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Abstract

In this paper, we propose an estimation procedure to identify and disentangle the partial (direct) effects of GATT/WTO membership on the variable and fixed trade costs. The methodology builds on the structural modeling of trade incidence by Helpman, Melitz and Rubinstein (2008) and that of multilateral resistance by Anderson and van Wincoop (2003). We then develop a general equilibrium framework to simulate the impact of the GATT/WTO system (via all trade cost changes and also by the respective channel of variable and fixed trade costs estimated earlier) on the aggregate welfare across countries, and on the trade flows, trade status, and trade margins (the domestic cutoff, export cutoff, count of products exported, mass of firms weighted by size, and intensive margins) across bilateral trading relationships for the period 1991–2017.

Key Words: Truncated Pareto Distribution; Identification of Fixed and Variable Trade Costs; Simulation of Counterfactual Changes in Trade Status; Quantitative Welfare Analysis
JEL Classification: F13; F14; F17; F61

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1 Introduction

In this paper, we propose an estimation procedure to identify and disentangle the partial (direct) effects of GATT/WTO membership on the variable and fixed trade costs. The methodology builds on the structural modeling of trade incidence by Helpman, Melitz and Rubinstein (2008) [henceforth HMR] and that of multilateral resistance (MR) by Anderson and van Wincoop (2003) [henceforth AvW]. Given the variable and fixed trade costs estimated, we develop a general equilibrium framework to simulate the impact of the GATT/WTO system (via all trade cost changes and also by the respective channel of variable and fixed trade costs) on the aggregate welfare across countries, and on the trade flows, trade status, and trade margins (the domestic cutoff, export cutoff, count of products exported, mass of firms weighted by size, and intensive margins) across bilateral trading relationships for the period 1991–2017.

This paper makes three methodological contributions to the literature. First, a large literature has analyzed the behavior of the extensive and intensive margins of trade theoretically and empirically. See Section 1.1 for a review. In this literature, the sign of the intensive margin changes is often used to infer whether the variable or fixed trade cost has played a more prominent role in the context studied, given that these two types of trade costs have opposite effects on the intensive margin (under general assumptions about the firm productivity distribution). In other words, the qualitative relative importance of a trade shock in reducing the variable or fixed trade cost is *indirectly* inferred/suggested by the sign of the change in the intensive margin. In Section 2.2, we propose a three-stage procedure that allows us to identify/estimate the direct effects of GATT/WTO membership indicators on: (i) the variable trade cost, (ii) the total trade cost, and (iii) the fixed trade cost. In essence, we identify the effects on the total and fixed trade costs by recovering the standard deviation of the error term in the HMR trade status equation. By generalizing the AvW setup to allow zero trade in the construction of the MR terms, we then regress the combination of exporter-year and importer-year fixed effects (of the trade flow and trade status equations, respectively) on the GATT/WTO membership indicators, the imputed outward and inward MR terms, and other structural variables, to isolate the effects of GATT/WTO on the respective components of trade costs.

Second, we develop a structural general equilibrium framework that allows for counterfactual changes in trade status (active/inactive bilateral trading relationship). In HMR, the authors suggested a counterfactual exercise that simulates the impact of the variable trade cost on bilateral trade incidence and volume, but the procedure stops short of general equilibrium. We extend the methodology and fully characterize the response of the economies

around the world to trade cost shocks, including firm-level adjustments (the export cutoff, count of products exported, mass of firms weighted by size, and intensive margins) for each bilateral trading relationship, and also aggregate variables of interest (such as the domestic production cutoff, mass of entrants, gross production, expenditures, wage rates, prices, and aggregate welfare) for each economy. These general equilibrium responses take into account goods-market and labor-market clearing conditions, free entry, as well as input-output production structures. The details of the structure are described in Section 2.3.

Third, limited by the difficulty of modeling/simulating counterfactual trade status, the literature on the GATT/WTO's general-equilibrium impacts typically conducts the counterfactual analysis assuming no changes in zero trade observations. In addition, the policy shocks used to proxy the GATT/WTO's mechanism are often restricted to the tariff changes observed of members; see Section 1.1 for a review. Both of these limitations could underestimate the impacts of the GATT/WTO system, by omitting the trade status margin and the non-tariff barriers (which could have bearing on both variable and fixed trade costs). The methods proposed above help address/accommodate these concerns. In the implementation, we use the GATT/WTO membership indicators (whether both trading partners are members; whether only the importer is a member; or whether only the exporter is a member) to capture all potential changes in border and domestic policies of GATT/WTO members toward members and toward non-members, and their effects on the variable and fixed trade costs, respectively. The estimation results of the GATT/WTO effects on the trade costs are summarized in Section 3. The structural model (calibrated to the world economy) is then used to simulate the counterfactual if the GATT/WTO system were shut down (by rescinding the estimated trade cost shocks induced by the GATT/WTO). Section 4 reports the impacts on the firm-level and aggregate variables of interest, with the impacts further decomposed by the channel of variable versus fixed trade costs.

Our analysis also has interesting policy implications on the income disparity within countries. Given the estimates of the GATT/WTO shocks to the trade costs, we can simulate the corresponding effects on the firm sales distribution. Depending on the findings, GATT/WTO can have very different consequences for the distribution of firm sales. If the GATT/WTO mainly reduces the fixed trade cost, this tends to allow export entry by weaker firms and dilutes the sales of all existing firms, flattening the sales distribution. The implications could change fundamentally if the GATT/WTO mainly lowers the variable trade cost, which has a proportionally larger effect on the sales of larger firms and hence tends to increase the initial firm sales disparity. We report our findings in this regard in Section 5. In particular, we provide an anatomy of such GATT/WTO effects in terms of changes in: (i) the productivity cutoffs, (ii) the macro components that scale the firm sales (for given productivity

levels); and (iii) the mean and standard deviation of the sales distribution for each bilateral trading relationship. The results of this study thus provide a first look at how GATT/WTO may have affected income disparity within countries by the way it affects the firm sales distribution.

We discuss further how our paper is related to the existing studies, and how it contributes to the various strands of the trade literature below.

1.1 Related Literature

The direct effects of GATT/WTO on trade flows are required inputs (shocks) for the counterfactual general-equilibrium analysis. In this regard, the paper is related to the empirical studies that have attempted to estimate the trade effects of GATT/WTO, including, e.g., Rose (2004), Tomz, Goldstein and Rivers (2007), Subramanian and Wei (2007), Chang and Lee (2011), Dutt (2020), and Larch, Monteiro, Piermartini and Yotov (2020), among others. By using the membership indicators to capture the trade effect, the parametric estimations are subject to the multi-collinearity issues highlighted by Cheong, Kwak and Tang (2014). That is, the membership indicators *bothwto* (indicator for whether both trading partners are members) and *imwto* (indicator for whether only the importing country is a member) are jointly collinear with the importer-year fixed effects (FEs). By similar arguments, the membership indicators *bothwto* and *exwto* (indicator for whether only the exporting country is a member) are jointly collinear with the exporter-year FEs. The previous studies often have eschewed this issue serendipitously by omitting the exporter-year or import-year FE controls in the regression (Rose, 2004; Tomz, Goldstein and Rivers, 2007), or by including only subsets of the membership indicators, e.g., including the equivalent of *bothwto* but not *imwto* (Dutt, 2020). Alternatively, Larch, Monteiro, Piermartini and Yotov (2020) appended the sample of analysis with *internal* trade flows to circumvent this identification issue in parametric estimation frameworks. In contrast, Chang and Lee (2011) proposed *non-parametric* matching estimators that bypass this issue (without the need for internal trade data). In this paper, we propose a multi-stage procedure that allows for all GATT/WTO membership indicators and the exporter-year and importer-year FEs in parametric frameworks. The GATT/WTO effects of each of the membership indicators on trade flows and on variable/fixed trade costs are disentangled by the proposed procedure.

