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The GATT/WTO welfare effects: 1950–2015

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Abstract

This paper evaluates the welfare effects of GATT/WTO-induced reductions in tariffs, variable and fixed trade costs, based on identified direct effects of membership indicators on trade flows via nonparametric matching estimations. The identification does not require the use of tariff data, which permits a comprehensive evaluation of the welfare impact of GATT/WTO for a long panel since its inception (1950–2015) of as many as 180 economies. The results indicate substantial (but highly dispersed) welfare gains across members of different development stages and increasing welfare losses of nonmembers in later decades by staying outside the system. An extensive set of robustness checks with respect to model specifications, parameter values, and matching estimations are provided. We also characterize the effects of GATT/WTO on cross-country income disparity, its complementarity with preferential trade agreements, and the welfare impacts of China's WTO entry on the other economies.

Key Words: matching estimation; quantitative analysis; welfare; firm entry; income disparity
JEL Classification: F13; F14; F17

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1 Introduction

International trade has grown substantially since the Second World War, and the GATT/WTO has played a central role in coordinating trade policy across countries via multilateral trade negotiations. Not only have tariffs been lowered substantially from their historical high (witnessed during the Great Depression), but nontariff barriers have also become increasingly regulated under the GATT/WTO. Meanwhile, the global economy has grown steadily in spite of interruptions by a few major negative shocks, such as the 2009 financial crisis.

Nonetheless, we are seeing rising sentiment against globalization and an impasse in trade negotiations at the current Doha Round of multilateral trade talks. It is thus important to provide a historical assessment of what the GATT/WTO has imparted to the world economy. In this paper, we evaluate the welfare effects of GATT/WTO for each country (as many as 180 countries where data permit) in each year for the entire GATT/WTO history during 1950–2015. In addition to the main analysis, we also evaluate three policy questions surrounding the institution: (i) whether the GATT/WTO has improved or worsened the cross-country income disparity; (ii) whether the provision of preferential trade agreements (PTAs) has facilitated or inhibited multilateral trade liberalization; and (iii) how China's accession to the GATT/WTO in 2001 has impacted the other countries.

We build a generalized Melitz (2003) framework to allow for tariffs and trade costs (variable/fixed), intermediate inputs in the production and entry process, and trade imbalances. This leads to an estimable trade flow equation that allows us to identify the direct effects of GATT/WTO membership status (of the bilateral trading country pairs) on trade flows. The identified trade effects map to underlying changes in tariffs, variable and fixed trade costs. These inputs when coupled with information on tariff data (factual versus counterfactual had the GATT/WTO not existed) allow us to simulate the comprehensive welfare effects of GATT/WTO based on the structural framework developed above, which takes into account trade barrier changes due to tariffs, variable and fixed trade costs, and the effect of tariff revenues in income and expenditures.

The need to compile factual tariffs and to impute counterfactual tariffs (the noncooperative tariffs that countries would impose in the scenario without GATT/WTO) poses great challenges in implementing the quantitative analysis. As documented by Anderson and van Wincoop (2004, pp. 694–695), public tariff data are available only since 1988 from TRAINS, and even then, the entries are plagued with substantial incompleteness. We thus: (i) propose an algorithm to impute the noncooperative tariffs based on the tariffs the country imposes before joining the GATT/WTO (if available) and the tariffs the country imposes against nonmembers; (ii) for 1988–2015 when such tariff compilation is feasible, demonstrate that focusing on tariff changes alone understates by a large margin the full extent of trade liberalization and the full welfare effects of the GATT/WTO; and (iii) show that by using the identified direct trade effects of GATT/WTO membership indicators (which reflects the effects of changes in tariffs and trade costs on trade) as inputs in the same structural framework but ignoring the tariff revenues in income generates quantitative effects that are in similar orders of magnitudes as the full welfare effects for the period 1988–2015 (when compilation of tariffs is feasible). Given these observations, we then propose to proceed with the main analysis based on the approximation approach (that ignores tariff revenues in income but otherwise captures the impacts of changes in tariffs on trade flows). This bypasses the need to impute tariffs (factual or counterfactual) and avoids the potential caveats/errors surrounding the imputed tariffs, and in turn, allows us to extend the analysis to the entire history of the GATT/WTO for all economies for the period of 1950–2015.

Specifically, we adopt the nonparametric matching approach of Chang and Lee (2011) to obtain the partial direct effect of the GATT/WTO membership status on trade flows. In particular, we define $bothwto = 1$ when both countries are GATT/WTO members and zero otherwise; and $imwto = 1$ when only the importing country is a GATT/WTO member and zero otherwise. These indicators help capture potentially all changes in trade barriers (tariffs or nontariff barriers, variable or fixed trade costs) of members toward fellow members, and toward nonmembers, respectively. As documented by Jackson (1997), GATT/WTO has induced policy changes in many areas beyond tariffs (e.g., in quotas, technical barriers to trade, trade facilitation, anti-dumping measures, intellectual property rights protection, among others). Focusing on tariffs alone will thus omit a significant aspect of the GATT/WTO agreements. Methodologically, the nonparametric matching approach allows us to circumvent the parametric identification issue when using the GATT/WTO membership status as treatment indicators.[1] It also has the additional advantages of allowing for: endogenous selection into membership, potential heterogeneity in treatment effects (across years and countries), heteroskedasticity, and arbitrary trade-cost functional forms (that relate the unobserved trade cost to the observable set of proxies).

We design the matching procedure to allow the two treatment effects to be heterogeneous across the development combinations of the country pairs (developed countries, developing countries, developing-developed exporting-importing countries, and developed-developing exporting-importing countries), and across time periods demarcated by eight GATT negotiation rounds. Since the estimated GATT/WTO effect at each given point in time represents the cumulative extent of trade liberalization with the presence of GATT/WTO (relative to the level of trade restriction if GATT/WTO had not existed), we expect (and we observe in our analysis) that the extent of trade liberalization estimated is: (i) larger over time, (ii) larger by developed members than developing members, and (iii) larger against developed member exports than developing member exports. These are in line with many GATT/WTO scholars' observations that the coverage of the GATT/WTO trade agreements has broadened with each round of trade negotiation (Jackson, 1997), and that due to the special and differential exemptions developing members received in the past trade negotiation process (Bagwell and Staiger, 2010, 2016), the developing members have not liberalized as much, and in return their export interests have not received as much market access

[1] As argued in Cheong, Kwak and Tang (2014), one cannot separately identify the effects of $bothwto$ and $imwto$ in a parametric framework that also uses the exporter-year and importer-year fixed effects (FEs) to control for countries' multilateral resistance to trade. This is because these sets of indicator variables are multi-collinear. Intuitively, the combinations of $bothwto$ and $imwto$ reveal whether the importing country is a GATT/WTO member in a year and therefore is collinear with the importer-year FE. The importing country is a GATT/WTO member in a year if $bothwto + imwto = 1$ and not if $bothwto + imwto = 0$.

concession from other members.

The quantitative framework used in the current study is consistent with the extended version of Arkolakis et al. (2012, Section IV.B), where intermediate goods are used in production as well as in firm entry. By shutting down certain margins of adjustment, the framework corresponds to one of the three representative generations of trade models, the Anderson and van Wincoop (2003) [AvW] and the Eaton and Kortum (2002) [EK] model with perfect competition, the Krugman (1980) model with firm entry, and the Melitz (2003) model with selection into export. In this framework, the welfare impacts are not isomorphous across the models for two main reasons. First, the use of intermediates in firm entry introduces non-equivalence across models of perfect and monopolistic competition (as also noted by Arkolakis et al., 2012). Second, the current analysis is not a comparison of the status quo and autarky, but a comparison of the status quo and a world without GATT/WTO. The same estimated trade effects given by the matching procedure map into a combined change in the variable and fixed trade costs in the Melitz-type model, but only in the variable trade cost in the other models. This has non-trivial implications on the order of quantitative welfare effects inferred from across these trade models.[2]

Our work is closely related to Caliendo et al. (2020). They analyze the welfare effects of observed MFN (and preferential) tariff changes between 1990 and 2010, using a Melitz framework with multi-sectors and input-output linkages. As argued above, we think that MFN tariff changes are only a fraction of what GATT/WTO has accomplished, especially in the 1990–2010 period when the Uruguay Round successfully included many agreements on nontariff trade-related policies. Focusing on 1990–2010 may also create a misperception that developing countries have undertaken more trade liberalization under GATT/WTO. The fact is, however, that by 1990, developed countries had reduced tariffs to very low levels, and not much scope was left for them to further liberalize in terms of tariffs. Thus, without better information on the tariff structure across countries at the beginning of GATT, quantitative exercises based on tariffs in recent decades are better interpreted as the effects of tariff changes per se, and not representing the comprehensive GATT/WTO effect.[3]

Two caveats are in order. First, as argued above, the membership indicators (*bothwto*, *imwto*) allow us to capture changes in trade-related policies induced by GATT/WTO, including both trade costs and tariffs. For the period before 1988 without complete information on tariffs, however, it is difficult to decompose the estimated effects into trade costs and tariffs. Thus, for the large part

[2] In these exercises, the welfare gain cannot be calculated directly using the formula of Arkolakis et al. (2012, Section IV.B), because the counterfactual is not autarky but a world without GATT/WTO. The counterfactual changes in the key variables of interest in a world without GATT/WTO are simulated, given the matrices of trade shocks (for each country pair and year) due to GATT/WTO estimated by the matching procedure.

[3] Our work is also related to the quantitative studies of the GATT/WTO welfare effects by Ossa (2011), Ossa (2014), and Bagwell, Staiger and Yurukoglu (2021). These studies focus on tariffs as the trade policy variable and analytically simulate the endogenous non-cooperative tariffs, given the negotiation principles of GATT/WTO. The welfare effects of GATT/WTO are then imputed based on the difference between the factual tariff outcomes and non-cooperative tariff outcomes. Bagwell, Staiger and Yurukoglu (2021), in particular, focus on the value of the MFN principle, and compare the factual tariff outcomes with the counterfactual outcomes if the MFN requirement were abandoned and countries negotiated over discriminatory tariffs. In these studies, because of their focus on tariffs, the simulated welfare gains are typically modest. The computation burden of numerically solving for the non-cooperative tariff profiles also constrains substantially the number of countries that can be included in the study.

of analysis, we abstract from the revenue effects of tariffs, although the effects of tariffs on trade are taken into account in the same way as trade costs. As noted earlier, data on tariffs have many missing entries (Anderson and van Wincoop, 2004). There also exists the complication due to specific tariffs that must be converted to ad valorem equivalents by using the price information, which in turn has its own measurement and concordance problems. See, however, the tremendous efforts by Caliendo et al. (2020) to compile such tariff data dating back to 1984.[4]

Second, to account for multiple sectors and input-output (IO) linkages is another challenge when the study period spans 1950–2015. This is due to the fact that most comparable international IO tables are available only since 1990, although some regional tables date back to 1985 (such as Japan IDE-JETRO input-output tables for ten Asian countries).[5] National IO tables are in general available only as early as 1990.[6,7] We thus conduct the analysis based on aggregate bilateral trade flows. We do, however, allow for the use of intermediates in production, and hence input-output linkages in an aggregate sense. The welfare effects of GATT/WTO presented in this paper can be regarded as conservative lower-bound estimates, because adding multiple sectors and IO linkages will amplify the welfare gains from trade as emphasized in Costinot and Rodríguez-Clare (2015).

The rest of the paper is organized as follows. In Section 2, we present the Melitz framework (incorporating tariffs/trade costs, intermediates and trade imbalance), introduce the nonparametric estimation methodology, and set up the counterfactual structural equations. The AvW and Krugman models are isomorphic to restricted versions of the Melitz framework. The estimation and counterfactual results are presented in Sections 3–4. Section 5 conducts extended analyses, and Section 6 concludes. Details regarding the data and simulation algorithms are documented in the appendix. Additional theoretical derivations, and estimation/simulation results are provided in the Online Appendix. Without risk of confusion, we will often omit the year subscript in developing the models to simplify the notations. But the year subscript will be explicitly included when we refer to estimation specifications and measurement of variables.

[4]Treating trade friction as solely trade cost and omitting the revenue effects of tariffs are done in many quantitative trade models following Eaton and Kortum (2002) and Melitz (2003). This model choice is likely driven also by the fact that tariff revenue is not a significant source of national income. According to *OECD.Stat* (http://stats.oecd.org/), the share of tariff revenue in GDP in most countries is declining over the years and is usually below 2%. For example, in 1965, the share of tariff revenue in GDP for the US was 0.2%. The average for OECD, Latin America and the Caribbean, and Africa in 2000 were 0.3%, 1.9%, and 2.1%, respectively.

[5]The World Input-Output Database (WIOD) starts from 1995 for 27 EU countries and 13 non-EU countries. The OECD Input-Output Tables (IOTs) include all OECD countries and 27 non-member economies for 1995–2011.

[6]The exceptions are Australia, Canada, Denmark, France, Japan, Netherlands, the UK, and the US, for which the national IO tables are available as early as the 1970s.

[7]Most time series on national IO tables are characterized by temporal gaps and sectoral misalignment. The Eora project (Lenzen et al., 2013) provides the most comprehensive international IO tables to date, with 187 countries for 1990–2015, and national IO tables since 1970. The Eora national IO tables before 1990 are, however, imputed/constructed based on automatic constrained optimization algorithms with more degrees of freedom (IO entries) than constraints (data sources). The constructed national tables are also not harmonized across countries, and vary in terms of types of classification and numbers of sectors/products, making them difficult to use for cross-country studies.

2 The Structural Framework

We motivate our estimation strategy and counterfactual analytical framework based on the Melitz (2003) model, allowing for tariff and trade cost, under untruncated Pareto distribution. In the Math Appendix, equivalent sets of estimation and counterfactual equations are derived for the AvW and Krugman models. The mapping across models is summarized in Section 2.4.

Let each country be characterized by the Melitz (2003) structure, but with possibly asymmetric trade barriers and country characteristics. Each country is endowed with a fixed supply of labor L_i. Buyers have CES preferences with an elasticity of substitution $\sigma > 1$ defined over the differentiated varieties supplied by firms. Let c_i denote the cost of an input bundle and N_i the mass of entrants in country i. Each entrant pays a fixed cost of entry $c_i F_i$ in order to take a productivity draw $1/a$ from a cumulative Pareto distribution $G_i(a) \equiv (a/\bar{a}_i)^\theta$ over the support $[0, \bar{a}_i]$ with dispersion parameter $\theta > (\sigma - 1)$. Firms from country i incur fixed trade cost $c_i f_{ij}$ (in terms of input bundles) to serve country j, and face variable trade cost factor τ_{ij} (> 1) and ad-valorem import tariff rate $\mathfrak{t}_{ij}$ (imposed by country j on goods imported from country i).[8]

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:

$$\frac{1}{\sigma} \frac{1}{(1 + \mathfrak{t}_{ij})} \left(\frac{\sigma}{\sigma - 1} \frac{c_i \tau_{ij} (1 + \mathfrak{t}_{ij}) a_{ij}}{P_j} \right)^{1-\sigma} E_j = c_i f_{ij}, \tag{1}$$

where P_j and E_j are the aggregate price index and the nominal expenditure of country j, respectively. It follows that the expenditure of country j spent on goods from country i is $X_{ij} = \left(\frac{\sigma}{\sigma-1} \frac{c_i \tau_{ij}(1+\mathfrak{t}_{ij})}{P_j} \right)^{1-\sigma} E_j N_i V_{ij}$ and $P_j^{1-\sigma} = \sum_i \left(\frac{\sigma}{\sigma-1} c_i \tau_{ij} (1 + \mathfrak{t}_{ij}) \right)^{1-\sigma} N_i V_{ij}$, where

$$V_{ij} \equiv \int_0^{a_{ij}} a^{1-\sigma} dG(a) = \frac{\theta}{\theta - \sigma + 1} \frac{a_{ij}^{\theta - \sigma + 1}}{\bar{a}_i^\theta} \tag{2}$$

indicates the proportion of firms (weighted by their market shares) that export from i to j.[9] Note that the import value of country j from country i is $M_{ij} = X_{ij}/(1 + \mathfrak{t}_{ij})$.

Let Y_i denote the total sales of goods by country i to all destinations. Following the technique used in the literature on structural gravity equations (Anderson and van Wincoop, 2003; Anderson and Yotov, 2010; Head and Mayer, 2015; Anderson and Yotov, 2016), we can derive a modified gravity equation by imposing the market-clearing condition:

$$Y_i = \sum_j M_{ij} = \left(\frac{\sigma}{\sigma - 1} c_i \right)^{1-\sigma} N_i \sum_j (\tau_{ij}/P_j)^{1-\sigma} E_j V_{ij} (1 + \mathfrak{t}_{ij})^{-\sigma} \tag{3}$$

[8] In robustness checks in Section 4.3, we allow the entry to use input bundles that have different labor intensity from the input bundles used in the production process. The modifications to the counterfactual equations are shown in the Math Appendix.

[9] As in Melitz (2003), suitable conditions are imposed such that not all firms export.

to solve for $\left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma} N_i$ and substitute the result in the expression of M_{ij} and P_j to obtain:

$$M_{ij} = \frac{Y_i E_j}{Y_w}\left(\frac{\tau_{ij}}{\Pi_i P_j}\right)^{1-\sigma} V_{ij}\left(1+\mathfrak{t}_{ij}\right)^{-\sigma}, \tag{4}$$

where

$$\Pi_i^{1-\sigma} \equiv \sum_j (\tau_{ij}/P_j)^{1-\sigma} V_{ij} e_j \left(1+\mathfrak{t}_{ij}\right)^{-\sigma}, \tag{5}$$

$$P_j^{1-\sigma} = \sum_i (\tau_{ij}/\Pi_i)^{1-\sigma} V_{ij} s_i \left(1+\mathfrak{t}_{ij}\right)^{1-\sigma}, \tag{6}$$

$Y_w \equiv \sum_i Y_i$ indicates the world output, $e_j \equiv E_j/Y_w$ the expenditure share of country j, and $s_i \equiv Y_i/Y_w$ the output share of country i. Equation (4) resembles the structural gravity equation, and Π_i and P_j in (5)–(6) the outward and inward multilateral resistance (MR) proposed by Anderson and van Wincoop (2003), but with the extra terms V_{ij} indexing the extensive margin and further adjusted for the tariff margins. To arrive at an implementable estimation equation, note that the definitions of a_{ij} and V_{ij} in (1) and (2) imply:

$$\begin{aligned}\tau_{ij}^{1-\sigma} V_{ij}\left(1+\mathfrak{t}_{ij}\right)^{-\sigma} = {} & \left({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}\left(1+\mathfrak{t}_{ij}\right)^{-\frac{\sigma\theta}{\sigma-1}}\right)\left({P_j}^{\theta-\sigma+1}\right)\left({c_i}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right)\left({E_j}^{\frac{\theta}{\sigma-1}-1}\right) \\ & \times constant,\end{aligned} \tag{7}$$

where $constant = \left(\frac{\theta}{\theta-\sigma+1}\right)\left(\frac{1}{\bar{a}_i^{\theta}}\right)\sigma^{\frac{\theta-\sigma+1}{1-\sigma}}\left(\frac{\sigma-1}{\sigma}\right)^{\theta-\sigma+1}$. Using (7), we can rewrite the trade flow equation (4) and the MR equations (5)–(6) in terms of variable trade costs, fixed trade costs, and tariffs as:

$$M_{ij} = \frac{Y_i E_j}{Y_w}\left(\frac{{\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}\left(1+\mathfrak{t}_{ij}\right)^{-\frac{\sigma\theta}{\sigma-1}}}{\chi_i\ \zeta_j}\right), \tag{8}$$

where[10]

$$\chi_i \equiv \sum_j \frac{{\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}\left(1+\mathfrak{t}_{ij}\right)^{-\frac{\sigma\theta}{\sigma-1}}}{\zeta_j} e_j, \tag{9}$$

$$\zeta_j = \sum_i \frac{{\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1}\left(1+\mathfrak{t}_{ij}\right)^{1-\frac{\sigma\theta}{\sigma-1}}}{\chi_i} s_i. \tag{10}$$

We may regard χ_i as the market access potential of exporter i, defined as the weighted average of its access to each market weighted by the destination market's expenditure share (relative to the world output). Similarly, ζ_j can be regarded as the sourcing potential of importer j, with each bilateral sourcing relationship weighted by the source country's supply share.

