The GATT/WTO Welfare Effects: 1950–2015*

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Abstract

This paper uses nonparametric matching estimators to estimate the partial effects of membership in GATT/WTO on imports from members and nonmembers, and evaluates the welfare effects of GATT/WTO in its entire history of 1950-2015 for as many as 180 countries. The estimation methodology takes into account trade liberalization induced by GATT/WTO in all aspects (tariff or non-tariff barriers, variable or fixed trade cost, border or domestic trade-related measures). With nonparametric matching, the framework is also able to accommodate heterogeneous treatment effects (across negotiation rounds and development stages) and potential selection into treatment based on observables. Given the partial trade effect estimates, we quantify the general equilibrium effect of GATT/WTO on welfare, trade flows, firm entry, outward and inward multilateral resistance, wages and production cost for each country in each year. The results are overall confirmative of the large welfare gains created by the GATT/WTO system at the global level and across more than six decades of its history, but the distribution of the gains across members is highly heterogeneous with long right tails. Nonmembers see small gains in earlier decades but increasingly bigger welfare losses after 1980. The global income inequality is lower with GATT/WTO, and the positive effect on income equality across countries is especially pronounced after 1995.

Key Words: matching estimator; welfare; firm entry; income inequality; quantitative analysis

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1 Introduction

Given the rising sentiment against globalization and the impasse of trade negotiations at the multilateral front, it is important to provide a historical assessment of what the GATT/WTO has imparted on the world economy. We combine the nonparametric method to estimate the direct effects of GATT/WTO on trade flows (Chang and Lee, 2011) and the quantitative trade models to assess the welfare effects of GATT/WTO in its entire history of 1950-2015 for as many as 180 countries (where data permit). Our work builds on the literature of quantitative trade analysis (e.g. Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Dekle et al., 2007; Ossa, 2014; Caliendo and Parro, 2015); the theoretical literature of welfare comparison across trade models (e.g. Arkolakis et al., 2012; Melitz and Redding, 2015); the literature of structural gravity equations (e.g. Anderson and Yotov, 2010; Head and Mayer, 2015; Anderson and Yotov, 2016); and the literature on the empirical estimation of GATT/WTO trade effects (e.g. Rose, 2004; Tomz et al., 2007; Subramanian and Wei, 2007; Chang and Lee, 2011).

As documented by Jackson (1997), the GATT/WTO has induced policy changes in many areas beyond border tariff measures. Domestic regulations and nontariff barriers (such as quotas, technical barriers to trade, import licensing procedures, government procurement, customs valuation, anti-dumping measures and intellectual property rights protection) have become increasingly important topics in trade negotiations. Further, these policy changes among members might not only affect variable trade cost but also fixed trade cost. For example, by signing the Technical Barriers to Trade Agreement, members abide by the general principle of treating imported goods in terms of safety standards and technical regulations. These do not entail tariff reductions but will likely reduce exporters' fixed trade cost to meet the regulation standards in destination markets. Thus, tariff rate alone is likely not a sufficient measure of trade liberalization undertaken by GATT/WTO members. On the other hand, observed tariff changes sometimes may not necessarily be the outcome of GATT/WTO negotiations. For example, Baldwin (2016) noted that some developing countries (such as China) have unilaterally lowered import tariffs on a nondiscriminatory basis in the 1990s not due to GATT/WTO (before it became a member) but because of offshoring-led development incentives. Thus, tariff reduction is not necessarily the lower-bound measure of trade liberalization induced by GATT/WTO either.

In view of these, we use GATT/WTO membership indicator variables, *bothwto* and *imwto*, to capture all the potential (or nil) changes in trade cost due to GATT/WTO. In particular, *bothwto* indicates whether both exporting and importing nations are GATT/WTO members and *imwto* indicates whether only the importing nation is a GATT/WTO member. It turns out difficult to identify these two effects in the typical parametric approach. In particular, it has become a norm to use exporter-year and importer-year indicator variables in the empirical gravity literature to control for multilateral resistance (MR) terms highlighted by Anderson and van Wincoop (2003). As suggested by Cheong et al. (2014), however, this will create a mulit-collinearity problem among *bothwto*, *imwto*, and the importer-year indicator variables. This may in part explain why the estimates of GATT/WTO effects are often found to be sensitive and insignificant in studies following this estimation specification. An alternative parametric approach is to take the trade ratios across four countries (Head et al., 2010) to remove the MR terms. However, we can show that the two modified GATT/WTO indicator variables corresponding to the trade ratio approach will be co-linear with each other. Finally, it is also not appropriate to simply drop *imwto* from the set of regressors; this will create biased estimates of *bothwto* if the *imwto* effect is significant. We cannot rule out the possibility of a positive or negative effect of *imwto*, because GATT/WTO member countries may extend most-favored-nations (MFN) treatment to nonmembers as they do to members; alternatively, GATT/WTO members may become more protective against nonmembers while they lower trade restrictions against fellow members.

We thus adopt the nonparametric matching approach proposed by Chang and Lee (2011). This approach circumvents the multi-collinearity problem, because in each matching exercise, by design, only the group of observations $bothwto_{ijt} = 1$ or the other group of observations $imwto_{ijt} = 1$ is used as the treatment group; they are not included in the analysis at the same time. This estimator has the usual advantage of nonparametric estimators, of being robust to misspecification. In particular, it does not impose a particular functional form on the trade cost function, but allow the trade cost to depend on the observable proxies in arbitrary ways. This is useful, because although the gravity equation for trade flows has clear theoretical foundations, it is less obvious how the trade cost depends on observable covariates. Finally, the matching estimator can also accommodate heterogeneous treatment effects and heteroskedasticity in a convenient way, by restricting the matching to a subset of observations and calculate the mean treatment effect within the subset.

In particular, we allow the effects of *bothwto* and *imwto* to vary across eight GATT negotiation rounds, and across country pairs of different development combinations as suggested by the work of Jackson (1997) and Bagwell and Staiger (2010, 2016).

The matching effect estimates are summarized in Tables 3 and 4. Let γ_1 indicates the treatment effect of *bothwto* and γ_2 of *imwto*. We find that GATT/WTO membership has positive effects on trade among members, but the effects are the largest among developed members and the weakest among developing members ($\gamma_{1,HH} > \gamma_{1,LL}$). The effects also tend to be larger when the importing country is a developed member ($\gamma_{1,HH} > \gamma_{1,HL}$ and $\gamma_{1,LH} > \gamma_{1,LL}$); and the bilateral trade cost of developed member importers tends to drop by more against developed members than against developing members ($\gamma_{1,HH} > \gamma_{1,LH}$). These results are in line with the literature's observations of differential trade liberalization by developed and developing members, and potential bias in the sectoral composition of liberalization favoring developed countries. Across rounds, we see generally increasing effects over time especially for imports by developed members ($\gamma_{1,HH}$ and $\gamma_{1,LH}$). We see that the effect is especially strong following the Uruguay Round, reflecting the broad coverage of its agreements. The exception is the trade among developing members ($\gamma_{1,LL}$), whose effect is weak and erratic across years. In comparison, the *bothwto* effects are on average (across all rounds) bigger than the *imwto* effects ($\gamma_1 > \gamma_2$) for all development combinations. The smaller effect of *imwto* relative to *bothwto* suggests that there is still a difference in the importing members' barriers against members versus nonmembers. The gap may reflect that not all members extend the MFN treatment to nonmembers, or that such extensions are not granted at all times; uncertainty in the members' policy toward nonmembers may also create a higher trade cost facing nonmember exporters. The effect of *imwto* is positive if the importing member is a developed country and zero to negative if it is a developing country ($\gamma_{2,HH} > \gamma_{2,HL} = 0$ and $\gamma_{2,LH} > 0 > \gamma_{2,LL}$). This suggests that GATT/WTO developed members tend more likely to extend MFN treatment to imports from nonmembers. The negative effect of $\gamma_{2,LL}$ indicates that developing members actually tend to raise their trade restriction against nonmember developing countries, especially in recent years.

We then conduct counterfactual analysis and estimate how the GATT/WTO membership has affected welfare, trade flows, mass of firm entrants, outward and inward multilateral resistance, wages and production cost, in general equilibrium for each country in our panel in each year during 1950-2015. In these counterfactual analyses, the shocks to the trade cost (trade flows) introduced by GATT/WTO are given by the round and development-combination specific matching estimates discussed above. We formulate three representative quantitative trade models of Anderson and van Wincoop (2003) (AvW), Krugman (1980), and Melitz (2003) (with untruncated Pareto distribution) in a unified framework connected by structural gravity equations. In this framework, we allow for the use of intermediates in production and the presence of trade imbalance, which are empirically mandated when we attempt to match the models with the data on trade and production. With the use of intermediates, the three models are no longer isomorphic; in particular, the mass of firm entrants is not constant in the Krugman and Melitz models, and this introduces extra margins of gains from trade not present in trade models of perfect competition (Anderson and van Wincoop, 2003; Eaton and Kortum, 2002).

The results on cross-country welfare effects are summarized in Figures 1 (AvW), 2 (Krugman), and 4 (Melitz) across years, and in Tables 9–11 across models and parameter values. We see that the three economic models imply qualitatively similar patterns of welfare effects across countries. Welfare gains for GATT/WTO members tend to increase over the years and become increasingly dispersed. Nonmembers tend to gain in initial years due to free-riding on members' extension of MFN treatment, but start to sustain welfare losses after 1980, and the welfare cost is increasing over the decades. Quantitatively, the welfare effects (in magnitude) are uniformly larger in the Krugman framework than the AvW framework due to the extra margin of adjustment in firm entry. In particular, the adjustment in firm entry varies with the gains in real income monotonically. Thus, the larger the initial gain under the AvW framework, the stronger the amplification mechanism due to firm entry in the Krugman model. The Melitz model implies in general smaller welfare effects than the Krugman model but bigger effects than the AvW model, although its welfare effects could be dominated by the AvW model for sufficiently low degrees of firm productivity dispersion. We explain in the main text in more details why this may be the case. Here, we offer some quick comments. First, we infer the welfare effects given the observed trade flows, which do not necessarily imply the same underlying trade cost in the Krugman and Melitz models (as they correspond to different structural gravity equations). In contrast, Melitz and Redding (2015) compare the two models' welfare implications on the premise of the same initial condition and the same change in trade cost. Second, we did not modify the original Krugman model to introduce entry cost and fixed trade cost as is done in Melitz and Redding (2015). These discrepancies in setups and economic structures help explain the finding in favor of the Krugman model. Next, because the AvW model implies the same structural equations as the Krugman model, the same mechanism discussed above would imply a smaller welfare effect in the Melitz model. However, the extra margin of adjustment in firm entry present in the Melitz model but not in the AvW model exerts a countervailing effect. When the parameter value for firm dispersion θ increases, the first mechanism becomes more pronounced and simultaneously the entry effect becomes weaker. Thus, with sufficiently large θ, the welfare effects could be larger in the AvW model than the Melitz model.

Overall, across different decades, countries, economic models, parameter values and matching estimates, the GATT/WTO has raised the welfare of members by 1.85% to 11.44% at the upper 75 percentile, and 0.70% to 3.42% at the lower 25 percentile. This reflects a heterogeneous distribution of effects across years and development stages, and much muted effects under extremely high degrees of trade elasticity. The effects tend to be more pronounced in recent decades as the system's membership enlarges, for developed countries, based on the Krugman framework, and (naturally) with smaller parameter values for trade elasticity and firm productivity dispersion. The results are overall confirmative of large welfare gains created by the GATT/WTO system at the global level and across more than six decades of its history. In Figure 7, we illustrate the diverse welfare effects of GATT/WTO across countries. We choose for each region (America, Asia, Europe/Africa/Middle East) six countries, of various development stages, country sizes, and timing of GATT/WTO accession. We see that, of the big developed members, Germany (DEU) has benefited the most, followed by the UK (GBR), Japan (JPN), and the US (USA). Developing members such as India (IND) and Brazil (BRA) tend to gain relatively less, with Argentina (ARG) seeing a stronger effect in recent years. Small open economies in particular benefit a lot from GATT/WTO. For example, Singapore (SGP) has gained more than 50% (and up to 100%) in real GDP every year since 1980 with the optimistic estimate based on the Krugman framework. Denmark (DNK) also experiences a steady large welfare gain of 7–13% annually since its accession to the system. For countries who joined the GATT/WTO relatively later or never, we see that the welfare dynamics typically see a dramatic shift following the accession. For example, China (CHN) has seen a big annual welfare gain of up to 8% since its accession in 2001, in contrast with small welfare losses during 1980-2000. The welfare gains following accession are more dramatic for small open economies such as Thailand (THA) and Vietnam (VNM), while they are not as pronounced for more closed economies such as Ecuador (ECU). Vietnam has benefited as much as 20% and Thailand 15% annually since joining the GATT/WTO in 2007 and 1982 respectively. Finally, the last three countries (Belarus, Yemen, and Ethiopia) illustrate the welfare cost sustained by countries who have remained nonmembers throughout most of the study period (1950-2015). The welfare cost is as high as 25% for Belarus (BLR) in 2012 in the aftermath of its currency crisis, and more than 10% for Yemen (YEM), a relatively poor country. It is also increasingly costly for least developed African countries such as Ethiopia (ETH) to stay outside the system, even though they are relatively closed to begin with.

In extended analysis, we also use the frameworks that we have established to examine two interesting issues. First, the counterfactual GDPs across countries (together with data on populations) allow us to quantify how global inequality would have been without GATT/WTO, compared to the factual cross-country income inequality. Figure 8 shows the Gini coefficient using factual GDP per capita's across countries, weighted by each country's population, against the counterfactual Gini coefficient in a world without GATT/WTO. We see that the global income inequality is higher under the counterfactual of no GATT/WTO after 1980 (the results are similar based on AvW or Krugman; thus only two counterfactuals given different parameter values are visible). The difference is especially large after 1995. These patterns suggest that the GATT/WTO has in fact brought the poor nations/people up the ladder of livelihood through trade integration and improved the global equality. Second, we also examine how the presence of preferential trade agreements (PTAs) has interacted with the working of GATT/WTO in terms of its welfare effects. Figure 6 shows the welfare effects of GATT/WTO without PTAs relative to its effects with the observed PTAs. We see that the ex-post gains of members are smaller and the ex-post losses of nonmembers are bigger without the PTAs. The difference becomes more significant in recent decades when the PTAs surge in numbers (and also noticeable in 1960 during the first wave of PTAs). Thus, for GATT/WTO members, PTAs appear complementary to multilateral liberalization, but for nonmembers, PTAs reduce their incentives to participate in GATT/WTO as their potential losses by not joining GATT/WTO are lower with PTAs in place.

Our work is closely related and complementary to Caliendo et al. (2015), which only came to our attention at the closing of our project. They analyze the GATT/WTO impacts using changes in observed MFN tariff rates between 1990 and 2010, based on the Melitz framework with multi-sectors and input-output linkages. Their model is thus able to capture potential heterogenous trade effects across sectors and input-output linkages; by Caliendo and Parro (2015), this likely will imply larger welfare effects all else being equal. Second, they explicitly account for the revenue effects of tariffs and its differential impacts on firm behaviors. As shown by Caliendo et al. (2015), tariff revenues introduce many complications in theoretical modelling. We consider our work as complementary, because data requirement on IO tables and sectoral tariff rates limit their analysis to the recent two decades. By focusing on the aggregate bilateral trade flows and using the simple catch-all GATT/WTO indicator variables (*bothwto*, *imwto*), we are able to conduct the impact analysis of GATT/WTO for its entire history since 1950. As we argue above, the indicator variables allow us to capture changes in trade-related policies induced by GATT/WTO beyond tariff reductions, including liberalization in nontariff barriers and domestic regulations. Our setup also allows these GATT/WTO-induced policy changes to affect the fixed (as well as variable) trade cost, which in practice is likely a very important feature of GATT/WTO. As a whole, looking back across the trade negotiation rounds (since the GATT/WTO's beginning and with its expanding scope) helps us put the current welfare effects in perspective against its historical trajectory.[1]

The rest of the paper is organized as follows. In Sections 2–4, we review the basic AvW framework adjusted for the use of intermediates and trade imbalance, discuss the estimation issues of the GATT/WTO (partial) trade effects, and derive the counterfactual structural equations based on the hat algebra of Dekle et al. (2007). We then extend the framework to the Krugman and Melitz models in Sections 5–6, and highlight the extra counterfactual structural conditions (and variables) required in these two settings. The results are summarized in Sections 7 and 8. Section 9 analyzes the cross-country income inequality effect of GATT/WTO and the interaction between GATT/WTO and PTAs on welfare. Section 10 concludes. Data descriptions and proofs are provided in the appendix.

[1]As a technical note, it is useful to highlight that the entry effects arise in our framework because fixed operating costs and entry costs are assumed to use input bundles (combining labor and intermediate inputs) instead of labor alone. In contrast, in Caliendo et al. (2015), fixed cost and entry use labor alone (which implies zero entry effects in one-sector model); the entry effects are thus driven by sectoral linkages and tariff revenues in their model.

2 The AvW Framework

We start with the basic framework of Anderson and van Wincoop (2003) [AvW], modified here to allow for the use of intermediates and trade deficits. We explain how we estimate such a system and use it to conduct counterfactual analysis of the GATT/WTO effects. This setup is isomorphic to Eaton and Kortum (2002) [EK]; they imply the same set of structural gravity equations and counterfactual welfare effects, as suggested by Arkolakis et al. (2012) and Head and Mayer (2015). With intermediates, however, the isomorphism in welfare effects between trade models of perfect competition (AvW and EK) and of monopolistic competition (Krugman, 1980; Melitz, 2003) is broken.We return to the second class of models in Sections 5 and 6.

Let each country be endowed with a fixed supply of labor L_i. Goods are differentiated by the country of origin, and buyers in each country j choose imports q_{ij} from country i for all i to maximize

$$Q_j = \left(\sum_i b_i^{(1-\sigma)/\sigma} q_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \qquad \text{st.} \; \sum_i p_{ij} q_{ij} = E_j \tag{1}$$

where b_i is a (dis)taste parameter for goods produced in i, $\sigma > 1$ the elasticity of substitution across sources of imports, E_j the nominal expenditure of country j, and $p_{ij} \equiv p_i \tau_{ij}$ the destination price, equal to the exporter's supply price p_i scaled up by the variable (iceberg) trade cost factor τ_{ij}. The solution to (1) implies a nominal value of exports from i to j equal to $X_{ij} = \left(\frac{b_i p_i \tau_{ij}}{P_j}\right)^{1-\sigma} E_j$, where $P_j = \left[\sum_i (b_i p_i \tau_{ij})^{1-\sigma}\right]^{1/(1-\sigma)}$ is the aggregate price index in country j. The goods market-clearing condition requires that

$$\begin{aligned} Y_i &= \sum_j X_{ij} \\ &= (b_i p_i)^{1-\sigma} \sum_j (\tau_{ij}/P_j)^{1-\sigma} E_j, \end{aligned} \tag{2}$$

where Y_i is the total sales of goods by country i to all destinations. Use (2) to solve for $(b_i p_i)^{1-\sigma}$ and substitute the result in the expression of X_{ij} and P_j. We have

$$X_{ij} = \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \tag{3}$$

where

$$\Pi_i^{1-\sigma} \equiv \sum_j (\tau_{ij}/P_j)^{1-\sigma} e_j, \tag{4}$$

$$P_j^{1-\sigma} = \sum_i (\tau_{ij}/\Pi_i)^{1-\sigma} s_i, \tag{5}$$

$Y_w \equiv \sum_j Y_j$, $e_j \equiv E_j/Y_w$, and $s_i \equiv Y_i/Y_w$. As first introduced by AvW, Π_i and P_j can be regarded as the multilateral resistance (MR) to trade of exporter i and importer j respectively. They reflect the weighted average of relative bilateral trade cost across all destinations of sales for an exporter i and all sources of imports for an importer j, using as weights the expenditure share (e_j) of destination markets and the supply share (s_i) of sources of imports relative to the world, respectively.