By simulating counterfactual scenarios pertaining to changes in trade barriers associated with GATT/WTO, the paper also contributes to the literature evaluating the welfare impacts of GATT/WTO. There is a long tradition of welfare analysis in this regard, based on computable general equilibrium models; see, e.g., the survey by Anderson (2016). Recent

studies have applied quantitative structural trade models to readdress the issue. Prominent works along this line of research include Ossa (2011), Ossa (2014), and Bagwell, Staiger and Yurukoglu (2021). These studies focus on tariffs as the trade policy variable and simulate analytically 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. The computation burden of numerically solving for the non-cooperative tariff profiles often substantially constrains the number of individual customs territories that can be included in the study. Caliendo, Feenstra, Romalis and Taylor (2020) similarly focused on the welfare effects of tariffs. In particular, they evaluated the impacts of observed MFN (and preferential) tariff changes between 1990 and 2010, using a Melitz framework with untruncated Pareto productivity distribution and with multiple sectors and input-output linkages. Our paper complements the above studies by estimating the ex-post realized trade effects of GATT/WTO membership (via both variable and fixed trade costs), and using structural trade models to simulate the welfare effects of GATT/WTO for a comprehensive set of individual economies. Our structural framework explicitly allows for changes in extensive margins as well as intensive margins (contrary to Ossa, 2011, 2014; Bagwell, Staiger and Yurukoglu, 2021), and most importantly, the changes in trade status not modeled in the above studies. Although Arkolakis, Costinot and Rodríguez-Clare (2012) suggested that within the ACR class of models, aggregate welfare gains could be the same regardless of the underlying microstructure of the trade models (and the margins of adjustment), this does not apply to the Melitz (2003) model when the productivity distribution is truncated.

By adopting the HMR framework with truncated Pareto distribution, this paper is related to the literature that explores the implications of the Melitz (2003) model under alternative productivity distributions. Head, Mayer and Thoenig (2014) replaced the Pareto with log-normal distributions and highlighted important differences when quantifying the gains from trade. Fernandes, Klenow, Meleshchuk, Pierola and Rodríguez-Clare (2022) pointed out that a Melitz model with log-normal distribution can generate predictions consistent with the stylized facts observed in the data that intensive margins vary with trade flows and decrease with distance, while a Melitz model with untruncated Pareto distribution cannot. We show in Appendix D that the Melitz model with truncated Pareto distribution (used in our analysis) can generate trade patterns that are consistent with the stylized facts noted by Fernandes et al. (2022) as well. In comparison with the log-normal distribution, the truncated Pareto assumption has the obvious advantage of reconciling the model with the prevalence of zero trade observations in the data.

There is a large literature analyzing the behavior of extensive and intensive margins of

trade theoretically and empirically. This includes some of the studies discussed above, and also Chaney (2008), Felbermayr and Kohler (2006), Lawless (2010), Felbermayr and Kohler (2010), and Hsieh, Li, Ossa and Yang (2021), among others. Despite the catch-all phrases, the definitions of these two margins vary across studies, where the extensive margin could correspond to the productivity cutoff for firms to export (Chaney, 2008), the count of firms that export (Lawless, 2010), the count of products exported (Dutt, Mihov and Van Zandt, 2013), the set of firms serving domestic and foreign markets (Hsieh, Li, Ossa and Yang, 2021), and the share of active trading relationships (Felbermayr and Kohler, 2006; Helpman, Melitz and Rubinstein, 2008; Felbermayr and Kohler, 2010). Our paper contributes to this literature by disentangling the implied underlying changes in variable and fixed trade costs for a policy shock of interest, given observed variations in trade flows, trade status, and margins of trade. Based on the inferred changes in variable and fixed trade costs, the framework can then be simulated to study changes in the extensive margins by each of these definitions listed above. When reporting the results, however, we will focus on changes in the trade status and the mass of firms that serve each destination market (weighted by size). The other measures of extensive margins (e.g., the domestic cutoffs, export cutoffs and count of firms/products, for each bilateral trading relationship) are also generated in the process as byproducts.

2 Structural Framework

2.1 Model

As highlighted by HMR, inactive trade is prevalent in bilateral trading relationship. The HMR framework, by assuming bounded support for firm productivity and the presence of fixed export cost, allows arbitrary patterns of inactive trade across trading relationships in theory. We develop the estimation strategies based on the HMR framework.

Let countries be indexed by i or j. Each country is endowed with a fixed supply of labor L_i. Preferences of consumers in i are characterized by CES utility functions:

$$U_i = \left[\int_{l \in B_i} q_i(l)^{\frac{\sigma-1}{\sigma}} dl \right]^{\frac{\sigma}{\sigma-1}}, \ \sigma > 1, \tag{1}$$

where $q_i(l)$ is the consumption of product l in country i; B_i is the set of products available for consumption in country i; and σ corresponds to the elasticity of substitution across products. Let E_i denote the aggregate expenditure of country i. It follows that country i's demand for

product l is:

$$q_i(l) = \frac{p_i(l)^{-\sigma}}{P_i^{1-\sigma}} E_i, \tag{2}$$

where $p_i(l)$ is the price of product l in country i, and P_i is country i's aggregate price index, given by:

$$P_i = \left[\int_{l \in B_i} p_i(l)^{1-\sigma} dl \right]^{1/(1-\sigma)}. \tag{3}$$

Let c_i denote the cost of an input bundle. Following Eaton and Kortum (2002), we model the input bundle to incorporate labor and intermediate inputs (which consist of the same basket of goods as used for consumption) in a Cobb-Douglas manner such that $c_i = w_i^{\alpha_i} P_i^{1-\alpha_i}$, given the wage rate w_i and the labor share α_i in country i.

Let N_i denote the mass of firms in country i. A firm pays a fixed cost of entry $c_i F_i$ to take a productivity draw $1/a$ from a truncated Pareto distribution $G_i(a)$ over the support $[a_{L_i}, a_{H_i}]$, where $0 < a_{L_i} < a_{H_i}$, given by:

$$G_i(a) = \frac{a^k - a_{L_i}^k}{a_{H_i}^k - a_{L_i}^k}, \tag{4}$$

with dispersion parameter $k > (\sigma - 1)$. Firms with productivity level $1/a$ and located in country i incur a constant marginal cost $\tau_{ij} c_i a$ and a fixed cost $c_i f_{ij}$ to serve country j, where τ_{ij} is the iceberg trade cost and f_{ij} the fixed trade cost (in terms of input bundles). In other words, τ_{ij} units of goods need to be shipped from country i for one unit of the good to arrive at the destination j.

Given CES preferences and monopolistic competition, a firm charges a constant markup $\frac{\sigma}{\sigma-1}$ over its marginal cost. The corresponding profit of a firm with productivity $1/a$ in country i to serve market j is given by:

$$\pi_{ij}(a) = \frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \frac{\tau_{ij} c_i a}{P_j} \right)^{1-\sigma} E_j - c_i f_{ij}. \tag{5}$$

A firm in country i does not serve market j if its cost draw is above the cutoff a_{ij} defined by the zero-profit condition:

$$\frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \frac{\tau_{ij} c_i a_{ij}}{P_j} \right)^{1-\sigma} E_j = c_i f_{ij}. \tag{6}$$

It is assumed that a_{Hi} is sufficiently large such that not all firms export (as is the case in empirical stylized facts). Define the proportion of firms (weighted by market shares) that

export from i to j by:

$$V_{ij} \equiv \begin{cases} \int_{a_{L_i}}^{a_{ij}} a^{1-\sigma} dG(a) & \text{when } a_{ij} \geq a_{L_i}; \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

Given the demand function (2), the aggregate price index (3), and the definition of V_{ij}, the value of trade from country i to country j can be expressed as:

$$X_{ij} = \left(\frac{\sigma}{\sigma - 1} \frac{\tau_{ij} c_i}{P_j} \right)^{1-\sigma} N_i E_j V_{ij}, \tag{8}$$

where

$$P_j^{1-\sigma} = \sum_i \left(\frac{\sigma}{\sigma - 1} \tau_{ij} c_i \right)^{1-\sigma} N_i V_{ij}. \tag{9}$$

The goods-market clearing condition requires that the total production Y_i of country i equals its total sales to all destinations:

$$Y_i = \sum_j X_{ij} = \sum_j \left(\frac{\sigma}{\sigma - 1} \frac{\tau_{ij} c_i}{P_j} \right)^{1-\sigma} N_i E_j V_{ij}. \tag{10}$$