[10]Specifically, $\chi_i \equiv \Pi_i^{1-\sigma}/\left\{constant \times \left({c_i}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right)\right\}$ and $\zeta_j \equiv P_j^{-\theta}/{E_j}^{\frac{\theta}{\sigma-1}-1}$.

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

$$E_j = Y_j + D_j + T_j, \tag{11}$$

where D_j is the nominal trade deficit of country j, and $T_j = \sum_i M_{ij}\mathfrak{t}_{ij}$ the tariff revenue of country j. We assume that 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. This implies that the cost of an input bundle in country i is

$$c_i = w_i^{\beta_i} P_i^{1-\beta_i}. \tag{12}$$

Under the Pareto distribution for firm productivity, the aggregate profit is a constant share $\frac{\sigma-1}{\sigma\theta}$ of sales revenue. Thus, the free-entry condition requires that:

$$\frac{\sigma-1}{\sigma\theta} Y_i = N_i F_i c_i, \tag{13}$$

where the aggregate profit equals the total entry cost. Finally, the labor-market clearing condition requires that:

$$w_i L_i = \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta} + \frac{\sigma-1}{\sigma\theta}\right) Y_i, \tag{14}$$

where $\beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) Y_i$ is the part of labor cost incurred by firms in the production process and $\beta_i \left(\frac{\sigma-1}{\sigma\theta}\right) Y_i$ the part incurred in the entry process.

2.1 Identification of the GATT/WTO Trade Effect

We introduce the year subscript t in view of the panel data to be used. Define $bothwto_{ijt}$ as an indicator that equals one when 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 when *only* importer j is a GATT/WTO member in year t and zero otherwise. The control group is composed of observations where both countries are nonmembers. When a country j becomes a GATT/WTO member, the country is required to apply the tariff-binding and nontariff commitments negotiated in its accession package or in general trade negotiation sessions by the most-favored-nation (MFN) principle to all other members. This is expected to lower the variable (and fixed) trade costs and tariffs for exports from member i to member j, relative to the control group. Thus, we expect the effect of $bothwto_{ijt}$ to be positive on bilateral imports. In contrast, members are not obligated by GATT/WTO to extend the same MFN treatment to nonmembers. It is ex ante possible for the trade policy of member j to become liberalized against nonmembers i' (if members extend MFN treatment to nonmembers), such that the effect of $imwto_{i'jt}$ is positive relative to the control group. But it is also possible for members to raise their barriers against nonmembers as they liberalize toward members, such that the effect of $imwto_{i'jt}$ is negative relative to the control group. As a whole, we expect *bothwto* to have a larger trade-promoting effect than *imwto* because the extension of

MFN treatment to nonmembers, if any, is likely to be partial in terms of coverage, duration, or predictability.[11]

Typically, the literature assumes the unobserved trade cost to be log-linear in a vector of trade-cost proxies $\mathbf{Z}_{ijt}$, and uses exporter-year and importer-year FEs to control for the multilateral terms (χ_{it} and ζ_{jt}). The gravity equation (8) is then estimated using either an OLS regression in its log transformation or a Poisson Pseudo Maximum Likelihood (PPML) estimator in levels (Silva and Tenreyro, 2006). Unfortunately, this approach is not ideal in the current application, because we cannot estimate the standard set of exporter-year and importer-year FEs, the effect of *bothwto*, and the effect of *imwto* all in the same regression. As shown by Cheong, Kwak and Tang (2014) and discussed in the introduction, these indicator variables are multi-collinear. Intuitively, the combinations of $bothwto_{ijt}$ and $imwto_{ijt}$ reveal whether the importing country j is a GATT/WTO member in a year t and therefore is collinear with the importer-year (jt) FE.[12] This may help explain the difficulty of the literature to find robust and significant GATT/WTO trade effects using the parametric approach.[13]

Alternatively, we may consider normalizing the trade flows across four countries (e.g., $\frac{M_{hit}/M_{hjt}}{M_{kit}/M_{kjt}}$) to eliminate the exporter-year and importer-year FEs, as suggested by Head, Mayer and Ries (2010), and taking a corresponding transformation of the trade-cost proxies $\mathbf{Z}_{ijt}$ under log-linear functional form assumptions. This approach still does not solve the multi-collinearity problem discussed above, because the transformed *bothwto* and *imwto* variables are collinear with each other. Specifically, define $z^{\dagger}_{ijhk,t} \equiv (z_{hit} - z_{hjt}) - (z_{kit} - z_{kjt})$ for a trade-cost proxy variable z.[14] Then, it can be shown that $bothwto^{\dagger}_{ijhk,t} = -imwto^{\dagger}_{ijhk,t}$.

Finally, some studies have chosen to dismiss *imwto* from the list of controls in parametric regressions. This specification avoids the multi-collinearity problem, but will suffer omitted variable bias in the estimation of the *bothwto* effect if members do change their trade policy against nonmembers such that the effect of *imwto* is not zero. Intuitively, the control group now includes observations where neither country is a member and also observations where only the importer is a member. Omitting *imwto* from the list of controls will lead to a downward bias in the estimate of the *bothwto* effect if the true effect of *imwto* is positive, and vice versa.[15]

As a solution, we adopt the nonparametric matching method proposed by Chang and Lee (2011). The original paper provides more methodological exposition on the robustness/advantages of the matching estimator. Here, we briefly summarize its main procedure. First, write the gravity

[11] Note that $imwto_{ijt}$ is not designed to capture general-equilibrium trade diversion effects, as these effects would be controlled for by the multilateral terms χ_{it} and ζ_{jt}. Instead, $imwto_{ijt}$ is used to identify any direct changes in trade barriers for exports from a nonmember to a member, due to the reasons discussed above.

[12] In particular, the importing country is a member in a year if $bothwto_{ijt} + imwto_{ijt} = 1$, and not if $bothwto_{ijt} + imwto_{ijt} = 0$.

[13] Note that $imwto_{ijt}$ is a bilateral-year (not multilateral-year) indicator, so it is not by itself collinear with the importer-year FE.

[14] The notation z represents the log of a continuous trade-cost proxy variable Z (e.g., distance) or a discrete trade-cost proxy variable (e.g., *bothwto*).

[15] We conducted preliminary Monte Carlo simulations and verified the potential bias of dropping *imwto*. The exercise provided in Yotov et al. (2016) is an example where the WTO accession effect is based on *bothwto* alone.

equation (8) in its log transformation:

$$\ln M_{ijt} = \ln Y_{it} + \ln E_{jt} + \ln \left(\tau_{ijt}{}^{-\theta} f_{ijt}{}^{-\frac{\theta}{\sigma-1}+1} (1+\mathfrak{t}_{ij})^{-\frac{\sigma\theta}{\sigma-1}} \right) - \ln \left(\chi_{it}\ \zeta_{jt} \right) - \ln Y_{wt}. \tag{15}$$

Assume that the variable (and fixed) trade costs and tariffs depend on GATT/WTO membership status as well as the set of trade-cost proxies identified. This allows us to write:

$$\ln \left(\tau_{ijt}{}^{-\theta} f_{ijt}{}^{-\frac{\theta}{\sigma-1}+1} (1+\mathfrak{t}_{ij})^{-\frac{\sigma\theta}{\sigma-1}} \right) = h(bothwto_{ijt}, imwto_{ijt}, \mathbf{Z}_{ijt}). \tag{16}$$

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 all the observable characteristics $(\ln Y_{it}, \ln E_{jt}, \mathbf{Z}_{ijt}, \ln(\chi_{it}\ \zeta_{jt}), \mathcal{T}_t)$, where $\mathcal{T}_t$ are year dummies used to control for $\ln Y_{wt}$ and any other year-specific shocks.[16] In implementation, including year dummies effectively means that most matched observations will come from the same year; alternatively, we can directly restrict the matching within years. The multilateral terms, $\ln(\chi_{it}\ \zeta_{jt})$, are approximated by the supply/expenditure-share weighted trade-cost proxies à la Baier and Bergstrand (2009). The difference in the trade flows $\ln M_{ijt}$ between the matched treated and untreated observations is then attributed to the *bothwto* status, given that the treated and untreated country pairs are similar in all other aspects. The average of the effects 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 to be treated. The procedure to estimate the *imwto* effect is analogous but with the treatment group now replaced by observations where $imwto_{ijt} = 1$. To improve the confidence in the estimates, we also use a 40% caliper rule such that only the matched pairs with a matching distance less than the 40th percentile of all matches are used in calculating the mean treatment effects.[17] This procedure discards matched observations where a treated observation may not find a reasonably good match from the control group. Chang and Lee (2011) consider calipers in the range of $\{100\%, 80\%, 60\%, 40\%\}$. We take the conservative lower bound of 40% as the benchmark and the 100% caliper as a robustness check.

This nonparametric approach has several advantages. First, the matching estimator circumvents the multi-collinearity problem at hand. This is the case because in each matching exercise, by design, only one group of observations, $bothwto_{ijt} = 1$ or $imwto_{ijt} = 1$, is used as the treatment group. The two groups are not included in the analysis at the same time. Second, the matching

[16] 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, $i'j't'$ a potential control subject, and Σ_w a diagonal matrix containing the sample variances of the covariates w (i.e., the vector of the observable characteristics to be matched) in 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). In parallel with the restricted matching within years and development combination to be discussed below, the sample variances of the covariates w are calculated specific to the year and development combination.

[17] Suppose $\mathcal{M}$ matches are formed. They could be ranked in terms of the closeness of the match. A $x\%$ caliper uses $(x\% \cdot \mathcal{M})$ matched pairs that have a matching distance smaller than the x-th percentile of all $\mathcal{M}$ matches.

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 barrier function $h(\cdot)$, but allows the trade barriers to depend on the observable proxies in arbitrary ways. This is an advantage, because although there are strong theoretical foundations for the gravity equation, it is less than clear how the trade cost depends on observable proxies. The log-linear functional form assumption often made about $h(\cdot)$ in the literature can be regarded as a convenient approximation but not a theoretical mandate. Third, the matching framework can accommodate endogenous selection into GATT/WTO membership (based on observables). This is because the treatment effect is estimated conditional on matched observations with similar observable characteristics and hence similar probabilities of selection into treatment. The heterogeneities in the probability of being treated and in treatment effect are controlled for by the matching process.[18] 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 judgment. For example, the GATT/WTO effects could potentially differ across development combinations of the country pairs and across trade negotiation rounds. The matching can be conducted by restricting the match to the subset of observations with the same development combination and/or within the same period. The mean effect can then be calculated conditional on the development stage and/or the period. Restricted matching also helps reduce the concern of selection on unobservables, to the extent that such unobservables are correlated with the criteria used for restricted matching. We elaborate further on how we refine the matching procedure to accommodate heterogeneous effects of *bothwto* and *imwto* in Section 3 when we present the estimation results.

To reduce the concern of omitted variable bias or selection on unobservables, we use an extensive set of controls as would be used in a typical parametric regression approach in this literature. First, it includes the gross output of the exporter $\ln Y_{it}$ and the aggregate expenditure of the importer $\ln E_{jt}$. Next, the list of trade-cost proxies $\mathbf{Z}_{ijt}$ includes: (i) 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 (ii) time-invariant variables: bilateral distance, common language indicator, common legal origin indicator, indicator for whether two countries were/are the same state or the same administrative entity, common border indicator, common colonizer indicator, indicator for whether exporter i has

[18] There remains the concern of selection on unobservables. In other words, the identification relies on the assumption that there are no unobservable variables that affect the trade flow and also the likelihood of being treated in a systematic way. Given that we use exactly the same set of controls as in a typical parametric regression approach in this literature, this identification assumption is no more restrictive than the identification assumption of no omitted variables in the parametric approach. In Chang and Lee (2011), the Rosenbaum (2002) sensitivity analysis was conducted to show that the positive matching estimates of the GATT/WTO membership effect (on the treated) are robust to selection on unobservables.

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 allowed to be asymmetric, specific to the direction of trade flows. This is in line with the theoretical setup of asymmetric trade barriers.

In principle, the matching procedure discussed above can be carried out in terms of levels based on equation (8) rather than in terms of its log transformation (15). We proceed with the latter alternative, because this will allow us to interpret the estimates of *bothwto* and *imwto* as their effects on $\ln\left({\tau_{ijt}}^{-\theta} {f_{ijt}}^{-\frac{\theta}{\sigma-1}+1} (1+\mathfrak{t}_{ijt})^{-\frac{\sigma\theta}{\sigma-1}}\right)$, and the exponential of these estimates as the ratio of trade flows with and without GATT/WTO. This is useful, as our counterfactual analysis in Section 2.2 will be based on effects expressed in terms of ratios of a variable under alternative scenarios, rather than in terms of level differences.[19]

2.2 Counterfactual Analysis

Given the estimates of the direct effects of *bothwto* and *imwto* on trade flows (via variable/fixed trade costs and tariffs), we can calculate how the change in trade barriers 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 in terms of changes à la the hat algebra of Dekle, Eaton and Kortum (2007).[20] In particular, let x' denote the counterfactual value of a variable x and $\widehat{x} \equiv x'/x$ the ratio of the counterfactual to the factual value of the variable.

Dividing both sides of (3) by Y_w, the market-clearing condition implies the following:

$$\widehat{s}_i = \widehat{N}_i \, \widehat{c}_i^{1-\sigma} \, \widehat{\Pi}_i^{1-\sigma}. \tag{17}$$

The MR structural relationship (5)–(6) and the trade flow equation (4) imply that:

$$\widehat{\Pi}_i^{1-\sigma} = \sum_j \alpha_{ij} \frac{\widehat{\tau}_{ij}^{1-\sigma} \, \widehat{V}_{ij} \, \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\sigma}}{\widehat{P}_j^{1-\sigma}} \widehat{e}_j, \tag{18}$$

$$\widehat{P}_j^{1-\sigma} = \sum_i \lambda_{ij} \frac{\widehat{\tau}_{ij}^{1-\sigma} \, \widehat{V}_{ij} \, \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\sigma}}{\widehat{\Pi}_i^{1-\sigma}} \widehat{s}_i \, (\widehat{1+\mathfrak{t}_{ij}}), \tag{19}$$

where $\alpha_{ij} \equiv M_{ij}/Y_i$ 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. In static trade models, there are no

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

[20]Some scholars credit the hat algebra technique to Jones (1965), although the Jones hat algebra is in terms of small changes in the variables, while the algebra of Dekle, Eaton and Kortum (2007) is in terms of ratios of counterfactual to factual values, so the latter in principle can accommodate large discrete changes. The Jones hat algebra is also heavily used in the computable general equilibrium (CGE) models, represented by the Global Trade Analysis Project (GTAP) of Hertel (1997).

clear 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 (11), implies that:

$$\widehat{e}_i \cdot e_i = \widehat{s}_i \cdot s_i + \delta_i + T_i'/Y_w', \tag{20}$$

while by the definition of s_i, the following holds:

$$\widehat{s}_i \cdot s_i = \frac{\widehat{Y}_i \cdot Y_i}{\sum_k \widehat{Y}_k \cdot Y_k}. \tag{21}$$

Next, the Cobb-Douglas cost structure (12) for the input bundle requires that:

$$\widehat{c}_i = \widehat{w}_i^{\beta_i} \widehat{P}_i^{1-\beta_i}, \tag{22}$$

and the free-entry condition (13) implies that:

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

Finally, by the labor market-clearing condition (14), we have:

$$\widehat{Y}_i = \widehat{w}_i. \tag{24}$$

To close the model, note that given (7) we have:

$$\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\sigma} = \left[\widehat{\tau}_{ij}^{\,-\theta} \widehat{f}_{ij}^{\,-\frac{\theta}{\sigma-1}+1} \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\frac{\sigma\theta}{\sigma-1}}\right] \left(\widehat{P}_j^{\,\theta-\sigma+1}\right) \left(\widehat{c}_i^{\,-\frac{\sigma\theta}{\sigma-1}+\sigma}\right) \left(\widehat{E}_j^{\,\frac{\theta}{\sigma-1}-1}\right), \tag{25}$$

where by definition

$$\begin{aligned} \widehat{E}_i &= \frac{Y_i}{E_i}\widehat{Y}_i + \frac{D_i}{E_i}\widehat{Y}_w + \frac{T_i}{E_i}\widehat{T}_i, && (26) \\ \widehat{T}_i &= \sum_h \widehat{M}_{hi} \, M_{hi} \, t_{hi}'/T_i, && (27) \\ \widehat{Y}_w &= \sum_i s_i \widehat{Y}_i. && (28) \end{aligned}$$

Thus, using (17)–(28), we can solve for $\left\{\widehat{c}_i, \widehat{N}_i, \widehat{\Pi}_i, \widehat{P}_i, \widehat{s}_i, \widehat{e}_i, \widehat{w}_i, \widehat{Y}_i, \widehat{E}_i, \widehat{T}_i, \widehat{Y}_w, \widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\sigma}\right\}$ for $i = 1, 2, \ldots, N$, given exogenous shocks to $\left\{\widehat{\tau}_{ij}^{\,-\theta} \widehat{f}_{ij}^{\,-\frac{\theta}{\sigma-1}+1} \left(\widehat{1+\mathfrak{t}_{ij}}\right)^{-\frac{\sigma\theta}{\sigma-1}}\right\}$ estimated in the previous section and the information on $\left\{\mathfrak{t}_{ij}'\right\}$, observable variables $\{\alpha_{ij}, \lambda_{ij}, e_i, s_i, \delta_i, Y_i, \mathfrak{t}_{ij}\}$, and parameter values $\{1-\sigma, \theta, \beta_i\}$. The welfare effects of the given exogenous shocks can be evaluated based on real wages, real income, or real expenditure. In the current context, they differ due to the presence of tariff revenues and trade deficits. As the benchmark, we choose to focus on the real wage, because it can be calculated for the whole period of study (1950–2015), whereas the real income (incorporating tariff revenues) can only be implemented for the recent period (1988–2015) when the data on tariffs are available. Specifically, the welfare effect in the benchmark is measured by:[21]

$$\widehat{W}_i = \widehat{w}_i / \widehat{P}_i. \tag{29}$$

Finally, the general equilibrium trade effect is given by:

$$\widehat{M}_{ij} = \frac{\widehat{\tau}_{ij}^{1-\sigma}\, \widehat{V}_{ij}\, \big(\widehat{1+\mathrm{t}_{ij}}\big)^{-\sigma}}{\widehat{\Pi}_i^{1-\sigma}\, \widehat{P}_j^{1-\sigma}}\, \widehat{s}_i\, \widehat{E}_j. \tag{30}$$

For the parameter values, we choose as the benchmark $\sigma = 5$, which lies within the range of trade elasticity often reported in the gravity literature; see Head and Mayer (2015) for a meta-analysis. For $\{\beta_i\}$, we use the share of value added in gross output in country i, calculated as the median of the value-added shares across sectors obtained from Caliendo and Parro (2015).[22] The value varies in the range of $[0.37, 0.53]$ across countries. For the parameter θ, we choose the value based on the estimate of $\theta - (\sigma - 1)$ from Helpman, Melitz and Yeaple (2004). Most of their estimates fall in the range of $[0.5, 1.5]$. We adopt $\theta - (\sigma - 1) = 1$ as the benchmark; i.e., $\theta = 5$ when $\sigma = 5$. We will provide robustness checks for alternative parameter values of θ and σ.[23] Further details on the algorithm are provided in Appendix C.

