	0.115	0.099	0.142	0.118	USA
Australia	17.1	2546.9	0.096	0.136	0.109	0.069	0.054	Japan
Austria	7.7	3265.8	0.503	0.061	0.066	0.033	0.034	Germany
Belgium	10.0	3428.3	0.386	0.061	0.054	0.033	0.028	Germany
Brazil	149.4	742.1	0.019	0.259	0.169	0.136	0.094	USA
Canada	27.8	3138.7	0.336	0.080	0.081	0.041	0.030	USA
China	1140.9	72.1	0.084	0.102	0.111	0.076	0.071	USA
Denmark	5.1	3596.6	0.213	0.061	0.057	0.033	0.029	Germany
France	56.7	2315.9	0.241	0.061	0.059	0.033	0.030	Germany
Germany	79.4	5421.1	0.228	0.061	0.062	0.033	0.032	France
India	849.5	23.8	0.038	0.772	0.576	0.323	0.238	MENA NES
Indonesia	178.2	61.6	0.058	0.196	0.133	0.076	0.052	Japan
Italy	56.7	2051.8	0.259	0.061	0.052	0.033	0.027	Germany
Japan	123.5	5804.5	0.122	0.053	0.027	0.035	0.019	USA
Mexico	83.2	226.5	0.081	0.118	0.110	0.149	0.124	USA
Netherlands	15.0	2425.4	0.240	0.061	0.057	0.033	0.028	Germany
Russia	148.3	236.1	0.128	0.087	0.056	0.104	0.076	Europe NES
S. Korea	42.9	1875.7	0.176	0.109	0.089	0.083	0.049	USA
Spain	38.8	1815.3	0.410	0.061	0.054	0.033	0.027	France
Sweden	8.6	3731.1	0.383	0.061	0.061	0.033	0.030	Germany
Switzerland	6.7	6255.8	0.299	0.199	0.113	0.063	0.033	Germany
Thailand	54.6	408.7	0.091	0.397	0.317	0.136	0.096	Japan
Turkey	56.2	413.3	0.134	0.079	0.067	0.052	0.034	Germany
UK	57.6	3541.4	0.305	0.061	0.061	0.033	0.031	Germany
America NES	183.1	243.9	0.077	0.119	0.100	0.107	0.087	USA
AsiaPac NES	671.3	104.7	0.207	0.129	0.108	0.068	0.049	USA
MENA NES	207.5	181.9	0.140	0.167	0.151	0.192	0.136	Japan
Africa NES	480.8	48.1	0.041	0.153	0.136	0.118	0.106	USA
Europe NES	207.5	608.7	0.273	0.075	0.059	0.074	0.055	Germany

Notes: Trade and tariff summary statistics at the level aggregation used for the analysis.

of exports to total production at the country-sector level from the Global Trade Analysis Project (GTAP) database, and we complement these data with manufacturing value added data by country from UNIDO. Our measure of sector-level consumption by country is then given by the difference between production and net exports.

3.2 Tariff Data

We obtain country-sector tariff equivalent applied MFN tariffs from the UNCTAD Trains database on tariffs for 1990 and 2000. We use the 1990 applied tariffs as the pre-Uruguay Round tariffs, and the 2000 applied tariffs as the negotiated outcomes from the Uruguay Round.

There is an important distinction between the tariffs that countries actually *apply* to imports into their markets, and the tariff *bindings* that they negotiate in the GATT/-WTO.[16] While introducing this distinction into a quantitative trade model would be a very worthwhile project in its own right, it is well beyond the scope and focus of our paper. In addition, as is well-known, the results of GATT/WTO tariff negotiating rounds are typically phased in over an implementation period that can last a number of years. In this regard the Uruguay Round was no exception, with phase-in periods ranging across countries and sectors up to a maximum of roughly a decade. With the implementation period of the Uruguay Round commencing on January 1 1995, our decision to use the difference between the applied tariffs in place in 1990 and the applied tariffs in place in 2000 as a measure of the negotiating outcomes of the round represents an attempt to capture these complex features in a way that maintains the tractability of our quantitative model and its use for studying tariff bargaining.

Finally, while we will estimate the parameters of our trade model utilizing data on trade flows, production and value added, and tariffs for the full coverage of products, for our bargaining analysis we focus attention on bargaining over tariffs for non-agricultural

[16] A tariff binding represents a legal cap on the tariff that a country agrees not to exceed when it applies its tariff; the tariff it applies may be at the cap, but it may also be below the cap. For most industrialized countries, the vast majority of applied tariffs are at the cap (Australia is a notable exception), but for many emerging and especially developing countries, applied tariffs are often well below the cap (China is a notable exception). A recent literature has begun to explore the value of tariff bindings that are set above applied tariffs, and this literature finds that the reduction in uncertainty about worst-case (i.e., high-tariff) scenarios that such a binding implies can have large trade effects, e.g. Handley (2014) and Handley and Limao (2015).

products (product categories 10-11 and 13-49 as defined in Table 9).[17]

3.3 Gravity Data

We use data on distances between countries, existence of preferential trading arrangements, and a common language indicator from the Geography module of the CEPII Gravity Dataset (Head and Mayer, 2014). This data set constructs distances between countries based on distances between pairs of large cities and the population shares of those cities. For the regional entities, we construct the distance with a partner as the average distance between the countries forming the regional entity and the partner in question. For two regional entities, we use the average distance across all pairs formed with one country from each regional entity.

4 Estimation

We estimate the model in two steps. First, we estimate the taste, productivity, and iceberg cost parameters. Given these estimates, we then estimate the cost-of-transfers and bargaining parameters. The reason for splitting the estimation process into two steps is because the bargaining model is computationally much more intensive than the trade model, as solving the bargaining model once involves potentially thousands of computations of a trade equilibrium at differing tariff levels. Because the trade model has several thousand parameters, joint estimation with the bargaining model is prohibitively expensive. For feasibility, we thus sacrifice some efficiency by not jointly estimating the trade and bargaining/cost-of-transfers parameters. We do, however, allow the Uruguay Round bargaining outcomes to inform our trade model estimates along one dimension: we include inequality moments in the trade model estimation reflecting the implication that each bargaining pair in the Uruguay Round (based on the product-level principal supplier status in our trade data) should generate a higher joint surplus with its observed Uruguay Round agreed tariffs than if the pair had remained at its pre-Uruguay-Round tariff levels.

[17]The reason for not analyzing agricultural tariff changes is that many of the agricultural tariffs were specific rather than ad-valorem. To operationalize the model, we require ad valorem tariffs. However, ad valorem equivalents of specific agricultural tariffs display large fluctuations in levels due to world price movements rather than tariff changes.

4.1 Non-linear least squares estimation of trade parameters

We estimate the model to minimize the distance between the data and the model's predictions for (i) the ratio of each country's imports from each other country in each sector to the country's total consumption in that sector, (ii) relative total value added across countries, and (iii) for each bargaining pair, the difference between the pair's joint surplus at the observed post-Uruguay-Round tariffs and at the pre-Uruguay-Round tariffs on the goods that are principally supplied by one member of the pair to the other member.

More specifically, the parameters to estimate consist of a vector of taste parameters (α), a vector of productivity parameters (z), a vector of dispersion of productivity parameters (θ), and a vector of iceberg cost parameters (β). Given the Cobb-Douglas preference structure, the vector of taste parameters α can be inferred from the data directly as the share of expenditure on each sector over total expenditure. Given these α estimates, we then choose the remaining parameters to minimize the following criterion:

$$G(z,\theta,\beta) = \begin{bmatrix} \frac{x_{ij}^k}{\sum_i x_{ij}^k} - \frac{\hat{x}_{ij}^k(z,\theta,\beta)}{\sum_i \hat{x}_{ij}^k(z,\theta,\beta)} \\ \frac{\sum_{j,k} x_{ij}^k}{\sum_{j,k} x_{USA,j}^k} - \frac{\sum_{j,k} \hat{x}_{ij}^k(z,\theta,\beta)}{\sum_{j,k} \hat{x}_{USA,j}^k(z,\theta,\beta)} \\ \min\left(JS_{ij}(\tau_{ij}^{POST}) - JS_{ij}(\tau_{ij}^0), 0\right) \end{bmatrix}$$

$$\min_{z,\theta,\beta} G(z,\theta,\beta)' W G(z,\theta,\beta)$$

where $JS_{ij}(\tau_{ij}^{POST})$ is the joint surplus of the negotiating pair of countries i and j evaluated at the observed post-Uruguay-Round tariffs, and $JS_{ij}(\tau_{ij}^0)$ is the same joint surplus evaluated at the observed post-Uruguay-Round tariffs for all tariffs other than those being negotiated between the pair ij together with the pre-Uruguay-Round tariffs for the tariffs being negotiated between the pair ij. The inequality moments associated with JS_{ij} are implied by the Horn-Wolinsky bargaining equilibrium concept: if it were the case that $JS_{ij}(\tau_{ij}^{POST}) - JS_{ij}(\tau_{ij}^0) < 0$, then the pair ij would have been better off with no agreement. Evaluating the bargaining conditions increases the computational cost of the estimation as it requires solving for equilibrium at several different tariff vectors. For this reason, we include a subset of pairs motivated by size, trade flow patterns, and principal supplier relationships: US-EU, US-Japan, Canada-EU, Japan-EU, and Japan-South Korea.[18]

[18]We construct the weighting matrix W as follows. The weights on the trade shares are 1. The trade share difference between observed and reality can vary from -1 to 1, though most differences are on the

4.2 Discussion of Estimation and Data Variation

The non-linear mapping between trade shares, relative value added, and bilateral tariff agreements that generate positive surplus into model parameters is difficult to characterize formally. However, we now discuss the patterns in the data that help identify the model's parameters. We also compare our estimation approach to alternative estimation approaches from the previous literature.

The sector level θ_k parameters govern the responsiveness of trade flows to changes in the environment such as tariffs or productivities. Previous literature, such as Costinot et al. (2011) and Caliendo and Parro (2015), derive linear estimating equations where the left-hand-side variable is a non-linear transformation of bilateral trade flows at the country pair-sector-direction level and the right-hand-side variable is a non-linear transformation of either productivities (Costinot et al. (2011)) or tariffs (Caliendo and Parro (2015)). The parameter θ_k is the coefficient on the right-hand-side variable in these formulations.[19] With these linear estimating equations, these papers pay special attention to the identifying variation on the right hand side. Costinot et al. (2011) use an instrumental variables approach with additional data on productivities, while Caliendo and Parro (2015) use a rich set of fixed effects to isolate variation in tariffs that is within country-sector, and thus requires some countries to have discriminatory tariffs. These approaches do have the benefit of clear attribution of the identifying variation being used to estimate θ. That said, the log transformation of the left-hand-side variable entails dropping pairs of countries which have zero trade flows from the estimation as discussed in Silva and Tenreyro (2006). This approach also attributes idiosyncratic differences in a country pair's trade flows to iceberg costs and eliminates any role of measurement error in trade flows.