Using the market clearing condition (10) to solve for $\left(\frac{\sigma}{\sigma-1} c_i\right)^{1-\sigma} N_i$ and substitute them in (8) and (9) with the resulting expression, we have the following structural gravity equations:

$$X_{ij} = \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma} s_i e_j Y_w V_{ij}, \tag{11}$$

$$\Pi_i^{1-\sigma} \equiv \sum_j \left(\frac{\tau_{ij}}{P_j} \right)^{1-\sigma} e_j V_{ij}, \tag{12}$$

$$P_j^{1-\sigma} = \sum_i \left(\frac{\tau_{ij}}{\Pi_i} \right)^{1-\sigma} s_i V_{ij}, \tag{13}$$

where Y_w is the world's output, $s_i = Y_i / Y_w$ is country i's output share, $e_j = E_j / Y_w$ is country j's expenditure share, Π_i and P_j are, respectively, the outward multilateral resistance (MR) to export of country i and the inward multilateral resistance to import of country j. Note that the MR terms in this paper are different from the MR terms in Anderson and van Wincoop (2003). The expressions in (12) and (13) account for the extensive margins of trade, $\{V_{ij}\}$, which can take on a value of zero for inactive bilateral trading relationships.

Free entry requires that variable profit covers the fixed trade cost and entry cost, such

that:

$$\frac{1}{\sigma}Y_i - \sum_j N_{ij} c_i f_{ij} = N_i c_i F_i, \tag{14}$$

where $N_{ij} = N_i G_i(a_{ij})$ is the mass of firms in country i that export to country j. Given the truncated Pareto distribution in (4), N_{ij} can be expressed as:

$$N_{ij} = \begin{cases} \frac{N_i a_{L_i}^k}{a_{H_i}^k - a_{L_i}^k} \left[\left(\frac{a_{ij}}{a_{L_i}} \right)^k - 1 \right] & \text{when } a_{ij} \geq a_{L_i}; \\ 0 & \text{otherwise.} \end{cases} \tag{15}$$

Given (14) and the fact that all stages of production use the same input bundle with a constant labor share, the labor-market clearing condition suggests that the labor income is a constant share of gross output:

$$\alpha_i Y_i = w_i L_i. \tag{16}$$

Finally, we allow for trade deficit D_i. The aggregate budget constraint for each country requires that:

$$E_i = Y_i + D_i, \tag{17}$$

and the world trade deficit to be zero: $\sum_i D_i = 0$.

2.2 Identification of the GATT/WTO Effects

In this section, we propose estimation strategies to identify the partial (direct) effects of GATT/WTO on the variable and fixed trade costs, respectively. We add the year subscript t to the variables in the context of a panel data structure.

Define $bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$ as three binary indicators of GATT/WTO membership status: $bothwto_{ijt}$ takes the value of one if both exporting and importing countries ij are GATT/WTO members at time t, and zero otherwise; $imwto_{ijt}$ takes the value of one if only the importing country j is a GATT/WTO member (while the exporting country i is not) at time t, and zero otherwise; and $exwto_{ijt}$ takes the value of one if only the exporting country i is a GATT/WTO member (while the importing country j is not) at time t, and zero otherwise.

A GATT/WTO member is required to apply on a non-discriminatory basis (i.e., in the most-favored-nation principle) any tariff reductions and liberalizations in nontariff measures it has agreed to in its accession packages or in the general trade negotiation sessions to all other members. This is expected to lower the variable and fixed trade costs imposed by member j against firms of member i. In contrast, members are not constrained by GATT/WTO in their trade policies against nonmembers. It is ex ante possible for the

trade policy of members to become liberalized against nonmembers (if they extend MFN treatment to nonmembers) or more restrictive (if members realign their optimal trade policies against nonmembers). In addition, members may liberalize their barriers on exports (if any). This reduces the trade costs of exports to fellow members (reinforcing reductions in import barriers by importing members) and to nonmembers (again conditional on extension of MFN treatment to nonmembers). Thus, as a whole, we expect *bothwto* to have a larger trade-promoting effect than either *imwto* or *exwto*.

In estimations of gravity equations, the literature typically uses a list of observable proxies (such as distance, among others) to control for trade costs, and a vector of exporter-year and importer-year fixed effects (FEs) to control for the MR terms. In the current context, we cannot identify the effects of the membership indicators when the FE terms are included in the same regression. As implied by the work of Cheong, Kwak and Tang (2014), these membership indicators when combined are multicollinear with the exporter-year and importer-year FE terms. Below we develop our estimation strategies, in which we identify the extensive margin and the variable trade cost of bilateral trading relationships in the first two stages (built upon HMR), and in the third stage identify the fixed trade cost. Given the variable and fixed trade cost estimates obtained in the second and third stages, we then isolate the partial effects of *bothwto*, *imwto*, and *exwto* on these two types of trade costs, respectively.

2.2.1 Identification of the Extensive Margin

This stage follows HMR to identify the extensive margin of bilateral trade. Given the expression of the truncated Pareto distribution in (4) and the definition of V_{ijt}, it follows that $V_{ijt} = \frac{k}{k+1-\sigma}\frac{a_{L_i}^{k+1-\sigma}}{a_{H_i}^k - a_{L_i}^k}\Omega_{ijt}$, where Ω_{ijt} is given by:

$$\Omega_{ijt} \equiv \max\left\{\left(\frac{a_{ijt}}{a_{L_i}}\right)^{k+1-\sigma} - 1, 0\right\}. \tag{18}$$

Define the latent variable Z_{ijt} as the ratio between the most productive firm's variable profit and the fixed cost of exporting. Using the zero profit condition in (6), we have:

$$Z_{ijt} \equiv \frac{\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{\tau_{ijt}c_{it}a_{L_i}}{P_{jt}}\right)^{1-\sigma}E_{jt}}{c_{it}f_{ijt}} = \left(\frac{a_{ijt}}{a_{L_i}}\right)^{\sigma-1}. \tag{19}$$

Thus, Ω_{ijt} can be expressed in terms of the latent variable Z_{ijt} as:

$$\Omega_{ijt} \equiv \begin{cases} Z_{ijt}^{\frac{k+1-\sigma}{\sigma-1}} - 1 & \text{when } Z_{ijt} > 1; \\ 0 & \text{otherwise.} \end{cases} \tag{20}$$

An active trading relationship corresponds to $\Omega_{ijt} > 0$ (equivalently, $Z_{ijt} > 1$). Thus, the observed trading status can be used to infer the underlying latent variable. Writing (19) in log-linear form and allowing for idiosyncratic shocks η_{ijt}, we have:

$$z_{ijt} \equiv \ln Z_{ijt} = constant + \ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt} + \zeta_{it} + \xi_{jt} + \eta_{ijt}, \tag{21}$$

$$\zeta_{it} \equiv -\sigma \ln c_{it} + (1-\sigma) \ln a_{L_i}, \tag{22}$$

$$\xi_{jt} \equiv -\ln P_{jt}^{1-\sigma} + \ln e_{jt} + \ln Y_{wt}, \tag{23}$$

where $-\sigma \ln c_{it} = \sigma \ln \frac{\sigma}{\sigma-1} - \frac{\sigma}{\sigma-1} \ln N_{it} - \frac{\sigma}{\sigma-1} \ln \Pi_{it}^{1-\sigma} + \frac{\sigma}{\sigma-1} \ln s_{it}$ according to the goods-market clearing condition (10).