In the data, a country does not trade with every potential trading partner. Such trading relationships will be reflected by $\alpha_{ijt} = 0$ and $\lambda_{ijt} = 0$. All counterfactual changes in the trade barriers for these country pairs inferred based on the matching estimates are multiplied by zero shares and hence do not affect the counterfactual results. In a sense, this is appropriate, since the current framework (as well as the alternative AvW and Krugman models) 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

[21] The welfare effect in terms of real income is measured by: $\widehat{W}_i = \frac{\widehat{Y}_i}{\widehat{P}_i} \frac{Y_i}{Y_i + T_i} + \frac{\widehat{T}_i}{\widehat{P}_i} \frac{T_i}{Y_i + T_i}$, and that in terms of real expenditure is: $\widehat{W}_i = \widehat{E}_i / \widehat{P}_i$.

[22] In particular, the value added shares of Caliendo and Parro (2015) are for year 1993, which we apply across years of our study. Based on the OECD Input-Output Database and the IDE-JETRO Asian Input-Output Tables, the shares of value added (in gross output) are fairly constant over time for the years and countries reported by these IO tables.

[23] Alternative values of $\tilde{\theta} \equiv \theta/(\sigma - 1)$ are suggested by Eaton, Kortum and Kramarz (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 US firm data, Chaney (2008) uses a similar method as Helpman, Melitz and Yeaple (2004) of regressing the log of firm rank on the log of firm sales, and estimates $\tilde{\theta} \approx 2$. In Eaton, Kortum and Sotelo (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 implies $\theta = 4.87$ and is close to the benchmark values we adopt for the counterfactual simulations ($\sigma = 5$ and $\theta = 5$).

counterfactual analysis.

2.3 Tariff-only Effects and Comprehensive Effects of GATT/WTO

In Section 2.1, we have proposed methods to estimate the comprehensive direct effects of GATT/WTO membership on trade flows, $\widehat{\tau}_{ijt}{}^{-\theta}\,\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\,(\widehat{1+\mathsf{t}_{ijt}})^{-\frac{\sigma\theta}{\sigma-1}}$, inclusive of effects driven by variable/fixed trade costs and tariffs. This relies on the membership indicators and allows possibly heterogeneous effects across subsets of ijt (to be elaborated in Section 3). Thus, at the estimation stage, we do not require data on tariffs, although in the counterfactual analysis, the factual tariffs (with GATT/WTO) and the counterfactual tariffs (without GATT/WTO) are still required in equations (19), (20), (26) and (27) to fine tune the difference between supplier and consumer prices, and tariff revenues.

To highlight the comprehensive effects identified by this approach in comparison with the tariff-only effects, we will also conduct counterfactual analysis with only changes to tariffs $(\widehat{1+\mathsf{t}_{ijt}})$ due to GATT/WTO. In essence, the shock to the system, in equation (25), is reduced such that $\widehat{\tau}_{ijt}{}^{-\theta}\,\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\,(\widehat{1+\mathsf{t}_{ijt}})^{-\frac{\sigma\theta}{\sigma-1}} = (\widehat{1+\mathsf{t}_{ijt}})^{-\frac{\sigma\theta}{\sigma-1}}$; the equilibrium counterfactual values of the endogenous variables are re-calculated according to the same system of equations, (17)–(28). As will be reported in Section 4, the tariff-only effects are far smaller than the comprehensive effects of GATT/WTO.

As documented in detail in Appendix B.6, tariff data are not complete, and require a lot of subjective judgements by researchers to fill in missing entries (e.g., our procedure starts with filling in missing entries with respect to years conditional on a country pair ij, with respect to trade partner i conditional on an importer-year jt, and finally with respect to trade partner j conditional on an exporter-year it). Even then, the data are available only systematically for the period since 1988, based on UNCTAD-TRAINS and WTO-IDB. Added to the burden is the need to construct counterfactual tariffs that would have been imposed in a world without GATT/WTO. Given the same raw tariff data from the above two official sources, we basically take the maximum across three dimensions: first across rates observed for ijt in terms of Effectively Applied (AHS), Preferential (PRF), MFN applied (MFN) and MFN bound (BND) rates; further across years conditional on ij for rates observed in the current year (t) and in the period 1–3 years before j's obtaining the membership; and finally across i' for each jt. The maximum of this procedure is taken as the counterfactual tariffs (without GATT/WTO) for ijt.

Given the lack of reliable measurements of the factual and counterfactual tariffs, we then consider revised counterfactual equations of Section 2.2, ignoring the tariff revenues in equations (20), (26) and (27), and the adjustment term $(\widehat{1+\mathsf{t}_{ij}})$ in (19) for the wedge between supplier and consumer prices. The estimation stage remains the same as in the full model with tariff incorporated, and allows the estimated effects and the corresponding shocks to the system to reflect the effects of tariffs on trade flows. As we will show, the counterfactual welfare effects of this approximate version are very similar to the full model, despite the omission of the tariff revenues. Thus, for the second part of the analysis, we will proceed with the approximate version. This allows us to provide a long-panel analysis of the GATT/WTO effect for its entire history 1950–2015, without the need for tariff data.

2.4 Alternative Framework: AvW, EK, and Krugman

As one of the robustness checks, we document how the quantitative effects vary across trade models, in particular the AvW/EK model, Krugman model, and Melitz model. These models represent the three generations of trade models, where the margin of firm entry and the margin of selection into export are introduced by the second and the third model, respectively. As shown in the online appendix, the estimation and counterfactual framework that we present for the Melitz model can be applied to the AvW/EK and Krugman models by shutting down the relevant margins of adjustment. First, the counterfactual analysis of the AvW framework is isomorphic to the Melitz framework under the restrictions: (i) $\widehat{N}_i = 1$, (ii) $\widehat{V}_{ij} = 1$, and (iii) dropping equations (23) and (25). Next, the counterfactual analysis of the Krugman framework is equivalent to the Melitz framework under the restrictions: (i) $\widehat{V}_{ij} = 1$, and (ii) dropping equation (25). Thus, the Krugman model shuts down the extensive margin, while the AvW framework further shuts down the firm entry margin.

Provided that the direct effects of trade barriers — with a structural expression of $\widehat{\tau}_{ijt}^{1-\sigma}\widehat{(1+\mathfrak{t}_{ijt})}^{-\sigma}$ in the AvW and Krugman models and of $\widehat{\tau}_{ijt}{}^{-\theta}\,\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\,\widehat{(1+\mathfrak{t}_{ijt})}^{-\frac{\sigma\theta}{\sigma-1}}$ in the Melitz model — depend on the same set of trade-barrier proxies that we have identified, this implies the same set of primitive controls and also the same set of B&B controls in the estimations across the three frameworks. Given the parallel trade flow equations — (8) for Melitz and (A.3) for AvW and Krugman in the online appendix — it follows that we will obtain the same matching effect estimates of *bothwto* and *imwto* in the three frameworks, since the sets of controls are common.[24]

It is worthwhile noting that the entry effects arise in our framework because fixed costs and entry costs are assumed to use input bundles (combining labor and intermediate inputs) instead of labor alone. It can be shown that $\widehat{N}_i = \left(\widehat{w}_i/\widehat{P}_i\right)^{1-\beta_i}$ using (22), (23), and (24). Thus, without intermediates ($\beta_i = 1$), the number of firms will remain constant as in the original models of Krugman and Melitz. Without intermediates in fixed cost, the Krugman model will also be isomorphic to AvW and EK in terms of welfare effects (see also Arkolakis et al., 2012, p. 115).[25]

[24] Although not explicitly shown, the EK setup is isomorphic to AvW. They imply the same set of structural gravity equations and welfare effects, as suggested by Arkolakis, Costinot and Rodríguez-Clare (2012) and Head and Mayer (2015). The taste parameter $b_i^{1-\sigma}$ in AvW corresponds to the technology parameter T_i in EK, while the partial trade elasticity $\sigma - 1$ in AvW is replaced by the supply-side efficiency dispersion parameter θ in EK.

[25] In Caliendo et al. (2020), fixed cost and entry use labor alone (which implies zero entry effects in one-sector models); the entry effects in their model are thus driven by linkages across sectors, which in a sense are captured by the use of intermediates in our one-sector models.

3 Matching Results

As discussed in the introduction, the GATT/WTO membership effects identified by our matching procedures capture the realized (cumulative) extent of trade liberalization due to the presence of GATT/WTO. Thus, we expect the *bothwto* effect to increase in magnitude over the years as the GATT/WTO agreements increase in their depths and coverage. Similarly, we expect the *bothwto* effect to be stronger for developed members, because at each point in time, developed member countries have accumulated larger extents of liberalization than developing members since the beginning of GATT/WTO. We document these heterogeneous patterns of trade liberalization below.

In its history (1947–1994), GATT has sponsored eight rounds of trade negotiations (World Trade Organization, 2007; Bagwell, Bown and Staiger, 2016). Its initial treaty, GATT 1947, specifies the general obligations of members in setting tariffs and nontariff policies. The first five rounds of negotiations included a relatively small number of countries (23 to 38). The sixth round, the Kennedy Round (1964–67), saw a larger number (62) of participants. In addition to cutting tariffs, the Kennedy Round strengthened the discipline on anti-dumping measures (by interpreting Article 6 of GATT 1947). It also recognized the special needs of developing countries, which thenceforth encouraged the participation of developing countries in GATT. The Tokyo Round (1973–1979), with an even larger number (102) of participants, continued the GATT's tradition of cutting import tariffs. Most importantly, it embarked on negotiations over 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. With participation of 123 countries, the Uruguay Round (1986–94) succeeded in further lowering the general import tariffs 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 property rights, and trade-related investment measures. Trade that used to be exempted from the GATT rules such as textiles, clothing, and agriculture, also became subject to stricter rules. Importantly, the GATT dispute settlement procedure was overhauled, and under the new WTO procedure, members are subject to stronger enforcement mechanisms (Chang, 2009). As a result of these eight negotiation rounds, the average ad valorem tariffs on industrial goods have fallen from over 40% to below 4%, and members are subject to increasingly greater discipline on trade-related nontariff measures and domestic policies.[26]

Next, as documented by Jackson (1997) and many others, developing members have not undertaken as deep and extensive trade liberalization as industrialized countries in the history of GATT. For example, many developing countries joined 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

[26]Relatedly, based on semi-parametric estimations of the impact of WTO membership, Dutt (2020) finds evidence for strong WTO effects over time, with the WTO effects increasing almost monotonically with years of membership.

in GATT against quantitative restrictions, developing countries may implement such measures for balance of payment purposes. Thus, we expect smaller trade impact of membership for developing than developed countries. Further, the aggregate trade impact is likely larger on exports of developed members than developing members, even if the trade policy concessions of members are applied on a MFN basis (Bagwell and Staiger, 2010, 2016). In practice, we could expect this to occur when developed members predominantly focus their negotiation efforts on sectors where they have comparative advantages and less on those of developing members. The work by Subramanian and Wei (2007), based on the parametric framework, suggests that such heterogeneous membership effects are indeed observed in the data. Although as a result of the Uruguay Round negotiations, the developing countries are subject to greater discipline under WTO, they are often given longer phase-in periods to implement new trade agreements.[27]

Let H indicate developed and L developing countries. Let country pairs be classified according to their development combinations. For example, LH indicates developing exporter and developed importer country pairs, and HL developed exporter and developing importer country pairs; similarly, HH and LL represent both developed and both developing country pairs. We explain in the data appendix how we define development stages, 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 2.1, allowing for heterogeneous treatment effects. In particular, in addition to the matching controls listed in Section 2.1, we further restrict the matching to observations within the same year and development combination. We then calculate the mean treatment effect of *bothwto* (and *imwto* respectively) specific to each development combination and time period (demarcated by the trade negotiation rounds). This restricted matching has the added benefit of reducing the concern about selection on unobservables, if such unobservables are systematically correlated with the development stages (and years) and also with 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 (Chang and Lee, 2011).

Table 3, on the effect estimates of *bothwto*, shows that the GATT/WTO membership has positive effects on trade among members, but the effects are heterogeneous. In particular, the effects are the largest on trade among developed members and the weakest among developing members ($\gamma_{1,HH} > \gamma_{1,LL}$). The effects also tend to be larger on imports by developed members than developing members ($\gamma_{1,HH} > \gamma_{1,HL}$ and $\gamma_{1,LH} > \gamma_{1,LL}$). Furthermore, the trade effects tend to be more pronounced on exports of developed members than developing members ($\gamma_{1,HH} > \gamma_{1,LH}$). These results are in line with our discussions above that developed members tend to liberalize more than developing members, and such liberalization is likely biased in terms of composition in

[27] Although developing countries reduced tariffs by more during the period of 1990–2010, it remains the case that the extent of tariff reduction since 1947 is smaller in developing countries compared to developed countries. Besides this, the membership effects identified in the paper include trade-related policy changes in addition to tariffs. The finding that the degree of trade liberalization is much larger among developed members than developing members is consistent with many documented observations that developed countries have liberalized by larger extents in most aspects since the beginning of GATT in 1947.

favor of developed members' exports. Across rounds, we see generally increasing effects over time. This is especially the case for imports by developed members ($\gamma_{1,HH}$ and $\gamma_{1,LH}$). The effect is remarkably strong following the Uruguay Round, reflecting the broad coverage of its agreements. The exception is for trade among developing members ($\gamma_{1,LL}$), where the effect is weak and erratic across years.[28]

Table 4 reports the corresponding *imwto* effect. Compare Table 3 and Table 4. We note that the *bothwto* effects are, on average, bigger than the *imwto* effects ($\gamma_1 > \gamma_2$) for all development combinations. The smaller effect of *imwto* relative to *bothwto* suggests that not all members extend their MFN treatment to nonmembers, or that such extensions are not granted at all times, to all nonmembers, or across all sectors. The effect of *imwto* is on average positive if the member is developed and zero to negative otherwise ($\gamma_{2,HH}, \gamma_{2,LH} > 0$, $\gamma_{2,HL} = 0$ and $\gamma_{2,LL} < 0$). This suggests that developed members are 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 barriers against nonmember developing countries (especially after the Uruguay Round).

4 General Equilibrium Welfare Effects

In this section, we start by presenting the welfare effects of GATT/WTO membership. We compare the tariff-induced effects relative to the full effects (taking into account changes in variable/fixed trade costs as well), for the period 1988–2015 when the tariff data are available. We then present the welfare effects based on calculations that ignore the tariff revenues (as discussed in Section 2.4) for the whole period 1950–2015, after demonstrating that the welfare effects are similar in orders of magnitude between the full structural model and the version that omits the tariff revenues in income. This is then followed by extensive sensitivity analyses of the results (to alternative economic structures, variations in parameter values, and alternative sets of matching estimates).

4.1 Welfare Effects: Tariff-only Effects versus Comprehensive Effects

Figure 1 reports the distributions of the welfare effects of GATT/WTO (in terms of real wages) for developed/developing members/nonmembers. Subplots (a)–(d) illustrate the effects due to tariff changes induced by the GATT/WTO, while subplots (e)–(h) demonstrate the comprehensive effects (taking into account changes in tariffs, variable and fixed trade costs due to the GATT/WTO). See Section 2.4 for the three counterfactual setups of: tariff (effects due to tariffs only), full model

[28] To give an indication of how much the estimates in Table 3 imply in terms of trade barrier changes, we use the AvW/Krugman framework and note that $\widehat{\tau}_{ijt}^{1-\sigma}\widehat{(1+\mathrm{t}_{ijt})}^{-\sigma} = \exp(\gamma_1)$ due to *bothwto*. Based on the benchmark value of $\sigma = 5$, the average estimates for 1950–2005 from Table 3 imply that GATT/WTO reduced the direct trade barrier (inclusive of trade cost and tariffs) between two members by 12.4% (LL) to 63.9% (HH) if we approximate by bringing up the exponent of the tariff factor to $1 - \sigma$. The alternative numbers if we approximate by bringing down the exponent of the trade cost to $-\sigma$ are 10.1% (LL) to 55.8% (HH), respectively. These magnitudes appear very plausible given the rate of tariff reductions reached across rounds of GATT negotiations, in addition to many rules imposed on the use of non-tariff barriers as discussed above.

(effects taking into account tariffs and variable/fixed trade costs), and model without tariffs (effects ignoring tariff revenues).

As indicated by Table 5, the extent of tariff reduction due to GATT/WTO during 1988–2015 tended to be larger and more heterogeneous among the developing members than developed members, and was especially the case in later years. Consistently, we see that in Figure 1(a)–(d), the developing members' welfare gains (due to tariff reductions) dominate those of the developed members' and are more dispersely distributed. Understandably, the construction of counterfactual tariffs (as detailed in Appendix B.6) is subject to several potential caveats and could have systematically underestimated the degree of tariff reductions undertaken by developed members, e.g., due to limited observations of the tariffs that were imposed by developed countries before they became members. While similar limitations apply to developing members that joined the GATT/WTO before 1988 (the start of the period when systematic data on tariffs are available), relatively smaller fractions of developing members (compared to developed members) joined the GATT/WTO before 1988. In addition, developing members tended not to extend MFN treatment to nonmembers; as a result, we are better able to capture the non-cooperative tariffs that developing members could have adopted by observing what they imposed against nonmembers. Thus, the tariff reductions and their welfare effects captured by this set of analysis reflect to a larger extent the tariff reductions accomplished since 1988.