The aggregate budget constraint that allows for trade deficit requires that:

$$E_j = Y_j + D_j, \tag{6}$$

where D_j is the nominal trade deficit of country j.

In the current setup, goods markets are perfectly competitive. We assume that goods are produced one-to-one from an input bundle, where the input bundle combines labor and intermediate inputs with a constant labor share β_i. Intermediates comprise the full set of goods as for final demand, aggregated using the same CES function as in (1) . This implies that the cost of an input bundle (and hence the supplier price) in country i is

$$c_i = w_i^{\beta_i} P_i^{1-\beta_i}. \tag{7}$$

Finally, labor-market clearing requires that:

$$w_i L_i = \beta_i Y_i. \tag{8}$$

3 Matching Estimation

Our first step is to identify the partial (direct) effect of the GATT/WTO membership on the trade cost. Define $bothwto_{ijt}$ as an indicator that equals one if both countries i and j are GATT/WTO members in year t and zero otherwise. Similarly, define $imwto_{ijt}$ as an indicator that equals one if only the importer j is a GATT/WTO member in year t and zero otherwise. When a country j becomes a GATT/WTO member, the country extends most-favored-nation (MFN) treatment to all other members. This is expected to lower the trade cost of exporting from member i to member j. In contrast, members are not constrained by GATT/WTO in their trade policies against nonmembers. It is ex ante possible that trade cost may decrease against nonmembers (if members also extend MFN treatment to nonmembers) or increase (if members realign their optimal tariffs against nonmembers). As a whole, we expect *bothwto* to have a larger trade-promoting effect than *imwto*.

There exist several approaches in the literature to identifying the partial effects of observable trade cost proxies. Typically, the literature assumes that the unobserved trade cost $\tau_{ijt}^{1-\sigma}$ is log-linear in a vector of trade-cost proxies $\mathbf{Z}_{ijt}$, and uses exporter-year and importer-year fixed effects (FE) to control for the MR terms. The gravity equation (3) is then estimated by either an OLS regression in its log transformation or a Poisson Pseudo Maximum Likelihood (PPML) estimation in levels (Silva and Tenreyro, 2006). Unfortunately, this approach cannot be used in the current application, because *bothwto* and *imwto* would be multi-collinear with the importer-year indicator variable. See Cheong et al. (2014) for a formal proof. This may help explain the difficulty in the literature to find significant GATT/WTO trade effects using this estimation approach.

An alternative to handling the MR terms introduced by Head et al. (2010) is to use the trade ratio $\frac{X_{hit}/X_{hjt}}{X_{kit}/X_{kjt}}$ of four countries to eliminate the exporter-year and importer-year specific effects in the regression and to take a corresponding transformation of the trade-cost proxies $\mathbf{Z}_{ijt}$ under the same assumption that the unobserved trade cost $\tau_{ijt}^{1-\sigma}$ is log-linear in $\mathbf{Z}_{ijt}$. However, this approach does not help solve the multi-collinearity problem discussed above, because the transformed *bothwto* and *imwto* variables will be co-linear with each other. Specifically, let $z_{ijhk,t}^{\dagger} \equiv (z_{hit} - z_{hjt}) - (z_{kit} - z_{kjt})$ for a trade-cost proxy variable z. Then, it can be shown that $bothwto_{ijhk,t}^{\dagger} = -imwto_{ijhk,t}^{\dagger}$.

We thus adopt the nonparametric matching method proposed by Chang and Lee (2011). We refer the readers to the source for more details and summarize the main procedure here. Write the gravity equation (3) in its log transformation and add year subscript given the panel data to be used:

$$\ln X_{ijt} = \ln Y_{it} + \ln E_{jt} + \ln \tau_{ijt}^{1-\sigma} - \ln(\Pi_{it} P_{jt})^{1-\sigma} - \ln Y_{wt} \tag{9}$$

where the unobserved trade cost is assumed to depend on GATT/WTO status and other trade-cost proxies: $\tau_{ijt}^{1-\sigma} = h(bothwto_{ijt}, imwto_{ijt}, \mathbf{Z}_{ijt})$. To estimate the *bothwto* effect, we take the observations where $bothwto_{ijt} = 1$ as the treatment group, and the observations where neither country is a member as the control group. For each treated observation, we find the best match from the control group in terms of $(\ln Y_{it}, \ln E_{jt}, \mathbf{Z}_{ijt}, \ln(\Pi_{it} P_{jt})^{1-\sigma}, T_t)$, where T_t are year dummies and the MR terms are approximated by the Baier and Bergstrand (2009) methodology (more on this below). The difference in the trade flows $\ln X_{ijt}$ between the matched treated and untreated observations is then attributed to the difference in $\ln \tau_{ijt}^{1-\sigma}$ due to the *bothwto* status.[2] The average of the differences across the matched pairs is taken as the mean treatment effect of *bothwto* on the treated; in other words, this is the ex-post effect for those observations that are observed treated. The procedure to estimate the *imwto* effect is analogous but with the treatment group now comprised of observations where $imwto_{ijt} = 1$.

This approach has several advantages. First, the matching estimator circumvents the multi-collinearity problem at hand. This is so because in each matching exercise, by design, only the group of observations $bothwto_{ijt} = 1$ or the other group of observations $imwto_{ijt} = 1$ is used as the treatment group; they are not included in the analysis at the same time. Second, the matching estimator is arguably more robust to mis-specification bias than the parametric approach. In particular, it does not impose a particular functional form on the trade cost function $h()$, but allow the trade cost to depend on the observable proxies in arbitrary ways. This is useful, because although the gravity equation (3) has a clear theoretical foundation, it is less obvious how the trade cost depends on observable proxies. The log-linear functional form assumption on $h()$ made in the literature can be regarded as a convenient approximation but not a theoretical mandate. Third, estimation bias due to selection on observables is not a problem in the matching framework,

[2] We need to make the identifying assumption that there are no unobservable variables that affect the trade cost and also the likelihood of being treated in a systematic way, but this is no more restrictive than the identifying assumption of no omitted variables in the parametric approach.

because the treatment effect is estimated based on matched observations with similar observable characteristics and hence similar probabilities of selection into treatment. Fourth and relatedly, the matching estimator can accommodate heterogeneous treatment effects or heteroskedasticity concerns in a natural way. Because the matching is conditional on the observable characteristics, the effect (and its variance) is in principle allowed to vary across matched pairs of different observable characteristics. The subset of matched pairs used to calculate the mean treatment effect can be chosen based on economic theories or a priori judgement. For example, the GATT/WTO effects could potentially differ across development combinations of country pairs and across rounds of trade negotiations, because of heterogeneous degrees of trade liberalization. The matching can be restricted to, and the (development-stage specific and/or round-specific) mean effect can be calculated conditional on, the subset of observations with the same development combinations and/or within the same around of trade negotiations. Restricted matching also helps reduce the concern of selection on unobservables to the extent that such unobservables are correlated with the restriction criteria. We will elaborate further on how we refine the matching procedure to accommodate heterogeneous effects of *bothwto* and *imwto* in Section 7 when we present the estimation results.

We now explain the list of controls used in the matching. First, it includes the gross output of the exporter $\ln Y_{it}$, the aggregate expenditure of the importer $\ln E_{jt}$, and the year dummy T_t. Next, an extensive set of trade cost proxies $\mathbf{Z}_{ijt}$ are used to control for trade cost. This includes time-variant variables (indicator for use of common currency, indicator for preferential trade agreements, indicator for whether importer j offers GSP preferential treatment to exporter i, indicator for whether exporter i is currently a colonizer of importer j, and indicator for whether importer j is currently a colonizer of exporter i); and time-invariant variables (bilateral distance, common language indicator, common legal origin indicator, same country indicator, common border indicator, common colonizer indicator, indicator for whether exporter i has ever been a colonizer of importer j, indicator for whether importer j has ever been a colonizer of exporter i, the number of landlocked countries in a pair, and the number of island countries in a pair). Note that wherever applicable, trade cost proxies are defined to explicitly allow for asymmetric effects specific to the direction of trade flows. This is in line with the theoretical definition of asymmetric trade cost and asymmetric inward/outward MR terms.

Third, we adopt the approach proposed by Baier and Bergstrand (2009) to approximate the MR terms by a first-order Taylor-series expansion. In essence, the MR terms $\ln(\Pi_{it}P_{jt})^{1-\sigma}$ in (9) can be approximated by: $\sum_k e_k \ln \tau_{ikt}^{1-\sigma} + \sum_m s_m \ln \tau_{mjt}^{1-\sigma} - \sum_k \sum_m e_k s_m \ln \tau_{mkt}^{1-\sigma}$, which is the average trade cost of the exporter and the importer relative to the world benchmark (scaled by the power of $1-\sigma$). This can be written in terms of observable trade cost proxies: $\widetilde{z}_{ijt} = \sum_k e_k z_{ikt} + \sum_m s_m z_{mjt} - \sum_k \sum_m e_k s_m z_{mkt}$ for each of the trade-cost proxies $z \in \{bothwto, imwto, \mathbf{Z}\}$ under the log-linear approximation.

Three remarks are in order. First, the theoretical MR terms in (4) and (5) depend on internal trade cost τ_{ii} and τ_{jj}. This carries over to the B&B approximation formula. To account for this, we assume that the internal trade cost depends on a subset of the trade-cost proxies that are well defined for internal trade. These include: distance, common language indicator, common legal origin indicator, same country indicator, and common currency. Thus, in constructing $\widetilde{z}_{ijt}$, the summation includes observations on z_{iit} and z_{jjt} for this subset of trade cost proxies. We also experiment with alternative specifications of internal trade cost (eg. let $\tau_{iit} = 1$ or let τ_{iit} depend on internal distance only). The results turn out not to be sensitive to the specification of internal trade cost. Second, in adopting the B&B approach, the MR terms are subject to measurement errors due to log-linear approximation, but there are no better ways to control for the MR terms in the matching framework to the best of our knowledge. Note that it is not feasible to control for the MR terms using exporter-year and importer-year dummy variables as in the parametric approach, because each observation corresponds to a unique pair of exporter-year and importer-year dummy variables; match cannot be formed based on these two sets of indicator variables. Third, in principle, the matching procedure discussed above can be carried out in terms of levels of (3) rather than in terms of its log transformation (9). We proceed with the latter alternative, because this will allow us to interpret the estimates of *bothwto* and *imwto* as their effects on $\ln \tau_{ijt}^{1-\sigma}$, and exponential of these estimates as the ratio of trade cost with and without GATT/WTO. This is useful, as our counterfactual analysis in Sections 4-6 will be based on effects expressed in terms of the ratio of a variable under two scenarios, rather than in level differences.[3]

[3] By using only positive trade flows, the effect estimates are likely downward biased due to truncation at zero trade, but this does not pose threat to our conclusion of positive GATT/WTO effects. On the other hand, since in the matching framework, and in the permutation test we are using to compute statistical significance, heteroskedasticity is accommodated, it is less clear whether the matching estimate is still subject to the heteroskedasticity critique of Silva and Tenreyro (2006).

4 Counterfactual Analysis

Given estimates of the partial effects of *bothwto* and *imwto* on trade cost, we can calculate how the change in trade cost due to GATT/WTO affects the endogenous variables in the economy taking into account general equilibrium adjustment. To proceed, we rewrite the system of structural equations (2)–(8) in terms of changes à la the hat algebra of Dekle et al. (2007). In particular, let $\widehat{x} \equiv x'/x$ denote the ratio of the values of a variable x under two scenarios.

The market-clearing condition (2) and perfect competition require that the change in the supply share, the change in the cost of the input bundle, and the outward MR for each country satisfy the following condition:

$$\widehat{s}_i = \widehat{c}_i^{1-\sigma} \widehat{\Pi}_i^{1-\sigma}. \tag{10}$$

The MR structural relationship (4)–(5) and the trade flow equation (3) then require the changes in the MR terms to reflect the changes in trade cost and supply/expenditure shares according to:

$$\widehat{\Pi}_i^{1-\sigma} = \sum_j \alpha_{ij} \left(\widehat{\tau}_{ij} / \widehat{P}_j \right)^{1-\sigma} \widehat{e}_j \tag{11}$$

$$\widehat{P}_j^{1-\sigma} = \sum_i \lambda_{ij} \left(\widehat{\tau}_{ij} / \widehat{\Pi}_i \right)^{1-\sigma} \widehat{s}_i \tag{12}$$

where $\alpha_{ij} \equiv X_{ij}/Y_i$ is the share of country i's sales that goes to destination j and $\lambda_{ij} \equiv X_{ij}/E_j$ is the share of country j's expenditure that is spent on source i. There are no clearly good ways to deal with trade deficits in the counterfactual. We follow Caliendo and Parro (2015) and assume that in the counterfactual, a country's trade deficit as a share of world production remains constant: $D_i'/Y_w' = D_i/Y_w = \delta_i$. This, together with the aggregate budget constraint (6), implies that

$$\widehat{e}_i \cdot e_i = \widehat{s}_i \cdot s_i + \delta_i. \tag{13}$$

By the definition of s_i, it follows that

$$\widehat{s}_i \cdot s_i = \frac{\widehat{Y}_i \cdot Y_i}{\sum_k \widehat{Y}_k \cdot Y_k}. \tag{14}$$

By the Cobb-Douglas cost structure (7), we have:

$$\widehat{c}_i = \widehat{w}_i^{\beta_i} \widehat{P}_i^{1-\beta_i}. \tag{15}$$

Finally, by the labor market-clearing condition (8), we have

$$\widehat{Y}_i = \widehat{w}_i. \tag{16}$$

Using (10)–(16), we can solve for $\left\{\widehat{c}_i, \widehat{\Pi}_i, \widehat{P}_i, \widehat{s}_i, \widehat{e}_i, \widehat{w}_i, \widehat{Y}_i\right\}$ for $i = 1, 2, \ldots, N$, given exogenous changes in trade cost $\widehat{\tau}_{ij}^{1-\sigma}$, observable variables $\{\alpha_{ij}, \lambda_{ij}, e_i, s_i, \delta_i, Y_i\}$ and parameter values $\{1-\sigma, \beta_i\}$. The welfare effects of given exogenous changes in trade cost can then be measured by:[4]

$$\widehat{W}_{1,i} = \widehat{w}_i / \widehat{P}_i, \tag{17}$$

and the trade effects by:

$$\widehat{X}_{ij} = \frac{\widehat{\tau}_{ij}^{1-\sigma}}{\widehat{\Pi}_i^{1-\sigma} \widehat{P}_j^{1-\sigma}} \, \widehat{s}_i \, \widehat{E}_j, \tag{18}$$

where

$$\widehat{E}_j = \frac{Y_j}{E_j} \widehat{Y}_j + \frac{D_j}{E_j} \widehat{Y}_w \tag{19}$$

and $\widehat{Y}_w = \sum_i s_i \widehat{Y}_i$.

Suppose the matching estimates of the partial effects of *bothwto* and *imwto* are γ_1 and γ_2 respectively (ignoring heterogeneous effects for now to simplify notations). This implies an ex-post effect of $\widehat{\tau}_{ijt}^{1-\sigma} = \exp(\gamma_1)$ for country pairs that are both GATT/WTO members in year t, and $\widehat{\tau}_{ijt}^{1-\sigma} = \exp(\gamma_2)$ for country pairs where only the importer is a GATT/WTO member in year t. By allowing heterogeneous effect estimates of (γ_1, γ_2) across development combinations and/or negotiation rounds, $\widehat{\tau}_{ijt}^{1-\sigma}$ can be imputed similarly for all country pairs and years under study. These information on $\widehat{\tau}_{ijt}^{1-\sigma}$ can then be fed into the system (10)–(16) to derive the ex-post effects of GATT/WTO on the welfare (17) and the trade flows (18).

Regarding the choice of parameter values for the counterfactual analysis, note that the partial

[4] This formula evaluates the welfare effects based on changes in GDP. We also present the welfare effect when based on the expenditure: $\widehat{W}_{2,i} = \widehat{E}_i / \widehat{P}_i$.

effect estimate of a trade-cost proxy combines both the effect of the proxy on trade cost and the trade elasticity $(1-\sigma)$; the trade elasticity $(1-\sigma)$ is not separately identified. Thus, for the counterfactual analysis, we pick a benchmark value of $\sigma = 5$, ie., $1-\sigma = -4$. This value lies within the range of trade elasticity often reported in the gravity literature. For example, the median value of trade elasticity estimates based on studies using structural gravity models is found to be -3.78 by Head and Mayer (2015) in their meta-analysis. For the parameter $\{\beta_i\}$, we use the share of value added in gross output from Caliendo and Parro (2015). We take the median share across sectors as the country-level value-added share, which varies in the range of $[0.37, 0.53]$ across countries.

In the data, a country does not trade with every potential trading partners. Such trading relationships will be reflected by $\alpha_{ijt} = 0$ and $\lambda_{ijt} = 0$. All counterfactual changes in $\widehat{\tau}_{ijt}^{1-\sigma}$ calculated for these country pairs based on the matching estimates will be multiplied by zero shares and hence not affect the counterfactual results. In a sense, this is comforting, since the AvW model (as well as the Krugman and Melitz models used later) cannot explain zero trade and counterfactual changes in the occurrence of zero trade; it is best to leave out zero-trade relationships from the analysis. Thus, whatever counterfactual effects we obtain using these frameworks are conditional on the positive trading relationships. This also suggests that the matching estimates we obtain based on positive trade flows are consistent with the design of the counterfactual analysis.[5]

It is straightforward to verify that the above estimation and counterfactual analysis apply to the Eaton and Kortum (2002) framework. The taste parameter $b_i^{1-\sigma}$ in AvW corresponds to the technology parameter T_i in EK, while the partial trade elasticity $1-\sigma$ in AvW is replaced by the supply-side efficiency dispersion parameter $-\theta$ in EK.

5 The Krugman (1980) model

In the Krugman (1980) model with homogeneous firms and CES preferences, the same set of conditions (2)–(8) continue to hold, except with the following modifications. First, the market-

[5] As explained in the data appendix, we construct internal trade X_{ii} based on the difference between gross output Y_i and total exports of a country, where gross output is inferred from GDP and β_i. We use X_{ii} to construct α_{ii} and λ_{ii} to be used in the counterfactual. Since internal trade cost $\tau_{ii}^{1-\sigma}$ does not change in response to changes in the GATT/WTO status, $\widehat{\tau}_{ii}^{1-\sigma} = 1$ is set in the counterfactual analysis.

clearing condition in (2) is replaced by

$$\begin{aligned} Y_i &= \sum_j X_{ij} \\ &= N_i (p_i)^{1-\sigma} \sum_j (\tau_{ij}/P_j)^{1-\sigma} E_j, \end{aligned} \tag{20}$$

where N_i denotes the number of firms in country i. Second, assume that firms in i need to incur a production fixed cost f, expressed in terms of input bundle units, in addition to a constant input requirement a for each unit of production, where the input bundle is defined in the same way as in Section 2. Monopolistic competition and CES preferences imply that the supplier price charged by each firm is a constant markup over the marginal cost: $p_i = \frac{\sigma}{\sigma-1} a c_i$.

Third, free entry implies zero profit in the equilibrium, and hence sales equal production costs. Thus, labor-market clearing condition remains the same as in (8). With the use of intermediates, however, the number of firms is no longer constant as in the original model. It is instead:

$$N_i = \frac{Y_i}{\sigma f c_i}. \tag{21}$$

This introduces an extra margin of adjustment in firm entry not present in the trade models of perfect competition (as also suggested by Arkolakis et al., 2012, p. 115).