Let T_{ijt} indicate the trade status, which equals one if country i exports to country j in year t, and zero otherwise. Identify a vector of observable trade cost proxies $\mathbf{B}_{ijt}$ that can possibly affect bilateral variable and fixed trade costs. By writing the unobserved total trade cost term as log-linear in the observable trade cost proxies, i.e., $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt} \approx \boldsymbol{\gamma} \mathbf{B}_{ijt}$, the structural relationship (21) can be estimated as follows using the Probit estimator:

$$\rho_{ijt} \equiv Pr(T_{ijt} = 1 | \mathbf{B}_{ijt}) = \Phi(\boldsymbol{\gamma}^* \mathbf{B}_{ijt} + \zeta_{it}^* + \xi_{jt}^*), \tag{24}$$

where $\Phi(\cdot)$ is the cdf of a unit-normal distribution, ζ_{it}^* is the normalized exporter-year FE, and ξ_{jt}^* is the normalized importer-year FE. In particular, $\boldsymbol{\gamma}^* \equiv \boldsymbol{\gamma}/s_\eta$, $\zeta_{it}^* \equiv \zeta_{it}/s_\eta$, and $\xi_{jt}^* \equiv \xi_{jt}/s_\eta$, where s_η is the standard deviation of the error term in (21). The parameter s_η is not identified in the Probit estimation, but will be critical in the inference of the fixed trade cost. We will return to its identification later.

A consistent estimator of Ω_{ijt} can be obtained by:

$$\widetilde{\Omega}_{ijt} \equiv \max\left\{ e^{\delta \widetilde{z}_{ijt}^*} - 1, 0 \right\}, \tag{25}$$

where $\widetilde{z}_{ijt}^* = \Phi^{-1}(\widetilde{\rho}_{ijt})$ is the predicted value of the latent variable (in logarithm) and δ is a combination of the elasticity of substitution σ, the shape parameter of the Pareto distribution k, and the standard deviation s_η, given by:

$$\delta \equiv s_\eta (k + 1 - \sigma)/(\sigma - 1). \tag{26}$$

HMR suggested strategies to identify δ together with the coefficients of the main trade flow equation pertinent to the variable trade cost (to be discussed in the next section). As mentioned above, to pin down the fixed trade cost, we also need to identify s_η. We discuss the strategies in Section 2.2.3.

2.2.2 Identification of $\ln \tau_{ijt}^{1-\sigma}$ and GATT/WTO Effects on $\ln \tau_{ijt}^{1-\sigma}$

Given the relationship between V_{ijt} and Ω_{ijt}, the observed trade flow (11) in logarithm can be expressed as:

$$x_{ijt} \equiv \ln X_{ijt} = constant + \ln \tau_{ijt}^{1-\sigma} + \ln \Omega_{ijt} + \theta_{it} + \lambda_{jt} + u_{ijt}, \quad (27)$$

$$\theta_{it} \equiv -\ln \Pi_{it}^{1-\sigma} + \ln s_{it} + \ln \frac{a_{L_i}^{k+1-\sigma}}{a_{H_i}^k - a_{L_i}^k}, \quad (28)$$

$$\lambda_{jt} \equiv -\ln P_{jt}^{1-\sigma} + \ln e_{jt} + \ln Y_{wt}. \quad (29)$$

As suggested by HMR, consistent estimation of (27) requires controls for both the endogenous number of exporters (via $\omega_{ijt} \equiv \ln \Omega_{ijt}$) and the sample selection bias (since only observations of positive trade flows are used in the estimation). In particular, we need estimates of $E[\omega_{ijt}|., T_{ijt} = 1]$ and $E[u_{ijt}|., T_{ijt} = 1]$, given the use of positive trade flows in (27). Define $\bar{\eta}_{ijt}^* \equiv E[\eta_{ijt}^*|., T_{ijt} = 1]$. A consistent estimate for $\bar{\eta}_{ijt}^*$ is the inverse Mills ratio $\widetilde{\bar{\eta}}_{ijt}^* \equiv \phi(\widetilde{z}_{ijt}^*)/\Phi(\widetilde{z}_{ijt}^*)$, since η_{ijt}^* has a unit normal distribution. It follows that a consistent estimate for $E[\omega_{ijt}|., T_{ijt} = 1]$ is $\widetilde{\bar{\omega}}_{ijt} \equiv \ln\{\exp[\delta(\widetilde{z}_{ijt}^* + \widetilde{\bar{\eta}}_{ijt}^*)] - 1\}$. In addition, following Heckman (1979), $E[u_{ijt}|., T_{ijt} = 1] = corr(u_{ijt}, \eta_{ijt})(s_u/s_\eta)\bar{\eta}_{ijt}^*$, where s_u and s_η are the standard deviations of u_{ijt} and η_{ijt}. The trade flow equation thus can be estimated using the following specification:

$$x_{ijt} \equiv \ln X_{ijt} = constant + \boldsymbol{\beta}\mathbf{B}_{ijt} + \ln\{\exp[\delta(\widetilde{z}_{ijt}^* + \widetilde{\bar{\eta}}_{ijt}^*)] - 1\} + \theta_{it} + \lambda_{jt} + \beta_{u\eta}\widetilde{\bar{\eta}}_{ijt}^* + \kappa_{ijt}, \quad (30)$$

where $\beta_{u\eta} \equiv corr(u_{ijt}, \eta_{ijt})(s_u/s_\eta)$ and κ_{ijt} is an i.i.d. error term with zero mean conditional on positive trade. As in (21) for the total trade cost term, we have similarly assumed that the variable trade cost term in (27) can be written as log-linear in the observable trade cost proxies, that is, $\ln \tau_{ijt}^{1-\sigma} \approx \boldsymbol{\beta}\mathbf{B}_{ijt}$. We estimate (30) using nonlinear least squares (NLS) to obtain the parameter estimate $\widetilde{\delta}$ (and in turn the fitted value for the extensive margin $\widetilde{\Omega}_{ijt}$), the fitted value for the variable trade cost term ($\ln \widetilde{\tau}_{ijt}^{1-\sigma} \equiv \widetilde{\boldsymbol{\beta}}\mathbf{B}_{ijt}$), and the fitted value for the exporter-year FEs ($\widetilde{\theta}_{it}$) and the importer-year FEs ($\widetilde{\lambda}_{jt}$), where we have used the notation $\widetilde{}$ over a variable (or parameter) to indicate its empirical estimate.

As noted previously, it is not feasible to include the three GATT/WTO membership

indicators ($bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$) in the set of $\mathbf{B}_{ijt}$, because they are jointly multicollinear with the exporter-year and importer-year FEs ($\theta_{it} + \lambda_{jt}$) in the trade flow equation (30). By excluding the three GATT/WTO indicators, their potential effects are thus absorbed by the exporter-year and importer-year FE terms. The same applies to the estimation of the extensive margin in (21). We propose an iteration procedure to circumvent this multicollinearity issue and to identify the GATT/WTO effects on the variable trade cost term $\ln \tau_{ijt}^{1-\sigma}$. Section 2.2.3 will revisit the issue with respect to the fixed trade cost, after we propose a procedure to identify s_η and the original (not normalized) total trade cost term $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$.

In the first step of the iteration procedure, we solve for $\widetilde{\Pi}_{it}^{1-\sigma}$ and $\widetilde{P}_{jt}^{1-\sigma}$, by substituting $\widetilde{\tau}_{ijt}^{1-\sigma}$ in the definitions of the MR terms in (12) and (13), and by replacing $\widetilde{V}_{ijt}$ with $\widetilde{\Omega}_{ijt}$. This normalization is without loss of generality, because the solution of the system of the MR terms in (12) and (13) is unique up to a normalization.

In the second step, given the definitions of the exporter-year FEs in (28) and the importer-year FEs in (29), and the fact that the effects of the three GATT/WTO indicators on $\ln \tau_{ijt}^{1-\sigma}$ are absorbed by these terms, we estimate the GATT/WTO effects by the following specification:

$$\begin{aligned} \widetilde{\theta}_{it} + \widetilde{\lambda}_{jt} = {} & \beta_1 \times bothwto_{ijt} + \beta_2 \times imwto_{ijt} + \beta_3 \times exwto_{ijt} \\ & + \beta_\Pi \ln \widetilde{\Pi}_{it}^{1-\sigma} + \beta_P \ln \widetilde{P}_{jt}^{1-\sigma} + \beta_s \ln s_{it} + \beta_e \ln e_{jt} + \beta_Y \ln Y_{wt} \\ & + \beta_a \ln \frac{a_{L_i}^{k+1-\sigma}}{a_{H_i}^k - a_{L_i}^k} + \epsilon_{ijt}, \end{aligned} \tag{31}$$

where $\widetilde{\theta}_{it}$, $\widetilde{\lambda}_{jt}$, $\ln \widetilde{\Pi}_{it}^{1-\sigma}$, and $\ln \widetilde{P}_{jt}^{1-\sigma}$ were obtained from the estimation of (30) and from the first step above. We include exporter dummies to control for the term, $\ln \frac{a_{L_i}^{k+1-\sigma}}{a_{H_i}^k - a_{L_i}^k}$, in (31).