The non-linear least squares approach that we employ uses the information conveyed by pairs of countries which do not trade in a sector and allows for measurement error. Furthermore, it delivers, in one step, estimates of iceberg costs and country-sector level productivities that can be assessed against outside data sources and can be used to com-

order 0.01 or smaller. There are N*N*K=44100 of these. We weight the relative value added by 10. There are 29 of these. Their scale can be arbitrarily large, but at the estimates, the differences are also around 0.01 and smaller. Finally, we weight the five bargaining conditions by 10^5. Recall that these are in utility units, and absent weighting are on the order of 10^{-4}.

[19] Caliendo and Parro (2015) allow for θ to vary at the sector level, while Costinot et al. (2011) restrict θ to be constant across all sectors.

pute any counterfactual outcome in the domain of the model.[20] The disadvantage of the non-linear method is that it obscures the identifying variation being used to estimate θ_k and does not lend itself to straightforward instrumental variable techniques. That said, our estimation relies on patterns in the data which are similar to those relied on by the previous literature, such as, conditional on observable components specified in the iceberg costs, the covariance of trade shares with tariffs. The iceberg cost specification we employ has separate origin, destination, and sector fixed effects, but not destination-sector fixed effects. Therefore, identification does not hinge on observing discriminatory tariffs within importing country-sector; instead, identification is achieved since MFN tariffs vary across destinations for given sectors.

The bargaining conditions help ensure that the trade model parameters that we estimate are compatible with the observed tariff concessions from the Uruguay Round. In this sense, we are using bargaining outcomes to help estimate the trade model parameters such as the θ_k parameters. The trade model is point identified without these conditions, and thus remains point identified after adding these inequalities to the criterion function. The conditions we employ on the joint surplus are true for any bargaining power parameters. These conditions also have the potential to help allay concerns, were the model to be mis-specified, about unobserved factors affecting import shares that are also correlated with tariffs. To the extent that negotiations reflected beliefs about the world that are supported by unbiased estimates of trade elasticities, then including the bargaining conditions allows our estimates to incorporate that information.

4.3 Non-linear least squares estimation of cost-of-transfers and bargaining parameters

With estimates of the trade model in hand, we estimate the cost-of-transfers parameter and the bargaining parameters between pairs of countries in a second step. We again employ non-linear least squares. Using the estimated trade parameters, we can solve the bargaining model for predicted tariffs and net transfers given any cost-of-transfers parameter and vector of bargaining parameters. We numerically search over the cost-of-transfers parameter and bargaining parameters to minimize the distance between the

[20]Papers using the linear estimating equation approach are still able to run counterfactuals by using the exact-hat algebra as in Dekle et al. (2008). This method allows one to estimate certain types of counterfactual outcomes knowing only some aggregates rather than all of the model primitives.

observed tariff outcomes of the Uruguay Round and the tariff bargaining outcomes predicted by our model. In other words, we estimate the cost-of-transfers and bargaining parameters by solving the following:

$$\min_{\hat{\kappa},\hat{a}} \Sigma_{i,k}(\hat{\tau}_i^k(\hat{\kappa},\hat{a}) - \tau_i^k)^2$$

where $\hat{\tau}_i^k(\kappa, a)$ is the model's prediction for country i's MFN tariff in sector k for a candidate cost-of-transfers parameter κ and vector of bargaining parameters a, and τ_i^k is the observed MFN tariff of country i in sector k in the year 2000.

5 Model Estimates

5.1 Trade Parameter Estimates

Table 2 presents the within-country dispersion of productivity parameter estimates by sector, ordered by descending θ_k (descending trade elasticity). Our estimates of θ_k display substantial heterogeneity across sectors. According to our estimates, the three highest-θ_k sectors are Live animals (40.87), Miscellaneous edible products and preparations (24.44) and Petroleum (22.38), while the three lowest-θ_k sectors are Pharmaceuticals (4.36), Metal Ores (4.13) and Textile fibres (3.98). Our average θ across sectors is 10.77.

The range of estimates in the literature is arguably quite wide and comparison from paper to paper is difficult due to different degrees of product or geographical aggregation. That said, the Eaton and Kortum (2002) estimate of θ across sectors is 8.28. Costinot et al. (2011) estimate 6.53. Caliendo and Parro (2015) estimates an aggregate θ of 4.55 with a range from 50.01 (Petroleum) to 0.37 (Other transport). Ossa (2014) estimates a mean of 3.42 with a range from 10.07 (Wheat) to 1.19 (Other animal products). Overall, the θ values we estimate tend to be somewhat higher than the current consensus in the literature, a feature that is driven partly by including conditions from the bargaining model in estimating the trade model parameters. In particular, we find that while the bargaining conditions are not binding at the estimated parameters, there is another set of parameters that would deliver a lower objective function value if one ignores the bargaining conditions. This other parameter vector features θ estimates which are 34% lower on average than the estimates with the bargaining conditions in place, and which are closer to the estimates in the literature. However, at these estimates, the bargaining model does not predict tariff changes well for *any* bargaining parameters.

The estimated average iceberg cost across all sectors and country-pairs is 109.0%. The average-across-sectors incurred iceberg cost is 75.3% as lower iceberg cost country pairs trade with each other more. These iceberg costs estimates are smaller than other estimates in the literature. For example, Novy (2013) finds an average iceberg cost of 108% for a group of developed countries in 1990. For the same countries, our estimates indicate an average unweighted iceberg cost of 69.2%. The lower estimated levels of iceberg costs that we find relative to the literature is consistent with our finding as well of higher θ estimates relative to the literature, in that observed levels of trade can be matched by modifying θ or iceberg costs. That is, if for example the model is under-estimating the amount of trade relative to the data, one can decrease iceberg costs or decrease θ.

Table 2: θ Estimates by Industry.

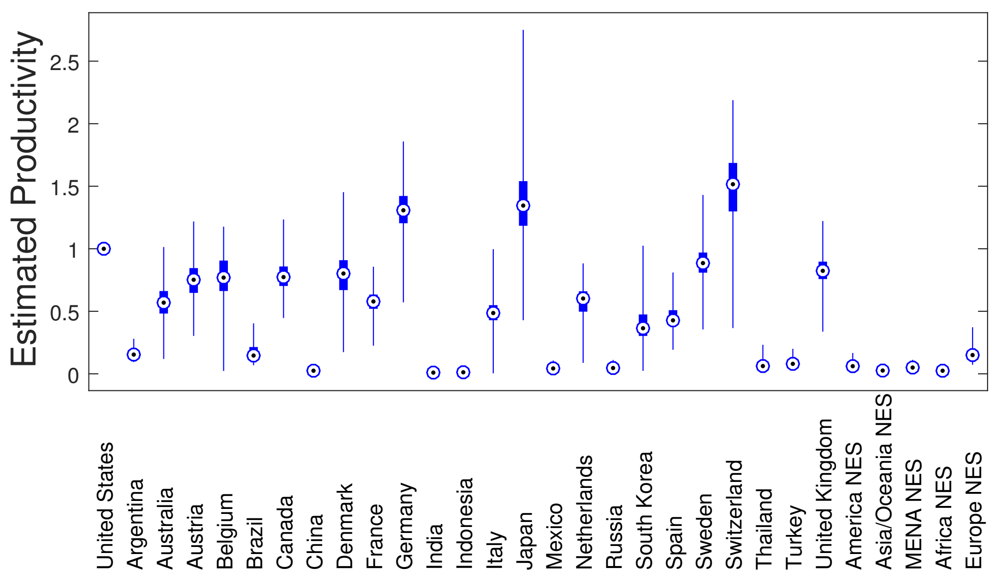
Sector	$\hat{\theta}$	SE	Sector	$\hat{\theta}$	SE
Live animals	40.87	2.10	Footwear	8.50	5.12
Misc. Edible	24.44	10.75	Chemical	8.32	5.03
Petroleum	22.38	11.31	Non-metallic mineral manufactures	8.31	8.00
Dairy	21.77	10.22	Crude rubber	8.09	4.73
All others	18.45	9.45	Office machines	8.02	3.42
Cereals	17.16	5.86	Specialized Machinery	7.82	4.15
Feeding stuff	16.94	7.19	Pulp and waste paper	7.77	2.10
Plumbing, heating and lighting	15.86	6.18	Crude materials,n.e.s.	7.74	3.31
Furniture and parts thereof	15.03	7.75	Travel goods and bags	7.67	3.80
Paper manufactures	11.98	10.67	Road vehicles	7.51	4.03
Electrical machinery	11.91	3.91	Meat	7.50	3.64
Wood manufactures	11.82	6.63	Non-ferrous metals	7.42	3.89
Vegetables and fruit	11.78	8.01	Fertilizers	7.32	4.91
Beverages	11.73	1.71	Tobacco	7.15	4.31
Misc manufactures	10.92	4.28	Fabrics	7.07	4.36
Rubber manufactures	10.81	5.49	Organic chemicals	6.99	5.25
Animal oils and fats	10.63	3.29	Iron and steel	6.94	5.87
Coffee, Tea, Spices	10.46	10.30	Scientific instruments	6.91	3.63
Power generating machinery	10.23	4.99	Other transport equipment	6.42	4.13
Inorganic chemicals	10.19	5.42	Seafood	5.67	3.83
Hides and skins	9.44	4.59	Coal	5.38	1.65
Sugar	9.35	3.52	Pharmaceutical	4.36	1.29
Cork and wood	9.07	5.63	Metal Ores	4.13	0.92
Resins	8.94	4.97	Textile fibres	3.98	0.98
Dyeing and tanning	8.78	4.85			

Notes: Non-linear least squares estimates of θ by sector in descending order of estimate.

With regard to cross-country fundamental productivity levels, Figure 1 plots the distribution of estimated productivity levels for each country. Productivity levels are positively correlated across sectors, so the higher productivity countries in agriculture also tend to be the higher productivity countries in manufacturing.