Since the same set of structural gravity equations (3)–(5) continue to hold, the estimation remains the same as in Section 3. The counterfactual analysis is modified to account for the change in N_i. Specifically, given the market-clearing condition (20) and constant markup pricing, we have

$$\widehat{s}_i = \widehat{N}_i \, \widehat{c}_i^{1-\sigma} \, \widehat{\Pi}_i^{1-\sigma}, \tag{22}$$

which replaces (10). In addition, (21) implies that

$$\widehat{N}_i = \widehat{Y}_i / \widehat{c}_i. \tag{23}$$

Thus, we have one more set of changes $\left\{ \widehat{N}_i \right\}$ to determine but also with one more set of conditions (23) to use. The remaining steps of the counterfactual analysis are the same as discussed in

Section 4. As a final remark, note that $\widehat{N}_i = \left(\widehat{w}_i/\widehat{P}_i\right)^{1-\beta_i}$ using (15), (16) and (23). Thus, without intermediates ($\beta_i = 1$), the number of firms will remain constant as in the original model. Without intermediates, this model will also be isomorphic to AvW and EK in quantitative welfare effects as suggested by Arkolakis et al. (2012).

6 The Melitz (2003) model with untruncated Pareto distribution

Let each country be characterized by the Melitz (2003) structure, but with possibly asymmetric trade costs and country characteristics. Let N_i be the mass of entrants, each of whom pays a fixed cost of entry c_iF_i to take a productivity draw $1/a$ from a cumulative Pareto distribution $G_i(a)$ over the support $[0, \bar{a}_i]$ with dispersion parameter $\theta > (\sigma - 1)$. Firms of productivity level $1/a$ located in country i incur a constant marginal cost $c_i\tau_{ij}a$ and a fixed cost c_if_{ij} to serve country j.

Given CES preferences and monopolistic competition, firms in country i exit from serving market j if its cost draw is above the cutoff a_{ij} defined by the zero-profit condition:

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{c_i\tau_{ij}a_{ij}}{P_j}\right)^{1-\sigma} E_j = c_if_{ij}. \tag{24}$$

It follows that the exports of country i to country j is $X_{ij} = \left(\frac{\sigma}{\sigma-1}\frac{c_i\tau_{ij}}{P_j}\right)^{1-\sigma} E_jN_iV_{ij}$ and the aggregate price index in country j is $P_j^{1-\sigma} = \sum_i \left(\frac{\sigma}{\sigma-1}c_i\tau_{ij}\right)^{1-\sigma} N_iV_{ij}$, where

$$V_{ij} \equiv \int_0^{a_{ij}} a^{1-\sigma}dG(a) = \frac{\theta}{\theta-\sigma+1}\frac{a_{ij}^{\theta-\sigma+1}}{\bar{a}_i^{\theta}} \tag{25}$$

indicates the proportion of firms (weighted by market shares) who exports from i to j.

The market-clearing condition requires that:

$$Y_i = \sum_j X_{ij} = \left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma} N_i \sum_j \left(\tau_{ij}/P_j\right)^{1-\sigma} E_jV_{ij}. \tag{26}$$

We could derive similar trade flow and MR equations as in the AvW framework by using (26) to solve for $\left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma} N_i$ and substitute the result in the expression of X_{ij} and P_j to obtain:

$$X_{ij} = \frac{Y_i E_j}{Y_w}\left(\frac{\tau_{ij}}{\Pi_i P_j}\right)^{1-\sigma} V_{ij} \tag{27}$$

where

$$\Pi_i^{1-\sigma} \equiv \sum_j (\tau_{ij}/P_j)^{1-\sigma} V_{ij} e_j, \tag{28}$$

$$P_j^{1-\sigma} = \sum_i (\tau_{ij}/\Pi_i)^{1-\sigma} V_{ij} s_i. \tag{29}$$

The aggregate budget constraint (6) and the cost of input bundle in (7) still apply. Since under untruncated Pareto distribution, the aggregate profit is a constant share $\frac{\sigma-1}{\sigma\theta}$ of sales revenue, the labor-market clearing condition implies that:

$$w_i L_i = \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) Y_i. \tag{30}$$

Finally, free-entry condition requires that the aggregate profit equals the total entry cost:

$$\frac{\sigma-1}{\sigma\theta} Y_i = N_i F_i c_i \tag{31}$$

6.1 estimation

Using the definitions of a_{ij} and V_{ij} in (24) and (25), we have

$$\tau_{ij}^{1-\sigma} V_{ij} = \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}\right)\left(P_j{}^{\theta-\sigma+1}\right)\left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right)\left(E_j{}^{\frac{\theta}{\sigma-1}-1}\right). \tag{32}$$

Given (32), we can rewrite the trade flow equation (27) and the MR equations (28)–(29) as:

$$X_{ij} = \frac{Y_i E_j}{Y_w}\left(\frac{\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}}{\chi_i\ \zeta_j}\right) \tag{33}$$

where[6]

$$\chi_i \equiv \sum_j (\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}/\zeta_j) e_j \tag{34}$$

$$\zeta_j = \sum_i (\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}/\chi_i) s_i. \tag{35}$$

Assume that the variable and fixed trade costs, $\ln \tau_{ijt}^{-\theta}$ and $\ln f_{ijt}^{-\frac{\theta}{\sigma-1}+1}$, each depend on the set of trade-cost proxies we have identified. This will allow us to write:

$$\ln\left(\tau_{ijt}^{-\theta} f_{ijt}^{-\frac{\theta}{\sigma-1}+1}\right) = h(bothwto_{ijt}, imwto_{ijt}, \mathbf{Z}_{ijt}). \tag{36}$$

Apply the B&B approach of approximating the MR terms χ_{it} and ζ_{jt} by first-order Taylor-series expansions. It is shown in the appendix that $\ln(\chi_i\zeta_j)$ in (33) can be approximated by: $\sum_i s_i \ln(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}) + \sum_j e_j \ln(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}) - \sum_i \sum_j s_i e_j \ln(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1})$. Thus, under log-linear approximation for the trade-cost function $h()$, we arrive at the same MR measures as in the AvW (Krugman) framework. Given (33) and (36), it also follows that we will obtain the same matching estimates as in the AvW (Krugman) framework, since the set of controls are the same. See the appendix for the proof of (33) and the derivations of the B&B approximations in the Melitz framework.

In spite of the same partial effect estimates, they take on a different structural interpretation in the Melitz framework from the AvW (Krugman) model: these estimates reflect the effect of *bothwto* and *imwto* on the variable as well as fixed trade costs, and in turn their combined effects on the intensive and extensive margins of export to a destination (the amount of exports per firm and the proportion of firms that export). For example, by joining the GATT/WTO, two members may liberalize trade-related policies (such as customs procedures and import-licensing) that lower fixed trade cost, above and beyond decreased variable trade cost.

[6]Specifically, $\chi_i \equiv \Pi_i^{1-\sigma}/c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}$ and $\zeta_j \equiv P_j^{-\theta}/E_j{}^{\frac{\theta}{\sigma-1}-1}$.

6.2 counterfactual analysis

The MR structural relationship (28)–(29) and the trade flow equation (27) now imply that:

$$\widehat{\Pi}_i^{1-\sigma} = \sum_j \alpha_{ij} \left(\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} / \widehat{P}_j^{1-\sigma} \right) \widehat{e}_j \quad (37)$$

$$\widehat{P}_j^{1-\sigma} = \sum_i \lambda_{ij} \left(\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} / \widehat{\Pi}_i^{1-\sigma} \right) \widehat{s}_i \quad (38)$$

The conditions (13)–(15) on changes in the expenditure share, output, and cost from Section 4 remain valid, while the labor-market clearing condition (30) implies the same condition on changes in wages (16). Finally, (26) and (31) lead to the same conditions on changes in the supply share and the mass of entrants (22)–(23) as in Section 5. To close the model, note that given (32) we have:

$$\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} = \left(\widehat{\tau}_{ij}{}^{-\theta} \widehat{f}_{ij}{}^{-\frac{\theta}{\sigma-1}+1} \right) \left(\widehat{P}_j{}^{\theta-\sigma+1} \right) \left(\widehat{c}_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma} \right) \left(\widehat{E}_j{}^{\frac{\theta}{\sigma-1}-1} \right), \quad (39)$$

where $\widehat{E}_j$ is as defined in (19).

Thus, using (13)–(16), (22)–(23), (37)–(39) and (19), we can solve for $\left\{ \widehat{c}_i, \widehat{\Pi}_i, \widehat{P}_i, \widehat{s}_i, \widehat{e}_i, \widehat{w}_i, \widehat{Y}_i, \widehat{N}_i, \widehat{E}_i, \widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} \right\}$ for $i = 1, 2, \ldots, N$, given exogenous shocks in $\left\{ \widehat{\tau}_{ij}{}^{-\theta} \widehat{f}_{ij}{}^{-\frac{\theta}{\sigma-1}+1} \right\}$, observable variables $\{\alpha_{ij}, \lambda_{ij}, e_i, s_i, \delta_i, Y_i\}$ and parameter values $\{1-\sigma, \theta, \beta_i\}$.

The welfare effects can be measured by the same formula in (17), while the trade effects are now replaced by

$$\widehat{X}_{ij} = \frac{\widehat{\tau}_{ij}^{1-\sigma} \, \widehat{V}_{ij}}{\widehat{\Pi}_i^{1-\sigma} \widehat{P}_j^{1-\sigma}} \, \widehat{s}_i \, \widehat{E}_j. \quad (40)$$

In the current framework, the estimates, $\exp(\gamma_1)$ and $\exp(\gamma_2)$, now represent the respective effect of *bothwto* and *imwto* on the combined trade cost $\left\{ \widehat{\tau}_{ij}{}^{-\theta} \widehat{f}_{ij}{}^{-\frac{\theta}{\sigma-1}+1} \right\}$. The effects could be heterogeneous across country pairs of different development combinations and rounds of trade negotiations, as explained in Section 3. These exogenous shocks to variable/fixed trade costs can thus be fed into the above system of equations to derive the welfare and trade effects of GATT/WTO.

In addition to the demand-side elasticity, we now need the extra information on the parameter θ. We choose the value based on the estimate of $\theta - (\sigma - 1)$ from Helpman et al. (2004). In particular, using Western European firm sales data for 52 sectors, they estimate the dispersion measure $\theta - (\sigma - 1)$. As most of the estimates fall in the range between 0.5 and 1.5, we adopt $\theta - (\sigma - 1) = 1$ as the benchmark value. We will also provide robustness checks using $\theta - (\sigma - 1) = \{0.5, 1.5\}$.[7]

7 Matching Estimates of Partial Trade Effects

In its history (1947-1994), GATT has sponsored eight rounds of trade negotiations (World Trade Organization, 2007; Bagwell et al., 2016). The first five rounds of negotiations concentrated mainly on lowering import tariffs. They were also participated by a relatively small number of countries. The sixth round, the Kennedy Round (1964–67), saw a larger number (62) of participants. In addition to cutting tariffs, the Kennedy Round also achieved an agreement on anti-dumping measures, interpreting Article 6 of GATT 1947. It also recognized the special need of developing countries, which henceforth encouraged the participation of developing countries in the GATT. The Tokyo Round (1973–1979) continued the GATT's tradition of cutting import tariffs. Most importantly, it embarked on negotiations in a wide range of nontariff measures, including technical barriers to trade, import licensing procedures, government procurement, customs valuation, anti-dumping measures and subsidies and countervailing measures. Although the Tokyo Round saw an even larger number (102) of participants, most of the agreements on nontariff measures were subscribed to by only a subset of countries. Given their "plurilateral" nature (partial but not multilateral subscription), these agreements were termed the "Tokyo Round Codes". This partial, selective, participation in agreements was amended in the subsequent Uruguay Round (1986–94). Participated by 123 countries, the Uruguay Round succeeded in lowering the general import tariffs further by 30+ percent and reached several new agreements on nontariff measures, including all issues addressed under the Tokyo Round but also new areas such as trade in services, intellectual

[7] Alternative values of $\tilde{\theta} \equiv \theta/(\sigma - 1)$ are suggested by Eaton et al. (2011), where they study the export behavior of French firms in a modified Melitz framework. Based on Figure 3B therein, the regression slope of -0.66 (between mean sales in France and entry into multiple countries) implies $\tilde{\theta} \approx 1.51$. If based on Figure 3C instead, the regression coefficient of -0.57 (between mean sales in France and entry into more difficult markets) implies $\tilde{\theta} \approx 1.75$. Their SMM estimate based on all the data suggests $\tilde{\theta} = 2.46$. Based on the US firm data, Chaney (2008) uses similar methodology as Helpman et al. (2004) of regressing the log of firm rank on the log of firm sales, and estimates $\tilde{\theta} \approx 2$. In Eaton et al. (2013), however, they find that simulations with $\sigma = 5.64$ and $\tilde{\theta} = 1.05$ match most closely the data and can explain the fact that a small number of French firms account for a large share of total exports. This set of parameter values imply $\theta = 4.87$ and are close to the benchmark values we adopt for the counterfactual simulations ($\sigma = 5$ and $\theta = 5$).

property rights, and trade-related investment measures. Trade that used to be exempted from the GATT rules such as trade in textiles, clothing, and agriculture, are also subject to stricter rules. Importantly, the GATT dispute settlement procedure was overhauled, and under the new WTO procedure, members are subject to stronger enforcement mechanism (Chang, 2009). Contrary to the plurilateral nature of Tokyo Round Code, most of the agreements reached under the Uruguay Round are multilateral in nature and are binding on all members, developed or developing. As a result of these rounds, the average ad valorem tariffs on industrial goods have fallen from over 40% to below 4%, and members are subject to greater disciplines on trade-related nontariff measures and domestic policies. Thus, the membership effects are likely heterogeneous across rounds due to the differential depths of liberalization and the changing compositions of nations in the system.

As documented by Jackson (1997) among others, developing member countries have not undertaken as deep trade liberalization in the history of GATT as industrialized countries. For example, many developing countries joined the GATT through the sponsorship by their colonizer after becoming independent; they were accepted into GATT without negotiating a tariff concession schedule or with very brief ones. Many agreements also gave explicit or implicit special and differential treatment to the developing countries. For example, despite nominal prohibitions in GATT against quantitative restrictions, developing countries may implement such measures for balance of payment purposes. As suggested by the work of Bagwell and Staiger (2010, 2016), this will imply smaller trade impact of membership for developing members than developed members. At the same time, even if the trade policy concessions of members that liberalize are applied on a MFN basis to all other members, the trade impact could be larger versus developed member exporters that also liberalize than developing member exporters. In practice, we could expect this to occur if developed countries focus their liberalization efforts on sectors of their comparative advantages. The work by Subramanian and Wei (2007) suggests that such heterogeneous membership effects are indeed observed in the data. Although with the Uruguay Round negotiations, the developing countries are subject to more disciplines under the WTO, they are often given longer phase-in periods to implement new trade agreements.

Let H indicate developed and L developing countries. Let country pairs be classified according to their development combinations. For example, LH indicates developing exporting and developed importing country pairs, and HL developed exporting and developing importing country pairs; similarly, HH and LL represent developed and developing pairs. We explain in the data appendix how development stage is defined and report the frequency of developed/developing and member/nonmember countries across years in Tables 1–2.

We implement the matching procedure described in Section 3, allowing for heterogeneous treatment effects. In particular, in addition to the matching controls listed in Section 3, we further restrict the matching to observations within the same year and development combinations. We then calculate the mean treatment effect of *bothwto* or *imwto* specific to each development combination and round of trade negotiations. The restricted matching has the added benefit of reducing the concern of selection based on unobservables that are systematically related to the development stages or years, and also the trade volumes. Tables 3 and 4 report the results. The statistical significance of the estimates and their confidence intervals are calculated based on permutation tests (cf. Chang and Lee, 2011). The 40% caliper indicates that given M_1 treated observations and hence matched pairs, only the best matched pairs (with matching distance less than the 40 percentile of all matches) are used in calculating the mean treatment effects.[8]

The effect estimates of *bothwto* in Table 3 show that GATT/WTO membership has positive effects on trade among members via a reduction in the bilateral trade cost, but the effects are heterogeneous. In particular, the effects are the largest among developed members and the weakest among the developing member countries ($\gamma_{1,HH} > \gamma_{1,LL}$). The effects also tend to be larger when the importing country is a developed member ($\gamma_{1,HH} > \gamma_{1,HL}$ and $\gamma_{1,LH} > \gamma_{1,LL}$). Further, the bilateral trade cost of developed member importers tends to drop by more against developed members than developing members ($\gamma_{1,HH} > \gamma_{1,LH}$). These results are in line with our discussion above of differential trade liberalization by developed and developing members, and potential bias in the sectoral composition of liberalization favoring developed countries. Across rounds, we see generally increasing effects over time especially for imports by developed members ($\gamma_{1,HH}$ and $\gamma_{1,LH}$). We see that the effect is especially strong following the Uruguay Round, reflecting the

[8]As in Chang and Lee (2011), we use the simple scale-normalized distance measure, $(w_{ijt} - w_{i'j't'})\Sigma_w^{-1}(w_{ijt} - w_{i'j't'})'$, where ijt is a treated observation to be matched and $i'j't'$ refers to a potential control subject and Σ_w is a diagonal matrix containing the sample variances of the covariates w on the diagonal. As w includes continuous variables such as log of distance, the likelihood of multiple-matching (multiple control subjects with the same distance to the treated subject) is negligible; thus, we restrict our attention to pair-matching (where each subject has a unique closest match). Suppose M matches are formed. They could be ranked in terms of the closeness of the match. A $x\%$ caliper uses $(x\% \cdot M)$ matched pairs that have a matching distance smaller than the x percentile of all M matches. In parallel with the restricted matching within year and development combination, the sample variances of the covariates w are calculated specific to the year and development combination.

broad coverage of its agreements. The exception is the trade among developing members ($\gamma_{1,LL}$), whose effect is weak and erratic across years.

Table 4 reports the corresponding *imwto* effect. We see that the *bothwto* effects are on average (across all rounds) bigger than the *imwto* effects ($\gamma_1 > \gamma_2$) for all development combinations. The smaller effect of *imwto* relative to *bothwto* suggests that there is still a difference in the importing members' barriers against members versus nonmembers. The gap may reflect that not all members extend the MFN treatment to nonmembers, or that such extensions are not granted at all times; uncertainty in the members' policy toward nonmembers may also create a higher trade cost facing nonmember exporters. The effect of *imwto* is on average positive if the importing member is a developed country and zero to negative if it is a developing country ($\gamma_{2,HH} > \gamma_{2,HL} = 0$ and $\gamma_{2,LH} > 0 > \gamma_{2,LL}$). This suggests that GATT/WTO developed members tend more likely to extend MFN treatment to imports from nonmembers. The negative effect of $\gamma_{2,LL}$ indicates that developing members actually tend to raise their trade restriction against nonmember developing countries especially in recent years.

To give an indication of how much the estimates in Tables 3–4 imply in terms of trade cost changes, note that $\widehat{\tau}_{ijt} = exp(\frac{\gamma_1}{1-\sigma})$ due to *bothwto* and similarly $\widehat{\tau}_{ijt} = exp(\frac{\gamma_2}{1-\sigma})$ due to *imwto*. Based on the benchmark value of $\sigma = 5$, this implies that the GATT/WTO reduces the direct trade cost between two members by 12.4% (LL) to 63.9% (HH), and the trade cost between a nonmember exporter and a member importer by 25.5% (HH) to 26.7% (LH). These magnitudes seem quite plausible given the rate of tariff reductions reached across the eight rounds of GATT negotiations, in addition to many disciplines imposed by the GATT/WTO on the use of non-tariff policy barriers in a wide range of issues (eg., import quotas, antidumping duties, customs facilitation, and technical standards, to name a few). In contrast, the negative effect of $\gamma_{2,LL}$ indicates that developing members have increased their trade restriction against nonmember developing countries by about 1% on average (across all years).