In the third step, we then update $\widetilde{\tau}_{ijt}^{1-\sigma}$ by adding the fitted value of $\widetilde{\beta}_1 \times bothwto_{ijt}$, $\widetilde{\beta}_2 \times imwto_{ijt}$, and $\widetilde{\beta}_3 \times exwto_{ijt}$, obtained from the second step, to the original value $\widetilde{\boldsymbol{\beta}}\mathbf{B}_{ijt}$. We then repeat the first step to the third step iteratively until $\widetilde{\beta}_1$, $\widetilde{\beta}_2$, and $\widetilde{\beta}_3$ converge. The final set of estimates, $\widetilde{\beta}_1$, $\widetilde{\beta}_2$, and $\widetilde{\beta}_3$, after the iterations converge, are taken to be the GATT/WTO effects on the variable trade cost term, $\ln \tau_{ijt}^{1-\sigma}$.

2.2.3 Identification of GATT/WTO Effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$ and on $-\ln f_{ij}$

Recall that the estimation of (21) provides us with the normalized fitted value of $\ln \tau_{ijt}^{*,1-\sigma} - \ln f_{ijt}^* \equiv \widetilde{\boldsymbol{\gamma}}^* \mathbf{B}_{ijt}$, the normalized exporter-year FEs $\widetilde{\zeta}_{it}^*$, and the normalized importer-year FEs $\widetilde{\xi}_{jt}^*$ in the Probit specification for trade status. We propose strategies below to obtain

estimates of s_η and in turn the original fitted values of the above terms without normalization.

First, we use the functional form of δ in (26), the estimate of $\widetilde{\delta}$ from Section 2.2.2, and the estimate of $k/(\sigma-1) = 1.4$ from Melitz and Redding (2015)[1] to obtain our benchmark estimate of s_η. Given s_η, we can recover the fitted value of the total trade cost term, $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt} \equiv s_\eta \times \widetilde{\boldsymbol{\gamma}}^* \mathbf{B}_{ijt}$, the exporter-year FEs, $\widetilde{\zeta}_{it} = s_\eta \times \widetilde{\zeta}_{it}^*$, and the importer-year FEs, $\widetilde{\xi}_{jt} = s_\eta \times \widetilde{\xi}_{jt}^*$, in their original scale.

The same multicollinearity issue discussed above applies to the estimation of the Probit equation (24). The three GATT/WTO indicators cannot be included in the set of observable trade cost proxies $\mathbf{B}_{ijt}$, because they would be multicollinear with the exporter-year and importer-year FEs ($\zeta_{it} + \xi_{jt}$) in the Probit equation (24). We use a similar strategy as in Section 2.2.2 to identify the GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$. The difference here is that the first and third steps (to calculate the structural MR terms based on $\ln \tau_{ijt}^{1-\sigma}$, and to update $\ln \tau_{ijt}^{1-\sigma}$ given the GATT/WTO effects on the variable trade cost) have been carried out in the previous section, and we need only to perform the second step.

In particular, given the definitions of ζ_{it} and ξ_{jt} in (22)–(23), and the fact they absorb the effects of the three GATT/WTO indicators on the total trade cost term, we estimate the GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$ as follows:

$$\begin{aligned}\widetilde{\zeta}_{it} + \widetilde{\xi}_{jt} = {} & \gamma_1 \times bothwto_{ijt} + \gamma_2 \times imwto_{ijt} + \gamma_3 \times exwto_{ijt} \\ & + \gamma_\Pi \ln \widetilde{\Pi}_{it}^{1-\sigma} + \gamma_p \ln \widetilde{P}_{jt}^{1-\sigma} + \gamma_s \ln s_{it} + \gamma_e \ln e_{jt} + \gamma_Y \ln Y_{wt} \\ & + \gamma_N \ln N_{it} + \gamma_a \ln a_{L_i} + \varepsilon_{ijt},\end{aligned} \tag{32}$$

where $\widetilde{\Pi}_{it}^{1-\sigma}$ and $\widetilde{P}_{jt}^{1-\sigma}$ are obtained from the previous section. Exporter dummies are used to control for the term, $\ln a_{Li}$, in (32). The way we obtain measures of N_{it} is documented in Appendix B.2. The parameter estimates, $\widetilde{\gamma}_1$, $\widetilde{\gamma}_2$, and $\widetilde{\gamma}_3$, are taken to be the impacts of the three GATT/WTO indicators on the total trade cost term, $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$.

Given the estimates of the GATT/WTO effects on the variable trade cost term ($\ln \tau_{ijt}^{1-\sigma}$) from Section 2.2.2, and on the total trade cost term ($\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$) from this section, we then take $\widetilde{\gamma}_1 - \widetilde{\beta}_1$, $\widetilde{\gamma}_2 - \widetilde{\beta}_2$, and $\widetilde{\gamma}_3 - \widetilde{\beta}_3$ to be consistent estimates of the GATT/WTO effects on $-\ln f_{ijt}$, due to *bothwto*, *imwto* and *exwto*, respectively.

2.3 Counterfactual Analysis

Given the estimates of the direct effects of GATT/WTO membership indicators on variable, fixed, and total trade costs, we simulate how the changes in (each component of these) trade

[1] In Melitz and Redding (2015), $k/(\sigma-1) = 1.42$.

costs due to GATT/WTO affect the variables of interest in general equilibrium. To start, we rewrite the system introduced in Section 2.1 using the hat algebra (Dekle, Eaton and Kortum, 2007), and represent changes of variables by $\widehat{x} \equiv x'/x$, where x' is the counterfactual value of a variable x. Our report will focus on the effects of GATT/WTO on welfare, trade flows, extensive margins, and intensive margins. We define welfare as the ratio of income and price, Y_{it}/P_{it}, given the CES preferences. Note that this measure omits expenditure due to trade deficits, because the modeling of counterfactual trade deficits is debatable. For the margins of trade flows, we use their theoretical counterparts V_{ijt} to measure the extensive margin (of bilateral exports from country i to country j in year t), and correspondingly X_{ijt}/V_{ijt} to measure the intensive margin. Below we propose the procedure to simulate the counterfactual equilibrium of the system given shocks to the trade costs.

Starting with a set of initial values of $\{\widehat{w}_{it}, \widehat{P}_{it}\}$ and shocks to trade costs $\{\ln \widehat{\tau}_{ijt}^{1-\sigma}, \ln \widehat{f}_{ijt}\}$, we can impute the counterfactual values of the variables of the system as follows. First, given the Cobb-Douglas structure of the composite input bundle, the labor-market clearing condition in (16), and the aggregate budget constraint condition in (17), we have:

$$\widehat{c}_{it} = \widehat{w}_{it}^{\alpha} \widehat{P}_{it}^{1-\alpha}, \tag{33}$$

$$\widehat{Y}_{it} = \widehat{w}_{it}, \tag{34}$$

$$\widehat{E}_{it} = \frac{Y_{it}}{E_{it}} \widehat{Y}_{it} + \frac{D_{it}}{E_{it}} \widehat{Y}_{wt}, \tag{35}$$

where $\widehat{Y}_{wt} = \sum_i \frac{Y_{it}}{Y_{wt}} \widehat{Y}_{it}$. In deriving (35), we have assumed that a country's trade deficit is a constant share of the world gross output. See, e.g., Caliendo and Parro (2015) for similar assumptions. See also Ossa (2014), Caliendo and Parro (2015), and Caliendo, Dvorkin and Parro (2019) for alternative setups of counterfactual trade imbalances.