As a test of the model, we compare the estimated wage levels across countries to wage data from the Bureau of Labor Statistics International Labor Comparisons (ILC) program for 1997. For the 19 countries we could match to these data, a regression of the model's predicted relative wage on the relative wage in the data produces a coefficient estimate of 0.933 with associated standard error of 0.157. The estimated R^2 for this regression is 0.674. While we did not use any wage data in estimating the model, the implied estimated wage rates are not systematically biased estimates and can account for about two-thirds of the cross-country variation.

Figure 1: Productivity Distributions by Country



Notes: For each country, the target is the median estimated productivity across sectors. The box represents the interquartile range. The line represents the full range. Each sector in the US is normalized to a productivity level one.

5.2 Model Benchmarks

We compute various benchmarks implied by the 1990-based estimated trade model. Table 3 reports the results. We begin with the first and second columns of Table 3, which report respectively the changes in welfare that would result if, with regard to all products, the world reverted to autarky, or if all iceberg costs (including tariffs) were removed. These

Table 3: Model Benchmarks

Country	Autarky	Zero Iceberg Costs	Free Trade	Total Welfare Maximizing	Nash
United States	-1.76%	18.82%	0.03%	-1.13%	-0.21%
EU	-5.44%	47.28%	0.00%	-1.62%	-0.01%
Austria	-10.20%	58.09%	0.00%	-2.01%	-0.02%
Belgium	-17.05%	79.49%	-0.04%	-1.63%	0.00%
Denmark	-5.19%	90.64%	-0.02%	-1.47%	-0.01%
France	-4.98%	64.75%	-0.01%	-1.08%	-0.02%
Germany	-2.86%	29.75%	-0.06%	-2.10%	0.03%
Italy	-5.07%	44.12%	-0.05%	-2.08%	0.00%
Netherlands	-11.74%	85.97%	0.05%	-1.77%	-0.02%
Spain	-6.42%	62.85%	0.02%	-1.79%	0.01%
Sweden	-8.92%	51.38%	0.00%	-1.78%	-0.06%
United Kingdom	-4.61%	36.92%	0.15%	-0.86%	-0.07%
Argentina	-1.20%	107.26%	0.11%	0.66%	-0.08%
Australia	-3.31%	103.94%	0.20%	1.67%	0.09%
Brazil	-1.14%	86.00%	0.10%	1.52%	-0.08%
Canada	-6.88%	51.62%	0.07%	0.35%	-0.21%
China	-2.41%	52.99%	0.60%	1.27%	-0.01%
India	-2.44%	89.39%	0.53%	3.16%	0.12%
Indonesia	-2.35%	76.23%	0.34%	0.67%	-0.07%
Japan	-1.81%	23.45%	0.20%	0.85%	0.06%
Mexico	-2.67%	59.80%	0.01%	0.32%	-0.06%
Russia	-3.52%	75.16%	0.21%	0.83%	-0.49%
South Korea	-5.11%	54.65%	0.42%	1.45%	-0.03%
Switzerland	-5.78%	60.00%	-0.05%	-0.12%	0.01%
Thailand	-4.98%	152.18%	0.70%	2.86%	0.04%
Turkey	-3.43%	59.62%	-0.12%	-0.15%	0.05%
America NES	-3.88%	119.63%	0.28%	6.55%	-0.29%
Asia/Oceania NES	-5.58%	58.74%	0.77%	2.39%	-0.41%
MENA NES	-5.45%	94.58%	0.29%	1.13%	-0.90%
Africa NES	-2.20%	55.41%	0.13%	2.58%	-0.19%
Europe NES	-5.46%	43.00%	0.92%	2.95%	-0.61%
Total Welfare	-3.42%	47.26%	0.17%	0.25%	-0.10%

Notes: Estimated model's predicted percentage change in national welfare from estimated 1990 status quo for benchmark scenarios. In column 1, we set iceberg costs for all countries in all sectors to 5000%, effectively shutting down trade across countries. In column 2, we set iceberg costs to zero for all countries in all sectors. In column 3, we set all non-agricultural tariffs for the US, Australia, EU, Japan, and South Korea to zero. These four countries and the EU make up the set of negotiating countries based on principal supplier status according to our estimates. In column 4, we solve for the total welfare maximizing levels of non-agricultural tariffs for the five negotiating countries. In column 5, we compute a Nash equilibrium in non-agricultural tariffs for the five negotiating countries. Tariffs in columns 4 and 5 are non-discriminatory.

are standard benchmarks in the quantitative trade modeling literature, and are useful for positioning the broad predictions from our quantitative trade model within that literature. We find that, relative to welfare under the status-quo 1990 tariffs, moving to autarky would reduce total world welfare by 3.42%, while eliminating iceberg costs would raise total world welfare by 47.26%. For the US, moving to autarky reduces country welfare by 1.76% which is somewhat larger than the 0.7% to 1.4% range computed by Arkolakis et al. (2012) under the assumption of a single trade elasticity in the range of 5 to 10 applied to all sectors. This number is lower, however, than the 13.5% estimated in Ossa (2015), despite the fact that our model also features heterogeneity in θ across sectors. Several features account for the difference between our predictions and Ossa's. Ossa's estimates are based on a model with 251 sectors for the base year 2007 whereas our model has 49 sectors and is estimated using data from the base year 1990 (Ossa reports an estimate for the US of 8.9% based on a more aggregated 28 sector calculation). Ossa also reports a trade-weighted cross-industry average trade elasticity of 2.94, substantially lower than that implied by our θ estimates.

We will also be interested in how the Horn-Wolinsky solution of our model compares to a benchmark tariff bargain that reached the efficiency frontier. There are no market imperfections or political economy forces in our model, and so achieving free trade in all tariffs would place the world on the efficiency frontier. But as a benchmark with which to compare our model outcomes, global free trade is not particularly meaningful, both because our bargaining analysis is limited to tariffs on non-agricultural products, and because according to our model under the principal supplier rule not all countries engaged in tariff bargaining in the Uruguay Round. A more meaningful free-trade benchmark with which to compare the Horn-Wolinsky solution of our model is a bargain that sets to zero just the non-agricultural tariffs under negotiation in the Uruguay Round according to our model. It is also meaningful to consider an alternative benchmark that sets these same tariffs equal to the levels that would maximize world welfare in light of the existing distortions implied by the fixed levels of all other tariffs in the world. Similarly, for assessing how the Horn-Wolinsky solution of our model compares to a benchmark Nash tariff war, we solve for the non-cooperative Nash tariff equilibrium over this same set of tariffs, holding all other tariffs fixed at their 1990 levels.

The third, fourth and fifth columns of Table 3 report benchmark welfare effects under these free-trade, world-welfare maximizing and Nash benchmarks, respectively. In particular, for the benchmark results reported in these three columns, we limit the tariff changes to those tariffs on non-agricultural products that were imposed by the set of negotiating countries in the Uruguay Round, defined as the set of countries that by their principal supplier status in 1990 according to our model had at least one viable bilateral bargaining partner in the Uruguay Round (i.e., a partnership where each country was the principal supplier of at least one product into the other country's market). We refer to the resulting set of tariffs as the set of tariffs that were "under negotiation in the Uruguay Round."

The third column of Table 3 reports the welfare results from reducing all the tariffs that were under negotiation at the Uruguay Round from their 1990 levels to zero, with all other tariffs held fixed at their 1990 levels. World welfare rises by 0.17%, an amount that is smaller than the findings in Ossa (2014)) who predicts a rise in total welfare of 0.5%. However, Ossa's prediction reflects the impact of eliminating all tariffs, whereas as we have noted above our prediction is about the impact of eliminating only the subset of (non-agricultural) tariffs that were under negotiation in the Uruguay Round based on the set of viable bilateral bargaining partners given principal supplier patterns in 1990.

The fourth column of Table 3 reports results when we solve for the levels of the tariffs negotiated in the Uruguay Round that would maximize total world welfare, corresponding to the utilitarian/Benthamite point on the (constrained) efficiency frontier. World welfare under these tariff levels is higher than world welfare under our free trade benchmark for two reasons. First, there are pre-existing distortions associated with the tariffs not under negotiation at Uruguay which remain fixed at their 1990 levels under both exercises, and in the presence of these pre-existing distortions some deviation from free trade for the remaining tariffs is optimal from the perspective of world welfare: in particular, we find that on average the world-welfare maximizing benchmark entails further tariff liberalization than the free trade benchmark (i.e., on average, import subsidies are needed to offset the trade restricting effects of the tariffs not under negotiation at Uruguay).[21] And second, the terms of trade effects of utilitarian tariffs redistribute income towards higher marginal utility of income countries.[22]

[21] This finding may be interpreted using the Lerner symmetry theorem. Specifically, given the pre-existing distortions associated with import tariffs not under negotiation in the Uruguay Round, an efficient outcome could be achieved if export policies were available so that each country could offset the effects of foreign import tariffs with appropriately selected export subsidies. We do not allow countries to use export policies in our model; however, due to the Lerner symmetry theorem, a country can similarly offset the effects of foreign import tariffs with appropriately selected import subsidies.

[22] At equal wages, the marginal utility of income is higher in countries with lower price indices. All

The fifth column of Table 3 reports the welfare results from increasing all the tariffs that were under negotiation in the Uruguay Round from their 1990 levels to their Nash equilibrium levels, with all other tariffs held fixed at their 1990 levels. Here we find that total welfare decreases for most countries relative to their welfare under status-quo tariffs, but a few countries would enjoy small gains due to favorable terms-of-trade movements as a result of the Nash trade war. In aggregate the decrease in total welfare amounts to 0.1%. This reflects the fact that our estimated losses from a move to autarky are relatively modest (as is true for much of the quantitative trade modeling literature), that the move to Nash tariffs is only allowed for products that were under negotiation in the Uruguay Round, and that the Nash tariffs are sizable but far from prohibitive. US tariffs rise on average from 4.44% to 9.4%. EU tariffs rise on average from 5.82% to 11.31%. Japanese tariffs rise from 5.03% to 12.6%. Ossa (2014)) finds Nash tariffs averaging 63% and an aggregate loss of 2.9% from a trade war relative to status-quo tariffs. In addition to the fact that our Nash calculations refer to only those tariffs that were under negotiation in the Uruguay Round whereas Ossa's Nash calculations cover all tariffs, the differences between our Nash results and Ossa's also reflect differing estimated trade elasticities, with Ossa's estimates again indicating less responsiveness of trade to tariffs on average than our estimates. The estimates of Markusen and Wigle (1989), who find Nash tariff rates for the US and Canada of 18% and 6% respectively and small losses from a trade war relative to free trade, are more in line with our numbers.