8 General Equilibrium Welfare Effects

8.1 AvW counterfactuals

We use the (development combination and round specific) estimates of *bothwto* and *imwto* that are statistically significant at the 10% level (from Tables 3 and 4) and their implied effects on $\widehat{\tau}_{ijt}^{1-\sigma}$ for all ijt to conduct the counterfactual analysis. This is first done based on the AvW framework (10)–(16). Due to space constraints, we report the results in every 5-year intervals. Figure 1 summarizes the ex-post welfare effects of GATT/WTO, relative to the counterfactual had the GATT/WTO not existed. In each year, two box plots are drawn that indicate the 25 percentile (the lower hinge of the box), the median, and the 75 percentile (the upper hinge of the box) of the effects for members (in red) and nonmembers (in blue), respectively.[9] We use the matching estimates from the period 1995-2005 (after the Uruguay Round) as inputs and extend the counterfactual analysis to the years 2006-2015. We do not update the matching estimates to the latest years, because data on some trade cost proxy variables are missing after 2005, while for counterfactual analysis, we need only data on trade flows and GDPs, which are available throughout 2015.

The estimates indicate significant welfare gains for GATT/WTO members, and the size and range of the member's gains tend to enlarge over the years up to 2005. Based on the real income measure W_1 in (17), the GATT/WTO increases the median member's welfare by 2.86% in 1950, 4.03% in 2005, and 3.69% in 2015. Due to some positive *imwto* effect estimates, nonmembers may also gain from GATT/WTO by free-riding on the trade liberalization of members and their extension of MFN treatment. But because developing members are the majority and their extension of MFN concession is limited, such positive externality is also limited. The median gains for nonmembers are in general less than 1% or negative. For example, the median nonmember gains 1.20% in 1950 in terms of real income, but sustains a loss of −3.15% in 2005 and −2.07% in 2015. The patterns of welfare effects are similar if instead the real expenditure measure (W_2) is used.

Table 5 provides a breakdown of changes in the key variables for two snapshot years 1950 and 2015. We note that the distribution of $\widehat{P}_j$ for members lies to the left of nonmembers', ie., members

[9]See http://www.stata.com/manuals13/g-2graphbox.pdf for more information on the box plot. Define $U = x_{[75]} + \frac{3}{2}(x_{[75]} - x_{[25]})$ and $L = x_{[25]} - \frac{3}{2}(x_{[75]} - x_{[25]})$, where $x_{[25]}$ and $x_{[75]}$ are the 25th and 75th percentile of x. Define $x_{(i)}$ as the ith ordered value of x. The upper adjacent value (the upper end of the whiskers) is defined as x_i, such that $x_{(i)} \leq U$ and $x_{(i+1)} > U$. The lower adjacent value (the lower end of the whisker) is defined as x_i, such that $x_{(i)} \geq L$ and $x_{(i-1)} < L$.

tend to experience a larger drop (or a smaller increase) in inward multilateral resistance. The structural relationship between $\{\Pi_i\}$ and $\{P_j\}$ in (4)–(5) implies that Π_i and P_i tend to move in opposite directions. It is indeed found that the distribution of $\widehat{\Pi}_i$ for members tends to be a rightward shift of nonmembers'.[10] The smaller drop (or a larger increase) in outward multilateral resistance experienced by members moves the nominal wage rate in a less favorable way than nonmembers', but the nominal wage increase in member countries dominates the aggregate price change, and leads to positive welfare gains.

Intuitively, nonmembers benefit from the extension of MFN treatments by some members to nonmember exporters, which lowers the nonmembers' outward multilateral resistance ($\Pi \downarrow$ for the median nonmember) and in turn helps raise the nominal wage of nonmembers. But by not joining the system, trade diversion away from members leads to a higher aggregate price in nonmembers. The increase in nominal wage dominates the increase in aggregate price for the median nonmember in 1950, but the pattern reverses in 2015 when there is an increase in trade restriction against nonmembers by members among developing countries ($\gamma_{2,LL} < 0$ in 1995-2005).

Figure 1 shows that the welfare effects are quite dispersed. The 75 percentile member sees a welfare gain of 4.40% in 1950, 8.32% in 2005 and 7.29% in 2015, while the 25 percentile member's gains are 1.73% in 1950, 1.74% in 2005, and 1.77% in 2015, respectively. Nonmembers' distribution, being more compressed and close to zeros before 1980, starts to diverge from the member's distribution and sees an increasing welfare loss of being outside the GATT/WTO system. These heterogeneities in GATT/WTO welfare effects across countries are driven by heterogeneous partial effects (γ_1, γ_2) across development combinations and rounds, but also by differences in country size and general equilibrium effects. In Section 8.5, we will showcase the diverse welfare effects for a selected set of countries, characterized by different membership status (members or nonmembers), development level (developed or developing), and country size (big or small).

8.2 Krugman counterfactuals

This section provides the alternative counterfactual results if the analysis is based on the Krugman framework (22)–(23) and (11)–(16). As indicated by Figure 2, the welfare effects of GATT/WTO are very similar qualitatively across the two frameworks, but the magnitudes of the gains (losses)

[10] See the online appendix.

are bigger in the Krugman framework. For example, the ex-post gain for the median member (nonmember) is 4.50% (1.87%) in 1950, 6.29% (−4.34%) in 2005, and 5.58% (−2.75%) in 2015 based on the real-income measure (see Table 6). These are uniformly bigger magnitudes compared with their counterparts in the AvW framework: 2.86% (1.20%) in 1950, 4.03% (−3.15%) in 2005, 3.69% (−2.07%) in 2015 (see Table 5). The difference in welfare gains could be as large as 4 percentage points for members at the upper 75 percentile of the distribution in 2015 (11.36% in Table 6 versus 7.29% in Table 5).

Recall that with the use of intermediates, the number of firms is not fixed in the Krugman model and this adjustment in firm entry introduces an extra margin of gains from trade relative to the AvW framework. In addition, as shown in Section 5, the adjustment in firm entry varies with the gains in real income monotonically $\widehat{N}_i = \left(\widehat{w}_i/\widehat{P}_i\right)^{1-\beta_i}$. Thus, the larger the initial gain under the AvW framework, the stronger the amplification mechanism due to firm entry in the Krugman model. These observations are confirmed by the changes of firm entry in Figure 3. Due to GATT/WTO, median members experienced a 2.63% (3.56% and 3.23%) increase in firm entry in 1950 (2005 and 2015). Nonmembers, with a smaller realized welfare gain in 1950, see a correspondingly smaller median increase of 1.09% in firm entry, and with a welfare loss in 2005 and 2015, a loss of firm entry (−2.57% and −1.63% at the median). The firm entry effect is substantial in recent decades for members at the 75 percentile; for example, it is as high as 7.08% in 2005 and 6.50% in 2015.

8.3 Melitz counterfactuals

We now turn to the Melitz framework, using (13)–(16), (22)–(23), (37)–(39) and (19). The results on welfare are summarized in Figure 4. We see that the pattern of ex-post gains for members and nonmembers across years are qualitatively similar to the first two frameworks. The quantitative gains in the Melitz framework (Table 7) turn out to be larger than the AvW but smaller than the Krugman framework. The ranking might first appear surprising given the work of Melitz and Redding (2015), but in fact the finding is consistent with the setup.

To see this, note that between the Krugman and Melitz models, they have the same equivalent set of counterfactual equations, except the shocks to the MR equations. It is $\widehat{\tau}_{ij}^{1-\sigma}$ in (11)–(12) for the Krugman model and $\widehat{\tau}_{ij}^{1-\sigma}\widehat{V}_{ij}$ in (37)–(38) for the Melitz model. As discussed earlier, the same set of matching effect estimates correspond to the GATT/WTO's effect on the variable trade cost ($\widehat{\tau}_{ij}^{1-\sigma}$) in the Krugman model, but its effect on both the variable and fixed trade costs ($\widehat{\tau}_{ij}{}^{-\theta}\widehat{f}_{ij}{}^{-\frac{\theta}{\sigma-1}+1}$) in the Melitz framework. Thus, given σ and θ, the estimates may map into different levels of changes in the underlying trade cost across these two models. In fact, the larger θ is, the smaller the corresponding decrease (increase) in variable and fixed trade costs in the Melitz model for given set of effect estimates, and intuitively, the smaller the welfare gains (losses). It is clear from (39) that the Melitz numerical results converge to those of the Krugman's as θ approaches its lower bound $\sigma - 1$. Thus, the same set of observed trade flows would actually imply in general a smaller welfare effect in the Melitz framework than in the Krugman model for all $\theta > \sigma - 1$. This is illustrated by Figure 5, which indicates smaller gains for members and smaller losses for nonmembers in the Melitz framework relative to the Krugman framework. For example, the median welfare gains for members (nonmembers) are 3.71% (1.54%) in 1950, 5.20% (−1.25%) in 2005, and 4.66% (−1.76%) in 2015 in the Melitz framework, versus 4.50% (1.87%), 6.29% (−4.34%), and 5.58%(−2.75%) in the Krugman framework. The smaller welfare effects in the Melitz framework also imply correspondingly smaller effects on firm entry as illustrated by Figure 3. For example, the median effects on firm entry for members (nonmembers) are 2.17% (0.90%) in 1950, 2.81% (−0.80%) in 2005, and 2.64% (−1.04%) in 2015 in the Melitz framework, compared with 2.63% (1.09%), 3.56% (−2.57%), and 3.23% (−1.63%) in the Krugman framework.

Two remarks are in order. First, note that we infer the welfare effects given the observed trade flows, which do not necessarily imply the same underlying trade cost in the two models. In contrast, Melitz and Redding (2015) compare the two models' welfare implications on the premise of the same initial condition and the same change in trade cost. Second, we did not modify the original Krugman model to introduce entry cost and fixed trade cost as is done in Melitz and Redding (2015). These discrepancies in setups and economic structures help explain the current finding in favor of the Krugman model.

We may also compare the AvW and Melitz models' welfare implications. Note that because the AvW model implies the same MR equations as the Krugman model, the same mechanism discussed above would imply a smaller welfare effect in the Melitz model. However, the extra margin of adjustment in firm entry present in the Melitz model but not in the AvW model exerts a countervailing effect. Thus, ex ante, it is not clear whether the effects would be necessarily bigger in the Melitz framework. For the benchmark parameter values ($\sigma = 5, \theta = 5$), we see that the firm entry effect dominates, and as a result, the estimated median welfare gains are bigger in the Melitz model (Table 7) than in the AvW framework (Table 5).

When the parameter value for firm dispersion θ increases, the first mechanism becomes more pronounced and simultaneously the entry effect becomes weaker. For example, as we increase θ from the benchmark to 5.5, the welfare effects in the Melitz model are reduced, accompanied by smaller changes in firm entry (see Table 8). As discussed in Section 8.4, we also experiment with larger values of θ in robustness checks. It can be shown that with sufficiently large θ (eg., $\sigma = 5$ and $\theta = 8$), the ranking would actually reverse such that the welfare effects are larger in the AvW model than the Melitz model for a majority of countries.

8.4 Robustness Checks

In this section, we conduct several sensitivity analyses. We consider raising the elasticity of substitution to an extreme high value ($\sigma = 10$), varying firm dispersion parameter values ($\theta = \{4.5, 5.5, 6, 8, 10\}$), and using instead the partial effect estimates based on 100% caliper. The results are reported in Tables 9, 10 and 11, which give the median, the 75 percentile, and the 25 percentile welfare effects of GATT/WTO, respectively.

First, Tables 12 and 13 show that the matching effect estimate based on 100% caliper choice is in general larger than with the 40% caliper, albeit with some exceptions (eg. $\gamma_{1,LH}$ in 1995–2005). Larger matching effect estimates map into larger welfare effects. For example, Tables 9–11 show that the welfare effects in Scenario 9 (with 100% caliper, $\sigma = 5$, $\theta = 5$) are overall larger (in absolute magnitudes) than the benchmark. This ranking also holds across variations in σ and θ. For example, it holds between Scenarios 1 and 8 (for $\sigma = 5$ and $\theta = 4.5$).

Next, we expect the welfare effects to be smaller when σ is bigger since goods are closer substitutes. In the Melitz model, we need to set the parameter $\theta > (\sigma - 1)$ such that the aggregate price is well defined. Thus, by setting $\sigma = 10$, we also modify θ up to $\theta = 10$. These parameter values are close to the upper-bound estimates in the literature, so we could take the associated welfare effects under this setting as the lower-bound predictions on the welfare effects of GATT/WTO. The results are shown in Scenarios 7 and 14 in Tables 9–11.

Finally, we fix σ but allow θ to vary within a range of values suggested by the literature (discussed in Footnote 7). A higher θ is expected to lower the welfare effect estimates in the Melitz model as the same observed changes in trade flows imply a lower reduction in the underlying trade costs. Indeed, across Tables 9–11, the welfare effects of the Melitz model monotonically decrease as we increase θ from 4.5 to 10 with either 40% or 100% caliper estimates. In particular, when $\theta = 8$, the Melitz model implies a lower welfare effect than both the AvW and Krugman models. As discussed in Section 8.3, the extra welfare gains due to firm entry in the Melitz model is in this scenario dominated by the lower implied trade cost change relative to the AvW model, leaving a net smaller welfare effect.

Overall, across different decades, countries, economic models, parameter values and matching estimates, we see that the GATT/WTO has raised the welfare of members by 1.85% to 11.44% at the upper 75 percentile, and 0.70% to 3.42% at the lower 25 percentile. This reflects a heterogeneous distribution of effects across years and development stages. The effects tend to be more pronounced in recent decades as the system's membership enlarges, for developed countries, based on the Krugman framework, and (naturally) with smaller parameter values for trade elasticity and firm productivity dispersion.

8.5 Country-specific welfare effects: Examples

In Figure 7, we illustrate the diverse welfare effects of GATT/WTO across countries. We choose for each region (America, Asia, Europe/Africa/Middle East) six countries, of various development stages, country sizes, and timing of GATT/WTO accession. We report the effects based on the AvW and Krugman frameworks with parameter values $\sigma = \{5, 10\}$, representing the median and the upper bound of elasticity estimates in the literature. Given the above counterfactual results, the Melitz framework's welfare implications likely lie in between the AvW and the Krugman model. The timing of a country's accession to the GATT/WTO is indicated by a vertical red line.

We see that, of the big developed members, Germany (DEU) has benefited the most, followed by the UK (GBR), Japan (JPN), and the US (USA). Developing members such as India (IND) and Brazil (BRA) tend to gain relatively less, with Argentina (ARG) seeing a stronger effect in recent years. Small open economies in particular benefit a lot from GATT/WTO. For example, Singapore (SGP) has gained more than 50% (and up to 100%) in real GDP every year since 1980 with the optimistic estimate based on the Krugman framework. Denmark (DNK) also experiences a steady large welfare gain of 7-13% annually since its accession to the system.

Turning to the next set of countries who joined the GATT/WTO relatively later or never, we see that the welfare dynamics typically see a dramatic shift following the accession. For example, China (CHN) has seen a big annual welfare gain of up to 8% since its accession in 2001, in contrast with small welfare losses during 1980-2000. The welfare gains following accession are more dramatic for small open economies such as Thailand (THA) and Vietnam (VNM), while they are not as pronounced for more closed economies such as Ecuador (ECU). Vietnam has benefited as much as 20% and Thailand 15% annually since joining the GATT/WTO in 2007 and 1982 respectively. The welfare dynamics of Paraguay (PRY) is quite volatile, mimicking its volatile trajectory of trade openness. Nonmembers typically do not lose much from being outside the system before 1980 and mostly free-ride on the MFN liberalization of members, but such positive externality generally disappeared after 1980. The welfare cost borne by these nonmembers since 1980 appears to have prompted several of them to join the GATT/WTO afterwards. Finally, the last three countries (Belarus, Yemen, and Ethiopia) illustrate the welfare cost sustained by countries who have remained nonmembers throughout most of the study period (1950-2015). The welfare cost is as high as 25% for Belarus (BLR) in 2012 in the aftermath of its currency crisis, and more than 10% for Yemen (YEM), a relatively poor country. It is also increasingly costly for least developed African countries such as Ethiopia (ETH) to stay outside the system, even though they are relatively closed to begin with.

9 Extended Analysis

9.1 Interaction of PTA and GATT/WTO

In this section, we use the frameworks that we have established to examine two interesting issues. First, the proliferation of preferential trade agreements (PTAs), especially since 1990s, has raised concerns about whether PTAs will impede the progress and objectives of multilateral trade liberalizations under GATT/WTO. The tension and interaction between multilateral trade liberalization (via GATT/WTO) and preferential trade liberalization (via preferential trade agreements) have always been a hotly debated theoretical and policy question. See for example, Grossman and Helpman (1995), Levy (1997), Krishna (1998), Chang and Winters (2002), Karacaovali and Limao

(2008), Estevadeordal et al. (2008) among many others. Without a full political economic model on the formation of PTAs, we cannot address the question fully. What we can do in a limited way is to conduct the welfare analysis of GATT/WTO for the scenario had all the PTAs not existed and compare the effects with what we have obtained in Section 8 under factual PTAs. We use the same matching procedure described in Section 3 to estimate the PTA effect, with the treatment now replaced by the PTA indicator, and *bothwto* and *imwto* as part of the matching controls. As shown in Table 14, the PTA trade effects are relatively homogeneous across development stages. Our preliminary analysis suggests that the PTA effects are also similar across decades. In any case, most of PTAs were signed since 1990s. Thus, we proceed with the set of PTA effect estimates in Table 14 that differ across development stages but not across time.

Figure 6 summarizes the welfare effects of GATT/WTO without PTAs relative to its effects with the observed PTAs. This is based on the AvW framework and benchmark parameter values. We see that the ex-post gains of members are smaller and the ex-post losses of nonmembers are bigger without the PTAs. The difference becomes more significant in recent decades when the PTAs surge in numbers (and also noticeable in 1960 during the first wave of PTAs). Thus, for GATT/WTO members, PTAs appear complementary to multilateral liberalization, but for non-members, PTAs reduce their incentives to participate in GATT/WTO as their potential losses by not joining GATT/WTO are lower with PTAs in place.

9.2 Effect of GATT/WTO on Cross-country Income Inequality

Last but not the least, we analyze how cross-country income inequality has been affected by the multilateral liberalization process introduced by GATT/WTO. Does the system tend to benefit the poor more than the rich countries and hence reduce the cross-country income inequality, or has it worsened the global inequality? In Figure 8, we calculate the Gini coefficient using factual GDP per capita's across countries, weighted by each country's population. This is then compared to the counterfactual Gini coefficient had the GATT/WTO not existed under the AvW/Krugman framework with $\sigma = \{5, 10\}$. The figures in the first column report the results when we simply include all countries available in our sample, while those in the second column report the results when we fix the set of countries to those available in every year during 1980–2005 (118 countries) and during 1980–2015 (111 countries), respectively. The second set of figures remove the concern that inequality index might have changed due to compositional changes in the set of countries.

First, we note that the global inequality has increased during 1980–1995, but has since gradually lowered toward its historically low level seen in 1958. The absolute level, however, is still alarmingly high at above 0.6. Next, we see that the global income inequality is higher under the counterfactual of no GATT/WTO after 1980 (the results are similar based on AvW or Krugman; thus only two counterfactuals given different parameter values are visible). The difference is especially large after 1995. These patterns suggest that the GATT/WTO has in fact brought the poor nations/people up the ladder of livelihood through trade integration and improved the global equality.