Next, Figure 1(e)–(h) present the comprehensive welfare effect. In this scenario, we follow the structural system (17)–(28) in Section 2.2 and feed in the matching estimates of the two membership indicators *bothwto* and *imwto* on $\left\{\widehat{\tau}_{ijt}{}^{-\theta}\,\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\,(\widehat{1+\mathrm{t}_{ijt}})^{-\frac{\sigma\theta}{\sigma-1}}\right\}$ from Tables 3–4 (that are statistically significant at the 10% level).[29] The findings indicate that the welfare effects are predominantly positive for developed members and dominate those of developing members, reflecting the larger reductions in trade barriers (inclusive of tariffs and trade costs) estimated for developed members as shown in Tables 3–4 and discussed in Section 3. In addition, due to the negative effect estimates of *imwto* for *LL* country-pairs for the period after the Uruguay Round, the distribution of welfare effects for the developing members is no longer uniformly positive as in the scenario with tariff changes only. Rather, some developing members experienced negative welfare effects in this period (e.g., in 2000 and 2015, as illustrated in the figure). It is also worthwhile to note that due to both general equilibrium effects and negative effect estimates of *imwto* for *LL* country-pairs for the period after the Uruguay Round, an increasing number of nonmembers (especially developing nonmembers) experienced negative welfare effects in later years by staying outside the GATT/WTO system.

Finally, in Figure 1(i)–(l), we then consider revised counterfactual equations of Section 2.2,

[29] Note that we have conducted the matching estimation only up to year 2005, but extend the counterfactual analysis to the period 2006–2015 (using the matching effect estimates of 1995–2005). This decision was made due to our concern that the set of nonmembers (especially developed countries) became very small in the period of 2006–2015, possibly violating the overlapping support assumption of matching estimation. Since most of the Uruguay Round agreements were implemented by 2005 and not much progress has been made since then in the Doha Round, we believe the trade effect estimates of 1995–2005 reflect reasonably well the extent of trade liberalization completed after the Uruguay Round.

ignoring the tariff revenues in equations (20), (26) and (27), and the adjustment term $(\widehat{1+\mathfrak{t}_{ij}})$ in (19) for the wedge between supplier and consumer prices. The estimation stage remains the same as in the full model with tariff incorporated, and allows the estimated effects and the corresponding shocks to the system to reflect the effects of tariffs on trade flows. As indicated by the figure, the distributions of the welfare effects of this approximate version are very similar to the full model, except for the developing members. In the approximate version, fewer developing members experienced negative welfare effects in later years. This is likely due to the fact that by omitting the tariff revenues from a nation's expenditures, it does not factor into the lost tariff revenues due to tariff reductions in the case of developing members and hence understates the negative general equilibrium impacts on these countries (which as discussed above saw substantial tariff reductions in later years).

Table 6 provides the summary statistics of the welfare effects corresponding to Figure 1 for the Melitz framework (and also for alternative economic structures based on AvW and Krugman as discussed in Section 2.4). Similar to the observations made above, the distributions of welfare effects are in similar orders of magnitude between the full model and the model without tariffs (by the median and the 75 percentile), but the 25-percentile effect tends to be larger in the model without tariffs than in the full model for the members in the later years (of 2000 and 2015). The welfare effects in these two scenarios in turn dominate those of tariff changes alone, and the discrepancies tend to be more pronounced in the upper quartile. Thus, relying on tariffs alone does not offer a complete picture of the welfare effects of GATT/WTO qualitatively or quantitatively.

Given the comparison and observations made above, we will proceed with the model without tariffs for the subsequent analysis. This allows us to provide a long-panel analysis of the GATT/WTO effect for its entire history 1950–2015, without the need for tariff data.

4.2 Benchmark Counterfactual Results: 1950–2015

Figure 2 provides a breakdown of the welfare effects by development stages and membership status. Due to space constraints, we report the results for selected years. The distribution of welfare effects became increasingly more dispersed over the years, with a long right tail. Developed members in general gained more relative to developing members. For example, in 2015, the mode was around +8% for developed members, but +2% for developing members. In early years, nonmembers tended to gain from GATT/WTO by free-riding on members' reductions in tariffs/trade costs and extensions of MFN treatment. But such positive externality was limited, and generally disappeared after 1980. The welfare-effect distribution of nonmembers, being more compressed before 1980, started to diverge from the members' distribution. Nonmembers experienced increasing welfare losses of staying outside the GATT/WTO system. These heterogeneities in welfare effects across countries were mainly driven by the heterogeneous partial effect estimates of (γ_1, γ_2) across development combinations and rounds, but also by differences in country sizes and the general equilibrium effects.

In Section 4.4, we showcase the diverse welfare effects for a variety of countries.[30]

With the use of intermediates in entry, the mass of entrants is not fixed in the Melitz framework and this adjustment in firm entry introduces an extra margin of gains from trade relative to the AvW framework. In addition, as discussed in Section 2.4, the adjustment in firm entry varies with the gains in real wage monotonically $\widehat{N}_i = \left(\widehat{w}_i/\widehat{P}_i\right)^{1-\beta_i}$ (subject to differences in value-added shares across countries). This implies that the larger the initial gain under the AvW framework, the stronger the amplification effect due to firm entry in the Melitz model. These observations are confirmed by the changes in firm entry in Figure 3: the distribution of the firm-entry effects closely follows that of the welfare effects in the AvW model shown in Online Appendix Figure B.3.

In Online Appendix, we report the parallel results based on the AvW and Krugman economic structures. The patterns of the welfare effects for members and nonmembers across years are qualitatively similar across the three frameworks. Figure 4 summarizes the differences in their quantitative implications. In general, the quantitative gains for members in the Melitz framework turn out to be smaller than in the Krugman framework, but larger than in the AvW framework.

To understand the rankings, 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 Online Appendix (A.8)–(A.9) for the Krugman model and $\widehat{\tau}_{ij}^{1-\sigma}\widehat{V}_{ij}$ in (18)–(19) for the Melitz model (in addition to the tariff changes). As (25) indicates, the Melitz numerical results converge to those of the Krugman model as θ approaches its lower bound $\sigma - 1$. On the other hand, the same set of matching estimates corresponds to the GATT/WTO effect on the variable trade cost ($\widehat{\tau}_{ij}^{1-\sigma}$) in the Krugman model, but on both the variable and fixed trade costs ($\widehat{\tau}_{ij}{}^{-\theta}\widehat{f}_{ij}{}^{-\frac{\theta}{\sigma-1}+1}$) in the Melitz framework (in addition to effects on tariffs in either model); as a result, the larger the parameter θ, the smaller are the implied changes in trade costs in the Melitz model for a given set of effect estimates, and hence, the smaller are the welfare effects. Thus, for all $\theta > \sigma - 1$, the same set of observed trade flows would actually imply smaller welfare effects in the Melitz than in the Krugman model. This is illustrated by Figure 4, which indicates smaller gains for members (and smaller losses for nonmembers) in the Melitz framework relative to the Krugman framework. The smaller welfare effects in the Melitz framework also imply correspondingly smaller effects on firm entry, given the monotonic relationship between changes in firm entry and changes in real wages (as discussed in Section 2.4).

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 change in trade cost in the two models. In contrast, Melitz and Redding (2015) compare the two models' welfare implications based 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 contrary to Melitz and Redding (2015).

[30] Although the set of countries included in the analysis varies across years because of data limitation (cf. Table 1), the heterogeneous pattern of welfare effects remains largely the same if we restrict the diagrams to include only the set of countries available in 1960.

Next, comparing 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 smaller welfare effects 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, in general, it is not necessary for the effects to be larger/smaller in the Melitz framework. For the benchmark parameter values ($\sigma = 5, \theta = 5$), we find that the firm entry effect dominates, and as a result, the estimated welfare gains for members are bigger in the Melitz model than in the AvW framework (cf. Figure 4).

When θ increases, the first mechanism becomes more pronounced and simultaneously the entry effect weakens. For example, as we increase θ from the benchmark to 5.5, the welfare effects in the Melitz model decline, accompanied by smaller changes in firm entry. These patterns are shown in Table 7. As discussed below in Section 4.3, we also experiment with larger values of θ in robustness checks. It is shown that with sufficiently large θ (eg., $\sigma = 5$ and $\theta = 8$), the ranking of the two models in terms of their welfare implications will eventually reverse.

4.3 Robustness Checks

In addition to robustness checks with respect to the underlying economic structures as shown above, in this section, we consider: variations in the parameter values, alternative matching effect estimates (based on 100% caliper), and different levels of labor intensity in the entry process. Although not explicitly reported, the results are similar when based on the real expenditure (instead of real wage) as the welfare measure. Online Appendix Tables B.3, B.4 and B.5 summarize the welfare effects of GATT/WTO across combinations of the parameter values for σ and θ, the matching effect estimates, and under the three alternative economic structures.

First, we allow θ to vary within a range of values suggested by the literature (as discussed in Footnote 23). A higher θ is expected to lower the welfare effect estimates in the Melitz model since the same observed changes in trade flows imply smaller changes in the underlying trade costs. Indeed, across Online Appendix Tables B.3–B.5, the welfare effects of the Melitz model monotonically decrease as we increase θ from 4.5 to 10. In particular, when $\theta = 8$, the Melitz model implies smaller welfare effects than both the AvW and Krugman models. As discussed in Section 4.2, the extra welfare gain due to firm entry in the Melitz model is in this scenario dominated by the smaller implied trade cost changes, leading to smaller welfare effects than in the AvW model.

Next, we consider a large parameter value for the elasticity of substitution ($\sigma = 10$). We expect the welfare effects to decrease with larger σ, because goods are closer substitutes in this case. In the Melitz model, we need to set the parameters $\theta > (\sigma - 1)$ such that the aggregate price is well defined. Thus, by setting $\sigma = 10$, we also modify θ up such that $\theta = 10$. These two parameter values are close to the upper bound used in the literature, so we could take the associated welfare effects derived under this setting as potential lower-bound predictions. Scenarios 7 and 14 in Online Appendix Tables B.3–B.5 provide the corresponding quantitative magnitudes for these lower bounds.

Third, we consider alternative matching effect estimates based on 100% caliper choice (instead of 40%). The effect estimates of *bothwto* and *imwto* are reported in Online Appendix Tables B.6 and B.7. They are in general larger than based on the 40% caliper, albeit with some exceptions. Larger matching effect estimates map into larger welfare effects. For example, Online Appendix Tables B.3–B.5 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 holds true across variations in σ and θ.

Last but not least, we allow the entry process in the Melitz model to use input bundles that have higher labor intensity than the input bundles used in the production process following Bollard, Klenow and Li (2016) [BKL] and Arkolakis, Costinot and Rodríguez-Clare (2012). The modifications to the counterfactual equations are shown in Math Appendix A. Let κ denote the value-added share in the entry process. The mean value-added share across the entry and the production process is then: $\bar{\beta}_i \equiv \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) + \kappa \left(\frac{\sigma-1}{\sigma\theta}\right)$. The value $\bar{\beta}_i$ corresponds to the value-added share observed in the data. Since the maximum value-added share observed across countries in the data is 0.53, we set κ to take on values in $[0.6, 0.8, 1]$ and calibrate β_i for given κ and observed $\bar{\beta}_i$. The effects on firm entry are summarized in Table 7, where we also include the Melitz benchmark results (when $\kappa = \beta_i = \bar{\beta}_i$). Consistent with theoretical implications, for majority of members that gain in real wages, the relatively larger increase in the wage relative to the aggregate price implies a higher entry cost if κ is larger, which as a result weakens the incentive to entry (because wage cost is weighed more heavily in the input bundle for the entry process with larger κ). The reverse is true for nonmembers when they experience a smaller increase in the wage relative to the aggregate price; an increase in κ reduces the negative effect on entry. In the limit when $\kappa = 1$, the mass of firms remains constant as suggested by the original Melitz model, and the GATT/WTO has zero effect on firm entry. The findings above remain to be valid as we vary the parameter values for σ, θ, or the caliper choice (for the matching estimates).

In spite of the impacts on firm entry as κ changes, Table 7 indicates that the impact of varying κ on welfare is negligible. To understand this result, note that we calibrate the parameter to imply the same mean value-added share as observed in the data. As κ increases in the entry, for given observed value-added shares $\bar{\beta}_i$, it implies smaller β_i in the production. A larger κ reduces the welfare effects (via smaller firm entry effects), but a smaller β_i amplifies the welfare effects (since the multiplier effect via the use of intermediates in the production process is stronger). The simulation results suggest that these two countervailing mechanisms exactly offset each other, leaving the same welfare effects with respect to variations in κ. Further details on the entry and welfare effects as κ varies are provided in Online Appendix Tables B.8–B.9.

4.4 Country-specific Welfare Effects and Regional Impacts

In Figure 5, we illustrate the diverse welfare effects of GATT/WTO across countries. We choose for each region (Americas, Asia, Europe/Africa/Middle East) six countries, of various development stages, country sizes, and timings 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 counterfactual results shown above, the Melitz framework's welfare implications generally lie between those of the AvW and the Krugman models. The timing of a country's accession to GATT/WTO is indicated by a vertical red line.

Figure 5 shows that, among the big developed members, Germany (DEU) benefited the most, followed by the UK (GBR), Japan (JPN), and the US (USA). Developing members such as India (IND) and Brazil (BRA) tended to gain relatively less, with Argentina (ARG) seeing a stronger effect in recent years. Small open economies in particular benefitted a lot from GATT/WTO. For example, Singapore (SGP) gained more than 50% (and up to 100%) in real GDP in the period since 1980 based on the Krugman framework. Denmark (DNK) also experienced a steady large welfare gain of 7–13% with its accession to the system.

Turning to the next set of countries, which joined GATT/WTO relatively late or not before 2015, we see that the welfare dynamics typically show a dramatic shift following accession. For example, China (CHN) saw a big welfare gain of up to 8% after its accession in 2001, in contrast with small welfare losses during 1980–2000. The welfare gains following accession were more dramatic for small open economies such as Thailand (THA) and Vietnam (VNM), while they were not as pronounced for more closed economies such as Ecuador (ECU). Vietnam benefitted as much as 20% and Thailand 15% after joining GATT/WTO in 2007 and 1982, respectively. The welfare dynamics of Paraguay (PRY) were quite volatile, mimicking its volatile trajectory of trade openness. Nonmembers typically did not lose much from being outside the system before 1980 and mostly free-rode on the MFN liberalization of members, but such positive externality generally disappeared after 1980. The welfare cost borne by these nonmembers since 1980 appeared to have prompted several of them to join GATT/WTO afterwards. Finally, the last three countries (Belarus, Yemen, and Ethiopia) illustrate the welfare cost sustained by countries that remained nonmembers throughout most of the period (1950–2015). The welfare cost was 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 was also increasingly costly for the least developed African countries such as Ethiopia (ETH) to stay outside the system, even though they were relatively closed to begin with.

Table 8 provides a summary of the impacts across geographical regions. We see that all OECD countries gained, and in 2015, the mean and median gains were substantial at 11–13% by the Krugman framework. East and South Asia, and Eastern Europe and Central Asia had some very big winners and some small losers, leaving an overall big positive welfare impact of more than 7%. Latin American and Caribbean countries experienced relatively homogeneous and positive welfare effects, with a mean/median of 4–6%. The other regions saw generally smaller positive effects from GATT/WTO. Sub-Saharan Africa, in particular, had very diverse experiences, reflecting its rather heterogeneous economic structures and degrees of participation in world trade.

5 Extended Analysis

In this section, we use the framework established earlier to examine three interesting issues.

5.1 Effects of GATT/WTO on Cross-country Income Disparity

First, we analyze how cross-country income disparity has been affected by the multilateral liberalization process introduced by GATT/WTO. Does the system tend to benefit poor countries more than rich ones, and reduce the cross-country income disparity, or has it worsened the global income disparity? To begin, we calculate the Gini coefficient of the factual GDP per capita weighted by the population size of each country.[31] This is then compared to the counterfactual Gini coefficient had GATT/WTO not existed, based on the AvW/Krugman framework with $\sigma = \{5, 10\}$. Figure 6 presents the results. Since the set of countries in our sample varies across years, we present four variations, where the set of countries includes all those available in each given year, or is fixed to those available across all years during 1980–2005 (118 countries) or during 1980–2015 (111 countries), respectively. The second set of results removes the potential effects (on the Gini coefficient) of changes in the composition of countries across years. For example, in panels (a) and (c), the spike in the Gini coefficient in 1961 and the discrete jump in 1978 are due to the inclusion of China in the sample.

Figure 6 indicates that the global income disparity increased during 1980–1995, but has since gradually declined toward its historically low level seen in 1958. The absolute level, however, was still alarmingly high at above 0.6. This reversal in the trend of global income disparity in recent decades is consistent with the findings documented by Milanovic (2016) and Bourguignon (2015).[32] Next, we see that the global income disparity was higher without GATT/WTO after 1980 (the results are similar based on AvW or Krugman, and actually not distinguishable). The difference was especially large after 1995. These patterns suggest that GATT/WTO has in fact brought the

[31] This is the second concept of inequality (*Inequality 2*) as classified by Milanovic (2013). The first concept of inequality focuses on inequality between nations of the world, using GDPs per capita (or mean incomes obtained from household surveys) of countries, without population weighting. The concept *Inequality 2* differs from the first concept by taking into account countries' population sizes. The third concept is the global inequality, which focuses on individuals: all people, regardless of their country, enter in the calculation with their actual income. Because the third concept relies on household surveys, which are not available for most countries before the mid- or late 1980s, it cannot be calculated with much precision before then.

[32] Acemoglu and Ventura (2002) argue that the relative income across countries remained stable between 1960 and 1990, as indicated by Figure I in their paper. This appears in tension with the pattern suggested by Figure 6, where the global income disparity increased from 1960 to 1990. Even if we exclude China, the pattern is a smooth increase from 0.64 in 1960 to 0.71 in 1990. This may be reconciled by the fact that Figure I in their paper is plotted in terms of the log of GDP per capita. Although most countries' log of GDP per capita values in 1990 relative to the world average are similar to those in 1960, there is a cluster of Asian countries (Japan, Hong Kong, Singapore, and Korea, etc.) that are positioned well above the 45 degree line and became richer in 1990 than in 1960, relative to the world average. The opposite is true for another cluster of African countries, which started poorer in 1960 and became even poorer in 1990 relative to the world average. When we restrict the sample of our analysis to those available in 1960 (89 countries), we can reproduce similar patterns as Figure I in Acemoglu and Ventura (2002), with two clusters of economic miracles and laggards, respectively. At the same time, the calculated Gini coefficient continues to show an increase from 1960 to 1990. Thus, although the increase in the standard deviation of income may not be large in the log scale, as suggested by Acemoglu and Ventura (2002), the increase in the Gini coefficient of income in terms of the original scale is clearly present.

poor nations/people up the ladder of livelihood, improving the global equality across countries. In particular, the integration of China (and other developing Asian countries) into the world economy via GATT/WTO likely contributed significantly to this trend.