Together our estimates in the third and fifth columns of Table 3 suggest that, beginning from Nash tariffs, the GATT rounds up to but not including the Uruguay Round had achieved by 1990 roughly 40% of the potential aggregate world-wide gains from the complete elimination of the tariffs that were under negotiation in the Uruguay Round. Compared to a benchmark that sets these same tariffs equal to the levels that would maximize world welfare in light of the existing distortions implied by the fixed levels of all other tariffs in the world as of 1990, the fourth and fifth columns of Table 3 suggest that, beginning from Nash tariffs, the GATT rounds leading up to the Uruguay Round achieved roughly a third of the aggregate world-wide welfare gains that were possible with changes to the tariffs under negotiation in the Uruguay Round.

else equal, larger and/or more centrally located countries thus may be expected to have higher marginal utilities of income. Since in our model countries do not have sufficient policy instruments with which to effect lump-sum transfers, the utilitarian calculus balances the benefits of such redistribution against the associated distortion costs.

5.3 Cost-of-Transfers and Bargaining Parameter Estimates

We now turn to our second step and estimate the cost-of-transfers and bargaining parameters. As described above, our approach is to use our trade model to solve for the Horn-Wolinsky bargaining outcomes beginning from 1990 tariff bindings and respecting MFN and the principal supplier rule, and to search over cost-of-transfers and bargaining-power parameters to minimize the distance between the observed tariff outcomes of the Uruguay Round and the tariff bargaining outcomes predicted by our model. We let the model predictions regarding principal supplier status guide our set of bilateral bargains.

For reference, the top panel of Table 4 displays the observed pattern of principal supplier status at the level of product aggregation in our data. For this table, we have combined the (at the time of the Uruguay Round) 10 EU member countries into the EU, because these countries negotiated their (common external) GATT Uruguay Round tariff commitments as a bloc; and to focus on the major traders, we have omitted from the table the 5 regional NES entities. Also, in defining the principal suppliers relevant for Uruguay Round negotiations, for the numbers in this table we have netted out trade with fellow PTA members (e.g., US exports to Canada are excluded when calculating the identity of principal suppliers into Canada). For each cell in the table, the first entry gives the number of products for which the column country is the principal supplier into the row country, and the second entry gives the number of products for which the row country is the principal supplier into the column country. The top panel of Table 4 records 12 country-pairs where both entries are non-zero (highlighted in the table with square brackets around those entries), reflecting the double coincidence of wants that can support a bilateral tariff negotiation between the pair. The 12 pairings involve 6 countries: the 4 Quad members – the US, the EU, Canada and Japan – and two additional countries, Australia and South Korea.

According to our trade model estimates, the predicted pattern of principal supplier status for the same set of countries is displayed in the bottom panel of Table 4. As the bottom panel of Table 4 reflects, the principal supplier relations predicted by our model capture 7 of the 12 pairings in the data and involve 5 of the 6 countries: three of the four Quad members, US, EU and Japan, and the two additional countries Australia and South Korea. This seems to capture the main bilaterals in the Uruguay Round (US-EU, US-Japan, EU-Japan, Japan-South Korea) but misses some others that are potentially important (e.g., EU-Canada). Overall, our current set of bargaining countries includes the 14 major industrialized countries that were arguably the key actors in the

Table 4: Principal Supplier Relationships

	US	Argentina	Australia	EU	Brazil	Canada	China	India	Indonesia	Japan	Mexico	Russia	Korea	Switzerland	Thailand
US															
Argentina	12,0														
Australia	[11,2]	0,1													
EU	[25,26]	0,11	[1,21]												
Brazil	9,0	0,0	0,0	11,0											
Canada	0,0	0,0	[1,1]	[30,3]	0,0										
China	4,0	0,0	2,0	15,0	0,0	1,0									
India	8,0	0,0	1,0	21,0	0,0	0,0	0,0								
Indonesia	6,0	0,0	4,0	12,0	0,0	0,0	0,0	0,0							
Japan	[18,5]	0,0	[3,3]	[13,3]	0,0	0,3	0,12	0,2	0,10						
Mexico	35,0	0,0	0,0	2,0	0,0	0,0	0,0	0,0	0,0	0,0					
Russia	0,0	0,0	1,0	33,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0				
Korea	[13,2]	0,0	[2,1]	[4,2]	0,0	0,1	0,0	0,0	0,2	[17,4]	0,0	0,0			
Switzerland	0,0	0,0	0,0	39,0	0,0	0,0	0,1	0,0	0,0	0,1	0,0	0,0	0,0		
Thailand	7,0	0,0	0,0	13,0	0,0	0,0	0,0	0,0	0,0	14,0	0,0	0,0	2,0	0,0	
Turkey	3,0	0,0	0,0	34,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,0	0,0

	US	Argentina	Australia	EU	Brazil	Canada	China	India	Indonesia	Japan	Mexico	Russia	Korea	Switzerland	Thailand
USA															
Argentina	17,0														
Australia	[20,1]	0,0													
Europe	[30,24]	0,17	0,7												
Brazil	9,0	0,0	0,0	17,0											
Canada	0,0	0,0	1,0	27,0	0,0										
China	3,0	0,0	2,0	19,0	0,0	0,0									
India	3,0	0,0	1,0	25,0	0,0	0,0	0,0								
Indonesia	2,0	0,0	4,0	19,0	0,0	0,0	0,0	0,0							
Japan	[28,9]	0,0	0,8	[7,3]	0,0	0,5	0,11	0,2	0,8						
Mexico	0,0	0,0	2,0	28,0	0,0	0,0	0,0	0,0	0,0	1,0					
Russia	3,0	0,0	0,0	32,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
Korea	4,0	0,0	[2,2]	[16,2]	0,0	0,0	0,2	0,0	0,0	[14,2]	0,1	0,1			
Switzerland	1,0	0,0	0,0	37,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0		
Thailand	3,0	0,0	2,0	21,0	0,0	0,0	0,0	0,0	0,0	7,0	0,0	0,0	0,0	0,0	
Turkey	1,0	0,0	0,0	36,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Notes: The top panel presents principal supplier relationships according to the data. The bottom panel represents principal supplier relationships according to the trade model at the estimated parameter vector. For each cell in the table, the first entry gives the number of products for which the column country is the principal supplier into the row country, and the second entry gives the number of products for which the row country is the principal supplier into the column country. For the numbers in this table, trade with fellow PTA members has been netted out. Square brackets indicate the bilateral relationships where both entries are positive.

tariff negotiations of the Uruguay Round (the exclusion of Canada from this set being potentially the most important omission, mitigated to some degree by the fact that the US and Canada did not engage in bilateral negotiations over MFN tariffs in the Uruguay Round due to the existence of the US-Canada FTA and subsequently NAFTA).[23]

Table 5 displays the bargaining parameter estimates for each of the negotiating countries,[24] as well as the estimated cost-of-transfers parameter κ. Two points are clear from Table 5.

Table 5: Bargaining Model Parameter Estimates

Country	Bargaining Parameter	SE
USA	0	-
Australia	-10.981	0.174
EU	-12.017	0.224
Japan	6.841	0.453
South Korea	-3.349	0.928
	Parameter	SE
Cost of Transfers Coefficient	277.613	0.928

Notes: Estimated bargaining parameters (a_i) and coefficient on quadratic transfer cost. The parameter for the US is normalized to 0.

First, transfers were possible in the Uruguay Round, but they were not costless. The point estimate of κ reported in Table 5 translates into an average cost of transfers amounting to 84.68% when evaluated at the mean level of net transfers paid by countries who made positive net transfers. That is, according to our estimates, on average a country wishing to transfer 1 unit of utility to a bargaining partner in the Uruguay Round gave up 1.8468 units of utility to do so. And averaged across those countries making positive net transfers, the marginal cost of the last unit of utility transferred rises to 129.06%.

The second point that is clear from Table 5 is the relative ranking of bargaining powers, with Japan the strongest bargainer followed in descending order by the US, South Korea, Australia and the EU. As we describe further in the next subsection, Japan's strong

[23]As we noted earlier, we do not allow the possibility of (costly) transfers to relax the requirement of a principal-supplier-based "double coincidence of wants" for each viable bargaining pair. But a comparison of the entries in the top and bottom panels of Table 4 suggests that allowing this expanded definition of viable bargaining pairs might improve the match between the set of bilateral bargaining partners in the model and those suggested by the principal supplier relationships in the data. We return in the Conclusion to discuss this as a possible direction for future research.

[24]Because the same constant could be added to each bargaining parameter without changing predictions, we normalize the US bargaining parameter to zero.

bargaining position manifests itself in our model as Japan receiving large tariff concessions from its bargaining partners while making tariff concessions and non-tariff transfers that were small in comparison to the benefits it received. The EU's weak bargaining position leads it to agree to both relatively large tariff cuts and positive transfers in its bilaterals.

Interpreting the estimates in Table 5 requires some caution. A naive interpretation of the bargaining parameters as relative "power" between the pairs can be misleading. These parameters reflect how the two negotiating countries split the marginal surplus that can be obtained by their agreement conditional on all other bilateral negotiation outcomes. Here we are relying heavily on the Horn-Wolinsky bargaining solution structure, which pins down the particular disagreement point from which the marginal surplus of a bilateral agreement is defined. A country could have strong bargaining power in each of its bilaterals and nevertheless fare poorly in the Uruguay Round relative to the 1990 status quo if the outcomes from all other bilaterals have served to disproportionately worsen this country's disagreement payoff in each of its bilaterals. Alternatively, a country could fare well as a result of the Uruguay Round outcomes relative to its welfare in the 1990 status quo, and yet be revealed to have very weak bargaining power in a given bilateral where the disagreement payoff had moved strongly in its favor.[25]

While the bargaining parameter estimates do reflect how evenly the surplus from the bilateral tariff bargain is split between the two parties, in our tariff-bargaining setting these parameters also reflect an additional feature, namely, the slope of the bilateral bargaining frontier. Our cost-of-transfers estimate indicates that countries did not have access to lump-sum transfers in the Uruguay Round, and so utility is not transferable across countries and the slopes of the bilateral bargaining frontiers will typically not be equal to -1. Instead, with the countries in any bilateral using tariff changes combined with costly transfers to transfer utility between them, the slope of the bargaining frontier in any given bilateral will reflect the cost of transfers and the relative degree to which the incidence of each country's tariff changes falls on, and only on, its bilateral bargaining partner.[26]

[25]Of course, if the actual disagreement point in a bilateral deviates significantly from that under the Horn-Wolinsky bargaining solution, the implied split and hence the implied bargaining parameters could be different.