Next, given the latent variable definition in (21), we have:

$$z_{ijt}^{*\prime} - z_{ijt}^{*} = \frac{\ln \widehat{\tau}_{ijt}^{1-\sigma} - \ln \widehat{f}_{ijt}}{s_\eta} + \frac{-\sigma \ln \widehat{c}_{it} - \ln \widehat{P}_{jt}^{1-\sigma} + \ln \widehat{E}_{jt}}{s_\eta}. \tag{36}$$

Given the definition of Ω_{ijt} in (18), it follows that:

$$\Omega_{ijt}' \equiv \max\left\{e^{\delta z_{ijt}^{*\prime}} - 1, 0\right\}. \tag{37}$$

The counterfactual extensive margin V_{ijt}' in turn can be calculated as:

$$V_{ijt}' = \frac{k}{k+1-\sigma} \frac{a_{L_i}^{k+1-\sigma}}{a_{H_i}^{k} - a_{L_i}^{k}} \Omega_{ijt}'. \tag{38}$$

It is worthwhile noting that the expressions above of Ω'_{ijt} and V'_{ijt} can accommodate both active and inactive trading relationships in the factual. Naturally, the changes $\widehat{\Omega}_{ijt}$ and $\widehat{V}_{ijt}$ are only applicable when the factual trade status is active:

$$\widehat{\Omega}_{ijt} = \widehat{V}_{ijt} = \Omega'_{ijt}/\Omega_{ijt}, \text{ when } z^*_{ijt} > 0. \tag{39}$$

Third, given (12), the counterfactual outward MR terms can be obtained by:

$$\Pi'^{\,1-\sigma}_{it} = \sum_j \left(\frac{\tau'_{ijt}}{P'_{jt}}\right)^{1-\sigma} e'_{jt} V'_{ijt}, \tag{40}$$

where $e'_{jt} = E'_{jt}/Y'_{wt}$. Furthermore, given the definition of trade flow in (11), counterfactual trade flow and the change in trade flow are given by:

$$X'_{ijt} = \left(\frac{\tau'_{ijt}}{\Pi'_{it} P'_{jt}}\right)^{1-\sigma} s'_{it} e'_{jt} V'_{ijt} Y'_{wt}, \tag{41}$$

$$\widehat{X}_{ijt} = \left(\frac{\widehat{\tau}_{ijt}}{\widehat{\Pi}_{it}\widehat{P}_{jt}}\right)^{1-\sigma} \widehat{s}_{it}\widehat{e}_{jt}\widehat{V}_{ijt}\widehat{Y}_{wt}, \text{ when } z^*_{ijt} > 0, \tag{42}$$

where $s'_{it} = Y'_{it}/Y'_{wt}$ and $\widehat{s}_{it} = s'_{it}/s_{it}$.

Fourth, given the free entry condition in (14), $\widehat{N}_{it}$ can be inferred by:

$$\frac{Y'_{it} - \sum_{j:z^{*\prime}_{ijt}>0} X'_{ijt}/\nu'_{ijt}}{Y_{it} - \sum_{j:z^*_{ijt}>0} X_{ijt}/\nu_{ijt}} = \widehat{N}_{it}\widehat{c}_{it}, \tag{43}$$

where

$$\nu_{ijt} \equiv \frac{\frac{k}{k+1-\sigma}\left(a^{k+1-\sigma}_{ijt} - a^{k+1-\sigma}_{L_i}\right)}{a^{1-\sigma}_{ijt}(a^k_{ijt} - a^k_{L_i})}, \text{ for } z^*_{ijt} > 0. \tag{44}$$

The derivations are provided in Appendix A. We explain in Appendix B.1 how the parameters a_{ijt} and a_{Li} are calibrated. Given (15) and (19), $\widehat{N}_{ijt}$ can be calculated according to:

$$\widehat{N}_{ijt} = \widehat{N}_{it} \frac{\max\left\{[exp(z^{*\prime}_{ijt})]^{\frac{k\, s_\eta}{\sigma-1}} - 1, 0\right\}}{\max\left\{[exp(z^*_{ijt})]^{\frac{k\, s_\eta}{\sigma-1}} - 1, 0\right\}}, \text{ when } z^*_{ijt} > 0. \tag{45}$$

Strategies to obtain N'_{ijt} for $z^*_{ijt} \leq 0$ are elaborated in Appendix B.2.

Fifth, following the above iterations, changes in output and wages can then be updated by using the goods-market clearing condition in (10) and the definition of the outward MR

term in (12):

$$\widehat{w}_{it} = \widehat{Y}_{it} = \widehat{N}_{it}\widehat{Y}_{wt}\left(\widehat{c}_{it}^{1-\sigma}\widehat{\Pi}_{it}^{1-\sigma}\right). \tag{46}$$

The counterfactual price index P'_{jt} (and the change in the price index $\widehat{P}_{jt}$) can then be updated, given its definition in (13):

$$P_{jt}'^{\,1-\sigma} = \sum_i \left(\frac{\tau'_{ijt}}{\Pi'_{it}}\right)^{1-\sigma} s'_{it}V'_{ijt}, \tag{47}$$

$$\widehat{P}_{jt} = \frac{P'_{jt}}{P_{jt}}. \tag{48}$$

The new values of $\{\widehat{w}_{it}, \widehat{P}_{it}\}$ are fed back into the loop of (33)–(48) iteratively until convergence. These provide us with the changes in the wage and price index across countries in a given year due to the trade cost shocks. The welfare changes ($\widehat{Y}_{it}/\widehat{P}_{it}$), changes of trade flow (X'_{ijt} for $z^*_{ijt} \leq 0$ and $\widehat{X}_{ijt}$ for $z^*_{ijt} > 0$), extensive margins (V'_{ijt} for $z^*_{ijt} \leq 0$ and $\widehat{V}_{ijt}$ for $z^*_{ijt} > 0$), and intensive margins (X'_{ijt}/V'_{ijt} for $z^*_{ijt}{}' > 0$) can be obtained accordingly.

To illustrate the algorithm, consider the counterfactual if the GATT/WTO had not come into being. This is equivalent to turning all the factual values of $bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$ to zeros. Recall that the effect estimates of *bothwto*, *imwto*, and *exwto* are $\widetilde{\gamma}_1$, $\widetilde{\gamma}_2$, and $\widetilde{\gamma}_3$ on the total trade cost term, respectively, and $\widetilde{\beta}_1$, $\widetilde{\beta}_2$, and $\widetilde{\beta}_3$ on the variable trade cost term, respectively. By shutting down the GATT/WTO system, this implies a counterfactual shock to the total trade cost of $\ln \widehat{\tau}_{ijt}^{1-\sigma} - \ln \widehat{f}_{ijt} = -\widetilde{\gamma}_1 \times bothwto_{ijt} - \widetilde{\gamma}_2 \times imwto_{ijt} - \widetilde{\gamma}_3 \times exwto_{ijt}$. In addition, the counterfactual variable trade cost term would be $\ln(\tau'_{ijt})^{1-\sigma} = \widetilde{\boldsymbol{\beta}}\mathbf{B}_{ijt}$, which excludes the GATT/WTO effects on the variable trade cost. These shocks are fed into the system (33)–(48) to derive the ex-post effects of GATT/WTO on the welfare, and the other variables of interest as discussed.

We also isolate the GATT/WTO effects via the variable and fixed trade cost channels, separately. The shocks are $\ln \widehat{\tau}_{ijt}^{1-\sigma} = -\widetilde{\beta}_1 \times bothwto_{ijt} - \widetilde{\beta}_2 \times imwto_{ijt} - \widetilde{\beta}_3 \times exwto_{ijt}$ in the case of variable trade cost, and $-\ln \widehat{f}_{ijt} = -(\widetilde{\gamma}_1 - \widetilde{\beta}_1) \times bothwto_{ijt} - (\widetilde{\gamma}_2 - \widetilde{\beta}_2) \times imwto_{ijt} - (\widetilde{\gamma}_3 - \widetilde{\beta}_3) \times exwto_{ijt}$ in the case of fixed trade cost. Specifically, in the case with only variable trade cost shocks, the counterfactual variable trade cost term would be $\ln(\tau'_{ijt})^{1-\sigma} = \widetilde{\boldsymbol{\beta}}\mathbf{B}_{ijt}$ (which excludes the GATT/WTO effects), while in the case with only fixed trade cost shocks, $\ln(\tau'_{ijt})^{1-\sigma} = \ln(\tau_{ijt})^{1-\sigma} = \widetilde{\boldsymbol{\beta}}\mathbf{B}_{ijt} + \widetilde{\beta}_1 \times bothwto_{ijt} + \widetilde{\beta}_2 \times imwto_{ijt} + \widetilde{\beta}_3 \times exwto_{ijt}$ (which keeps the variable trade cost unchanged).