As a final remark, the current paper has not addressed the question 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 extent. It would be interesting to answer these questions based on quantitative trade/FDI models that allow for heterogeneous factors of production. We leave this to future research.

5.2 Interaction of PTA and GATT/WTO

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 liberalization under GATT/WTO. The tension and interaction between PTAs and GATT/WTO are of two folds. On one hand, the presence of PTAs may alter the incentives to participate in multilateral trade liberalization or the extent of multilateral trade liberalization that is feasible (Levy, 1997; Krishna, 1998; Karacaovali and Limao, 2008; Estevadeordal, Freund and Ornelas, 2008). We cannot address this issue, since it requires a completely different structural model with endogenous trade-policy formation. We leave this interesting quantitative evaluation to future work. On the other hand, given the presence of the PTA network and the GATT/WTO membership status, the PTA provisions may undermine or complement the multilateral trade policies. For example, Bagwell, Bown and Staiger (2016) suggest many avenues where PTAs may worsen the terms-of-trade externality that the GATT/WTO multilateral approach is designed to eliminate. Nevertheless, when looking beyond the terms-of-trade argument, the same survey (pp. 1196–1206) suggests that PTAs could potentially address issues that GATT/WTO's shallow integration approach fails to do, for example, in response to the commitment problem (Ethier, 1998) or the complications introduced by production offshoring (Antràs and Staiger, 2012). We evaluate this second issue by conducting the welfare analysis of GATT/WTO in the counterfactual had all the PTAs not existed, and compare the effect with what we obtained in Section 4 under factual PTAs. We use the same matching procedure described in Section 2.1 to estimate the PTA effect, with the treatment now replaced by the PTA indicator, and with *bothwto* and *imwto* as part of the matching controls. As shown in Table 9, the PTA trade effects are relatively homogeneous across development stages. In unreported analyses, we found that the PTA effects are also similar across decades. In any case, most of the PTAs were signed after 1990s. Thus, we proceed with the set of PTA effect estimates in Table 9 that differ across development stages but not across time.[33]

[33] The estimates of *bothwto* and *imwto* in each cell of Tables 3 and 4 are the mean effects across treated observations with or without PTAs. The estimates are very similar when we further restrict the sample to those without PTAs. It is, however, difficult to implement the same estimation for only those observations with PTAs, because there are often no or very few observations in the control group for the development combinations of HH, LH, and HL. In other words, there are few observations where a country pair has PTAs but neither is a GATT/WTO member in these development combinations.

Figure 7 summarizes the welfare effects of GATT/WTO without PTAs relative to its effects with the observed PTAs. This is based on the Melitz framework and benchmark parameter values. The ex-post gains of members were smaller without the PTAs. The difference became more significant in recent decades when the PTAs surged in numbers (and was also noticeable in 1960 during the first wave of PTAs). Thus, for GATT/WTO members, PTAs appeared to complement multilateral liberalization, supporting the view in Antràs and Staiger (2012) that individualized deep-integration PTAs may be required (alongside GATT/WTO) to guide governments to efficient policy choices. As documented by Hofmann, Osnago and Ruta (2019), PTAs on average have become deeper since the late 1990s in the sense that many of them include WTO-plus and WTO-extra provisions that go beyond the GATT/WTO mandate. The results in Figure 7 provide some supporting evidence of the potential complementarity between deep PTAs and GATT/WTO.

As shown in the previous sections, nonmembers sustained welfare losses (especially since 1980s) by staying outside the GATT/WTO system and were disadvantaged in terms of market access. Figure 7 shows that the ex-post losses of nonmembers were bigger without the PTAs. In other words, welfare losses of nonmembers were alleviated with access to PTAs. A closer look into the data suggests that most nonmembers have signed some PTAs in recent years. In a way, this suggests that PTAs are in general welfare-improving for nonmembers and that trade creation dominates potential trade diversion of PTAs for these countries. However, this also implies that the relief offered by PTAs may reduce nonmembers' incentives to participate in GATT/WTO, related to the first issue of the debate discussed above. Thus, in this perspective, PTAs could be stumbling blocks to multilateral trade liberalization.

5.3 Effects of China's Accession to GATT/WTO

Since the 1990s, China has grown exponentially in its production and exports: its share of world exports increased from 1.18% in 1990 to 11.42% in 2015; in 2013, it became the world's largest exporter (according to the World Bank's World Development Indicator). Naturally, such rapid growth in trade led to great anxiety from its trading partners. In this section, we evaluate the welfare effect of China's WTO entry on the world, by shutting down China's membership in the counterfactual (since its accession in 2001). This is different from the analysis we have conducted so far, where we shut down the GATT/WTO system as a whole in the counterfactual.

Figure 8 illustrates the welfare effects for a selected set of countries/customs territories. The legends for the countries are arranged in descending order by their mean welfare effects during 2001–2015. Hong Kong and Vietnam turned out to be the biggest winner and loser, respectively. The large gain to Hong Kong is understandable given the intermediary role it played in China's external trade, while Vietnam likely suffered due to its similarity to China in terms of comparative advantages in production structures. China itself has benefitted the most from its decision to enter the WTO, relative to the rest of the world, although the gain has been weakening in recent years. Strong externality effects (positive or negative) tended to be concentrated in the Asian region (Singapore, Korea, Malaysia and Thailand), with relatively small impacts on OECD countries

(UK, USA, Germany and Japan). Online Appendix Figure B.6 illustrates for years 2005 and 2015 the geographical distribution of the welfare impacts. For most countries in the world, the impact was relatively small in the range of $[-1\%, 1\%]$. While the welfare impact on China itself lessened over the years, they increased in Latin America, Africa, Australia, and Asia. Finally, Online Appendix Figure B.7 illustrates the welfare impact of China's WTO entry for developed/developing members and nonmembers across years. The distribution has over time shifted to the right. By 2015, developed members tended to gain, while developed nonmembers generally experienced negligible welfare effects. The biggest losers from China's entry into WTO tended to be developing nonmember countries.

di Giovanni, Levchenko and Zhang (2014) studied a related but different counterfactual, in which China returns to complete autarky. As a comparison, we produce a summary table (Table 10) similar to Table 3 (Panel A) in their study. We present the results based on the AvW model, since they used a generalized EK model. Note that the sample of countries is much bigger in the current study (175 in 2005 and 180 in 2015). We follow the same geographical classifications as in their study in assigning the countries. Contrary to intuition, Table 10 indicates bigger welfare impacts if China had not entered GATT/WTO than in di Giovanni, Levchenko and Zhang (2014) (with the counterfactual if China had returned to complete autarky). This can potentially be reconciled by the fact that the trade cost estimation in di Giovanni, Levchenko and Zhang (2014) does not take into account the GATT/WTO indicators and hence may have under-estimated the extent of China's trade liberalization since 2001.[34]

6 Conclusion

In this paper, we first compare the welfare effects of GATT/WTO via tariff reductions versus the comprehensive effects (with changes in variable/fixed trade costs also taken into account). For the tariff-only exercises, we compile factual tariff data and construct counterfactual tariffs that would be in place had the GATT/WTO not existed. For the comprehensive-effect exercises, we identify changes in bilateral trade flows as a result of membership in the GATT/WTO by non-parametric matching estimations. The identified direct trade effects of GATT/WTO membership map into changes in tariffs, as well as changes in variable/fixed trade costs, in a generalized Melitz framework, and can be used as inputs in counterfactual exercises to simulate the welfare impacts of GATT/WTO. We demonstrate that evaluating the welfare effects (in terms of real wages) based on tariff changes alone understates by a large margin the comprehensive welfare effects of GATT/WTO. We then show that if we ignore tariff revenues in income in the counterfactual exer-

[34]In another study, Ianchovichina and Martin (2004) also evaluated the impacts of China's WTO accession but from an ex ante perspective. Although based on very different approaches (CGE modeling) and structures, they predicted some qualitative patterns that are consistent with our findings above. In particular, they predicted Vietnam to suffer the most (in percentage terms), and most of the positive/negative impacts to be concentrated in Asia, with China itself the biggest winner. The quantitative impacts predicted tend to be smaller in their work. This could be due to their focus on tariff changes, with nontariff import barriers omitted (although, on the other hand, they took into account additional structural changes due potentially to accession).

cises, the resulting welfare effects are in similar orders of magnitude as the comprehensive welfare effects. This approximation allows us to carry out the welfare analysis for the entire history of the GATT/WTO based on the input of the non-parametric estimates discussed above (which incorporate the direct effects of tariffs and trade costs on trade flows), without the need for tariff data (which are not available systematically for the large set of economies studied here for the period before 1988).

Bearing in mind potential caveats of the approximations, we provide a comprehensive analysis of the welfare effects of GATT/WTO for a large set of economies (as many as 180) during 1950–2015. The analysis suggests a robust pattern of welfare gains for members, and that the distribution of the gains is increasingly dispersed with a long right tail. The developed members' distribution clearly dominates the developing members' by a large margin, reflecting the differential degrees of trade liberalization undertaken by members across development stages and in favor of developed countries' exports. Nonmembers did not experience welfare loss by staying outside the GATT/WTO system in earlier decades and in fact benefitted from MFN treatment extended by members to nonmembers. Such positive externality diminished after 1980, when the nonmembers' distribution started to diverge from members' and shifted to the left with increasingly larger welfare losses. Welfare effects are also heterogeneous across geographical regions with disproportionately larger gains accruing to Europe and Asia. Still, the global income disparity across countries is lower with GATT/WTO, and the impact is especially pronounced after 1995. Thus, overall, GATT/WTO has improved global welfare in a progressive way.

The difficulty for members to reach major agreements in the current Doha round negotiations, however, signifies that the multilateral approach may have reached its limit, due perhaps to bargaining frictions, weak commitment enforcement, or inefficiencies that cannot be addressed by shallow integration. The results in this paper suggest that PTAs can potentially play a complementary role to GATT/WTO. As an implication, it might be productive to re-think how to streamline the provisions for PTAs under GATT/WTO (beyond the GATT Article XXIV and the Enabling Clause), and to re-define the scopes for permissible PTAs so as to maximize their potential benefits. In this regard, more research that quantifies how the nature or depth of PTAs affects their welfare effects and their interactions with GATT/WTO would be very useful.

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A Math Appendix

A.1 Derivation of Equation (8)

Given (7), we can rewrite (5) as:

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

Similarly, we can rewrite (6) as:

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

Define $\chi_i \equiv \Pi_i^{1-\sigma} / \left\{constant \times \left(c_i{}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}\right)\right\}$ and $\zeta_j \equiv P_j^{-\theta} / E_j{}^{\frac{\theta}{\sigma-1}-1}$. We have (9) and (10) in the main text. In addition,

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

A.2 Alternative Formulations of the Input Bundle in the Melitz Framework

Suppose that instead of (12), the entry uses an input bundle with a different labor intensity, characterized by:

$$c_i^e = w_i^\kappa \, P_i^{1-\kappa}. \tag{31}$$

The free-entry condition in (13) is modified to be:

$$\frac{\sigma-1}{\sigma\theta} Y_i = N_i F_i c_i^e, \tag{32}$$

and the labor-market clearing condition is instead:

$$w_i L_i = \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) Y_i + \kappa \left(\frac{\sigma-1}{\sigma\theta}\right) Y_i. \tag{33}$$

In addition to (22) and (24), we have:

$$\widehat{c}_i^e = \widehat{w}_i^\kappa \, \widehat{P}_i^{1-\kappa}, \tag{34}$$

and the modified free-entry counterfactual equation:

$$\widehat{Y}_i = \widehat{N}_i \, \widehat{c}_i^e. \tag{35}$$

Thus, we have one extra set of variables $\{\widehat{c}_i^e\}$ to determine but also one extra set of conditions (34).

To set the parameter for κ, define $\bar{\beta}_i \equiv \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) + \kappa \left(\frac{\sigma-1}{\sigma\theta}\right)$. The value $\bar{\beta}_i$ corresponds to the value-added share observed in the data. The assumption $\kappa = \beta_i$ corresponds to the case where $\bar{\beta}_i = \beta_i$. In general, following Bollard, Klenow and Li (2016), we allow for the scenarios where the input bundle used for entry is more labor intensive than in production, i.e., $\kappa > \beta_i$. Thus, we set κ to take on values greater than $\max_i\{\bar{\beta}_i\}$, where $\max_i\{\bar{\beta}_i\}$ is the maximum value-added share observed across countries in the data (0.53). In particular, we allow κ to take on values of $[0.6, 0.8, 1]$. Given $\bar{\beta}_i$ and κ, we then back out the values for β_i given the relationship $\bar{\beta}_i \equiv \beta_i \left(1 - \frac{\sigma-1}{\sigma\theta}\right) + \kappa \left(\frac{\sigma-1}{\sigma\theta}\right)$.

B Data Appendix

The data used in this paper comprise four main components: trade flows, GDPs, trade-cost proxy variables, and import tariffs. We compiled the first three components for the period of 1950–2015 and the import tariffs for the period 1988–2015. The matching estimation is conducted using the data on the first three components in 1950–2005. The counterfactual quantitative analysis is carried out yearly for 1950–2015 (for models excluding tariffs) and for 1988–2015 (for models incorporating tariffs), although due to space constraints, results are reported only for selected years.

B.1 Bilateral Trade Flows

Bilateral merchandise trade flows are obtained from the IMF Direction of Trade Statistics (DOTS).[35] They are recorded in current US 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 for each bilateral trade relationship (Rose, 2004).

B.2 GDP and Gross Output

We use the GDP data from the CEPII's Gravity dataset,[36,37] and supplement the missing entries with the GDP data from the World Bank's World Development Indicators (WDI).[38] We construct the 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 are taken 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 Appendix E in their paper). For countries included in our analysis but not separately studied in Caliendo and Parro (2015), we use their ROW value-added share.

We use the population data from the CEPII's Gravity dataset, and supplement the missing entries with the population data from WDI and the International Monetary Fund's International Financial Statistics (IFS).[39] The data on GDP per capita are also obtained from the CEPII's Gravity dataset. When it is missing in CEPII, we calculate the variable by the ratio of GDP and population as compiled above.

B.3 Expenditure

Based on bilateral trade flows, we construct the trade deficit of a country by: $\widetilde{D}_{jt} = \sum_i M_{ijt} - \sum_i M_{jit}$. However, due to omissions, the world trade deficit $\widetilde{D}_{wt}$ does not always sum to zero. We allocate the discrepancy $\widetilde{D}_{wt}$ to each country in proportion to its output share of the world, i.e., $D_{jt} = \widetilde{D}_{jt} - s_j\widetilde{D}_{wt}$. The gross expenditure of a country is then constructed as: $E_{jt} = Y_{jt} + D_{jt} + T_{jt}$ in general, and $E_{jt} = Y_{jt} + D_{jt}$ if tariff revenues are ignored.

B.4 Classification of Developed and Developing Countries

Rose (2004) and Subramanian and Wei (2007) classify the traditional industrialized countries as developed countries.[40] 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 US$6,000 per capita (in 1987 prices) used

[35] http://www.imf.org/en/Data.
[36] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8.
[37] https://sites.google.com/site/hiegravity/data-sources.
[38] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.
[39] http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B.
[40] See Appendix Table 2 in Subramanian and Wei (2003).

by the World Bank for high-income countries.[41] These thresholds have been 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.[42] For the period 1950–1959, when the SDR deflator does not exist, we use the US GDP deflator,[43] 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 industrialized countries listed in Subramanian and Wei (2003). Otherwise, it is classified as a developing country.

B.5 Proxies for Asymmetric Bilateral Trade Cost

The main bulk of the trade cost variables is taken from CEPII's Gravity dataset and GeoDist dataset.[44] The original dataset includes 225 countries. 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 equal 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 state or the same administrative entity for a long period of time (25–50 years in the twentieth century, 75 years in the nineteenth century, and 100 years before; $ComNat_{ij}$); 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 switches in the period of our study, we construct the 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 cur-

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

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

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

[44] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6.

rently 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, Mayer and Ries (2010), available via the Sciences Po website.[45] We supplement the legal origin data from CEPII with the information from La Porta et al. (1999), La Porta, de Silanes and Shleifer (2008) and the CIA's *World Factbook* website,[46] to construct the common legal origin indicator ($ComLeg_{ij}$), which equals one if two countries share a common legal origin. The information on the number of landlocked or island countries in a pair ($Landl_{ij}$, $Island_{ij}$) is from Andrew Rose,[47] supplemented with information from the CIA's *World Factbook* website.

The data on the preferential trade agreement indicator (PTA_{ijt}) and the common currency indicator ($ComCur_{ijt}$) are from de Sousa by default,[48] and supplemented with CEPII's Gravity dataset. We also update missing PTA entries using the WTO Regional Trade Agreements Information System (RTA-IS).[49]

B.6 Import Tariffs

We collect the raw import tariff data from two sources, the United Nations Conference on Trade and Development–Trade Analysis and Information System (UNCTAD-TRAINS) and the World Trade Organization Integrated Data Base (WTO-IDB). The data are downloaded via the World Bank World Integrated Trade Solutions (WITS) website,[50] and observations are available starting 1988. For each partner-reporter-year (ijt-specific) combination, four types of tariff rates are available: Effectively Applied (AHS), Preferential (PRF), MFN applied (MFN) and MFN bound (BND). For each type of these rates, we choose the simple average rate (across products) reported by the database. We take the UNCTAD-TRAINS data as the benchmark, and supplement missing values with the WTO-IDB data. For the EU countries, we utilize the information for the reporter "EU". Specifically, we set the tariff rate between two EU members as zero, and that between an EU country and a non-EU country to be the rate between EU and this non-EU country, unless the bilateral rate is explicitly reported between the two countries.

To measure the import tariff rate $\mathfrak{t}_{ijt}$, we take the AHS rate as the default. If the AHS rate is missing, we take the PRF rate as the next alternative if the PTA or GSP indicator equals one ($PTA_{ijt} = 1$ or $GSP_{ijt} = 1$). If both are missing, we fill in missing entries according to the following sequence:

(I) Conditional on ij: if the reporter/importer j is a GATT/WTO member, we replace a missing entry $\mathfrak{t}_{ijt}$ with observation $\mathfrak{t}_{ijt'}$ according to the conditions (a)–(b) listed below, where t' is

[45] `http://econ.sciences-po.fr/node/131`.
[46] `https://www.cia.gov/library/publications/the-world-factbook`.
[47] `http://faculty.haas.berkeley.edu/arose/RecRes.htm`.
[48] `http://jdesousa.univ.free.fr/data.htm`.
[49] `http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx`.
[50] `http://wits.worldbank.org/WITS/WITS/AdvanceQuery/TariffAndTradeAnalysis/AdvancedQueryDefinition.aspx?Page=TariffandTradeAnalysis`.

the closest year to t and in the same GATT/WTO round as t. If two candidate observations satisfy this timing condition, the observation of the earlier year is adopted.[51] Specifically:

(a) if $PTA_{ijt} = 1$ or $GSP_{ijt} = 1$, and $PTA_{ijt'} = 1$ or $GSP_{ijt'} = 1$, then $AHS_{ijt'}$ is used if $PRF_{ijt'}$ is also available at time t';[52]

(b) if $PTA_{ijt} = 0$ and $GSP_{ijt} = 0$, $MFN_{ijt'}$ is used as the default, and $BND_{ijt'}$ as the next candidate, provided the partner/exporter i is a GATT/WTO member at both t and t'. If i is not a GATT/WTO member at time t or t', $AHS_{ijt'}$ is used instead;

(c) if the above fails, we drop the restriction of the same GATT/WTO round and allow t' to be at $t-1$ or $t+1$.