[26]If countries were bargaining over a sufficiently complete set of trade taxes, they would be able to use adjustments in these trade taxes to transfer surplus between them in a lump-sum manner. For example, in a two-good two-country general equilibrium setting, Mayer (1981) shows that adjustments in the import tariff in each country that preserve the equality of the relative price in each country can effect lump-sum

Figure 2: US and EU Welfare Frontier

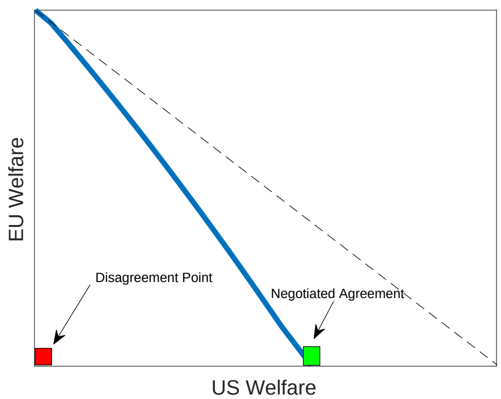
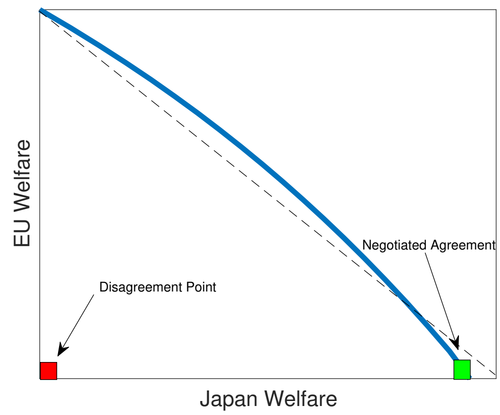


Figure 3: EU and Japan Welfare Frontier



Notes: These curves represents the frontier of feasible welfare pairs for the US-EU bilateral (left panel) and Japan-EU bilateral (right panel) negotiations holding the other pairs fixed at the equilibrium outcomes. The dashed line has slope equal to minus one.

Figures 2 and 3 illustrate this feature for the US-EU and Japan-EU bilaterals. The bilateral bargaining frontier in each figure is constructed by optimally adjusting the tariffs under negotiation in that bilateral and the costly transfer between the two negotiating countries, holding all other tariffs and transfers fixed at their predicted agreement levels, to shift surplus between the two countries. As Figure 2 depicts, the slope of the bargaining frontier between the US and the EU is essentially linear but steeper than -1 throughout the relevant range, indicating that the tariffs (and transfer) negotiated in this bilateral were more effective at shifting surplus from the US to the EU than in the other direction. This means in turn that for any given bargaining parameter for the US-EU bilateral, the division of the surplus under the Nash bargaining solution will be shifted in the direction of the EU relative to what it would be if the slope of the bilateral bargaining frontier were -1 throughout. Figure 3 reveals that the bargaining frontier between Japan and the EU is more clearly concave over the relevant range, and takes on a slope of -1 at a point that favors the EU relative to Japan, indicating that in the Japan-EU bilateral, the tariffs under negotiation were more effective at shifting surplus from Japan to the EU.

In Table 6, we present evidence suggesting that asymmetries in market power, the position of the initial tariffs relative to their best-response levels, and the spillovers to third parties are all factors in understanding the slopes of the bilateral bargaining frontiers.

transfers across countries. This is infeasible in the bilaterals under study in the present setting, because the set of import tariffs under negotiation do not constitute a sufficiently complete set of trade taxes.

Consider for example, the first two rows of this table, which relate to the US-Australia bilateral. With all other tariffs positioned at their agreed levels as predicted by our model, the first three columns of Table 6 report that, beginning from the US-Australia negotiated agreement tariffs as predicted by our model, when the US lowers its tariffs under negotiation in this bilateral by an amount that reduces its welfare by 1 unit, it increases the surplus of all other countries by 6.271 units, with Australia receiving 2.677 units and third parties receiving the remaining 3.594 units. By contrast, beginning from these same tariffs, when Australia lowers its tariffs under negotiation in this bilateral by an amount that reduces its welfare by 1 unit, it increases the surplus of all other countries by 0.467 units, with the US receiving 0.083 units and third parties receiving the remaining 0.384 units.

Table 6: Spillover Benefits to Third Parties (MFN Negotiations)

			Tariff Reduction from Agreement			Tariff Reduction from Binding		
Country 1	Country 2	Reducing Country	Δ Welfare Country 1 (1)	Δ Welfare Country 2 (2)	Δ Welfare 3rd Parties (3)	Δ Welfare Country 1 (4)	Δ Welfare Country 2 (5)	Δ Welfare 3rd Parties (6)
US	Aus	US	-1.000	2.677	3.594	-1.000	3.285	4.520
US	Aus	Aus	0.083	-1.000	0.384	0.090	-1.000	0.398
US	EU	US	-1.000	1.557	1.231	-1.000	2.516	2.144
US	EU	EU	0.335	-1.000	1.410	0.405	-1.000	1.728
US	Japan	US	-1.000	1.166	0.712	-1.000	2.240	1.347
US	Japan	Japan	0.501	-1.000	0.460	0.576	-1.000	0.564
Aus	Korea	Aus	-1.000	0.731	3.909	1.000	0.048	0.240
Aus	Korea	Korea	0.786	-1.000	1.015	0.725	-1.000	1.134
EU	Japan	EU	-1.000	0.609	0.677	-1.000	15.438	19.550
EU	Japan	Japan	0.739	-1.000	0.573	1.495	-1.000	1.382
EU	Korea	EU	-1.000	0.513	4.766	1.000	0.160	1.361
EU	Korea	Korea	0.783	-1.000	1.972	0.928	-1.000	2.658
Japan	Korea	Japan	-1.000	0.826	1.555	1.000	0.629	1.103
Japan	Korea	Korea	0.991	-1.000	1.275	5.723	1.000	8.413

Notes: Each row corresponds to a unilateral marginal decrease in tariffs by the "reducing country." The reducing country reduces tariffs on all goods that it negotiates with the partner country in that row. The welfare changes are normalized so that the reducing country has an absolute welfare change equal to one. The first set of welfare columns presents changes in welfare when all tariffs begin from the negotiated agreement. The second set of welfare columns presents changes in welfare when all tariffs begin from 1990 levels.

These asymmetric effects reflect a combination of factors. The feature that the US tariff cuts generate substantially more surplus gains for the rest of the world overall than do Australia's tariff cuts when Australia and the US make the above-described tariff cuts reflects in part the differences across these two countries in import volumes and market power over world prices with respect to the products on which they are bargaining. Another factor is the relative distance of the agreed tariffs from best-response levels for the tariffs over which these two countries bargain; this factor governs the magnitude of the described tariff cuts.[27] And the feature that Australia captures a greater portion of the rest-of-world gains generated by the US's tariff cuts (roughly 43%) than is captured by the US when Australia makes the described tariff cuts (roughly 18%) reflects asymmetries in the degree of dominance that each country's principal suppliers play in serving the other country's markets.

The last three columns of Table 6 report analogous measures, but do so beginning from the bargaining pairs' disagreement (1990) tariffs rather than from the pairs' negotiated agreement tariffs (with all other tariffs also positioned at their 1990 levels). Similar asymmetric effects arise from this starting point and have similar interpretations, but now it is possible that unilateral tariff reductions can increase a country's welfare (if the 1990 levels for the tariffs it negotiates in this bilateral are above its best-response levels in light of the 1990 levels of all other tariffs) and, because these calculations do not begin from a point on the bilateral bargaining frontier, could (but need not) increase the welfare of all countries.

Notably, the third-party spillovers reported in both columns 3 and 6 of Table 6 are uniformly positive. While the overall surplus gain for the rest of the world generated by an importing country's MFN tariff cuts is expected to be positive due to the induced terms-of-trade effects, the sign of the spillovers to individual countries is not guaranteed to be positive, and depends on trade patterns. That is, while the sum of the impacts on the bargaining partner and third parties should be positive when an importing country reduces its import tariffs as part of a bilateral bargain, the impact on third parties taken as a group could be positive or negative and is ultimately an empirical question for which columns 3 and 6 of Table 6 provide an answer.[28]

This point was emphasized by an early study commissioned by GATT which became known as the *Haberler Report*. Written by a Panel of Experts that included Roberto de Oliveira Campos, Gottfried Haberler, James Meade and Jan Tinbergen, the purpose of the

[27]For example, if a country's agreed tariffs were at their best-response levels, then an envelope argument ensures that small tariff reductions would have no first-order effect on that country's welfare. This suggests that a country may need to make larger tariff cuts to generate a 1 unit welfare reduction when that country's tariffs are positioned closer to their best-response levels.

[28]In fact, even the overall impact could in principle be of either sign in a multi-product environment, depending on the signs and strengths of the interactions across products.

report was to investigate the prevalence of agricultural protectionism and "...the failure of the export trade of the under-developed countries to expand at a rate commensurate with their growing import needs." (Campos et al., 1958). The issue of spillovers was explained by the Report in these terms:

> The problem of the interests of different primary producing countries outside industrialized Western Europe and North America is ... not only a question which of the other countries would gain by a moderation of agricultural protectionism in these two great industrialized regions; there are undoubtedly cases in which an increase in agricultural protectionism in these two regions, while it would be to the disadvantage of some of the unindustrialized countries, would actually be to the advantage of others. ... An increased stimulus to the production of wheat in any of the countries of North America or of Western Europe by increasing the exportable surplus of North America and decreasing the import requirements of Western Europe would depress the world market for wheat. This might mean that a country like India or Japan would obtain cheaper imports of wheat (either because of a fall in the world price or because of a development of special sales or gifts for the disposal of surplus wheat by the United States), but a country like Australia or the Argentine which competed in the world export market for wheat would be damaged. ...
>
> In general, if one considers any particular agricultural product, a protective stimulus to its production in any one country by increasing supplies relatively to the demand for that product will tend to depress the world market for that product. This will damage the interests of other countries which are exporters of the product on the world market. But it will be to the national interest of countries which import the product from world markets. Whether the initial protective stimulus confers a net benefit or a net damage to all other countries concerned depends, therefore, upon whether the country giving the protective stimulus to its own production is an exporter or an importer of the product; if it is an exporter it is conferring a benefit on the world by giving its supplies away at a cheap price; if it is an importer it is damaging the rest of the world by refusing to take their supplies. (Campos et al. (1958), footnotes omitted).