3 Estimation Results

We consider the period 1991–2017 for the analysis. The beginning year is limited by data availability for bilateral trade flows at the product level. The end year is chosen in view of the fact that most major economies had joined the GATT/WTO by 2017 (identification requires a meaningful size of control groups) and most of the significant multilateral trade talks facilitated by the GATT/WTO had taken place before then. The sources and compilation of the data are documented in Appendix C. These include: bilateral trade flow X_{ijt}, count of products exported N_{ijt}, GDP, value-added share α_{it} in gross output, gross output Y_{it}, expenditure E_{jt}, and the trade cost proxies $\mathbf{B}_{ijt}$.

The sample of countries studied is characterized in Tables 1–2. We trim the sample such that a country in the sample imports and exports with at least one other country in a year.[2] We also drop the countries that have negative aggregate expenditures or negative internal trade (due to data measurement errors). Summary statistics for the list of asymmetric trade cost proxies used in the estimation of Equations (24) and (30) are provided in Tables 3–4.

The estimations of the Probit equation (24) and the trade flow equation (30) are done year by year, due to computation constraints.[3] HMR similarly implemented this set of non-linear estimations for only a cross section. The resulting estimates of the exporter FEs and importer FEs of Equation (30) are then pooled across years to estimate the GATT/WTO effects on the variable trade cost term using the estimation equation (31). Similarly, the exporter and importer FE estimates of Equation (24), after being scaled, are pooled across years to estimate the GATT/WTO effects on the total trade cost term using the estimation equation (32).

3.1 Benchmark Results

The estimates of the parameters, δ from Equation (30) and s_η from Equation (26), are reported in Table 5. In the benchmark case, we impute s_η assuming $k/(\sigma-1) = 1.4$, the latter being chosen based on the findings in Melitz and Redding (2015). As suggested above, the estimations of Equation (30) are done year by year. This produces estimates of δ that

[2]This is so that the country's MR terms are not dependent on only the internal trade cost factor (an issue we will address below).

[3]Following HMR and Manova (2013), we replace those $\widetilde{\rho}_{ijt} > 0.9999999$ with the value 0.9999999, and replace those $\widetilde{\rho}_{ijt} < 0.0000001$ with the value 0.0000001. Since internal trade is always active, we replace unobserved $\widetilde{\rho}_{iit}$ to be 0.9999999. We fill in the missing observations $\widetilde{\rho}_{ijt}$ based on the Probit coefficient estimates. If the observation on $\widetilde{\rho}_{ijt}$ is still missing, e.g., because of missing estimates of importer and/or exporter FEs in a given year, we fill in the missing $\widetilde{\rho}_{ijt}$ by the average value of the same country pair ij across years. If with this, $\widetilde{\rho}_{ijt}$ is still missing, we fill in the missing observation with the corresponding average value of the same exporter in a specific year across its trading partners.

vary across years, and correspondingly the estimates of s_η. Table 5 suggests a very narrow range of estimates for these two parameters for the period studied. The estimates of δ are in the same order of magnitude as reported by HMR for their cross section.

Given $\tilde{\theta}_{it} + \tilde{\lambda}_{jt}$ from estimations of Equation (30), Table 6 reports in Column (1) the GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma}$ based on the iterative estimation procedure of Equation (31). We note that $bothwto_{ijt}$ has a larger positive effect on the variable trade cost factor $\ln \tau_{ijt}^{1-\sigma}$ than $exwto_{ijt}$. In contrast, the significant and negative coefficient of $imwto_{ijt}$ in Column (1) implies that members tend to increase variable import barriers on goods from nonmembers.

Next, given $\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$, based on estimations of Equation (24) and the scale parameter estimate of s_η, Column (2) reports the GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$ using the estimation equation (32). Column (2) indicates that $bothwto_{ijt}$ has a larger positive effect on the extensive margin (via the total trade cost factor) than $exwto_{ijt}$ and $imwto_{ijt}$. Column (3) then reports the GATT/WTO effects on $-\ln f_{ijt}$, corresponding to the difference between Column (2) and Column (1). The GATT/WTO effects in Column (2) are statistically larger than its effects in Column (1), implying a statistically significant effect of GATT/WTO membership in reducing the fixed trade cost.

In addition, Column (3) indicates that the effect of $bothwto_{ijt}$ is significantly larger than $imwto_{ijt}$ or $exwto_{ijt}$ in reducing the fixed trade cost. In contrast to the case of variable trade cost, the positive and significant coefficient of $imwto_{ijt}$ in Column (3) implies that GATT/WTO members tend to extend their reductions in fixed import barriers to goods from nonmembers (although not required by their membership in the GATT/WTO). Overall, the significant and positive coefficient estimates of GATT/WTO indicators in Columns (2) and (3) suggest that GATT/WTO membership effectively reduces the total trade cost and the fixed trade cost for either the outward or inward trade flows of member economies.

We may also further translate the GATT/WTO effects on the trade cost terms to the underlying trade cost, by taking a stand on the value of σ. For this purpose, we take the median value of $\sigma = 5$ suggested by the gravity literature (Head and Mayer, 2015). The estimates in Table 6 imply a reduction of variable trade cost by 7.09% due to *bothwto* (e.g., $1 - \exp[0.294/(1-5)] = 7.09\%$), an increase of variable trade cost by 21.96% due to *imwto*, and a reduction of variable trade cost by 1.93% due to *exwto*. In parallel, the fixed trade costs are lowered by 78.37% due to *bothwto*, by 66.81% due to *imwto*, and by 69.00% due to *exwto*. As a result, we can conclude that the GATT/WTO has a larger impact on the members' fixed trade costs than on their variable trade costs.

Dutt, Mihov and Van Zandt (2013) used the empirical measure of intensive margin, X_{ijt}/N_{ijt}, and the argument that a reduction in variable trade cost has a positive effect

(while a reduction in fixed trade cost has a negative effect) on the intensive margin, to infer that the GATT/WTO effect on the fixed trade cost is larger than on the variable trade cost, since they found that *bothwto* has negative effects on the intensive margin. Our analysis here provides a direct decomposition of changes in the underlying variable and fixed trade costs due to the GATT/WTO. The methodology can be applied to contexts due to alternative shocks of interest in general.

3.2 Robustness Checks

We verify the robustness of our conclusions (regarding the GATT/WTO effects on fixed and variable trade costs) to the choice of the parameter values for $k/(\sigma-1)$ and σ.

In the first set of robustness checks, we alter the parameter value from the benchmark for $k/(\sigma-1)$ and use alternative values of 1.35, 1.38, 1.42, and 1.45 (instead of $k/(\sigma-1)=1.4$ in the benchmark). In the second set of robustness checks, we alter the parameter value for σ: instead of 5 used in the benchmark, we experiment with $\sigma = 3, 4, 6, 7$. Note that this does not affect the estimate of s_η (which is fixed conditional on δ and $k/(\sigma-1)$), but it does affect the measure of N_{it} used in Equation (32). In particular, as explained in Appendix B.2, we estimate N_{it} based on Equation (15). The proposed method divides N_{ijt} by $\frac{a_{L_i}^k}{a_{H_i}^k - a_{L_i}^k}\left[\left(\frac{a_{ijt}}{a_{L_i}}\right)^k - 1\right]$, and then takes the average of the results within each it to obtain an estimate of N_{it}. The choice of σ affects the parameter value k, given $k/(\sigma-1)$, and hence the measure of N_{it}.

Given these alternative values of $k/(\sigma-1)$, σ, or N_{it}, we repeat the estimations of Equation (32). These provide alternative estimates of the GATT/WTO effects on the extensive margin (via the total trade cost factor) and the corresponding effects on the fixed trade cost. The results are reported in Tables A.1–A.2. Note that the results of GATT/WTO effects on the variable trade cost remain the same, since the estimations of Equation (30) do not depend on s_η or N_{it}.