10 Conclusion

In this paper, we analyze the effects of GATT/WTO on the welfare, firm entry, production, trade, and inward/outward multilateral trade resistance of its members and nonmembers in its entire history (1950–2015). The matching estimator is used to identify the GATT/WTO's partial direct effect on bilateral trade flows using membership indicators ($bothwto = 1$ if both trading partners are members and $imwto = 1$ if only the importing country is a member). The estimation results indicate heterogeneous direct trade effects of membership on imports from fellow members and from nonmembers across development combinations of the country pairs and across time periods demarcated by the GATT negotiation rounds. These shocks to the trade cost/flows are used as inputs in quantitative trade models (Anderson and van Wincoop, 2003; Krugman, 1980; Melitz, 2003) that are characterized by increasingly extra margins of adjustment in firm entry (into production and export markets).

The results overall indicate large welfare gains created by the GATT/WTO system at the global level and across more than six decades of its history, but the distribution of the gains across members is highly heterogeneous with long right tails. Nonmembers see small gains in earlier decades but increasingly bigger welfare losses after 1980. The global income inequality is lower with GATT/WTO, and the positive effect on income equality across countries is especially pronounced after 1995. This indicates that poorer member countries have benefited more from joining the GATT/WTO relative to the rich members. Preferential trade agreements appear complementary to multilateral liberalization for members as their welfare gains due to GATT/WTO are larger with the presence of PTAs, but reduce nonmembers' incentives to participate in the GATT/WTO as their welfare losses of not joining the GATT/WTO are smaller with the PTAs.

The Krugman (1980) framework always implies a bigger welfare effect than the benchmark Anderson and van Wincoop (2003) model because of the extra firm entry effect. In contrast, the Melitz (2003) model implies distinctly different structural gravity equations from the first two. Given the same observed trade flows, it implies smaller changes in underlying trade cost and smaller welfare effects than the Krugman (1980) model. With extra entry effects, however, it may still lead to larger welfare effects than the Anderson and van Wincoop (2003) framework. These quantitative assessments across models serve as one sensitivity analysis of our findings with respect to trade model specifications. In addition, we conduct extensive sensitivity analysis to provide a spectrum of welfare effect estimates corresponding to various model parameter values (trade elasticity or degree of firm heterogeneity) and partial effect estimates (caliper choice at 100% or 40% that sets looser or more stringent criteria on the quality of match). We conclude with a positive report of the substantial trade and welfare gain that GATT/WTO has helped promote. It does so in a progressive way by bringing up the poorer nations' income more than the richer nations'.

As a final remark, the current paper has not addressed the important question (and popular sentiment) of whether GATT/WTO has worsened the within-country income inequality, and if so, in what set of countries, through what mechanisms, and to what extents. It would be interesting to conduct counterfactual analysis of GATT/WTO based on trade/FDI models that allow heterogeneous labors to answer these questions. We leave this to future research.

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Math Appendix

Derivation of equation (33)

Proof. Given (32), we can rewrite (28) as:

$$
\begin{aligned}
\Pi_i^{1-\sigma} &= \sum_j \left(\tau_{ij}/P_j\right)^{1-\sigma} V_{ij} e_j \\
&= \sum_j \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1} / P_j^{1-\sigma}\right) \left(P_j{}^{\theta-\sigma+1}\right) \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) \left(E_j{}^{\frac{\theta}{\sigma-1}-1}\right) e_j \\
&= \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) \sum_j \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}\right) / \left(P_j^{-\theta} / E_j{}^{\frac{\theta}{\sigma-1}-1}\right) e_j \\
\Pi_i^{1-\sigma} / \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) &= \sum_j \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}\right) / \left(P_j^{-\theta} / E_j{}^{\frac{\theta}{\sigma-1}-1}\right) e_j.
\end{aligned}
$$

Similarly, we can rewrite (29) as:

$$
\begin{aligned}
P_j^{1-\sigma} &= \sum_i \left(\tau_{ij}/\Pi_i\right)^{1-\sigma} V_{ij} s_i \\
&= \sum_i \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1} / \Pi_i^{1-\sigma}\right) \left(P_j{}^{\theta-\sigma+1}\right) \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) \left(E_j{}^{\frac{\theta}{\sigma-1}-1}\right) s_i \\
&= \left(P_j{}^{\theta-\sigma+1}\right) \left(E_j{}^{\frac{\theta}{\sigma-1}-1}\right) \sum_i \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}\right) / \left(\Pi_i^{1-\sigma} / c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) s_i \\
P_j^{-\theta} / E_j{}^{\frac{\theta}{\sigma-1}-1} &= \sum_i \left(\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}\right) / \left(\Pi_i^{1-\sigma} / c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) s_i.
\end{aligned}
$$

Define $\chi_i \equiv \Pi_i^{1-\sigma} / \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right)$ and $\zeta_j \equiv P_j^{-\theta} / E_j{}^{\frac{\theta}{\sigma-1}-1}$, we have $\chi_i \equiv \sum_j (\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1} / \zeta_j) e_j$ and $\zeta_j = \sum_i (\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1} / \chi_i) s_i$, and

$$
\begin{aligned}
X_{ij} &= \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}}{\Pi_i P_j}\right)^{1-\sigma} V_{ij} \\
&= \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}}{\Pi_i^{1-\sigma} P_j^{1-\sigma}}\right) \left(P_j{}^{\theta-\sigma+1}\right) \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) \left(E_j{}^{\frac{\theta}{\sigma-1}-1}\right) \\
&= \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}{}^{-\theta} f_{ij}{}^{-\frac{\theta}{\sigma-1}+1}}{\chi_i \ \zeta_j}\right).
\end{aligned}
$$

■

B&B approximations in the Melitz framework

Proof. Recall that $\chi_i \equiv \sum_j ({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}/\zeta_j) e_j$ and $\zeta_j = \sum_i ({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}/\chi_i) s_i$. We have

$$\begin{aligned}
\ln \zeta_j &= \ln \left[\sum_i ({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}/\chi_i) s_i \right] \\
&= \ln \left[\sum_i e^{\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) - \ln \chi_i} s_i \right] \\
&\approx \sum_i \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) - \ln \chi_i \right] s_i, \qquad (41)
\end{aligned}$$

where from the second to the third equation, we have taken Taylor expansion w.r.t. $\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1})$ and $\ln \chi_i$ around the origin. Similarly, we have

$$\ln \chi_i \approx \sum_j \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) - \ln \zeta_j \right] e_j. \qquad (42)$$

Use (42), we have

$$\begin{aligned}
\sum_i \ln \chi_i s_i &\approx \sum_i s_i \sum_j \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) - \ln \zeta_j \right] e_j \\
&= \sum_i \sum_j \left[s_i e_j \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) - s_i e_j \ln \zeta_j \right]. \qquad (43)
\end{aligned}$$

Plugging (43) in (41), we have

$$\begin{aligned}
\ln \zeta_j &\approx \sum_i \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) s_i \right] - \sum_i \ln \chi_i s_i \\
&= \sum_i \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) s_i \right] - \sum_i \sum_j \left[s_i e_j \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) \right] + \sum_i \sum_j s_i e_j \ln \zeta_j \\
&= \sum_i \left[\ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) s_i \right] - \sum_i \sum_j \left[s_i e_j \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) \right] + \sum_j e_j \ln \zeta_j,
\end{aligned}$$

which together with (42) imply that

$$\ln \chi_i + \ln \zeta_j = \sum_i \left[s_i \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) \right] + \sum_j \left[e_j \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) \right] - \sum_i \sum_j \left[s_i e_j \ln({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}) \right].$$

■

Data Appendix

The data used in this paper comprise three main components: trade flows, GDP and trade cost proxy variables. We compile the data for the period of 1950–2015. The matching estimation is conducted using the data in 1950–2005 at the annual frequency. The counterfactual quantitative analysis is carried out yearly for 1950–2015, but due to space constraints, we report most of the figures at every 5-year interval $(1950, 1955, \ldots, 2015)$.

We use the matching estimates from the period 1995-2005 (after the Uruguay Round) as inputs and extend the counterfactual analysis to the years 2006-2015. We do not update the matching estimates to the latest years, because data on some trade cost proxy variables are missing after 2005, while for counterfactual analysis, we need only data on trade flows and GDPs, which are available throughout 2015.

Bilateral Trade Flows

The bilateral merchandise trade flows are obtained from the Direction of Trade Statistics (DOTS) database of the IMF.[11] They are recorded in the current U.S. dollars. As we allow asymmetric trade cost and trade flows, we use the CIF import value as the dependent variable, rather than the average of exports and imports between a pair of countries (Rose, 2004).

GDP and Gross Output

We use the GDP data from the CEPII's Gravity dataset,[12,13] and supplement the missing entries with the GDP data from the World Bank's World Development Indicators (WDI).[14] We construct gross output Y_i data by taking the ratio of GDP and the value-added share β_i in gross output: $Y_{it} = GDP_{it}/\beta_i$, where the data on β_i is sourced from Caliendo and Parro (2015). In their dataset, the share varies across sectors and countries. We take the median across sectors in each country as the country-level value-added share. These are available for 30 countries and a ROW (as listed in

[11] http://www.imf.org/en/Data
[12] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8
[13] https://sites.google.com/site/hiegravity/data-sources
[14] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators

Appendix E in their paper). The ROW value-added share is adopted for countries in our dataset that are not separately studied in Caliendo and Parro (2015).

Expenditure

Based on bilateral trade flows, we construct the trade deficit of a country by: $\widetilde{D}_{jt} = \sum_i X_{ijt} - \sum_i X_{jit}$. However, due to measurement errors, the world trade deficit $\widetilde{D}_{wt}$ does not sum to zero typically. We allocate the discrepancy $\widetilde{D}_{wt}$ to each country in proportion to its output share of the world, ie., $D_{jt} = \widetilde{D}_{jt} - s_j \widetilde{D}_{wt}$. The gross expenditure of a country is then constructed as: $E_{jt} = Y_{jt} + D_{jt}$.

Classification of Developed and Developing Countries

Rose (2004) and Subramanian and Wei (2007) classify the traditional industrial countries as developed countries.[15] This is our benchmark. However, this classification is time invariant and thus does not reflect the rise of newly industrialized countries. Hence, we also consider classifying a country as developed based on the income threshold of $6,000 U.S. dollars per capita (in 1987 prices) used by the World Bank for high-income countries.[16] These thresholds are updated annually by the World Bank since 1987, using the IMF's SDR (Special Drawing Rights) deflator to adjust for inflation. We extrapolate the thresholds for the period 1960–1986 using the same SDR deflator.[17] For the period 1950–1959 when the SDR deflator does not exist, we use the U.S. GDP deflator,[18] but adjust for the difference in the levels of these two deflators by the average of their ratios in 1960–1964. The World Bank threshold is in terms of GNI per capita, but the GNI data in earlier years are not readily available for a large number of countries. Thus, we classify countries as developed or developing based on their GDP per capita instead.

Together, a country is classified as developed, if its GDP per capita exceeds the threshold constructed above or if it belongs to the set of traditional industrial countries reported in Subramanian and Wei (2003). Otherwise, it is classified as a developing country.

[15] See Appendix Table 2 in Subramanian and Wei (2003)

[16] https://datahelpdesk.worldbank.org/knowledgebase/articles/378833-how-are-the-income-group-thresholds-determined.

[17] https://datahelpdesk.worldbank.org/knowledgebase/articles/378829-what-is-the-sdr-deflator.

[18] https://fred.stlouisfed.org/series/GDPDEF.

Proxies for Asymmetric Bilateral Trade Cost

The main bulk of the trade cost variables are taken from CEPII's Gravity dataset and GeoDist dataset.[19] The original dataset includes 225 countries for the period 1948–2006. We drop French Southern and Antarctic Lands because it does not have a permanent population.

The GATT/WTO indicator variables $bothwto_{ijt}$ and $imwto_{ijt}$ are constructed from the CEPII variables gatt_o and gatt_d (which equals one if the exporting country or the importing country is a GATT/WTO member, respectively).

The other variables used include: population-weighted bilateral distance ($Dist_{ij}$); common language indicator, which equals one if a language is spoken by at least 9% of the population in both countries ($ComLang_{ij}$); common border indicator, which equals one if two countries are contiguous ($Border_{ij}$); common colonizer indicator, which equals one if two countries have had a common colonizer after year 1945 ($Comcol_{ij}$); same country indicator, which equals one if two countries were or are the same country ($ComNat_{ij}$); preferential trade agreement indicator, which equals one if a preferential trade agreement is in force between two countries (PTA_{ijt}); common currency indicator, which equals one if two countries use a common currency ($ComCur_{ijt}$); indicator for whether exporter i has ever been a colonizer of importer j ($Exheg_{ij}$) and indicator for whether importer j has ever been a colonizer of exporter i ($Imheg_{ij}$).

Because the identity of a colonizer versus a colony never swaps in the period of our study, we construct indicator for whether exporter i is currently a colonizer of importer j based on the CEPII variable $CurCol_{ijt}$ (whether i is currently a colony of j or vice versa) and $Exheg_{ij}$: $Excurheg_{ijt}$=1 if $CurCol_{ijt}$=1 and $Exheg_{ij}$=1. The indicator for whether importer j is currently a colonizer of exporter i is constructed in a similar way: $Imcurheg_{ijt}$=1 if $CurCol_{ijt}$=1 and $Imheg_{ij}$=1. Data on whether importer j offers GSP preferential treatment to exporter i (GSP_{ijt}) are obtained from the gravity dataset used in Head et al. (2010) available via the Sciences Po website.[20] We supplement the legal origin data from CEPII with the information from La Porta et al. (1999), La Porta et al. (2008) and the CIA's *World Factbook* website,[21] to construct the common legal origin indicator ($ComLeg_{ij}$), which equals one if two countries share a common legal origin. The information on

[19]http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6
[20]http://econ.sciences-po.fr/node/131
[21]https://www.cia.gov/library/publications/the-world-factbook/

the number of landlocked or island countries in a pair ($Landl_{ij}$, $Island_{ij}$) are from Andrew Rose,[22] supplemented with information from the CIA's *World Factbook* website.

The data on preferential trade agreement indicator (PTA_{ijt}) and the common currency indicator ($ComCur_{ijt}$) are from de Sousa by default,[23] and supplemented with CEPII's Gravity dataset. We also update missing PTA entries using the WTO Regional Trade Agreements Information System (RTA-IS).[24]

Pseudo World

For obvious reasons, we have to drop countries that do not have GDP data. We also drop countries that do not import from or export to any other countries. Given the set of remaining countries, we construct trade deficit and expenditure as discussed above, and drop countries if the constructed expenditure is negative. We also drop countries if the implied internal trade is negative: $X_{ii} \equiv Y_i - \sum_{j \neq i} X_{ij} < 0$. These are typically small territories whose data are prone to measurement errors. We iterate the process of constructing trade deficit and expenditure after each round of adjustment in the set of countries until the constructed expenditure and internal trade of all countries are positive. We call this set of countries the pseudo world and calculate the supply and expenditure shares of each country relative to the pseudo world.

The number of countries and the total GDP (imports) of the countries in the pseudo world relative to the real world are reported in Table 1. As shown, the pseudo world is overall representative of the real world and its coverage improves over the years as the quality of the data on trade flows improves. In Table 2, we also decompose the pseudo world import flows by GATT/WTO members versus nonmembers. As shown, GATT/WTO members are proportionally larger importers. Even in the early decades (1950–1960) when the membership size is small (26–31), about 70.4% of the world import flows are covered under the GATT treaties, with another 13.9% imported by members from nonmembers. With the membership size continuing to grow, these figures have increased (reduced) to 91.6% (4.9%) by 2005, and 97.4% (1.1%) in 2015.

[22] http://faculty.haas.berkeley.edu/arose/RecRes.htm
[23] http://jdesousa.univ.free.fr/data.htm.
[24] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

Table 1: Characteristics of countries included in the pseudo world

	(a)	(b)	(c)	(d)	(e)
year	no. of countries in the raw data	no. of countries in pseudo world	GDP share of the pseudo world	Import share of the pseudo world	no. of obs. with positive bilateral imports
1950	50	50	0.760	0.611	1,303
1955	61	59	0.812	0.691	2,038
1960	101	89	0.840	0.802	3,173
1965	117	105	0.864	0.808	4,201
1970	127	119	0.882	0.813	6,144
1975	135	124	0.898	0.829	7,164
1980	142	123	0.908	0.800	7,518
1985	152	152	0.936	0.828	9,682
1990	152	151	0.913	0.828	11,184
1995	170	170	0.937	0.873	15,222
2000	175	175	0.941	0.940	18,476
2005	176	175	0.940	0.940	19,680
2010	174	174	0.987	0.940	20,503
2015	180	180	0.977	0.921	23,126

Note:
(a) refers to the number of countries: (i) with at least one non-missing bilateral import and one non-missing bilateral export data from DOTS, (ii) with trade cost proxy data, and (iii) with GDP data.
(b) refers to the number of countries in the pseudo world after the iterated adjustment described above to ensure that every country has positive expenditure and internal trade.
(c) refers to the total GDP of the countries in the pseudo world relative to the real world GDP reported by WDI. In 1950 and 1955, the WDI did not report the world GDP; in this case, we calculate the total GDP of the 224 CEPII countries as the approximate real world GDP.
(d) refers to the total imports of the countries in the pseudo world relative to the real world imports reported by DOTS.
(e) refers to the number of observations with positive bilateral imports reported by DOTS in the pseudo world.

Table 2: Characteristics of countries included in the pseudo world (continued)

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
year	no. of countries in pseudo world	no. of *H* members	no. of *L* members	no. of *H* nonmembers	no. of *L* nonmembers	Import share of members	Import share of nonmembers	Import share of *bothwto* observations	Import share of *imwto* observations
1950	50	13	13	6	18	0.844	0.157	0.704	0.139
1955	59	16	14	5	24	0.835	0.165	0.699	0.137
1960	89	16	15	7	51	0.810	0.190	0.656	0.154
1965	105	19	37	6	43	0.861	0.140	0.720	0.140
1970	119	23	46	5	45	0.904	0.096	0.806	0.098
1975	124	24	49	10	41	0.893	0.107	0.733	0.159
1980	123	26	47	11	39	0.884	0.116	0.713	0.171
1985	152	25	59	13	55	0.877	0.123	0.750	0.127
1990	151	26	65	9	51	0.943	0.057	0.861	0.082
1995	170	33	83	5	49	0.929	0.071	0.836	0.094
2000	175	37	94	6	38	0.938	0.062	0.829	0.109
2005	175	42	97	6	30	0.964	0.036	0.916	0.049
2010	174	49	94	6	25	0.962	0.038	0.911	0.051
2015	180	53	100	3	24	0.985	0.015	0.974	0.011

Note:
(a) refers to the number of countries in the pseudo world.
(b) refers to the number of developed GATT/WTO member countries in the pseudo world.
(c) refers to the number of developing GATT/WTO member countries in the pseudo world.
(d) refers to the number of developed nonmember countries in the pseudo world.
(e) refers to the number of developing nonmember countries in the pseudo world.
(f) refers to the total imports of GATT/WTO member countries relative to the total imports of the pseudo world.
(g) refers to the total imports of nonmember countries relative to the total imports of the pseudo world.
(h) refers to the total imports of country pairs where both are GATT/WTO members (relative to the pseudo world).
(i) refers to the total imports of country pairs where only the importer is a GATT/WTO member (relative to the pseudo world).