In the context of bilateral MFN tariff bargaining, the general principle described by the Haberler Report describes well the pattern of externalities that each bilateral bargain has to confront. Based on this principle, we would expect the overall surplus gain for the rest of the world generated by an importing country's MFN tariff cuts to be positive, and this is confirmed in the results reported in Table 6. What is also confirmed by the results in Table 6 is that both the bargaining partner, and third parties as a group, each gain from the importing-country MFN tariff cuts being negotiated in the Uruguay Round.

5.4 MFN Tariff Bargaining in the Uruguay Round

Comparing our Horn-Wolinsky model solution to the actual Uruguay Round tariff bargaining outcomes, we find that we can explain 57.86% of the variation in 190 tariffs under negotiation in the Uruguay Round using our cost-of-transfers parameter and four bargaining parameters. The welfare impacts of the Round's MFN tariff bargaining as predicted by our model are presented in the first and second columns of Table 7. The first column reports the impact of the negotiated tariff cuts predicted by our model, while the second column includes as well the impacts of the net transfers negotiated according to our model as part of the Round.[29]

The total world welfare gain from the Round reported in Table 7 is small in magnitude, which is not surprising in light of our benchmark findings presented in columns 3 and 4 of Table 3 that, beginning from their 1990 levels, the gains in world welfare are small from eliminating all tariffs under negotiation in the Uruguay Round or from setting these tariffs at their world welfare maximizing levels (0.17% and 0.25% respectively). That said, our Horn-Wolinsky model solution indicates that in increasing total world welfare by 0.11%, the Uruguay Round achieved roughly 40% of the potential aggregate world-wide welfare gains in moving from the non-cooperative Nash tariff levels to this free-trade benchmark, and it achieved roughly a third of the world-wide welfare gains beginning from Nash that would have been possible under world-welfare maximizing levels of these tariffs. Overall, and recalling that our focus is on the tariffs under negotiation in the Uruguay Round, our model indicates that the GATT rounds leading up to the Uruguay Round and the Uruguay Round itself together achieved roughly two thirds of the potential aggregate world-wide welfare gains in moving from the non-cooperative Nash to the world-welfare maximizing benchmark, leaving roughly a third of the potential world welfare gains from

[29]Transfers are determined at the aggregate level for the EU. For the purposes of Table 7, we allocate transfers to member countries of the EU directly in proportion to population.

Table 7: Estimated Uruguay Round and Counterfactual Outcomes

	MFN		No MFN	
	Tariffs			
Average Tariffs	-46.95%		-47.43%	
Weighted Average Tariffs	-54.50%		-48.96%	
	Country Welfare			
		with transfers		with transfers
United States	0.00%	0.04%	0.03%	0.09%
EU	0.04%	0.02%	-0.03%	-0.05%
Austria	0.07%	0.05%	-0.02%	-0.04%
Belgium	0.01%	0.00%	0.00%	-0.01%
Denmark	0.02%	0.00%	-0.04%	-0.05%
France	0.03%	0.00%	0.05%	0.03%
Germany	0.00%	-0.01%	-0.09%	-0.10%
Italy	0.02%	-0.02%	0.01%	-0.02%
Netherlands	0.05%	0.03%	0.02%	0.01%
Spain	0.07%	0.02%	-0.07%	-0.10%
Sweden	0.06%	0.04%	0.02%	0.00%
United Kingdom	0.14%	0.12%	-0.03%	-0.04%
Argentina	0.05%	0.05%	-0.02%	-0.02%
Australia	0.08%	0.04%	0.22%	-0.03%
Brazil	0.05%	0.05%	-0.02%	-0.02%
Canada	0.00%	0.00%	-0.10%	-0.10%
China	0.35%	0.35%	-0.10%	-0.10%
India	0.31%	0.31%	-0.06%	-0.06%
Indonesia	0.14%	0.14%	-0.05%	-0.05%
Japan	0.21%	0.20%	0.29%	0.28%
Mexico	0.00%	0.00%	-0.04%	-0.04%
Russia	0.07%	0.07%	-0.04%	-0.04%
South Korea	0.47%	0.43%	-1.86%	-2.02%
Switzerland	-0.04%	-0.04%	-0.07%	-0.07%
Thailand	0.42%	0.42%	-0.07%	-0.07%
Turkey	-0.08%	-0.08%	-0.06%	-0.06%
America NES	0.11%	0.11%	0.02%	0.02%
Asia/Oceania NES	0.36%	0.36%	-0.16%	-0.16%
MENA NES	0.06%	0.06%	-0.08%	-0.08%
Africa NES	0.05%	0.05%	-0.02%	-0.02%
Europe NES	0.40%	0.40%	-0.12%	-0.12%
Total Welfare	0.12%	0.11%	0.00%	-0.01%

Notes: Each column represents changes in the row relative to the pre-Uruguay tariff levels. The first set of columns represents the Horn-Wolinsky MFN solution at the estimated bargaining parameters. The second set of columns represents the Horn-Wolinsky discriminatory solution at the estimated bargaining parameters.

negotiating over this set of tariffs as "unfinished business."[30]

The first two columns of Table 7 also reveal that there is significant variation in the gains from the Uruguay Round's MFN tariff bargaining across the member countries, with substantially higher than average gains going to a number of emerging and developing countries and smaller gains going to some of the industrialized countries. Among the emerging and developing economies with especially high gains are China (who was not a GATT member at the time of the Uruguay Round but enjoyed MFN treatment from the EU and the US), India, Thailand and the regional entities in Asia/Oceana NES and Europe NES. These countries were not among our bargaining pairs and hence these gains reflect favorable terms-of-trade movements as a result of the Round. Turning to the industrialized countries, the US gains are relatively small, amounting to a little less than half of the average gains experienced by countries as a result of the Round, while the EU gains are even smaller once the EU net transfers to bargaining partners are accounted for. And Australia's gains are comparable to those of the US, once its large net transfer payments to bargaining partners are taken into account. Japan enjoys above average gains, but it is South Korea that enjoys the largest gains of any country from the Round.

Of special interest are the results for Japan reported in Table 7. Japan's gains from the Round are above-average, but they are substantially smaller than those of South Korea, despite the fact that as we observed earlier our bargaining parameter estimates indicate that Japan is the strongest bargainer, with South Korea only possessing moderate bargaining power. This apparent contradiction is resolved by noting that here we are comparing how countries fared in the Uruguay Round relative to their 1990 welfare levels, while the bargaining power parameters reflect how well a country does in each of its bilateral bargains relative to the Horn-Wolinsky disagreement point for that bilateral. Evidently, Japan's strong bargaining position is reflected in the fact that it did extremely well in its bargains relative to the Horn-Wolinksy disagreement points for those bargains, but the Horn-Wolinsky disagreement points moved in an unfavorable direction for Japan relative to the 1990 status quo.

It is interesting to note that, according to our model predictions, not all countries gained from the Uruguay Round. In particular, we find that Switzerland and Turkey

[30] It is also interesting to note from a comparison of column 2 of Table 7 and column 4 of Table 3 that, under the world welfare maximizing benchmark, much of the increased gains relative to the negotiated MFN tariff cuts would go to developing and emerging economies, as might be expected given that these countries were not among the bargaining pairs in the Uruguay Round and hence their interests were not directly represented in those bilateral bargains.

suffer losses. As these two countries were not among our bargaining pairs and hence do not alter their own tariffs from 1990 levels, the losses they suffer as a result of the Uruguay Round reflect adverse terms-of-trade movements that resulted according to our model from the negotiated MFN tariff cuts of others. This illustrates the point highlighted in the Haberler Report and discussed above, that the MFN tariff reductions of each country are expected to generate positive effects for the rest of the world taken as a whole, but need not lead to positive effects for every country in the rest of the world.

Also interesting are losses that are theoretically possible but that we do *not* find. While under Nash-in-Nash bargains each bilateral negotiation must lead to an agreement which, with the outcomes of all other negotiations taken as given, benefits both negotiating parties, the externalities across bargaining pairs raise the possibility that a country engaged in bargaining could nevertheless be made worse off as a result of the web of bilateral tariff bargains negotiated in the multilateral round than it would have been if the round had never taken place. That said, all the bargaining parties in our representation of the Uruguay Round did benefit from the negotiations, as the second column of Table 7 reflects. Some EU member countries were slightly worse off, but the EU as a whole enjoys a small welfare improvement, as we have noted.

6 Counterfactual

As we have described above, under our representation of the Uruguay Round bargaining protocol, our results point to the existence of unfinished business in tariff liberalization with respect to the tariffs under negotiation in the Uruguay Round, in line with the under-liberalization possibility identified by Bagwell et al. (2017b) when negotiations proceed over MFN tariffs. This raises the possibility that changes to the protocol that stimulate further negotiated tariff liberalization could be attractive from the perspective of world welfare. In particular, in light of the potential drag on tariff liberalization generated by the positive third-party externalities associated with MFN tariff cuts as reported in Table 6, could the abandonment of MFN have allowed countries to achieve greater tariff liberalization than occurred under the MFN restriction, and in so doing have allowed the Uruguay Round to achieve greater gains in world welfare? And would the distribution of the gains from the Uruguay Round across countries have been impacted in a substantial way had the MFN requirement not been in place? We now turn to these and other counterfactual questions, by comparing the outcomes from the Uruguay Round with the outcomes that would be predicted by our model had the Uruguay Round negotiations occurred under a bargaining protocol that abandons the MFN requirement.

To this end, recall that, in addition to allowing countries to make costly transfers as part of their tariff negotiations, we have represented the Uruguay Round bargaining protocol with three institutional constraints, namely, that countries (i) are restricted to bargain over MFN tariffs, (ii) must respect existing GATT tariff commitments and not raise their tariffs above these commitments, and (iii) abide by the principal supplier rule, which guides each importing country to limit its negotiations on a given product to the exporting country that is the largest supplier of that product to its market. We now consider an alternative bargaining protocol under which the first and third of these constraints are removed and countries can negotiate discriminatory tariff bargains. Our primary interest is in how relaxation of the MFN requirement impacts tariff bargaining, and as the principal supplier rule was introduced into the GATT bargaining protocols in order to facilitate bilateral tariff bargaining in the presence of MFN, it is natural to consider removing these two constraints at the same time. Because the model does not perfectly predict tariffs under our representation of the Uruguay Round protocol, we compare simulated outcomes under the counterfactual protocol to simulated outcomes under our representation of the Uruguay Round protocol rather than to the observed post-Uruguay tariffs.