If the reporter/importer j is not a GATT/WTO member, we follow the same steps (a)–(c) above, but use available $AHS_{ijt'}$ rate regardless of PTA_{ijt}, GSP_{ijt}, or i's GATT/WTO membership status.

(II) Conditional on jt, we then fill in a missing entry t_{ijt} using information about the tariff rates imposed by j at time t on the other trade partners i':

(a) If the reporter/importer j is a GATT/WTO member, we replace the missing entry for i that is a member with the median value of available $MFN_{i'jt}$ (and if missing, $BND_{i'jt}$) based on the subset of i' that are GATT/WTO members; otherwise for i that is not a member, we use the median value of available $AHS_{i'jt}$ based on the subset of i' that are not GATT/WTO members. As the next alternative, we also consider extending the set of candidate tariffs from the same year t to all years of the same GATT/WTO round, and use the median value of candidate tariffs across all i' and t' that satisfy the conditions specified above.

(b) If the reporter/importer j is not a GATT/WTO member, we replace the missing entry with the median value of available $AHS_{i'jt}$ based on the subset of i' that shares the same GATT/WTO membership status as i. As the next alternative, we extend the subset of i' to all available $AHS_{i'jt}$ regardless of the membership status of i and i'.

(III) Conditional on it, we fill in the remaining missing entry t_{ijt} with the tariff rate of an importer j' with similar levels of real GDPs as described below. The set of qualified importer j' includes countries with the same GATT/WTO membership status as j, and its tariff data are complete with respect to all of its trade partners at time t after the procedure (I)–(II).

(a) We first rank all importers in each GATT/WTO round based on their average real GDPs. We collect the real GDP data from Penn World Table Version 9.1 (PWT9.1) and take

[51] The tariff sample period falls into: Tokyo to Uruguay Round (1988–1994) and after Uruguay Round (1995–2015).

[52] There may exist inconsistencies between the constructed PTA/GSP indicators and the factual AHS /PRF tariff rates (e.g. $PTA = 1$ or $GSP = 1$, but AHS and PRF rates are not equal). Thus, we use $AHS_{ijt'}$ as the default, instead of $PRF_{ijt'}$. If there are no tariff observations for ijt' in the Tokyo-to-Uruguay-round period, we look for observations from the nearest available year in the following round.

it as the benchmark.[53] For those countries not included in PWT9.1, we calculate the real GDP by using the nominal GDP data constructed (cf. Section B.2), and normalize it by the GDP deflators collected from World Development Indicators (WDI).[54]

(b) We then identify two countries j_1' and j_2' that have the nearest rankings to j in terms of real GDPs, such that $\text{rank}(j_1') < \text{rank}(j) < \text{rank}(j_2')$. If j is ranked at the top or bottom place of the list, we identify the two countries with the closest rankings to j such that either $\text{rank}(j_1') < \text{rank}(j_2') < \text{rank}(j)$ or $\text{rank}(j) < \text{rank}(j_1') < \text{rank}(j_2')$. We replace the missing entry by the average of the tariff rates of the two identified importers, i.e., $(\mathfrak{t}_{ij_1't} + \mathfrak{t}_{ij_2't})/2$.

In parallel to compiling the factual tariff rates, we also attempt to construct a complete set of non-cooperative tariffs $\mathfrak{t}_{ijt}'$, the tariffs that countries would set in the absence of the GATT/WTO, for use in the counterfactual analysis. For each ijt combination, we first take the maximum value of available rates across the four types (AHS, PRF, MFN, and BND). We then consider the tariff levels countries impose before they become the GATT/WTO members, and take the highest tariff rate among those available at time t, and at one, two, and three years before obtaining the membership. Given these rates across i' for each jt, we further identify the maximum rate imposed by j against all of its trade partners i'. Note that the non-cooperative tariffs are built based on the raw tariff data; we use the same procedure described above for factual tariffs to fill in missing entries for the non-cooperative tariffs. Lastly, since our counterfactual analysis is regarding the change of GATT/WTO membership status, we assume that the non-cooperative tariff rates $\mathfrak{t}_{ijt}'$ for non-members are the same as their factual tariff rates $\mathfrak{t}_{ijt}$.

In particular, the proportion of missing observations across ijt for the period 1988–2015 is 59.66% (59.63%) in the raw data for factual (and counterfactual) tariffs, 32.18% (32.22%) after Step I, and 17.68% (17.68%) after Step II above. After Step III, the procedure introduced above helps eliminate all missing factual tariff observations, and helps construct counterfactual non-cooperative tariffs, for all years in 1988–2015 and all the country pairs in the sample.

B.7 Pseudo World

For obvious reasons, we 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 deficits and expenditures as discussed above, and drop countries if the constructed expenditure is negative. We also drop countries if the implied internal trade is negative: $X_{ii} = M_{ii} \equiv Y_i - \sum_{j \neq i} M_{ij} < 0$. These are typically small territories whose data are prone to measurement errors. We iterate the process of constructing trade deficits and expenditures 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.

[53]https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1?lang=en.

[54]https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS.

The number of countries and the total GDPs (imports) of the countries in the pseudo world relative to the real world are reported in Table 1. As shown, the number of countries included in the pseudo world increased from 50 in 1950 to 180 in 2015. In spite of the small number of countries in 1950, the pseudo world represents more than three quarters of the real world GDP and more than 60 percent of the real world imports. The coverage increased to 97.7 percent and 92.1 percent, respectively, by 2015. 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, the import flows among members increased to 91.6% by 2005 and 97.4% by 2015, while those by members from nonmembers fell to 4.9% in 2005 and 1.1% in 2015.

C Algorithm of the Counterfactual Analysis

For the Melitz framework, we use the system of counterfactual equations (17)–(28) to solve for $\left\{\widehat{c}_{it}, \widehat{N}_{it}, \widehat{\Pi}_{it}, \widehat{P}_{it}, \widehat{s}_{it}, \widehat{e}_{it}, \widehat{w}_{it}, \widehat{Y}_{it}, \widehat{E}_{it}, \widehat{T}_{it}, \widehat{Y}_{wt}, \widehat{\tau}_{ijt}^{1-\sigma}\, \widehat{V}_{ijt}\, (\widehat{1+\mathfrak{t}_{ijt}})^{-\sigma}\right\}$ in each t for $i = 1, 2, \ldots, N$, given exogenous shocks to $\left\{\widehat{\tau}_{ijt}{}^{-\theta}\, \widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\, (\widehat{1+\mathfrak{t}_{ijt}})^{-\frac{\sigma\theta}{\sigma-1}}\right\}$ estimated by the matching methods, information on $\left\{\mathfrak{t}'_{ijt}\right\}$, observable variables $\{\alpha_{ijt}, \lambda_{ijt}, e_{it}, s_{it}, \delta_{it}, Y_{it}, \mathfrak{t}_{ijt}\}$, and parameter values $\{1-\sigma, \theta, \beta_i\}$. In the model without tariffs, we ignore the tariff revenues in equations (20), (26) and (27), and the adjustment term $(\widehat{1+\mathfrak{t}_{ij}})$ in (19) for the wedge between supplier and consumer prices. We use the nonlinear system solver "fsolve" in MATLAB (Anderson and Yotov, 2010; Ossa, 2014). If using "fsolve" encounters convergence issue, we solve the system of equations by iterations (Caliendo and Parro, 2015), and use the resulting solution as the initial value for the solver "fsolve". In the end, all the systems of structural equations can be solved by "fsolve".

The definition and construction of variables are as introduced in the main text and in the data appendix. To reiterate, $\alpha_{ijt} = M_{ijt}/Y_{it}$ is the share of country i's sales that goes to destination j, and $\lambda_{ijt} = X_{ijt}/E_{jt}$ is the share of country j's expenditure that is spent on source i. The expenditure and supply shares of country i are measured by: $e_{it} = E_{it}/Y_{wt}$ and $s_{it} = Y_{it}/Y_{wt}$, respectively, with $Y_{wt} = \sum_i Y_{it}$. The gross output is calculated as the ratio of GDP and the value-added share: $Y_{it} = GDP_{it}/\beta_i$. The trade-deficit share of a country is measured by: $\delta_{it} = D_{it}/Y_{wt}$, where D_{it} is constructed as in Appendix B.3. Internal trade X_{iit} is constructed as the difference between a country's gross output Y_{it} and its total exports. This information on X_{iit} is used to construct α_{iit} and λ_{iit} required in the counterfactual. Because internal trade barrier does not change in response to changes in a country's GATT/WTO membership status, $\widehat{\tau}_{iit}{}^{-\theta}\, \widehat{f}_{iit}{}^{-\frac{\theta}{\sigma-1}+1}\, (\widehat{1+\mathfrak{t}_{iit}})^{-\frac{\sigma\theta}{\sigma-1}} = 1$ is set in the counterfactual without GATT/WTO. Nonetheless, internal trade flows could change in the counterfactual due to general equilibrium adjustments (such as changes in the MR terms).

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 number 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 in Appendix B.7 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 world GDP as 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 world GDP.

(d) refers to the total imports of the countries in the pseudo world relative to the world imports as reported by DOTS.

(e) refers to the number of observations in the pseudo world with positive bilateral imports as reported by DOTS.

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 total imports of the pseudo world.

(i) refers to the total imports of country pairs where only the importer is a GATT/WTO member relative to the total imports of the pseudo world.

Table 3: Development- and round-specific matching estimates of *bothwto* (40% Caliper)

		HH				LH				HL				LL			
GATT/WTO round	caliper	**bothwto** estimates		95% CI		**bothwto** estimates		95% CI		**bothwto** estimates		95% CI		**bothwto** 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			
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: Development- and round-specific matching estimates of *imwto* (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			
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: Average factual and counterfactual import tariff rates

		H Member	L Member
Year 1988	Factual	0.06	0.20
		(0.09)	(0.16)
	Counterfactual	0.17	0.33
		(0.17)	(0.33)
Year 2015	Factual	0.03	0.10
		(0.06)	(0.10)
	Counterfactual	0.24	0.56
		(0.41)	(0.95)

Note: Refer to Appendix B.6 for the compilation of factual tariffs and counterfactual tariffs (in the counterfactual scenario where the GATT/WTO did not exist). H member indicates developed member countries (as importers) and L indicates developing member countries (as importers). Let t_{ijt} indicate the import tariff levied by j against exporter i in year t. The averages are taken across all i's for each jt and then across j's that are developed members for each t (and respectively, across j's that are developing members). Standard deviation is indicated in the bracket.

Table 6: Welfare effects of GATT/WTO (in terms of real wages)—tariff effects versus full effects

		Year 1988			**Year 1994**			**Year 2000**			**Year 2015**		
Scenarios	Member indicator	AvW	Krugman	Melitz	AvW	Krugman	Melitz	AvW	Krugman	Melitz	AvW	Krugman	Melitz
Tariff													
1. 25th Percentile	0	0.84	1.31	1.29	0.54	0.84	0.86	0.63	1.00	0.76	0.44	0.72	0.66
	1	0.73	1.15	1.10	0.99	1.56	1.48	1.21	1.82	1.66	0.76	1.19	1.09
2. Median	0	1.50	2.32	2.30	1.24	1.92	1.77	1.24	1.93	2.11	1.00	1.56	1.53
	1	1.74	2.55	2.48	2.15	3.33	3.27	2.67	4.00	3.46	1.76	2.74	2.47
3. 75th Percentile	0	2.75	4.23	4.10	2.00	3.11	3.00	1.91	2.94	3.03	2.24	3.49	3.48
	1	3.42	5.15	5.04	4.38	6.73	6.91	5.32	8.34	7.65	3.57	5.39	5.01
Full Model													
1. 25th Percentile	0	-0.67	-0.89	-0.70	-0.10	-0.11	-0.09	-2.72	-3.55	-2.41	-4.22	-5.98	-4.59
	1	2.13	3.32	2.66	2.70	4.15	3.30	0.29	0.53	0.16	-0.08	0.01	-0.50
2. Median	0	-0.24	-0.30	-0.21	0.14	0.28	0.24	-1.13	-1.61	-0.68	-2.18	-2.79	-1.83
	1	4.14	6.24	5.02	4.80	7.41	6.12	3.08	4.83	4.28	2.68	4.08	3.35
3. 75th Percentile	0	0.04	0.13	0.24	0.42	0.76	0.64	0.48	0.80	1.03	-1.28	-1.92	-1.19
	1	6.00	9.38	7.45	7.04	11.01	8.76	7.43	11.86	10.46	7.23	11.01	9.49
Model w/o Tariff													
1. 25th Percentile	0	-0.62	-0.83	-0.65	-0.09	-0.11	-0.09	-2.53	-3.37	-2.29	-3.66	-5.21	-4.09
	1	2.18	3.41	2.72	2.84	4.40	3.50	1.51	2.35	1.96	1.77	2.84	2.39
2. Median	0	-0.21	-0.28	-0.18	0.10	0.24	0.21	-1.01	-1.45	-0.63	-2.07	-2.75	-1.76
	1	3.71	5.82	4.64	4.72	7.05	5.86	3.87	6.06	5.69	3.69	5.58	4.66
3. 75th Percentile	0	0.02	0.10	0.16	0.38	0.64	0.58	0.45	0.75	0.96	-1.28	-1.77	-1.10
	1	5.78	8.84	7.02	6.61	10.38	8.24	7.93	12.59	10.49	7.29	11.36	9.39

Note: Based on the AvW, Krugman and Melitz frameworks, respectively, with parameters $\sigma = 5$, $\theta = 5$, and β_i from Caliendo and Parro (2015). The parameter value for θ is relevant only for the Melitz model. This set of analysis evaluates the effect of GATT/WTO given the observed membership status relative to the counterfactual had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt). Welfare is measured in terms of real wages. See Section 2.4 for the three counterfactual setups of: tariff (effects due to tariffs only), full model (effects taking into account tariffs and variable/fixed trade costs), and model without tariffs (effects ignoring tariff revenues).

Table 7: Welfare and Firm entry effects of GATT/WTO (Melitz vs BKL; median)

		Year 1950				**Year 2015**			
Parameters	Member indicator	Melitz	BKL $\kappa = 0.6$	BKL $\kappa = 0.8$	BKL $\kappa = 1$	Melitz	BKL $\kappa = 0.6$	BKL $\kappa = 0.8$	BKL $\kappa = 1$
Welfare effects									
1. 40% caliper, σ=5, θ=4.5	0	1.6903	1.6903	1.6903	1.6903	-2.1656	-2.1656	-2.1656	-2.1656
	1	4.0703	4.0703	4.0703	4.0703	5.0067	5.0067	5.0067	5.0067
2. 40% caliper, σ=5, θ=5	**0**	**1.5416**	**1.5416**	**1.5416**	**1.5416**	**-1.7612**	**-1.7612**	**-1.7612**	**-1.7612**
(benchmark)	**1**	**3.7111**	**3.7111**	**3.7111**	**3.7111**	**4.6578**	**4.6578**	**4.6578**	**4.6578**
3. 40% caliper, σ=5, θ=5.5	0	1.4159	1.4159	1.4159	1.4159	-1.4431	-1.4431	-1.4431	-1.4431
	1	3.4067	3.4067	3.4067	3.4067	4.2362	4.2362	4.2362	4.2362
4. 40% caliper, σ=5, θ=6	0	1.3096	1.3096	1.3096	1.3096	-1.2518	-1.2518	-1.2518	-1.2518
	1	3.1464	3.1464	3.1464	3.1464	3.8772	3.8772	3.8772	3.8772
5. 40% caliper, σ=5, θ=8	0	1.0252	1.0252	1.0252	1.0252	-0.7892	-0.7892	-0.7892	-0.7892
	1	2.4037	2.4037	2.4037	2.4037	2.8956	2.8956	2.8956	2.8956
6. 40% caliper, σ=5, θ=10	0	0.8299	0.8299	0.8299	0.8299	-0.6021	-0.6021	-0.6021	-0.6021
	1	1.9414	1.9414	1.9414	1.9414	2.3149	2.3149	2.3149	2.3149
7. 40% caliper, σ=10, θ=10	0	0.5905	0.5905	0.5905	0.5905	-0.4198	-0.4198	-0.4198	-0.4198
	1	1.3593	1.3593	1.3593	1.3593	1.7629	1.7629	1.7629	1.7629
Firm entry effects									
1. 40% caliper, σ=5, θ=4.5	0	0.99	0.67	0.34	0	-1.28	-0.87	-0.44	0
	1	2.38	1.61	0.80	0	2.90	1.97	0.98	0
2. 40% caliper, σ=5, θ=5	**0**	**0.90**	**0.61**	**0.31**	**0**	**-1.04**	**-0.71**	**-0.35**	**0**
(benchmark)	**1**	**2.17**	**1.47**	**0.73**	**0**	**2.64**	**1.84**	**0.91**	**0**
3. 40% caliper, σ=5, θ=5.5	0	0.83	0.56	0.28	0	-0.85	-0.58	-0.29	0
	1	2.00	1.35	0.67	0	2.41	1.67	0.83	0
4. 40% caliper, σ=5, θ=6	0	0.77	0.52	0.26	0	-0.74	-0.50	-0.25	0
	1	1.84	1.25	0.62	0	2.22	1.53	0.76	0
5. 40% caliper, σ=5, θ=8	0	0.60	0.41	0.20	0	-0.46	-0.32	-0.16	0
	1	1.40	0.95	0.48	0	1.68	1.15	0.57	0
6. 40% caliper, σ=5, θ=10	0	0.49	0.33	0.17	0	-0.35	-0.24	-0.12	0
	1	1.12	0.77	0.39	0	1.35	0.92	0.46	0
7. 40% caliper, σ=10, θ=10	0	0.35	0.24	0.12	0	-0.25	-0.17	-0.08	0
	1	0.80	0.54	0.27	0	1.02	0.70	0.35	0

Note: Based on the Melitz or BKL framework. This set of analysis evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 8: Welfare effects of GATT/WTO by regions