Table 3: Country-Combination and Round Specific Estimates of Partial Effects of *bothwto* on $\ln \tau_{ijt}^{1-\sigma}$ (40% Caliper)

		HH				LH				HL				LL			
		bothwto				**bothwto**				**bothwto**				**bothwto**			
GATT/WTO round	caliper	estimates		95% CI		estimates		95% CI		estimates		95% CI		estimates		95% CI	
Annecy to Torquay	40%	2.92	***	2.65	3.19	2.22	***	1.86	2.62	2.42	***	1.93	2.88	0.20		-0.45	0.85
(1950-1951)	M_1	307				253				260				110			
Torquay to Geneva	40%	2.64	***	2.44	2.86	1.00	***	0.73	1.26	1.33	***	1.11	1.56	0.64	***	0.25	1.02
(1952-1956)	M_1	943				834				834				363			
Geneva to Dillon	40%	2.83	***	2.67	3.00	1.23	***	0.97	1.48	2.15	***	1.89	2.39	0.28	*	-0.06	0.69
(1957-1961)	M_1	1,103				880				879				329			
Dillon to Kennedy	40%	3.01	***	2.84	3.16	1.41	***	1.27	1.54	1.10	***	0.97	1.22	0.07		-0.12	0.27
(1962-1967)	M_1	2,204				2,765				3,054				1,349			
Kennedy to Tokyo	40%	3.69	***	3.51	3.85	1.99	***	1.92	2.08	1.71	***	1.57	1.85	0.09	*	-0.02	0.20
(1968-1979)	M_1	5,889				10,513				10,871				9,692			
Tokyo to Uruguay	40%	4.10	***	3.98	4.23	2.10	***	2.01	2.18	2.03	***	1.95	2.12	0.81	***	0.74	0.88
(1980-1994)	M_1	9,988				20,378				21,038				26,789			
after Uruguay	40%	6.77	***	6.64	6.89	5.23	***	5.15	5.31	3.43	***	3.35	3.50	0.09	***	0.04	0.15
(1995-2005)	M_1	13,663				30,299				30,857				52,405			
sample average	40%	4.08	***	4.01	4.14	1.99	***	1.95	2.03	2.38	***	2.33	2.43	0.53	***	0.49	0.57
(1950-2005)	M_1	34,097				65,922				67,793				91,037			

Note: Based on the matching estimator of Chang and Lee (2011). Significance of the estimates and their confidence intervals are calculated based on permutation tests. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. M_1 indicates the number of treated observations. HH: developed exporting and developed importing country pairs; LH: developing exporting and developed importing country pairs; HL: developed exporting and developing importing country pairs; LL: developing exporting and developing importing country pairs.

Table 4: Country-Combination and Round Specific Estimates of Partial Effects of *imwto* on $\ln \tau_{ijt}^{1-\sigma}$ (40% Caliper)

		HH				LH				HL				LL			
		imwto				**imwto**				**imwto**				**imwto**			
GATT/WTO round	caliper	estimates		95% CI		estimates		95% CI		estimates		95% CI		estimates		95% CI	
Annecy to Torquay	40%	0.99	***	0.62	1.39	1.78	***	1.39	2.19	0.53	*	-0.15	1.16	-0.26		-0.81	0.28
(1950-1951)	M_1	133				293				64				128			
Torquay to Geneva	40%	0.88	***	0.62	1.15	0.97	***	0.73	1.19	0.39	***	0.11	0.65	0.19	*	-0.06	0.44
(1952-1956)	M_1	378				1,130				251				456			
Geneva to Dillon	40%	0.72	***	0.48	0.95	0.62	***	0.45	0.80	0.22	*	-0.09	0.55	0.06		-0.19	0.33
(1957-1961)	M_1	436				1,916				225				581			
Dillon to Kennedy	40%	1.13	***	0.79	1.45	1.30	***	1.18	1.43	-0.35	**	-0.63	-0.06	0.16	**	0.00	0.33
(1962-1967)	M_1	479				3,227				318				1,590			
Kennedy to Tokyo	40%	1.98	***	1.59	2.35	1.58	***	1.48	1.67	0.27	*	-0.17	0.68	-0.01		-0.12	0.09
(1968-1979)	M_1	1,225				8,049				919				6,454			
Tokyo to Uruguay	40%	0.62	***	0.31	0.90	0.82	***	0.74	0.91	-0.03		-0.24	0.20	0.03		-0.06	0.12
(1980-1994)	M_1	2,681				14,312				2,574				13,561			
after Uruguay	40%	2.16	***	1.86	2.45	3.93	***	3.81	4.05	0.21	*	-0.08	0.50	-0.29	***	-0.38	-0.21
(1995-2005)	M_1	1,407				11,885				1,814				15,822			
sample average	40%	1.18	***	1.04	1.33	1.24	***	1.19	1.29	0.08		-0.07	0.22	-0.04	*	-0.09	0.01
(1950-2005)	M_1	6,739				40,812				6,165				38,592			

Note: Based on the matching estimator of Chang and Lee (2011). Significance of the estimates and their confidence intervals are calculated based on permutation tests. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. M_1 indicates the number of treated observations. HH: developed exporting and developed importing country pairs; LH: developing exporting and developed importing country pairs; HL: developed exporting and developing importing country pairs; LL: developing exporting and developing importing country pairs.

Table 5: Ex-post Effects of GATT/WTO (The AvW Framework; $\sigma = 5$)

		Year 1950			**Year 2015**		
% $\triangle$ in	member indicator	25%	75%	Median	25%	75%	Median
$\mathbf{W_1}$	**0**	**0.59**	**1.75**	**1.20**	**-3.66**	**-1.28**	**-2.07**
	1	**1.73**	**4.40**	**2.86**	**1.77**	**7.29**	**3.69**
$\mathbf{W_2}$	**0**	**0.49**	**2.02**	**1.41**	**-8.88**	**0.61**	**-4.41**
	1	**2.16**	**4.66**	**4.04**	**0.23**	**9.72**	**4.22**
Ex	0	49.97	141.04	96.32	20.75	86.48	43.37
	1	159.31	705.54	417.29	184.62	1598.55	318.72
Im	0	38.17	162.11	110.91	11.17	36.58	27.89
	1	207.50	811.34	393.39	77.49	546.11	184.32
Π	0	-27.84	-14.48	-22.45	-47.29	-35.35	-44.98
	1	-21.16	6.69	-9.44	-46.26	-21.19	-39.01
P	0	14.93	30.42	24.28	44.10	75.34	63.88
	1	-4.80	18.34	8.13	21.36	64.12	49.03
Y	0	15.48	33.79	25.19	39.41	67.95	56.50
	1	-2.89	26.25	11.43	27.63	69.10	52.48
E	0	15.49	34.10	25.91	33.70	64.95	49.86
	1	-2.06	26.54	11.44	25.15	71.20	49.98
s	0	5.67	22.43	14.55	29.16	55.61	45.00
	1	-11.14	15.53	1.96	18.25	56.67	41.27
e	0	5.68	22.71	15.21	23.88	52.83	38.85
	1	-10.38	15.79	1.97	15.96	58.62	38.96
w	0	15.48	33.79	25.19	39.41	67.95	56.50
	1	-2.89	26.25	11.43	27.63	69.10	52.48
c	0	15.34	31.73	24.66	43.98	70.36	63.78
	1	-3.60	22.04	9.73	21.60	65.92	50.62

Note: The AvW framework is used. The analysis is based on the estimates in Tables 3 and 4 that are significant at 10% level, using parameters $\sigma = 5$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 6: Ex-post Effects of GATT/WTO (The Krugman Framework; $\sigma = 5$)

		Year 1950			Year 2015		
% △ in	member indicator	25%	75%	Median	25%	75%	Median
$\mathbf{W_1}$	**0**	**0.99**	**2.74**	**1.87**	**-5.21**	**-1.77**	**-2.75**
	1	**2.54**	**6.66**	**4.50**	**2.84**	**11.36**	**5.58**
$\mathbf{W_2}$	**0**	**0.95**	**2.88**	**2.13**	**-9.28**	**-0.31**	**-4.76**
	1	**3.09**	**7.17**	**5.27**	**1.47**	**14.07**	**5.84**
N	0	0.60	1.60	1.09	-3.10	-1.04	-1.63
	1	1.48	3.76	2.63	1.59	6.50	3.23
Ex	0	51.23	143.45	98.28	9.22	82.59	36.72
	1	161.90	719.85	422.92	173.60	1516.97	294.39
Im	0	39.24	166.13	112.53	5.22	29.94	22.54
	1	212.61	828.84	399.19	71.28	519.56	174.44
Π	0	-28.11	-14.62	-22.62	-44.20	-31.74	-41.87
	1	-21.80	6.47	-9.78	-43.27	-17.43	-35.60
P	0	15.18	30.69	24.61	37.03	67.09	55.83
	1	-4.68	18.34	8.23	15.31	55.94	41.09
Y	0	15.92	35.43	26.03	32.87	57.84	45.51
	1	-2.15	27.66	12.61	22.63	62.89	46.35
E	0	15.92	35.74	26.75	28.94	55.29	41.84
	1	-0.75	27.96	12.62	20.36	64.08	43.92
s	0	5.18	22.89	14.35	27.16	51.06	39.26
	1	-11.21	15.84	2.18	17.36	55.89	40.06
e	0	5.19	23.17	15.01	23.40	48.62	35.75
	1	-9.94	16.11	2.19	15.19	57.04	37.74
w	0	15.92	35.43	26.03	32.87	57.84	45.51
	1	-2.15	27.66	12.61	22.63	62.89	46.35
c	0	15.71	32.78	25.19	36.93	60.88	55.71
	1	-3.03	24.12	10.72	17.58	58.77	43.44

Note: The Krugman framework is used. The analysis is based on the estimates in Tables 3 and 4 that are significant at 10% level, using parameters $\sigma = 5$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 7: Ex-post Effects of GATT/WTO (The Melitz Framework; $\sigma = 5$ and $\theta = 5$)

		Year 1950			Year 2015		
% △ in	member indicator	25%	75%	Median	25%	75%	Median
$\mathbf{W_1}$	**0**	**0.80**	**2.22**	**1.54**	**-4.09**	**-1.10**	**-1.76**
	1	**2.02**	**5.46**	**3.71**	**2.39**	**9.39**	**4.66**
$\mathbf{W_2}$	**0**	**0.77**	**2.38**	**1.74**	**-6.98**	**-0.03**	**-3.22**
	1	**2.48**	**5.71**	**4.27**	**1.40**	**11.28**	**4.77**
N	0	0.49	1.30	0.90	-2.43	-0.65	-1.04
	1	1.18	3.05	2.17	1.36	5.41	2.64
Ex	0	41.58	122.68	82.24	10.15	74.03	28.27
	1	141.81	656.31	388.32	160.35	1525.63	267.21
Im	0	30.32	142.06	94.75	8.72	27.66	18.73
	1	183.45	768.24	363.47	72.99	504.35	161.71
Π	0	-19.13	-7.62	-14.33	-38.19	-28.57	-36.34
	1	-13.47	9.84	-3.49	-37.31	-16.04	-31.28
P	0	6.81	17.78	13.43	32.00	55.00	46.72
	1	-7.96	8.70	1.67	16.00	43.95	34.60
Y	0	7.39	21.14	14.57	30.18	47.08	39.37
	1	-5.97	15.60	4.93	22.29	51.86	40.03
E	0	7.39	21.35	15.07	27.36	46.73	36.82
	1	-4.94	15.81	4.94	20.34	51.12	37.84
s	0	4.04	17.36	10.99	19.78	35.32	28.23
	1	-8.90	11.99	1.66	12.51	39.72	28.84
e	0	4.04	17.56	11.48	17.18	35.00	25.89
	1	-7.91	12.19	1.66	10.72	39.04	26.82
w	0	7.39	21.14	14.57	30.18	47.08	39.37
	1	-5.97	15.60	4.93	22.29	51.86	40.03
c	0	7.23	19.27	13.90	33.08	49.41	45.92
	1	-6.65	12.98	3.54	16.94	47.73	37.27

Note: The Melitz framework is used. The analysis is based on the estimates in Tables 3 and 4 that are significant at 10% level, using parameters $\sigma = 5$, $\theta = 5$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 8: Ex-post Effects of GATT/WTO (The Melitz Framework; $\sigma = 5$ and $\theta = 5.5$)

		Year 1950			Year 2015		
% △ in	member indicator	25%	75%	Median	25%	75%	Median
$\mathbf{W_1}$	**0**	**0.73**	**2.03**	**1.42**	**-3.62**	**-0.90**	**-1.44**
	1	**1.83**	**4.96**	**3.41**	**2.18**	**8.68**	**4.24**
$\mathbf{W_2}$	**0**	**0.70**	**2.19**	**1.60**	**-6.22**	**0.02**	**-2.78**
	1	**2.26**	**5.19**	**3.90**	**1.34**	**10.25**	**4.38**
N	0	0.44	1.19	0.83	-2.14	-0.53	-0.85
	1	1.07	2.80	2.00	1.25	4.99	2.41
Ex	0	41.10	120.12	80.41	9.35	69.45	25.75
	1	139.81	649.83	386.24	151.69	1512.04	256.89
Im	0	29.87	138.80	92.65	8.93	26.12	16.67
	1	179.36	766.11	362.97	71.64	505.74	151.68
Π	0	-17.38	-6.89	-12.96	-35.57	-26.66	-33.61
	1	-12.12	8.87	-3.12	-34.58	-14.82	-29.03
P	0	6.10	15.83	11.96	28.56	49.00	41.86
	1	-7.25	7.67	1.47	14.82	39.28	31.47
Y	0	6.63	18.82	13.01	27.86	42.10	35.85
	1	-5.42	13.90	4.41	20.87	46.42	36.12
E	0	6.63	19.00	13.46	25.42	41.90	33.67
	1	-4.49	14.08	4.42	19.06	45.57	34.39
s	0	3.64	15.48	9.84	17.39	30.46	24.72
	1	-8.07	10.70	1.48	10.96	34.42	24.96
e	0	3.64	15.66	10.27	15.14	30.27	22.72
	1	-7.18	10.87	1.48	9.30	33.64	23.38
w	0	6.63	18.82	13.01	27.86	42.10	35.85
	1	-5.42	13.90	4.41	20.87	46.42	36.12
c	0	6.48	17.16	12.40	30.36	44.60	41.18
	1	-6.04	11.52	3.16	15.66	42.85	33.83

Note: The Melitz framework is used. The analysis is based on the estimates in Tables 3 and 4 that are significant at 10% level, using parameters $\sigma = 5$, $\theta = 5.5$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 9: Sensitivity Analysis; Median Ex-post Welfare Effects of GATT/WTO

		Year 1950			**Year 2015**		
parameters	member indicator	AvW	Krugman	Melitz	AvW	Krugman	Melitz
1. 40% caliper, σ=5, θ=4.5	0	1.20	1.87	1.69	-2.07	-2.75	-2.17
	1	2.86	4.50	4.07	3.69	5.58	5.01
2. **40% caliper, σ=5, θ=5**	**0**	**1.20**	**1.87**	**1.54**	**-2.07**	**-2.75**	**-1.76**
(benchmark)	**1**	**2.86**	**4.50**	**3.71**	**3.69**	**5.58**	**4.66**
3. 40% caliper, σ=5, θ=5.5	0	1.20	1.87	1.42	-2.07	-2.75	-1.44
	1	2.86	4.50	3.41	3.69	5.58	4.24
4. 40% caliper, σ=5, θ=6	0	1.20	1.87	1.31	-2.07	-2.75	-1.25
	1	2.86	4.50	3.15	3.69	5.58	3.88
5. 40% caliper, σ=5, θ=8	0	1.20	1.87	1.03	-2.07	-2.75	-0.79
	1	2.86	4.50	2.40	3.69	5.58	2.90
6. 40% caliper, σ=5, θ=10	0	1.20	1.87	0.83	-2.07	-2.75	-0.60
	1	2.86	4.50	1.94	3.69	5.58	2.31
7. 40% caliper, σ=10, θ=10	0	0.55	0.65	0.59	-0.41	-0.47	-0.42
	1	1.26	1.50	1.36	1.65	1.96	1.76
8. 100% caliper, σ=5, θ=4.5	0	1.23	1.91	1.73	-3.54	-5.22	-4.48
	1	2.96	4.64	4.15	3.88	6.06	5.40
9. 100% caliper, σ=5, θ=5	0	1.23	1.91	1.58	-3.54	-5.22	-3.92
	1	2.96	4.64	3.78	3.88	6.06	4.87
10. 100% caliper, σ=5, θ=5.5	0	1.23	1.91	1.45	-3.54	-5.22	-3.49
	1	2.96	4.64	3.47	3.88	6.06	4.43
11. 100% caliper, σ=5, θ=6	0	1.23	1.91	1.34	-3.54	-5.22	-3.14
	1	2.96	4.64	3.20	3.88	6.06	4.07
12. 100% caliper, σ=5, θ=8	0	1.23	1.91	1.03	-3.54	-5.22	-2.19
	1	2.96	4.64	2.45	3.88	6.06	3.11
13. 100% caliper, σ=5, θ=10	0	1.23	1.91	0.83	-3.54	-5.22	-1.65
	1	2.96	4.64	1.97	3.88	6.06	2.48
14. 100% caliper, σ=10, θ=10	0	0.56	0.66	0.60	-0.97	-1.14	-0.96
	1	1.29	1.53	1.39	1.78	2.12	1.90

Note: The parameter value for θ is relevant only for the Melitz model. This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 10: Sensitivity Analysis; 75 percentile Ex-post Welfare Effects of GATT/WTO

parameters	member indicator	Year 1950 AvW	Year 1950 Krugman	Year 1950 Melitz	Year 2015 AvW	Year 2015 Krugman	Year 2015 Melitz
1. 40% caliper, σ=5, θ=4.5	0	1.75	2.74	2.45	-1.28	-1.77	-1.37
	1	4.40	6.66	5.99	7.29	11.36	10.35
2. 40% caliper, σ=5, θ=5	**0**	**1.75**	**2.74**	**2.22**	**-1.28**	**-1.77**	**-1.10**
(benchmark)	**1**	**4.40**	**6.66**	**5.46**	**7.29**	**11.36**	**9.39**
3. 40% caliper, σ=5, θ=5.5	0	1.75	2.74	2.03	-1.28	-1.77	-0.90
	1	4.40	6.66	4.96	7.29	11.36	8.68
4. 40% caliper, σ=5, θ=6	0	1.75	2.74	1.87	-1.28	-1.77	-0.76
	1	4.40	6.66	4.53	7.29	11.36	8.06
5. 40% caliper, σ=5, θ=8	0	1.75	2.74	1.44	-1.28	-1.77	-0.43
	1	4.40	6.66	3.38	7.29	11.36	6.07
6. 40% caliper, σ=5, θ=10	0	1.75	2.74	1.16	-1.28	-1.77	-0.29
	1	4.40	6.66	2.69	7.29	11.36	4.89
7. 40% caliper, σ=10, θ=10	0	0.82	0.97	0.88	0.09	0.10	0.10
	1	1.85	2.20	1.98	3.19	3.80	3.45
8. 100% caliper, σ=5, θ=4.5	0	1.93	3.01	2.70	-0.78	-1.13	-0.94
	1	4.56	6.91	6.15	7.27	11.44	10.79
9. 100% caliper, σ=5, θ=5	0	1.93	3.01	2.45	-0.78	-1.13	-0.80
	1	4.56	6.91	5.60	7.27	11.44	9.75
10. 100% caliper, σ=5, θ=5.5	0	1.93	3.01	2.24	-0.78	-1.13	-0.70
	1	4.56	6.91	5.12	7.27	11.44	8.84
11. 100% caliper, σ=5, θ=6	0	1.93	3.01	2.06	-0.78	-1.13	-0.62
	1	4.56	6.91	4.68	7.27	11.44	8.12
12. 100% caliper, σ=5, θ=8	0	1.93	3.01	1.56	-0.78	-1.13	-0.42
	1	4.56	6.91	3.49	7.27	11.44	6.07
13. 100% caliper, σ=5, θ=10	0	1.93	3.01	1.26	-0.78	-1.13	-0.32
	1	4.56	6.91	2.78	7.27	11.44	4.84
14. 100% caliper, σ=10, θ=10	0	0.90	1.07	0.97	-0.15	-0.18	-0.16
	1	1.90	2.26	2.04	3.23	3.84	3.47