To predict outcomes under discriminatory negotiations, we again solve for a bargaining equilibrium with our estimated bargaining parameters. In the discriminatory case, however, each pair negotiates only over tariffs that they will apply to each other. These bilateral tariff bargains still affect the welfare of third countries because they affect production and consumption patterns in the trade equilibrium, but they lack the direct effect of altering tariffs on third countries automatically through MFN, and so the third-party effects will be different from the MFN case. More specifically, while we would expect and Table 6 confirms that the overall rest-of-world effect of a unilateral MFN tariff reduction is positive, and while as Table 6 confirms we also find a positive third-party effect from a country's unilateral MFN tariff reductions agreed within a bilateral, the third-party effect of an analogous unilateral *discriminatory* tariff reduction agreed within a bilateral is likely to be negative, and the implied transfer of surplus from third parties to bargaining parties is then likely to drive down the levels of these negotiated tariffs in the absence of the MFN constraint from what the negotiated levels of these tariffs would be under MFN, even as the liberalizing impact of the resulting tariff reductions are not automatically broadened by extension to apply to other trading partners under the MFN requirement.[31]

To isolate the intensive-margin impact that the third-party effects of discriminatory tariff reductions have on tariff bargaining outcomes in our model, we consider a counterfactual in which, for each country, the set of its tariffs being negotiated is constrained to include only the sectors that were negotiated by that country in the Uruguay Round, and the set of countries negotiating on these tariffs is constrained to include only the countries that it negotiated with in the Uruguay Round. That is, if county A was negotiating an MFN tariff cut on sector j imports with the principal supplier of sector-j exports into its market, then in our counterfactual country A is allowed to negotiate a discriminatory tariff cut on sector-j imports with each of the countries that it bargained with in the Uruguay Round and that also export sector-j goods to its market. But we do not allow additional extensive margin effects on the pattern of bargaining.

The third and fourth columns of Table 7 present the results of this counterfactual, with the third column presenting the welfare implications associated with the negotiated discriminatory tariff changes and the fourth column presenting the welfare implications once the negotiated transfers are also included. In the absence of MFN the average tariff under negotiation drops by 47.43% while under MFN it drops by 46.95%. This comparison, however, masks the degree to which countries are incentivized to negotiate deeper tariff cuts when those cuts can be discriminatory. The added inducement to negotiate tariff cuts when MFN is abandoned is brought into sharp relief when the No-MFN averages are calculated over only the product-and-country pairs that were also in play under MFN: as expected, under this calculation, the average tariff under negotiation when MFN is abandoned drops by 107.35% as compared to a drop of 46.95% when MFN is in place. But a comparison across the first two columns (MFN) and the third and fourth columns (No MFN) of Table 7 also reveals that the MFN negotiations are better for world welfare than discriminatory negotiations. More specifically, we would expect from the findings of Bagwell et al. (2017b) that in the absence of an MFN rule Nash-in-Nash tariff bargaining always results in inefficient over-liberalization, but what the findings in Table 7 indicate is that the degree of inefficient over-liberalization according to our model is sufficiently important to outweigh the inefficient under-liberalization that arises

[31]Intuitively, negotiated tariffs are likely to be lower in the absence of the MFN constraint than in the presence of the MFN constraint for the following reason: starting at their negotiated MFN tariffs, if two countries were allowed to use discriminatory tariffs, then they could jointly gain from exchanging (perhaps small) discriminatory tariff cuts with each other, since they thereby could enjoy a transfer of surplus from third parties due to the implied world-price movements.

according to the model under MFN, resulting in worse outcomes for total world welfare under discriminatory tariff bargaining than under MFN tariff bargaining. In fact, as the third and fourth columns of Table 7 indicate, our findings suggest that discriminatory tariff bargaining would have wiped out all the gains in total world welfare associated with MFN tariff bargaining, leaving total world welfare essentially at its 1990 level.

In principle, both the over-liberalization of tariffs and any additional tariff discrimination that results from discriminatory tariff bargaining could play a role in the poor performance of this bargaining protocol when judged on the basis of world welfare.[32] To assess quantitatively the roles played by these two features for our findings reported in Table 7, we recalculate the trade equilibrium at two sets of tariffs which vary the degree of discrimination while maintaining average levels of tariffs. First, setting the MFN tariffs of the negotiating countries in each sector equal to the average negotiated discriminatory tariff for that country and sector, and thereby eliminating any tariff discrimination that arose as a result of the discriminatory tariff bargaining, we find that world welfare would increase by 0.04%. And second, in a similar vein, setting the discriminatory tariffs that the negotiating countries apply to other negotiating countries in each sector equal to the average negotiated discriminatory tariff among the negotiating countries in that country and sector, and thereby eliminating tariff discrimination among the negotiating countries that arose as a result of the discriminatory tariff bargaining, we find that total world welfare would increase by 0.03%. Both of these calculations result in gains that are lower than those under the MFN negotiations reported in Table 7 (0.11%) and higher than those under the discriminatory negotiations reported in Table 7 (-0.01%), and the calculations suggest that roughly one third of the poor performance of the discriminatory tariff bargaining protocol is attributable to the tariff discrimination that results from bargaining, with the remaining two thirds attributable to over-liberalization.

Turning to the impact of the abandonment of MFN on the distribution of gains across countries, Table 7 shows that developing and emerging countries are among the biggest losers from the abandonment of MFN, in some cases (e.g. China, India, Asia/Oceana NES and Europe NES) faring substantially worse than under the 1990 status quo. Among industrialized countries, South Korea suffers the largest losses from the abandonment of

[32]For example, it is possible that discriminatory tariff bargaining could lead to inefficient over-liberalization with no tariff discrimination in equilibrium, if all countries were symmetric along the relevant dimensions, but with various asymmetries it is natural to expect that both over-liberalization and tariff discrimination would contribute to the poor performance of a discriminatory-tariff bargaining protocol.

MFN, experiencing a 2.02% reduction in welfare relative to the 1990 status quo level, and the EU and Canada also lose. By contrast, the US and some of the EU-member countries enjoy small gains from the abandonment of MFN, but our results indicate that Japan would be by far the biggest gainer.

In fact, Japan's large welfare gain from the abandonment of MFN and South Korea's large welfare loss are linked, with South Korea's welfare loss heavily influenced by Japanese outcomes: re-running the discriminatory counterfactual, but excluding Japan from all negotiations, we find that South Korea's welfare loss would be only 0.4%. This Japan-South Korea linkage reflects two key features. Japan has high bargaining power, and Japan shares strong similarities to South Korea in geographic location and industry specialization. In particular, with regard to the first feature, as we have observed, our estimates indicate that Japan was the strongest bargainer among negotiating partners at the Uruguay Round, and this translates into an ability to extract deep MFN tariff cuts from its bargaining partners in the presence of MFN, and deep discriminatory tariff cuts from its bargaining partners when MFN is abandoned. Japan's large gain from the abandonment of MFN stems in part from its enhanced ability to exploit its strong bargaining power when the constraint of MFN is lifted. With regard to the second feature mentioned above, the estimated sector productivity parameters for Japan and South Korea have a correlation of 0.79 whereas the mean, across countries, correlation is 0.5; and South Korea is the most correlated country for Japan and Japan is the second most correlated country, after China, for South Korea. Thus, Japan's strong bargaining power leads to low tariffs for South Korean exporters under MFN, as South Korean exporters compete closely with Japanese exporters for the same markets and therefore enjoy the same low MFN tariffs; and with the abandonment of MFN, Japan's strong bargaining power leads to favorable discriminatory outcomes for Japan which now *hurt* South Korea exporters.

Table 8 provides analogous information to Table 6 but now for the counterfactual case of discriminatory tariff bargaining. The most striking difference across the two tables is in the spillovers to third parties, which for MFN tariff bargaining are uniformly positive as we have noted but which for discriminatory tariff bargaining are now almost always negative.[33] It is this negative third-party externality that is driving down the levels of the

[33]There are two exceptions to the pattern of negative third-party externalities displayed in Table 6: beginning from the 1990 tariff bindings, in its bargain with the US when Australia offers discriminatory tariff cuts there is a small positive impact on third parties (in addition to the positive impact on the US),

negotiated tariffs in the absence of the MFN constraint from what the negotiated levels of these tariffs would be under MFN.

Table 8: Spillover Benefits to Third Parties (Discriminatory Negotiations)

			Tariff Reduction from Agreement			Tariff Reduction from Binding		
Country 1	Country 2	Reducing Country	Δ Welfare Country 1 (1)	Δ Welfare Country 2 (2)	Δ Welfare 3rd Parties (3)	Δ Welfare Country 1 (4)	Δ Welfare Country 2 (5)	Δ Welfare 3rd Parties (6)
US	Aus	US	-1.000	2.138	-0.270	-1.000	11.018	-1.598
US	Aus	Aus	0.201	-1.000	-0.004	0.312	-1.000	0.011
US	EU	US	-1.000	1.450	-0.538	-1.000	4.588	-1.136
US	EU	EU	0.521	-1.000	-0.060	1.717	-1.000	-0.180
US	Japan	US	-1.000	1.397	-0.197	-1.000	3.619	-0.633
US	Japan	Japan	0.608	-1.000	-0.120	1.004	-1.000	-0.066
Aus	Korea	Aus	-1.000	0.729	-0.720	1.000	1.672	-1.060
Aus	Korea	Korea	1.805	-1.000	-0.345	8.255	-1.000	-1.635
EU	Japan	EU	-1.000	0.941	-0.016	-1.000	4.635	-0.327
EU	Japan	Japan	0.944	-1.000	-0.267	1.596	-1.000	-0.079
EU	Korea	EU	-1.000	0.716	-0.294	-1.000	2.873	0.436
EU	Korea	Korea	1.026	-1.000	-0.985	20.792	-1.000	-2.628
Japan	Korea	Japan	-1.000	1.101	-0.712	-1.000	9.263	-3.009
Japan	Korea	Korea	0.936	-1.000	-0.374	89.785	1.000	-8.289

Notes: Each row corresponds to a unilateral marginal decrease in tariffs by the "reducing country." The reducing country reduces tariffs on all goods that it negotiates with the partner country in that row. The welfare changes are normalized so that the reducing country has an absolute welfare change equal to one. The first set of welfare columns presents changes in welfare from a discriminatory reduction when all tariffs begin from the negotiated agreement. The second set of welfare columns presents changes in welfare from a discriminatory reduction when all tariffs begin from 1990 levels.