	Mean	Median	Min	Max	Countries
Panel A. Ex-post welfare effects of GATT/WTO (AvW, 1950)					
OECD	2.45	2.15	0.12	6.17	18
East and South Asia	1.89	1.06	0.67	4.43	7
East. Europe and Cent. Asia	.	.	.	.	.
Latin America and Caribbean	2.48	1.96	1.04	7.75	18
Middle East and North Africa	1.77	1.94	0.16	3.64	6
Sub-Saharan Africa	0.43	0.43	0.43	0.43	1
Other	.	.	.	.	.
Panel B. Ex-post welfare effects of GATT/WTO (AvW, 2015)					
OECD	8.35	7.29	2.46	26.91	23
East and South Asia	4.60	2.18	-5.14	25.44	24
East. Europe and Cent. Asia	6.32	2.55	-4.16	27.94	15
Latin America and Caribbean	3.86	3.00	0.42	12.83	31
Middle East and North Africa	3.53	2.09	-4.34	20.23	22
Sub-Saharan Africa	1.71	1.72	-13.43	13.45	45
Other	3.84	4.58	-40.87	20.61	20
Panel C. Ex-post welfare effects of GATT/WTO (Krugman, 1950)					
OECD	3.77	3.23	0.20	9.44	18
East and South Asia	2.90	1.64	1.05	6.62	7
East. Europe and Cent. Asia	.	.	.	.	.
Latin America and Caribbean	3.83	2.98	1.43	12.27	18
Middle East and North Africa	2.72	3.03	0.28	5.55	6
Sub-Saharan Africa	0.67	0.67	0.67	0.67	1
Other	.	.	.	.	.
Panel D. Ex-post welfare effects of GATT/WTO (Krugman, 2015)					
OECD	13.38	11.36	3.67	44.64	23
East and South Asia	7.35	3.47	-7.04	41.56	24
East. Europe and Cent. Asia	10.59	3.97	-5.86	46.51	15
Latin America and Caribbean	6.02	4.69	0.84	20.63	31
Middle East and North Africa	5.70	3.05	-6.08	32.20	22
Sub-Saharan Africa	2.86	2.77	-16.85	21.36	45
Other	7.14	7.14	-48.52	33.68	20

Note: 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 $\sigma = 5$ and β_i from Caliendo and Parro (2015). The welfare effect of GATT/WTO (based on real wage) is calculated given the observed membership status relative to the counterfactual had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

Table 9: Development-specific matching effect estimates of PTA

HH					LH				
caliper	**PTA** estimates		95% CI		caliper	**PTA** 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				
caliper	**PTA** estimates		95% CI		caliper	**PTA** 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			

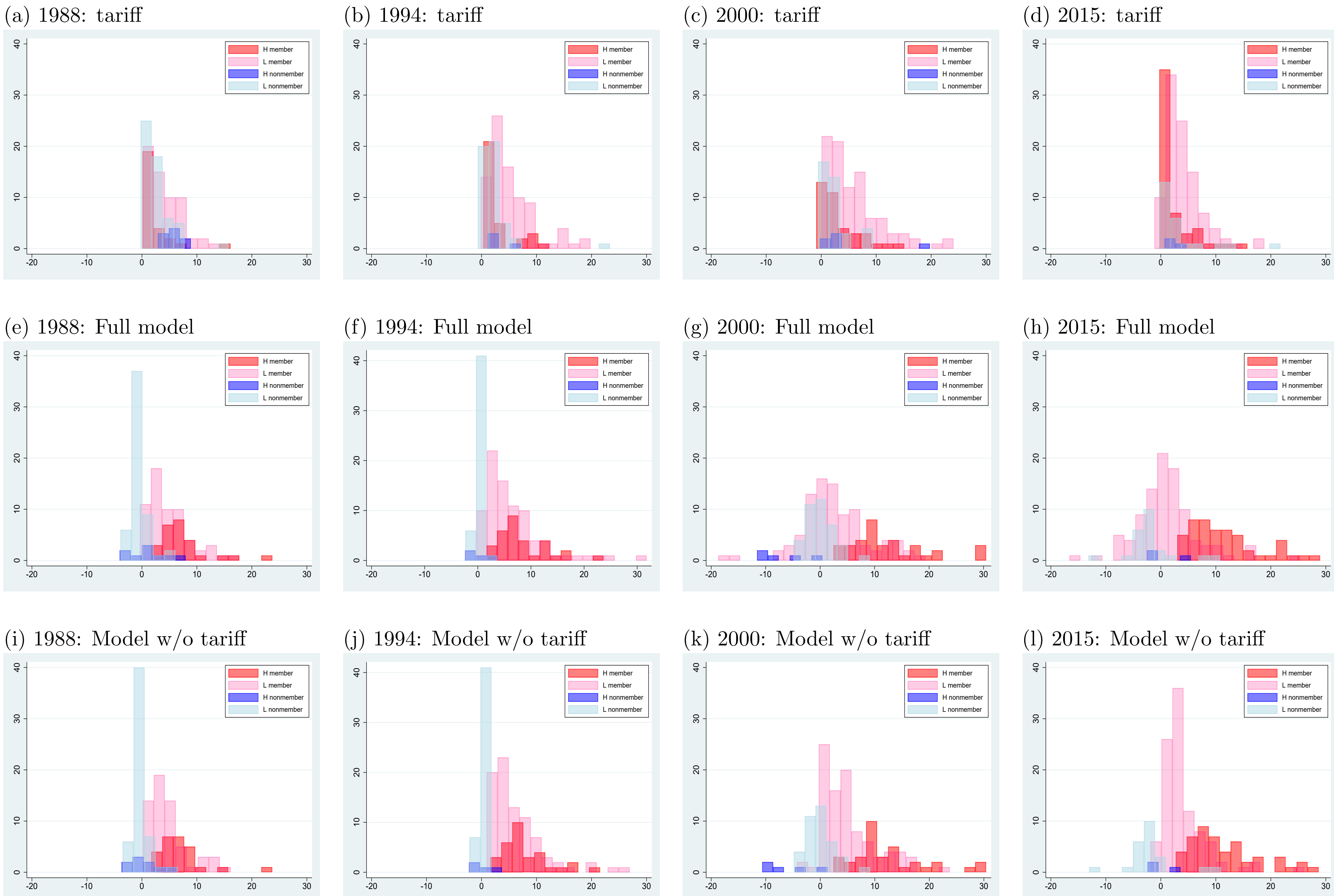
Note: See Table 3 footnote.

Table 10: Welfare effects of China's entry into WTO

	Mean	Median	Min	Max	Countries
Panel A. Welfare effects of China's entry (AvW, 2005)					
China	6.27				
OECD	0.31	0.24	0.06	1.10	23
East and South Asia	-0.30	-0.44	-4.23	6.52	21
East. Europe and Cent. Asia	-0.47	-0.46	-1.65	0.55	15
Latin America and Caribbean	-0.60	-0.44	-3.09	0.61	33
Middle East and North Africa	-0.18	-0.47	-1.66	1.54	23
Sub-Saharan Africa	-0.48	-0.39	-2.12	0.95	40
Other	-0.06	-0.26	-0.96	3.24	19
Panel B. Welfare effects of China's entry (AvW, 2015)					
China	2.64				
OECD	0.49	0.36	0.16	1.48	23
East and South Asia	-0.09	-0.21	-4.03	5.72	23
East. Europe and Cent. Asia	-0.12	-0.25	-1.06	1.14	15
Latin America and Caribbean	-0.16	-0.31	-1.39	1.73	31
Middle East and North Africa	0.32	0.02	-0.73	4.46	22
Sub-Saharan Africa	-0.33	-0.32	-1.68	0.52	45
Others	0.05	-0.08	-0.53	1.68	20

Note: Based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the AvW framework with parameters $\sigma = 5$ and β_i from Caliendo and Parro (2015). The welfare effect (based on real wage) is calculated using the counterfactual had China not entered WTO in 2001.

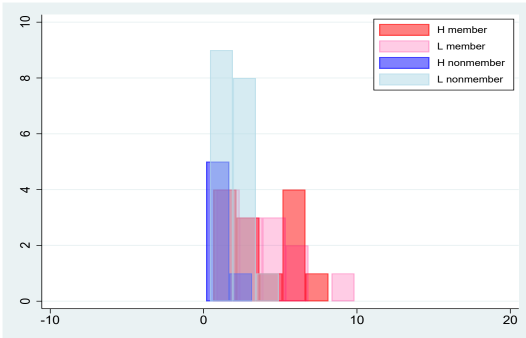
Figure 1: Welfare effects of GATT/WTO (in terms of real wages)—tariff effects versus full effects



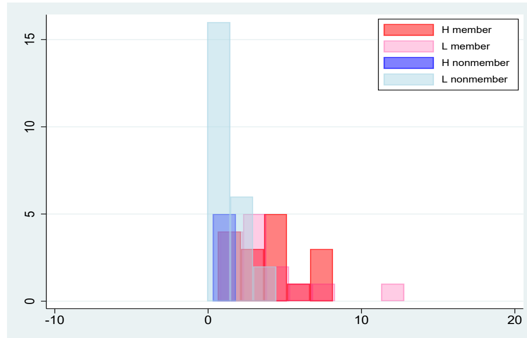
Note: Based on the Melitz framework with parameters $\sigma = 5$, $\theta = 5$, and β_i from Caliendo and Parro (2015). The y-axis indicates the number of countries, and the x-axis the % change in welfare (real wage). See Section 2.4 for the three counterfactual setups of: tariff (effects due to tariffs only), full model (effects taking into account tariffs and variable/fixed trade costs), and model without tariffs (effects ignoring tariff revenues).

Figure 2: Welfare effects of GATT/WTO (the Melitz framework)

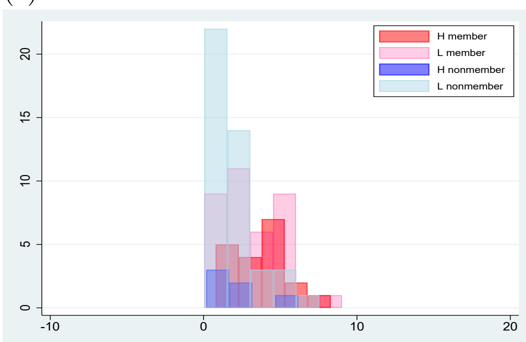
(a) 1950



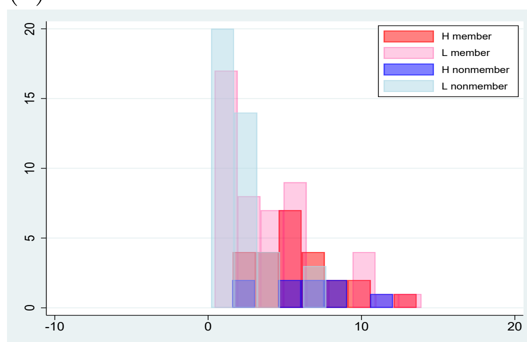
(b) 1955



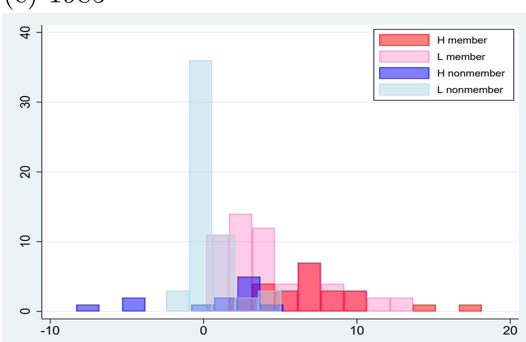
(c) 1965



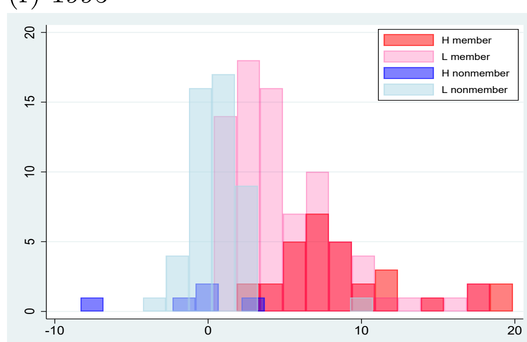
(d) 1975



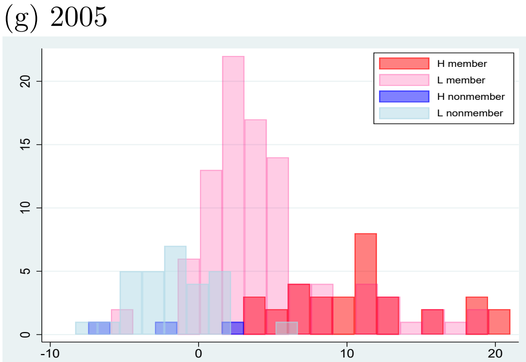
(e) 1985



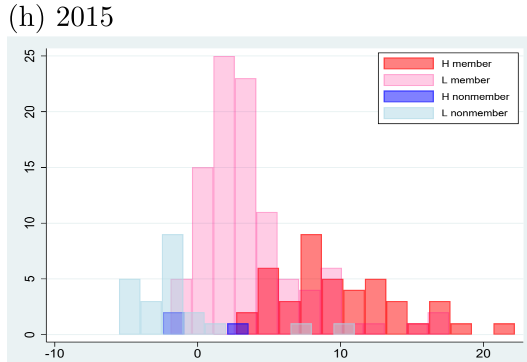
(f) 1995



(g) 2005



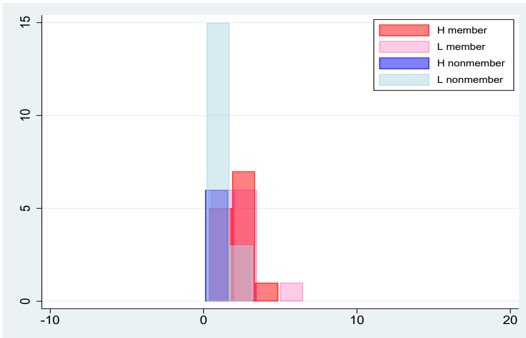
(h) 2015



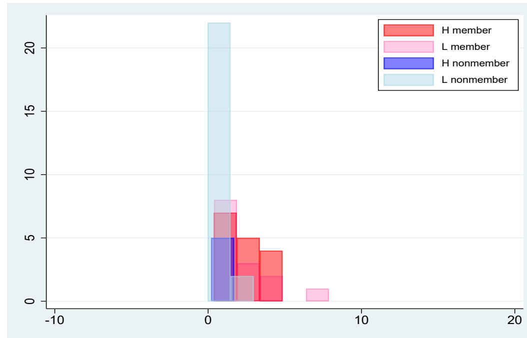
Note: Based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the Melitz framework with parameters $\sigma = 5$, $\theta = 5$, and β_i from Caliendo and Parro (2015). This set of analysis evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt). The y-axis indicates the number of countries, and the x-axis the % change in welfare (real wage). Outliers are omitted.

Figure 3: Firm entry effects of GATT/WTO (the Melitz framework)