Note: The parameter value for θ is relevant only for the Melitz model. This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 11: Sensitivity Analysis; 25 percentile Ex-post Welfare Effects of GATT/WTO

		Year 1950			Year 2015		
parameters	member indicator	AvW	Krugman	Melitz	AvW	Krugman	Melitz
1. 40% caliper, σ=5, θ=4.5	0	0.59	0.99	0.88	-3.66	-5.21	-4.60
	1	1.73	2.54	2.25	1.77	2.84	2.56
2. 40% caliper, σ=5, θ=5	**0**	**0.59**	**0.99**	**0.80**	**-3.66**	**-5.21**	**-4.09**
(benchmark)	**1**	**1.73**	**2.54**	**2.02**	**1.77**	**2.84**	**2.39**
3. 40% caliper, σ=5, θ=5.5	0	0.59	0.99	0.73	-3.66	-5.21	-3.62
	1	1.73	2.54	1.83	1.77	2.84	2.18
4. 40% caliper, σ=5, θ=6	0	0.59	0.99	0.67	-3.66	-5.21	-3.24
	1	1.73	2.54	1.68	1.77	2.84	2.00
5. 40% caliper, σ=5, θ=8	0	0.59	0.99	0.51	-3.66	-5.21	-2.28
	1	1.73	2.54	1.26	1.77	2.84	1.53
6. 40% caliper, σ=5, θ=10	0	0.59	0.99	0.41	-3.66	-5.21	-1.76
	1	1.73	2.54	1.02	1.77	2.84	1.24
7. 40% caliper, σ=10, θ=10	0	0.28	0.34	0.31	-0.86	-1.01	-0.89
	1	0.70	0.83	0.74	0.90	1.08	0.97
8. 100% caliper, σ=5, θ=4.5	0	0.77	1.29	1.15	-5.83	-8.27	-7.10
	1	1.98	2.92	2.62	2.24	3.42	3.11
9. 100% caliper, σ=5, θ=5	0	0.77	1.29	1.04	-5.83	-8.27	-6.21
	1	1.98	2.92	2.36	2.24	3.42	2.85
10. 100% caliper, σ=5, θ=5.5	0	0.77	1.29	0.95	-5.83	-8.27	-5.53
	1	1.98	2.92	2.16	2.24	3.42	2.61
11. 100% caliper, σ=5, θ=6	0	0.77	1.29	0.87	-5.83	-8.27	-4.97
	1	1.98	2.92	1.98	2.24	3.42	2.40
12. 100% caliper, σ=5, θ=8	0	0.77	1.29	0.66	-5.83	-8.27	-3.55
	1	1.98	2.92	1.50	2.24	3.42	1.82
13. 100% caliper, σ=5, θ=10	0	0.77	1.29	0.53	-5.83	-8.27	-2.81
	1	1.98	2.92	1.20	2.24	3.42	1.46
14. 100% caliper, σ=10, θ=10	0	0.36	0.44	0.40	-1.63	-1.92	-1.69
	1	0.87	1.02	0.92	0.99	1.18	1.06

Note: The parameter value for θ is relevant only for the Melitz model. This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 12: Country-Combination and Round Specific Estimates of Partial Effects of *bothwto* on $\ln \tau_{ijt}^{1-\sigma}$ (100% Caliper)

		HH				LH				HL				LL			
		bothwto				**bothwto**				**bothwto**				**bothwto**			
GATT/WTO round	caliper	estimates		95% CI		estimates		95% CI		estimates		95% CI		estimates		95% CI	
Annecy to Torquay	100%	3.54	***	3.34	3.77	2.25	***	1.97	2.48	2.56	***	2.28	2.84	0.33	*	-0.14	0.81
(1950-1951)	M_1	307				253				260				110			
Torquay to Geneva	100%	3.07	***	2.94	3.19	1.48	***	1.28	1.68	2.02	***	1.85	2.20	0.68	***	0.44	0.89
(1952-1956)	M_1	943				834				834				363			
Geneva to Dillon	100%	3.57	***	3.46	3.67	1.80	***	1.62	1.97	2.74	***	2.58	2.90	0.68	***	0.41	0.95
(1957-1961)	M_1	1,103				880				879				329			
Dillon to Kennedy	100%	4.22	***	4.12	4.33	1.59	***	1.50	1.68	2.37	***	2.27	2.46	0.11	**	-0.01	0.23
(1962-1967)	M_1	2,204				2,765				3,054				1,349			
Kennedy to Tokyo	100%	3.15	***	3.05	3.25	1.94	***	1.89	2.00	2.40	***	2.32	2.47	0.49	***	0.42	0.56
(1968-1979)	M_1	5,889				10,513				10,871				9,692			
Tokyo to Uruguay	100%	7.07	***	6.98	7.17	2.16	***	2.10	2.21	2.89	***	2.84	2.95	0.74	***	0.69	0.79
(1980-1994)	M_1	9,988				20,378				21,038				26,789			
after Uruguay	100%	7.74	***	7.67	7.81	3.72	***	3.67	3.77	4.34	***	4.29	4.38	0.17	***	0.14	0.21
(1995-2005)	M_1	13,663				30,299				30,857				52,405			
sample average	100%	6.22	***	6.17	6.27	2.81	***	2.77	2.84	3.44	***	3.41	3.47	0.38	***	0.35	0.40
(1950-2005)	M_1	34,097				65,922				67,793				91,037			

Note: Based on the matching estimator of Chang and Lee (2011). Significance of the estimates and their confidence intervals are calculated based on permutation tests. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. M_1 indicates the number of treated observations. HH: developed exporting and developed importing country pairs; LH: developing exporting and developed importing country pairs; HL: developed exporting and developing importing country pairs; LL: developing exporting and developing importing country pairs.

Table 13: Country-Combination and Round Specific Estimates of Partial Effects of *imwto* on $\ln \tau_{ijt}^{1-\sigma}$ (100% Caliper)

		HH				LH				HL				LL			
		imwto				**imwto**				**imwto**				**imwto**			
GATT/WTO round	caliper	estimates		95% CI		estimates		95% CI		estimates		95% CI		estimates		95% CI	
Annecy to Torquay	100%	1.42	***	1.11	1.72	1.87	***	1.57	2.16	0.17		-0.23	0.57	0.10		-0.23	0.46
(1950-1951)	M_1	133				293				64				128			
Torquay to Geneva	100%	1.35	***	1.13	1.55	1.37	***	1.21	1.54	0.17	*	-0.03	0.38	0.08		-0.12	0.30
(1952-1956)	M_1	378				1,130				251				456			
Geneva to Dillon	100%	1.51	***	1.32	1.68	1.31	***	1.19	1.44	0.23	**	-0.01	0.46	0.07		-0.12	0.25
(1957-1961)	M_1	436				1,916				225				581			
Dillon to Kennedy	100%	2.02	***	1.81	2.24	1.74	***	1.65	1.82	-0.06		-0.28	0.16	0.12	**	0.02	0.22
(1962-1967)	M_1	479				3,227				318				1,590			
Kennedy to Tokyo	100%	1.71	***	1.47	1.97	1.64	***	1.58	1.71	0.33	***	0.07	0.57	0.14	***	0.06	0.22
(1968-1979)	M_1	1,225				8,049				919				6,454			
Tokyo to Uruguay	100%	2.55	***	2.37	2.72	1.35	***	1.28	1.42	0.14	**	-0.03	0.30	0.15	***	0.09	0.22
(1980-1994)	M_1	2,681				14,312				2,574				13,561			
after Uruguay	100%	3.25	***	3.05	3.45	3.94	***	3.86	4.01	0.48	***	0.29	0.66	-0.15	***	-0.21	-0.09
(1995-2005)	M_1	1,407				11,885				1,814				15,822			
sample average	100%	2.35	***	2.26	2.45	2.19	***	2.16	2.23	0.26	***	0.17	0.36	0.02		-0.01	0.06
(1950-2005)	M_1	6,739				40,812				6,165				38,592			

Note: Based on the matching estimator of Chang and Lee (2011). Significance of the estimates and their confidence intervals are calculated based on permutation tests. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. M_1 indicates the number of treated observations. HH: developed exporting and developed importing country pairs; LH: developing exporting and developed importing country pairs; HL: developed exporting and developing importing country pairs; LL: developing exporting and developing importing country pairs.

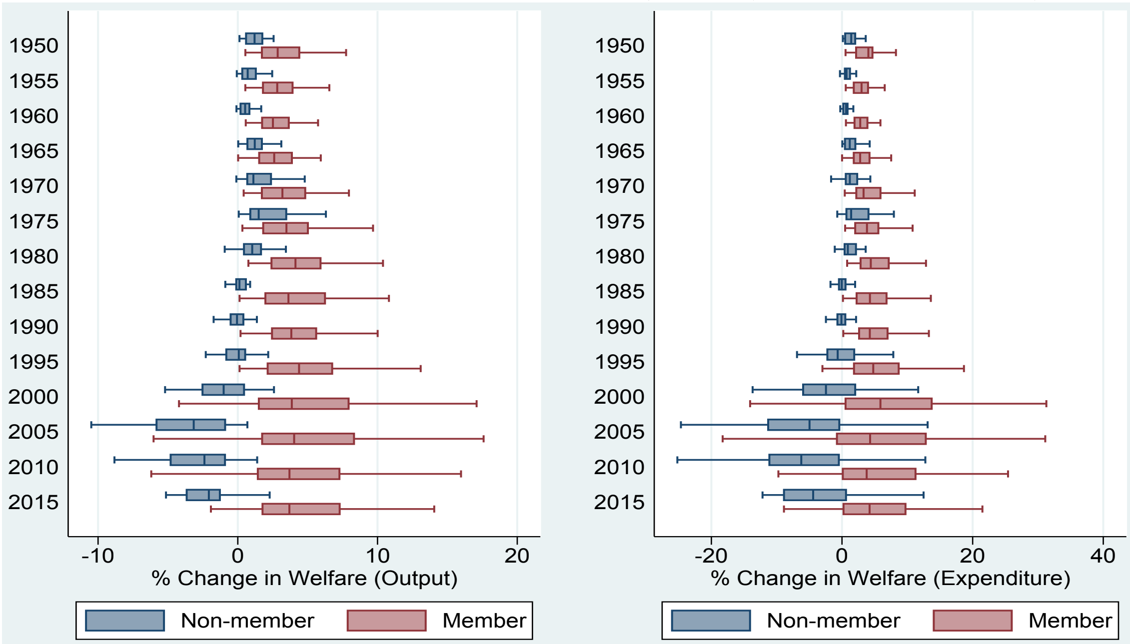
Table 14: Estimates of Partial Effects of PTA on $\ln \tau_{ijt}^{1-\sigma}$

HH					LH				
	PTA					**PTA**			
caliper	estimates		95% CI		caliper	estimates		95% CI	
100%	1.93	***	1.88	1.98	100%	1.65	***	1.55	1.74
40%	1.26	***	1.20	1.32	40%	1.25	***	1.14	1.37
M_1	9,667				M_1	3,931			

HL					LL				
	PTA					**PTA**			
caliper	estimates		95% CI		caliper	estimates		95% CI	
100%	1.46	***	1.39	1.54	100%	1.54	***	1.48	1.61
40%	1.12	***	1.02	1.20	40%	1.34	***	1.24	1.44
M_1	3,936				M_1	11,682			

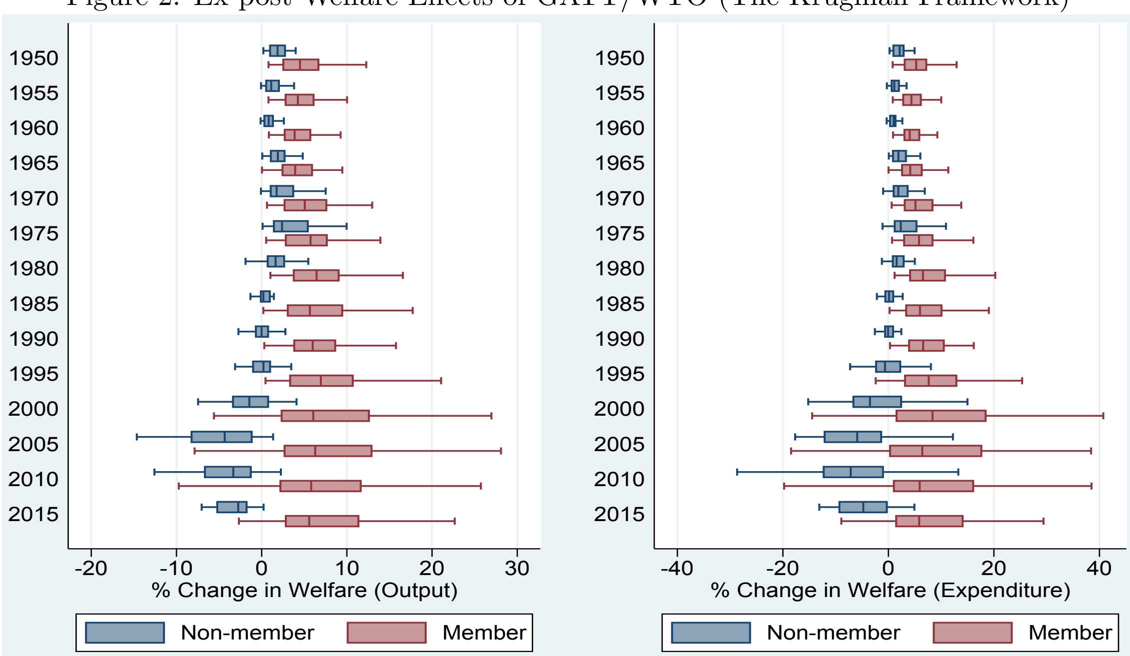
Note: See Table 3 footnote.

Figure 1: Ex-post Welfare Effects of GATT/WTO (The AvW Framework)



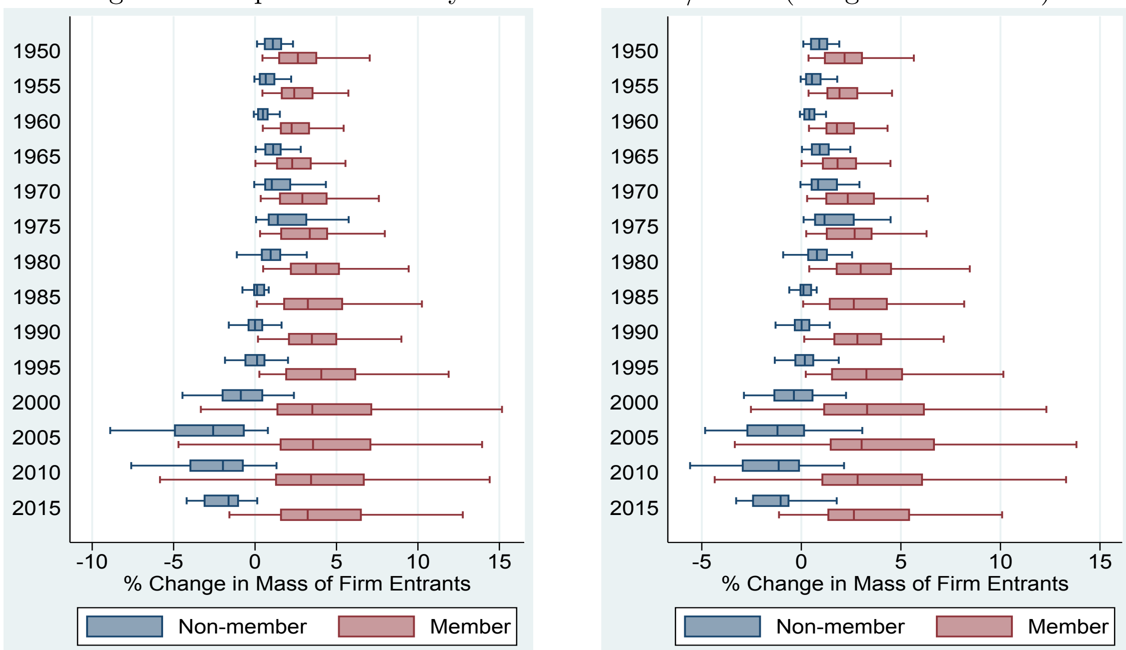
Note: See Table 5 footnote. In each year, two box plots are drawn that indicate the 25 percentile (the lower hinge of the box), the median, and the 75 percentile (the upper hinge of the box) of the effects for members (in red) and nonmembers (in blue), respectively. Outliers are omitted in the graphs.

Figure 2: Ex-post Welfare Effects of GATT/WTO (The Krugman Framework)



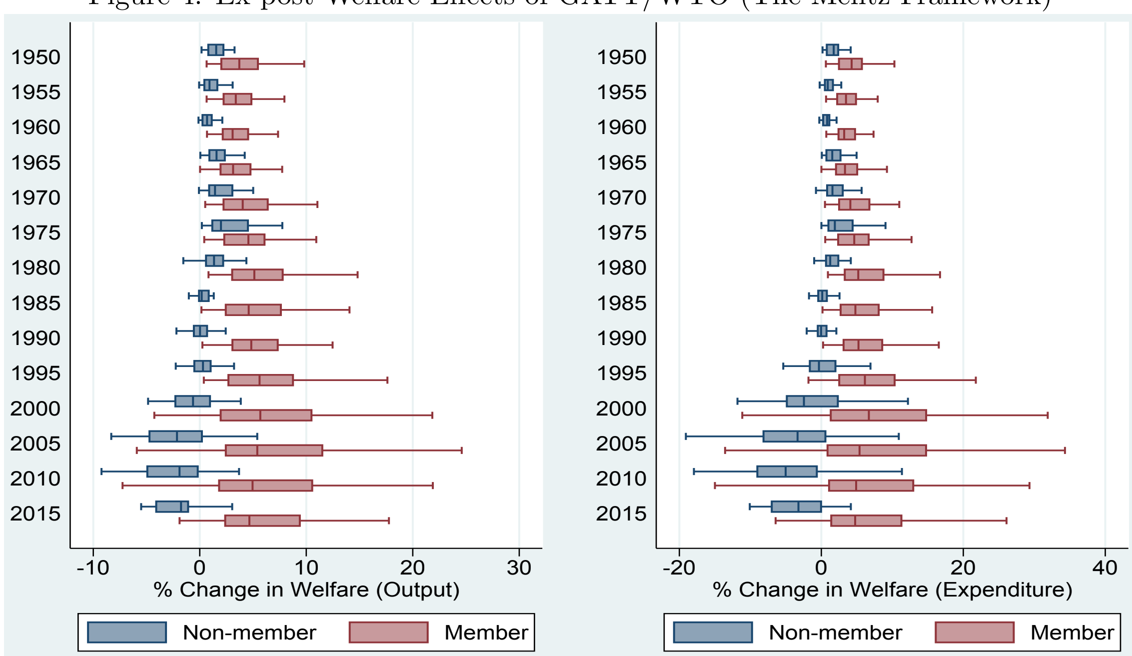
Note: See Table 6 footnote. In each year, two box plots are drawn that indicate the 25 percentile (the lower hinge of the box), the median, and the 75 percentile (the upper hinge of the box) of the effects for members (in red) and nonmembers (in blue), respectively. Outliers are omitted in the graphs.