More broadly, the results of our counterfactual point to an important conclusion. While the free-rider issue and associated drag on tariff liberalization created by the positive third-party externality from the GATT/WTO's MFN requirement is widely emphasized as a shortcoming of the GATT/WTO approach, in our model the abandonment of MFN in tariff bargaining would create negative third-party externalities that are even

and in its bargain with the South Korea when the EU offers discriminatory tariff cuts there is a positive impact on third parties (in addition to the positive impact on the South Korea). These cases can be understood by examining the particulars of the trade patterns in each case. For example, the positive third-party impact of the EU's discriminatory tariff reductions on imports from South Korea is driven by a large positive impact for Russia, and is associated with an induced rise in the world price of products in our industry 22 (SITC 33 and 34) – Petroleum, petroleum products and related; Gas, natural and manufactured materials – where Russia is a large exporter, a world price rise that stems from the EU's stimulated demand for these products as a result of the tariff preference on these products that the EU offers to South Korea.

more powerful, and ultimately lead to tariff bargaining outcomes that are worse from the perspective of world welfare.

7 Conclusion

This paper embeds a quantitative model of world trade into a model of bilateral bargaining over tariffs to examine the welfare effects of the most-favored-nation (MFN) requirement that characterizes negotiations at the GATT/WTO. We estimate the model using trade flows from 1990 and tariff outcomes from the Uruguay Round of GATT/WTO negotiations. As emphasized in the theoretical literature, the welfare effect of imposing MFN and thereby ruling out discriminatory tariff bargaining is ambiguous and depends on trade patterns. In a trade model whose parameters are estimated to match observed trade flows, we quantify a free-rider issue and associated drag on tariff liberalization that is created by the positive third-party externality from the MFN requirement and that leads to under liberalization relative to efficient outcomes, but our results indicate that the abandonment of MFN in tariff bargaining would create negative third-party externalities that are even more powerful and that would lead to substantial over liberalization. On balance we find that MFN tariff negotiations are superior to discriminatory tariff negotiations in terms of increasing world-wide welfare for this reason.

There are several promising avenues for future research. An obvious direction is to expand the current framework to allow for more products, that is, to handle a more disaggregated product classification. While this is essentially a computational challenge, it is an important extension, as actual tariff negotiations occur at a much more disaggregate level than the (essentially 2 digit) level that we have modeled here, and greater disaggregation could have important impacts on the principal supplier status that is central in shaping the bargaining patterns of the Round and associated externalities. Relatedly, as we noted above, while we allow bargaining partners to exchange costly transfers as part of their bilateral tariff negotiations, we do not allow this exchange of transfers to relax the double-coincidence-of-wants requirement that bargaining only over tariffs would imply. Allowing the presence of costly transfers to have this extensive-margin impact on bargaining could have important impacts on the bargaining outcomes.

Also important is to consider the possibility that countries bargained under an additional constraint in the Uruguay Round, namely, that of reciprocity. Bagwell et al. (2017a) review historical and institutional evidence that reciprocity was a significant constraint in GATT tariff negotiating rounds, and they identify a number of the stylized facts emerging from the GATT Torquay Round bargaining data that can be interpreted as consistent with bilateral tariff bargaining under a reciprocity constraint (and MFN). There is also specific evidence that the tariff negotiating outcomes of the Uruguay Round were consistent with reciprocity.[34] As we have noted above, the imposition of a reciprocity constraint can reduce and even eliminate third-party externalities from MFN tariff bargaining, implying potentially important impacts on the bargaining outcomes relative to those predicted under the Horn-Wolinsky MFN tariff bargaining protocol that we have considered here. For example, in helping to eliminate the third-party externalities of MFN tariff cuts, could the introduction of a reciprocity constraint ensure that no country would have lost from the Uruguay Round?

Our modeling framework highlights bilateral tariff negotiations, which were a central feature of the Uruguay Round. The Round also featured multilateral elements as well, however, such as "zero-for-zero" tariff negotiations in certain sectors and agreements concerning intellectual property. Capturing these multilateral elements would require extensions of our framework along various dimensions. For example, a bilateral disagreement concerning a multilateral issue could have implications that are not well captured by our transfer specification, since a breakdown for one negotiating pair might then impact transfers as well for other parties. An interesting and important direction for future work is to build on the model of bilateral negotiations considered here to include additional multilateral elements.

More broadly, the framework used here could be paired with a coalition formation model to examine how tariff negotiations and regional trade agreements co-evolve. And liberalization in the GATT/WTO has occurred over eight rounds (plus the now-suspended ninth Doha Round), creating the potential for inter-temporal linkages across rounds.

[34] For example, focusing on U.S. tariff cuts in the Uruguay Round and constructing a measure of market-access concessions while instrumenting to address the potential endogeneity issues, Limão (2006) and Limão (2007) find evidence consistent with reciprocity, reporting that a decrease in the tariff of a U.S. trading partner that exports a given product leads to a decrease in the U.S. tariff on that product and that a significant determinant of cross-product variation in U.S. tariff liberalization is the degree to which the United States received reciprocal market-access concessions from the corresponding exporting countries. Karacaovali and Limão (2008) perform a similar exercise for the EU tariff cutting behavior in the Uruguay Round. They find analogous support for the importance of reciprocity in explaining the pattern of EU tariff cuts, in that EU tariff reductions were largest for those products exported by countries who themselves granted large reductions in tariffs.

The static framework here could be embedded into a larger model that examines how the GATT/WTO affected world trade on a longer term basis. We leave this and other ambitious extensions for future work.

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A Data Appendix

Trade Data

The main source of trade data is NBER-United Nations Trade Data 1962-2000[35]. We supplement the 1995 Russian import data and the 2000 Indian import data with the Comtrade data. We aggregate the trade data up to the level of regional and product category used in the text. Our 49 product categories are defined in Table 9. Our first 13 product categories cover agriculture, with product categories 14-49 covering manufactures.

Tariff Data

The tariff data is from the TRAINS data accessed through WITS[36]. We use the MFN Applied rate throughout the analysis. If the tariff data is not available for any of the year 1990, 1995 and 2000, we borrow it from the closest year available. We then calculate the trade-weighted import tariff by the importing country (region) and the product category. For European countries, we calculate the euro-zone common import tariffs and apply to each country product-wise. For a given importing country (region) and a product category, if the import tariff is missing for a particular partner, we simply assume that the MFN tariff is applied to this partner.

Export Ratio

Export ratio is calculated using the GTAP 5 data (Dimaranan and McDougall, 2002), which provides the total production and the export for each country and sector in 1997. We then match the GTAP industries with our product classification to derive the export ratio by each product category.

Gravity Data & Preferential Trade Agreements

Gravity variables and the PTA relations between countries are from CEPII (Mayer and Zignago, 2011). For gravity variables, we use information on distance, GDP, population and common language. For distance between regions, we apply population weighted distance.

Domestic Value-Added

The domestic value-added is from INDSTAT 2 (2016), ISIC Revision 3.[37] We calculate the total manufacturing value-added by region.

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[35]http://cid.econ.ucdavis.edu/nberus.html

[36]http://wits.worldbank.org/

[37]https://stat.unido.org/

Table 9: Product Classification

Product Category	Corresponding SITC rev.2	Description
1	0	Live animals chiefly for food
2	1	Meat and meat preparations
3	2	Dairy products and birds'eggs
4	3	Fish,crustaceans,mollucs,preparations thereof
5	4	Cereals and cereal preparations
6	5,22	Vegetables and fruit; Oil seeds and oleaginous fruit
7	6	Sugar,sugar preparations and honey
8	7	Coffee,tea,cocoa,spices,manufactures thereof
9	8	Feeding stuff for animals,not incl.unmil.cereals
10	9	Miscel.edible products and preparations
11	11	Beverages
12	12	Tobacco and tobacco manufactures
13	21,61	Hides,skins and furskins,raw; Leather, leather manuf., n.e.s.and dressed furskisg
14	23	Crude rubber (including synthetic and reclaimed)
15	24	Cork and wood
16	25	Pulp and waste paper
17	26	Textile fibres (except wool tops) and their wastes
18	27,55,56,57	Crude materials; Essential oils & perfume mat.;toilet-cleansing mat; Fertilizers; Pyrotechnic products
19	28	Metalliferous ores and metal scrap
20	29	Crude animal and vegetable materials,n.e.s.
21	32	Coal,coke and briquettes
22	33,34	Petroleum,petroleum products and related; Gas,natural and manufactured materials
23	41,42,43	Animal oils and fats; Fixed vegetable oils and fats; Animal-vegetable oils-fats,processed,and waxes
24	51	Organic chemicals
25	52	Inorganic chemicals
26	53	Dyeing,tanning and colouring materials
27	54	Medicinal and pharmaceutical products
28	58	Artif.resins,plastic mat.,cellulose esters/ethers
29	59	Chemical materials and products,n.e.s.
30	62	Rubber manufactures,n.e.s.
31	63	Cork and wood manufactures (excl.furniture)
32	64	Paper,paperboard,artic.of paper,paper-pulp/board
33	65	Textile yarn,fabrics,made-upart.,related products
34	66	Non-metallic mineral manufactures,n.e.s.
35	67	Iron and steel
36	68,69	Non-ferrous metals; Manufactures of metal,n.e.s.
37	71	Power generating machinery and equipment
38	72,73,74	Machinery specialized for particular industries; Metalworking machinery; General industrial machinery & equipment,and parts
39	75,76	Office machines & automatic data processing; Telecommunications & sound recording apparatus equip.
40	77	Electrical machinery,apparatus & appliances n.e.s.
41	78	Road vehicles (incl. air cushion vehicles
42	79	Other transport equipment
43	81	Sanitary,plumbing,heating and lighting fixtures
44	82	Furniture and parts thereof
45	83,84	Travel goods,handbags and similair containers; Articles of apparel and clothing accessories
46	85	Footwear
47	87,88	Professional,scientific & controling instruments ; Photographic apparatus,optical goods,watches
48	89	Miscellaneous manufactured articles,n.e.s.
49	90,91,93,94,95,96,97	Others