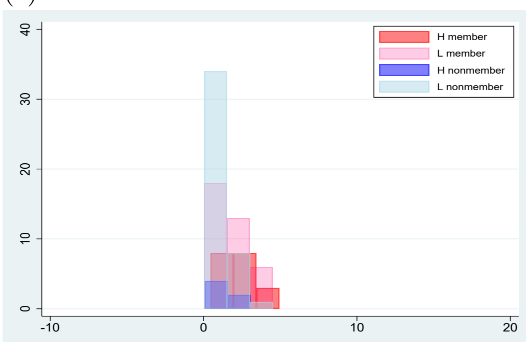
(a) 1950



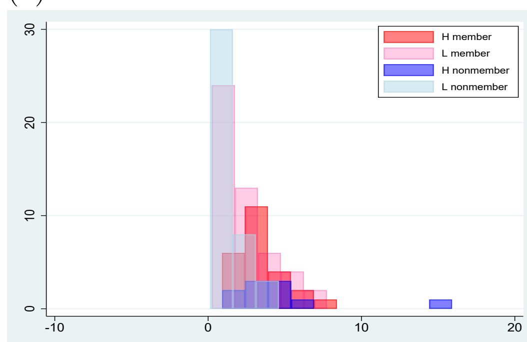
(b) 1955



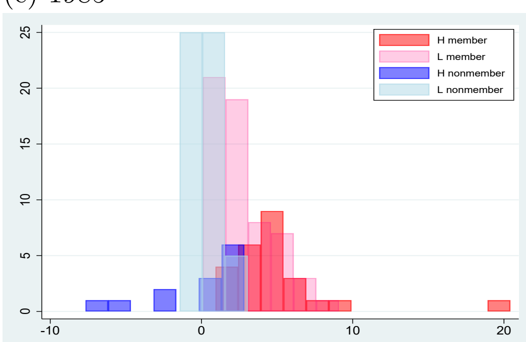
(c) 1965



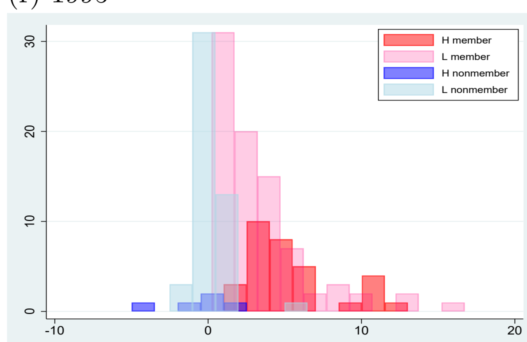
(d) 1975



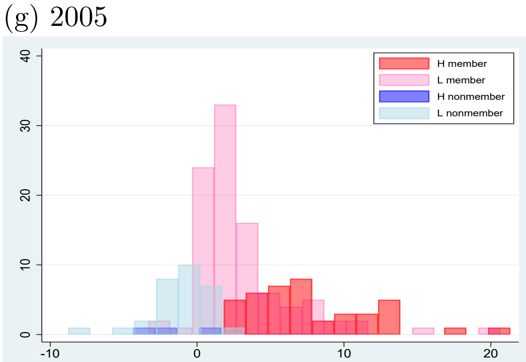
(e) 1985



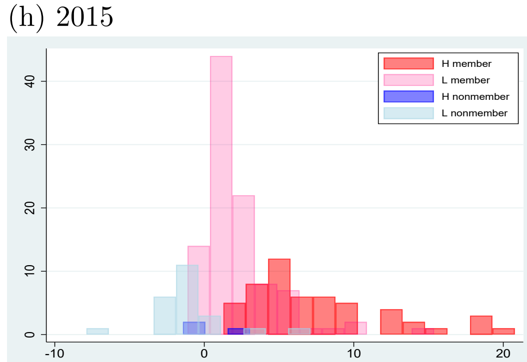
(f) 1995



(g) 2005



(h) 2015

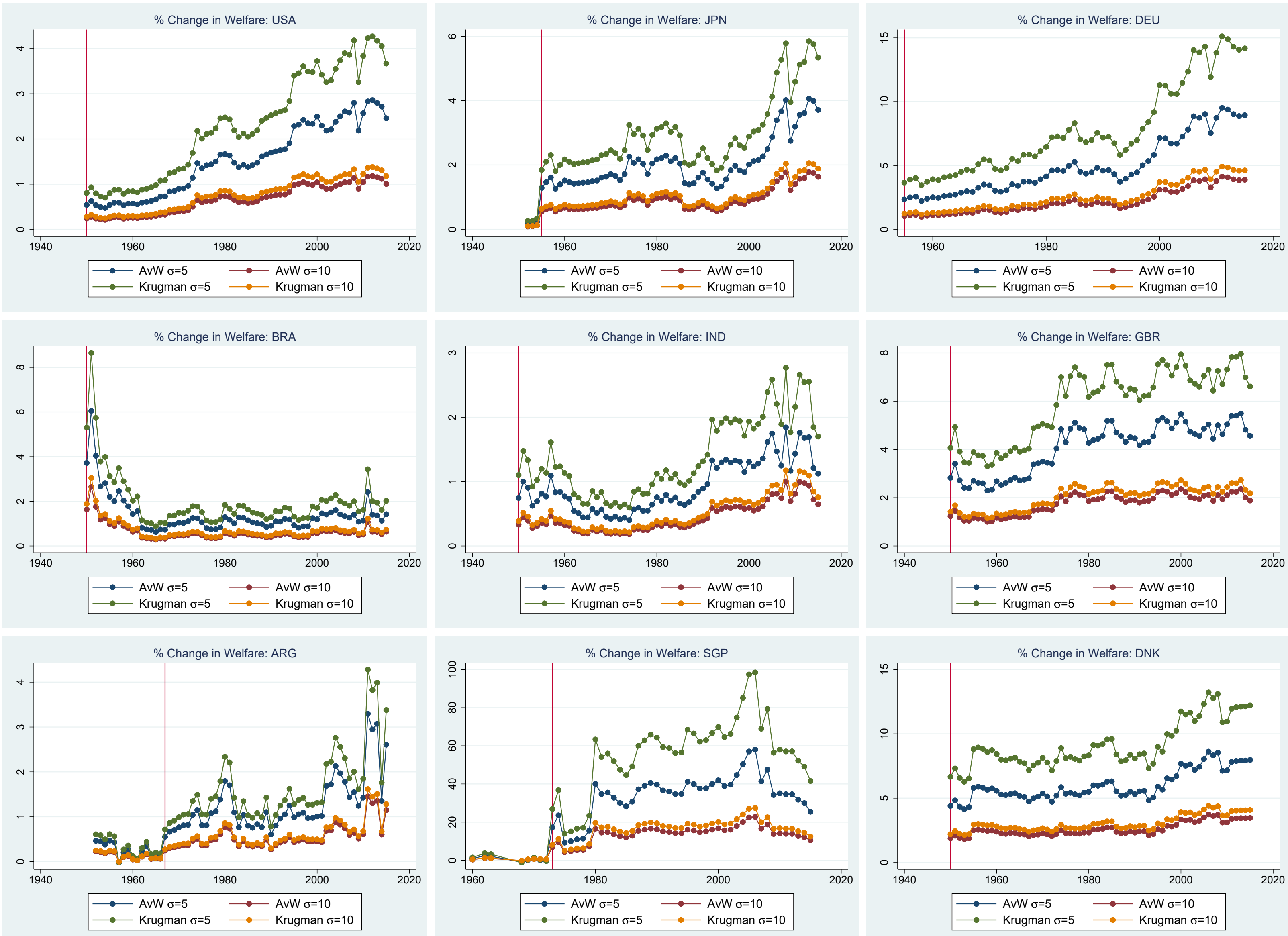


Note: See Figure 2 footnote. The y-axis indicates the number of countries, and the x-axis the % change in the mass of firm entrants. Outliers are omitted.

Figure 4: GATT/WTO welfare effects (Left: Melitz versus Krugman / Right: Melitz versus AvW)

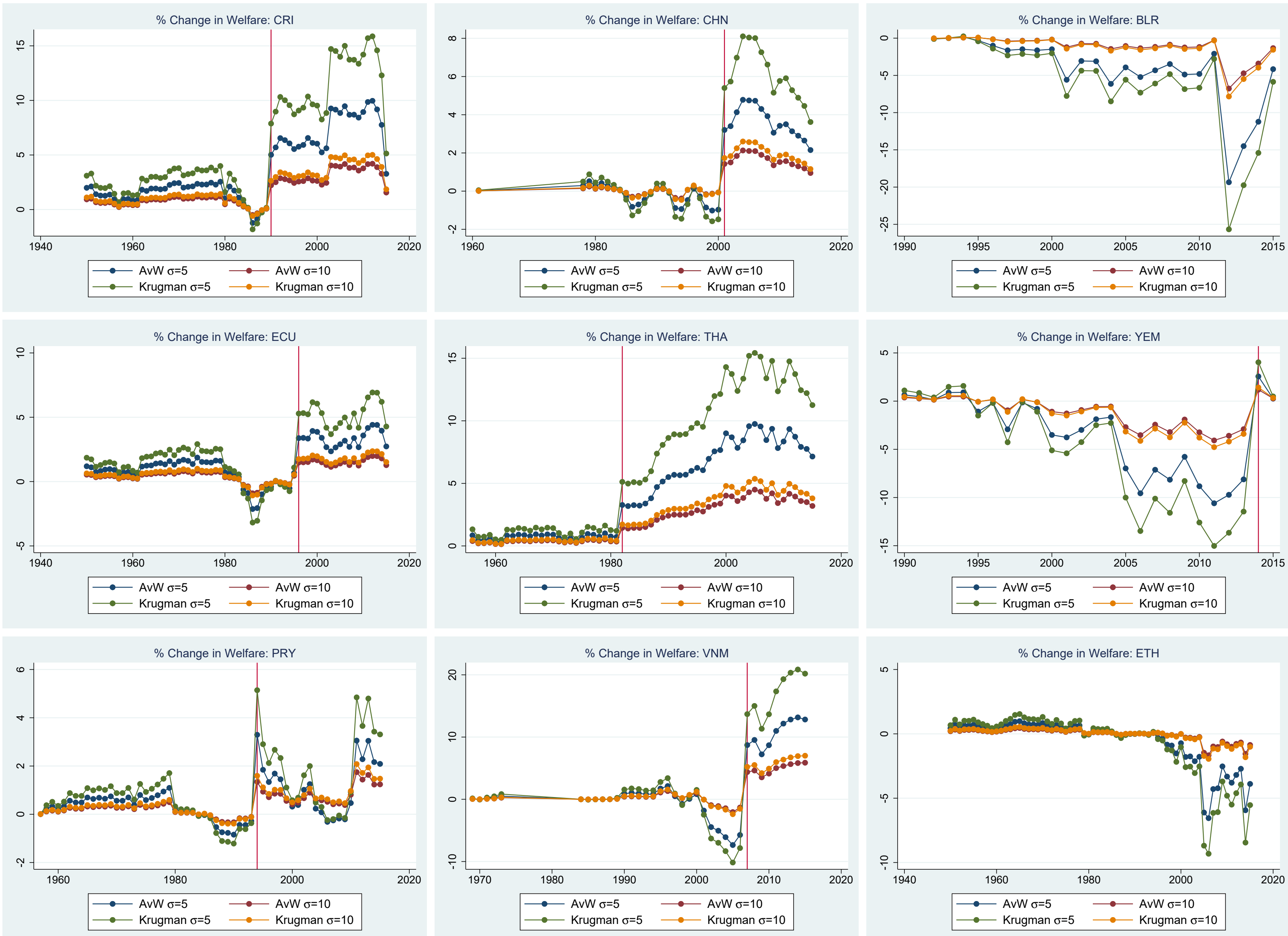
Note: See Figure 2 footnotes. This figure compares the Melitz framework relative to the Krugman and the AvW framework in their effects for members (in red) and nonmembers (in blue), respectively: $(W_M - W_K)/W_K$; $(W_M - W_A)/W_A$. The box plot indicates the 25th percentile (the lower hinge of the box), the median, and the 75th percentile (the upper hinge of the box) of the variable of interest. Outliers are omitted.

Figure 5: Welfare effects of GATT/WTO for a selected set of countries



Note: 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 set of analysis evaluates the effects of GATT/WTO given the observed membership status relative to the counterfactual had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt). Welfare is measured in terms of real wages.

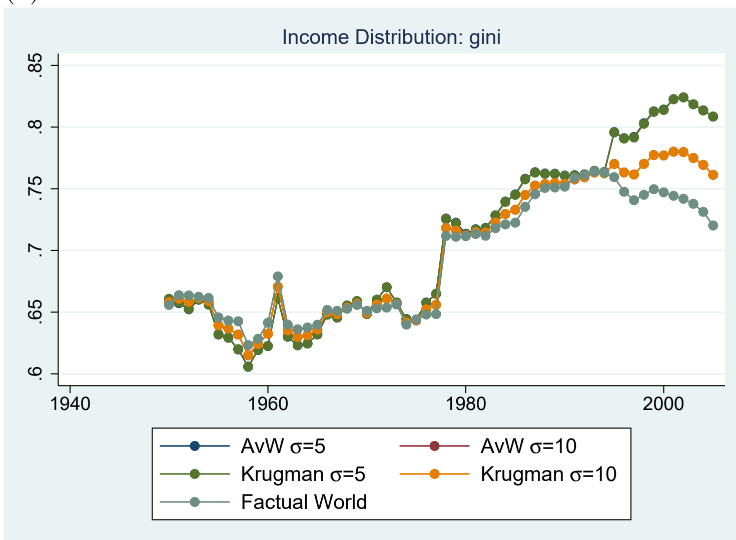
Figure 5 (continued): Welfare effects of GATT/WTO for a selected set of countries



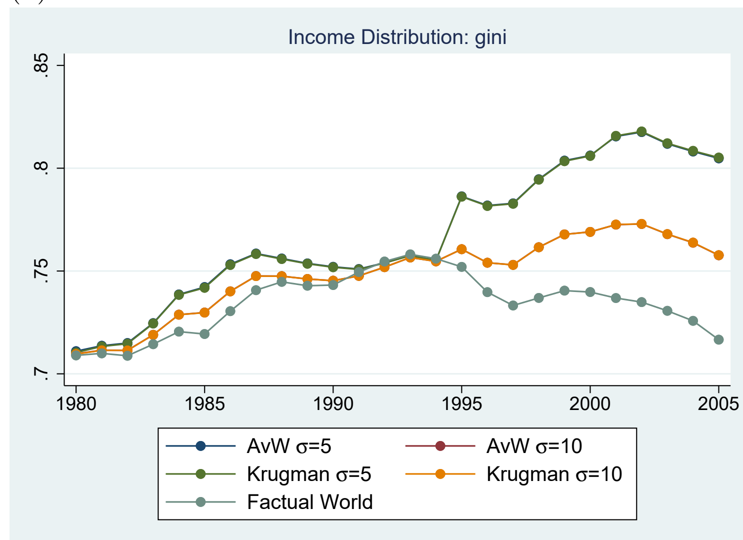
Note: Based on the 40% caliper estimates in Tables 3 and 4 that are significant at 10% level, using the AvW or Krugman framework with parameters $\sigma = \{5, 10\}$ and β_i from Caliendo and Parro (2015). This set of analysis evaluates the effects of GATT/WTO given the observed membership status relative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

Figure 6: Effects of GATT/WTO on global income disparity

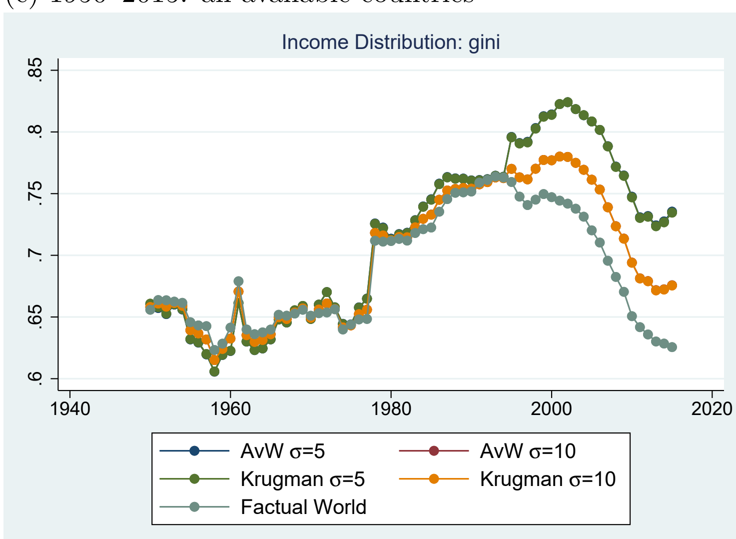
(a) 1950–2005: all available countries



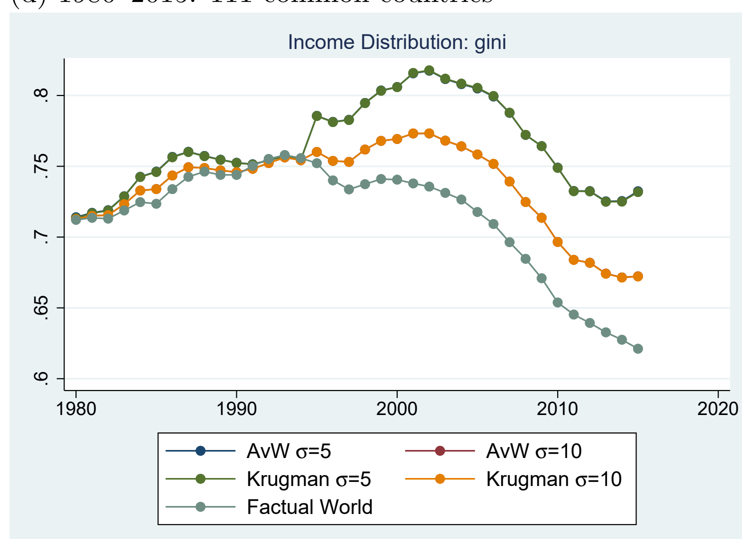
(b) 1980–2005: 118 common countries



(c) 1950–2015: all available countries

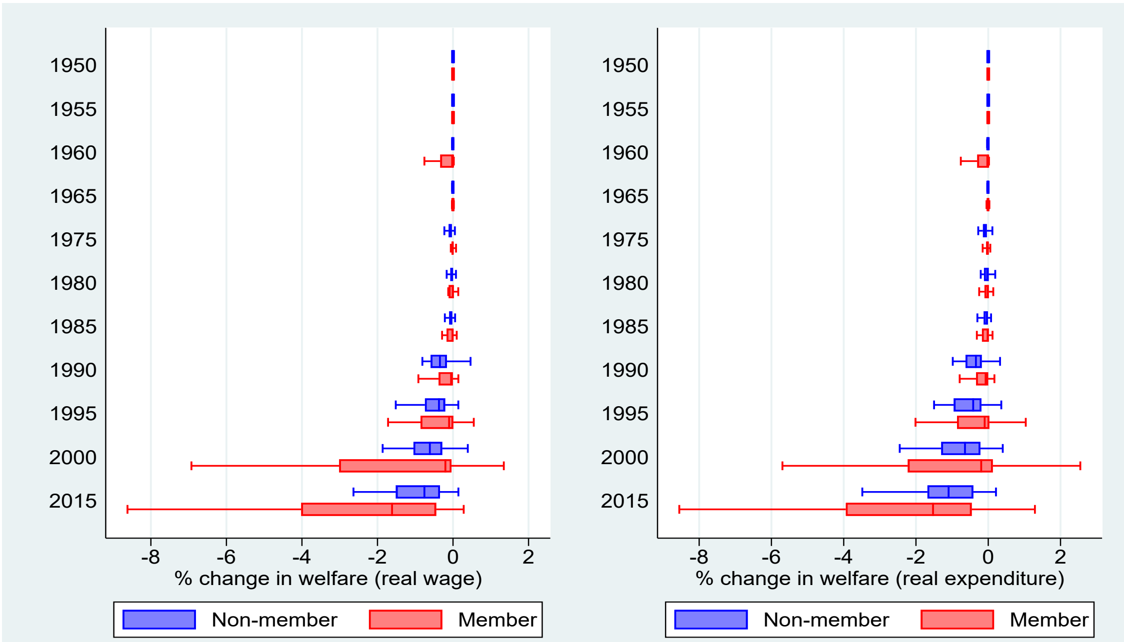


(d) 1980–2015: 111 common countries



Note: 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 factual Gini coefficient is calculated using the factual GDP per capita (weighted by country population size), and compared against the counterfactual Gini coefficient had GATT/WTO not existed ($bothwto = 0$ and $imwto = 0$ for all ijt).

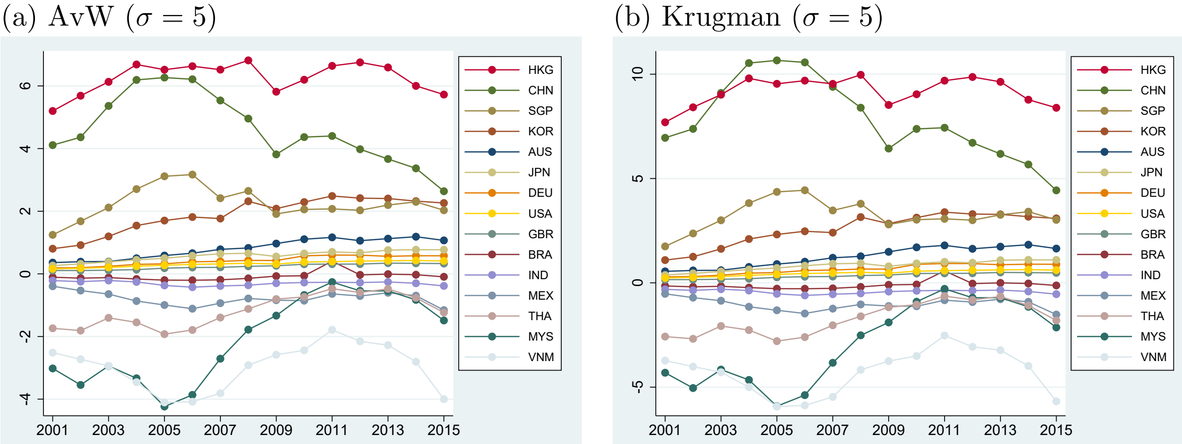
Figure 7: Welfare effects of GATT/WTO (without PTA versus with PTA)



Note: Based on the 40% caliper estimates in Tables 3, 4 and 9 that are significant at 10% level, using the Melitz framework with parameters $\sigma = 5$, $\theta = 5$and β_i from Caliendo and Parro (2015). This set of analysis evaluates the welfare effects of GATT/WTO under the scenario had all PTAs not existed relative to the scenario with the factual PTAs. Outliers are omitted.

Figure 8: Welfare effects of China's entry into WTO

(a) AvW ($\sigma = 5$) (b) Krugman ($\sigma = 5$)



Note: 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 $\sigma = 5$ and β_i from Caliendo and Parro (2015). The welfare effect (based on real wages) is calculated using the counterfactual had China not entered WTO in 2001.