Figure 3: Ex-post Firm Entry Effects of GATT/WTO (Krugman vs Melitz)



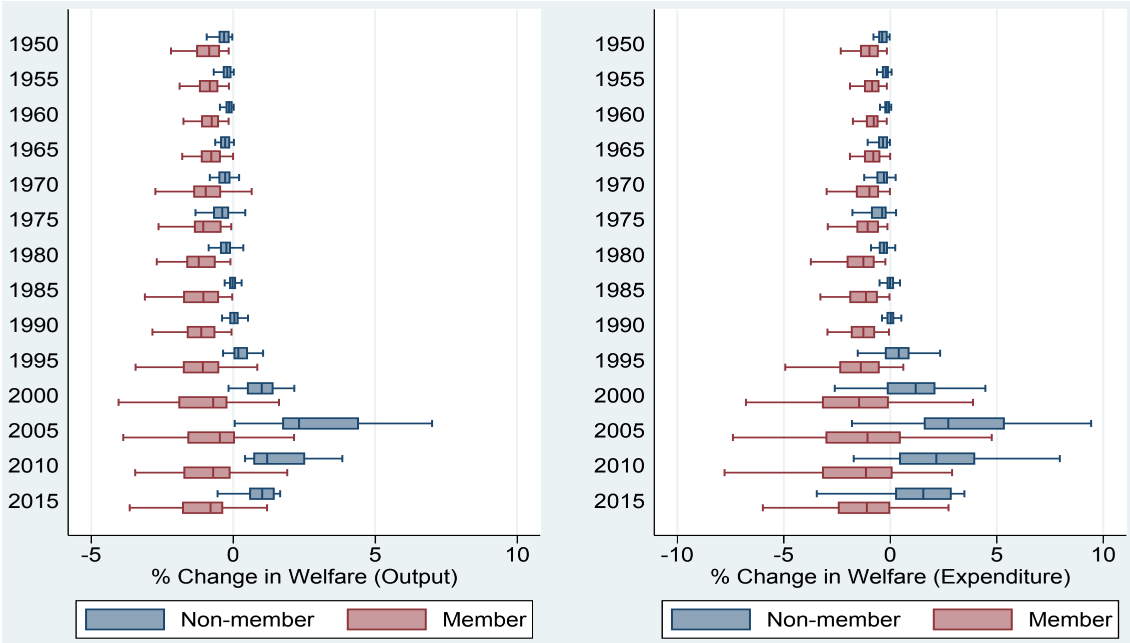
Note: Krugman on the left; Meltiz on the right. See Tables 6 and 7 footnotes. In each year, two box plots are drawn that indicate the 25 percentile (the lower hinge of the box), the median, and the 75 percentile (the upper hinge of the box) of the effects for members (in red) and nonmembers (in blue), respectively. Outliers are omitted in the graphs.

Figure 4: Ex-post Welfare Effects of GATT/WTO (The Melitz Framework)



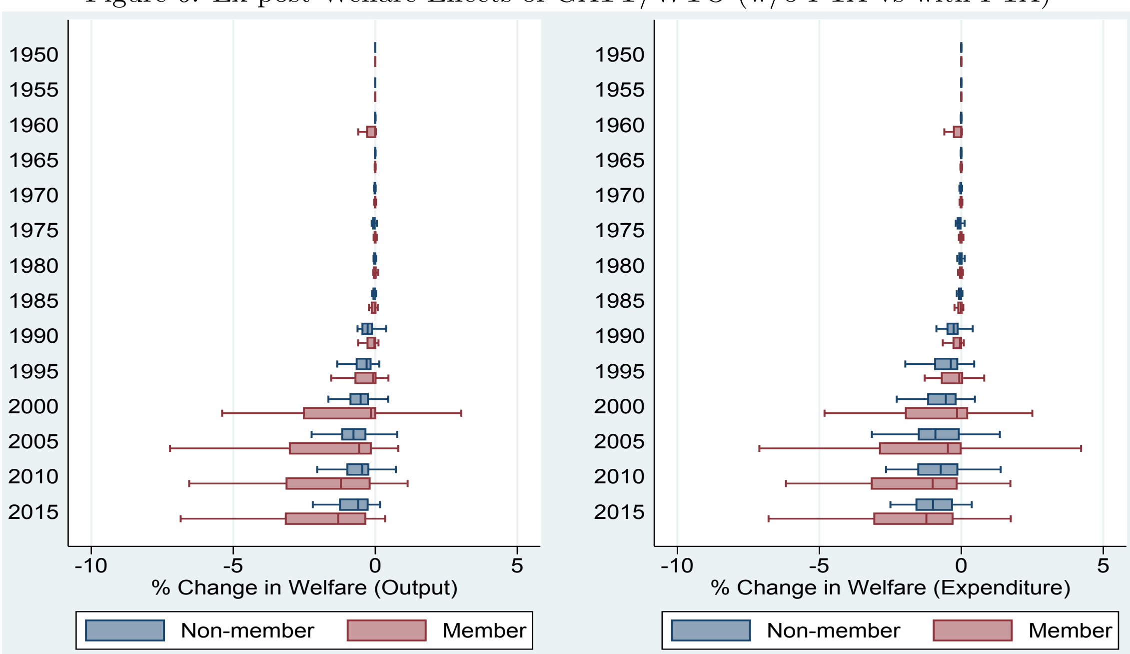
Note: See Table 7 footnote. In each year, two box plots are drawn that indicate the 25 percentile (the lower hinge of the box), the median, and the 75 percentile (the upper hinge of the box) of the effects for members (in red) and nonmembers (in blue), respectively. Outliers are omitted in the graphs.

Figure 5: Ex-post Welfare Effects of GATT/WTO (Melitz relative to Krugman)



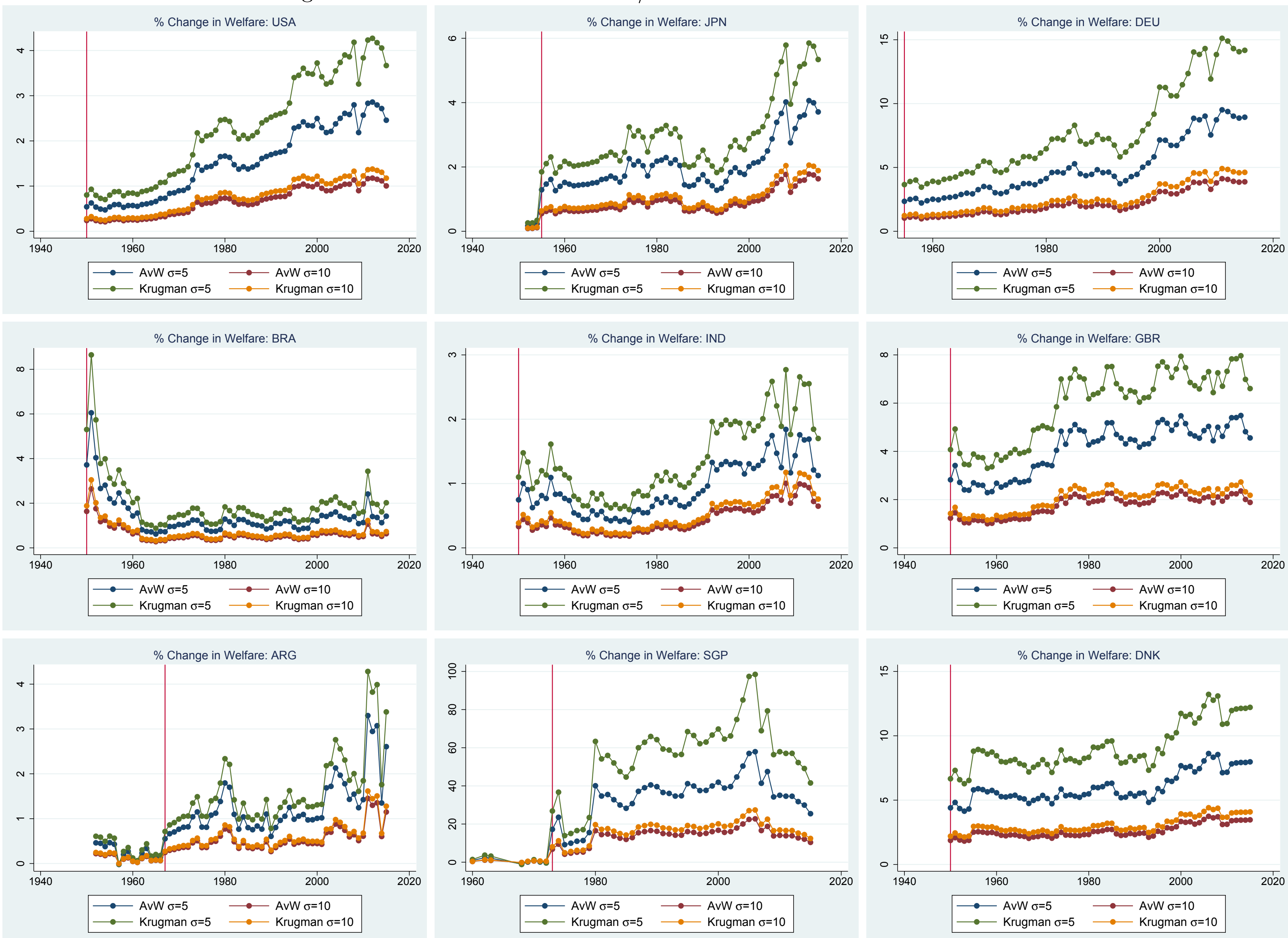
Note: See Tables 6 and 7 footnotes. This figure compares the difference between the Melitz framework relative to the Krugman framework in their effects for members (in red) and nonmembers (in blue), respectively: $(W_M - W_K)/W_K$. Outliers are omitted in the graphs.

Figure 6: Ex-post Welfare Effects of GATT/WTO (w/o PTA vs with PTA)



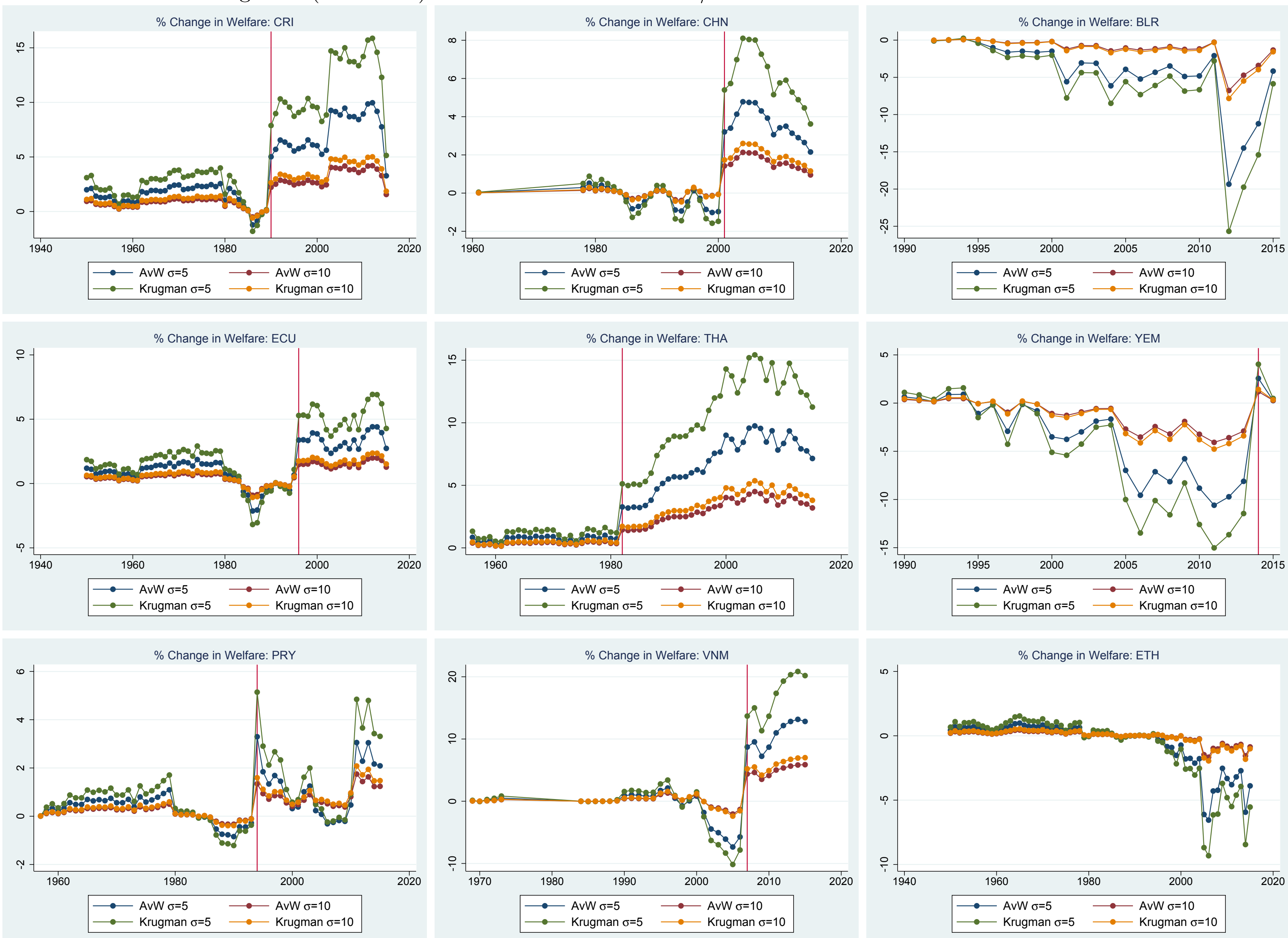
Note: The AvW framework is used. The analysis is based on the 40% caliper estimates in Tables 3, 4 and 14 that are significant at 10% level, using parameters $\sigma = 5$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the ex-post effects of GATT/WTO under the scenario had all the PTAs not existed relative to the scenario of factual PTAs. Outliers are omitted in the graphs.

Figure 7: Welfare Effects of GATT/WTO for a selected set of countries



Note: The analysis is based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the AvW or Krugman framework with parameters $\sigma = \{5, 10\}$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

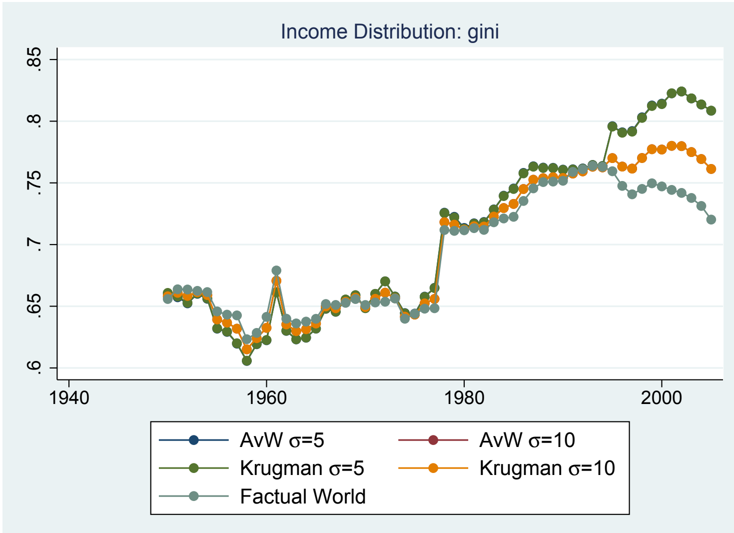
Figure 7 (continued): Welfare Effects of GATT/WTO for a selected set of countries



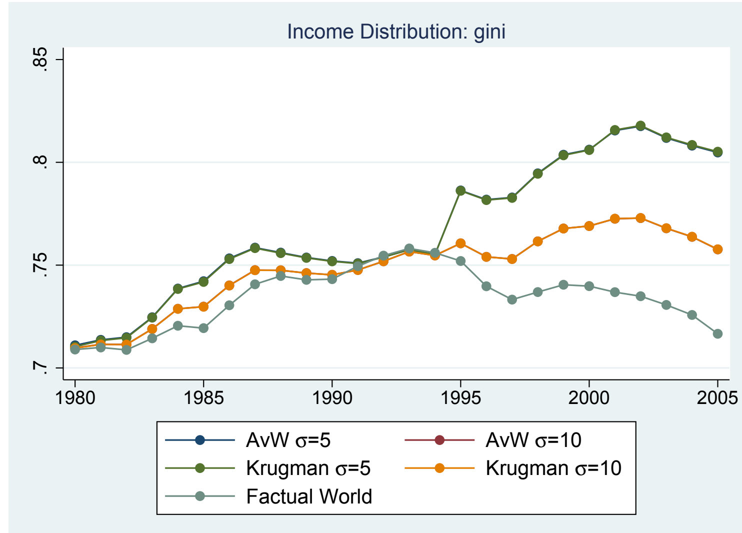
Note: The analysis is based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the AvW or Krugman framework with parameters $\sigma = \{5, 10\}$ and β_i from Caliendo and Parro (2015). This counterfactual evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Figure 8: Income Inequality Effects of GATT/WTO

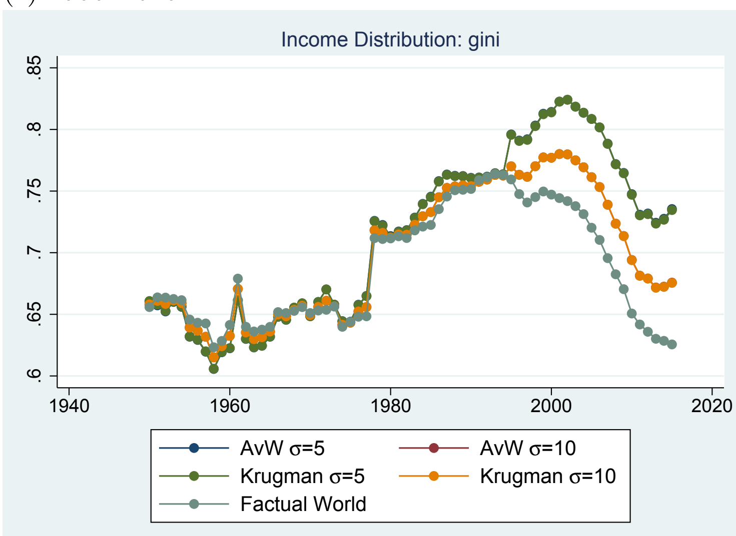
(a) 1950–2005: all available countries



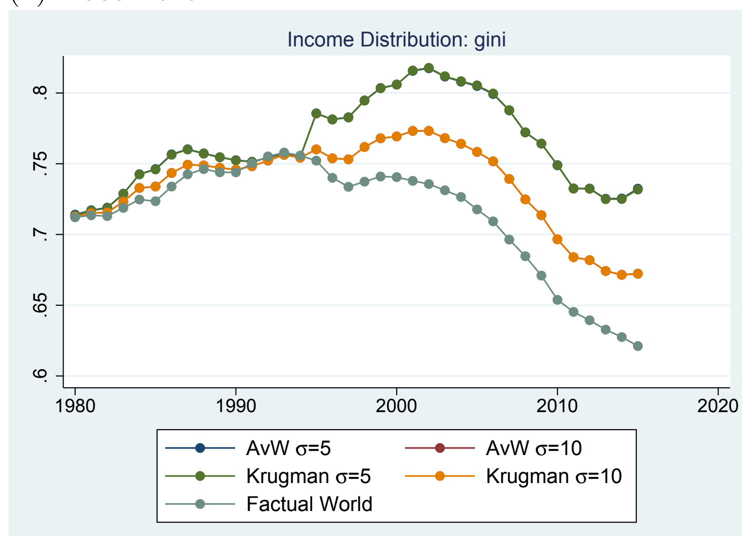
(b): 1980–2005: 118 common countries



(c) 1950–2015: all available countries



(d): 1980–2015: 111 common countries



Note: The analysis is based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the AvW or Krugman framework with parameters $\sigma = \{5, 10\}$ and β_i from Caliendo and Parro (2015). The Gini coefficient is calculated using the factual GDP per capita data (weighted by country populations) against the counterfactual had the GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).