Note that as $k/(\sigma-1)$ increases, the implied parameter value of s_η decreases given δ, according to Equation (26). The smaller the value of s_η, the smaller the scale of the exporter-year FEs, $\widetilde{\zeta}_{it} = s_\eta \times \widetilde{\zeta}^*_{it}$, and the importer-year FEs, $\widetilde{\xi}_{jt} = s_\eta \times \widetilde{\xi}^*_{jt}$, in Equation (21), and the smaller the effect estimates of the GATT/WTO indicators on the total trade cost term via $\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$. The effect estimates of the GATT/WTO indicators on the fixed trade cost term $-\ln f_{ijt}$, which reflects the difference between the total trade cost term and the variable trade cost term, are in turn smaller. The results in Table A.1 together with Table 6 confirm this ex ante expectation. Nevertheless, the effects on the fixed trade cost remain larger than on the variable trade cost by one order of magnitude.

Next, as the parameter value of σ increases, the implied value of k increases given the ratio $k/(\sigma-1)$. This reduces the density of the distribution for a at the lower end (i.e., the more productive firms) and has negative effects on the mass of firms that export given the cutoff a_{ijt}. Thus, by Equation (15), the imputed N_{it} will increase with k for given observations of N_{ijt}. Table A.2 indicates that this tends to weaken the effects of GATT/WTO on the total and fixed trade costs, but the differences from the benchmark are rather small.

Overall, the results of these robustness checks confirm the GATT/WTO membership's impacts on reducing total and fixed trade costs. The impacts are larger if both trading partners are members than if only the importing or the exporting country is a member. GATT/WTO members tend to extend their reductions in fixed import barriers (but not variable import barriers) to nonmember sources of imports. In contrast, members tend to lower their export barriers (fixed or variable) with respect to both member and nonmember destinations of exports.

4 General Equilibrium Effects

In this section, we analyze the general equilibrium effects of GATT/WTO membership, based on the benchmark estimates of the GATT/WTO effects on the trade cost factors in Table 6. We consider three counterfactual scenarios: (1) if the whole GATT/WTO system were shut down; (2) if all the countries became GATT/WTO members; and (3) if China had not joined the GATT/WTO in 2001. For the first counterfactual analysis, we further decompose the total effects into effects due to the variable trade cost channel and the effects due to the fixed trade cost channel. We present the counterfactual changes in welfare (real income) $\widehat{Y}_{it}/\widehat{P}_{it}$, trade flows $\widehat{X}_{ijt}$, trade status, extensive margins in terms of $\widehat{V}_{ijt}$, and intensive margins $\widehat{X}_{ijt}/\widehat{V}_{ijt}$, as a result of the counterfactual shocks.

Calibrations of the parameters required in the simulation, including the support of the (inverse) productivity distributions (a_{L_i} and a_{H_i}), and the value-added share (α_{it}), are documented in Appendices B.1 and C.2. Table A.3 provides a snapshot of the parameters (a_{L_i} and a_{H_i}) used in the analysis. The sources and compilation of the data required for the simulation are documented in Appendix C.

4.1 Shutting down the GATT/WTO

The first counterfactual scenario we consider is shutting down the GATT/WTO. This is equivalent to turning all the factual values of $bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$ into zeros. The shocks to the status quo are as elaborated at the end of Section 2.3, based on the

estimates of the GATT/WTO effects on the trade cost factors in Table 6.

4.1.1 Effects on Welfare

Panel A of Table 7 provides the summary statistics (the number of observations, 25th percentile, median and 75th percentile) of the welfare changes across countries by membership status for an earlier year (1995) and a more recent year (2010). In 1995, the majority of members would experience welfare losses (1.26%) if GATT/WTO were shut down. The welfare losses would be larger in 2010 (1.35%), but less dispersed. The reverse is true for nonmembers. The majority of nonmembers would be better off without the GATT/WTO. Thus, the GATT/WTO-induced reductions in trade barriers have benefitted its members, but left the nonmembers overall worse off. The negative welfare effects of GATT/WTO on nonmembers imply that trade diversion from nonmembers toward members as sources of imports (due to higher variable import barriers by members against nonmembers, as indicated by the negative effect estimate of *imwto* in Column (1) of Table 6, and due to potential general equilibrium effects) outweighed trade creation (due to members' extending reductions in fixed trade barriers on imports from nonmember sources, and in variable/fixed trade barriers on exports to nonmember destinations). The negative welfare effects of GATT/WTO on nonmembers became smaller in magnitude in recent years (1.55% to 0.74%), as implied by Panel A of Table 7. This could be due to changes in the number and composition of the nonmembers, as the data allow more observations to be included in recent years. Alternatively, countries that might have benefitted more from joining the GATT/WTO (such as China) could have chosen to do so in the course of 1995 to 2010, leaving behind those that did not suffer as much by remaining outside the system.

Figure 1 provides the detailed distribution of the welfare effects across countries by membership status every five years. Consistent with the discussions above, more economies chose to join the system over the years and those that did so tended to suffer the most from staying outside the system. By 2015, there remained a very small number of nonmembers, and these tended to be those with very modest welfare losses by remaining as nonmembers (in other words, they are nonmembers with very small positive gains if GATT/WTO were not in place). Table 8 indicates that by geographical region, economies in East and South Asia (as well as the Middle East and North Africa) in general would not fare much worse in the counterfactual without GATT/WTO, compared with economies in the other regions. OECD countries were in similar situations in 1995, but became relatively large beneficiaries of the GATT/WTO system in 2010. This echoes the results in Table 9, which suggests that the welfare benefits of the system tended to be biased toward low-income countries in 1995, but became skewed toward high-income countries in 2010.

4.1.2 Effects on Trade Flows, Trade Status, and Trade Margins

We now report the GATT/WTO effects on trade flows. Since our framework allows for changes in the trade status (active or inactive), we summarize the trade status changes across bilateral trading relationships in each year in Figure 2, where Panel A reports the frequency and Panel B reports the fraction of each category (inactive to inactive, active to active, active to inactive, and inactive to active). Since we are considering the counterfactual of shutting down GATT/WTO (an increase in trade costs), it tends to turn trade status from being active to inactive, rather than vice versa. Overall, most of the observed trade status would remain unchanged (in the range of 86.26%–93.31% across years). For those relationships where trade status would change (6.69%–13.74%), the majority of them would change from being active to inactive (6.69%–13.73%), while only a very small fraction of trading relationships would change from being inactive to active (0%–0.04%).

Figure 3 plots the distribution of trade flow changes in percentage terms for the trading relationships that remain active when shutting down the GATT/WTO. Overall, the impacts on trade flows by shutting down the GATT/WTO are quite substantial and negative for a large majority of trading relationships, driven by *bothwto* and *exwto* trading relationships. The reverse pattern of changes in trade flows for *imwto* trading relationships is related to the discussions above: members increase their variable import barriers (but decrease their fixed import barriers) against nonmembers, as implied by the estimates in Table 6. The results in Figure 3 suggest that the former effect on inward trade flows tends to dominate the latter, such that members reduce their imports from nonmembers. Thus, trade flows for *imwto* trading relationships tend to be larger in the counterfactual without GATT/WTO.

Figures 4 and 5 further illustrate the distribution of changes in extensive margin V_{ijt} and intensive margin X_{ijt}/V_{ijt}, respectively (including only observations where the trade status remains active). We note that in the counterfactual without GATT/WTO, the extensive margin V_{ijt} tends to decrease across all trading relationships involving a member, including *imwto*. Recall from Table 6 that all three GATT/WTO indicators (*bothwto*, *imwto*, *exwto*) lower the fixed trade barriers, which promotes trade via the extensive margin. Lower variable trade barriers for the *bothwto* and *exwto* trading relationships further enhance the extensive margin. Higher variable trade barriers for the *imwto* trading relationships, in contrast, diminish the extensive margin. The results here suggest that the fixed trade cost channel dominates, such that the extensive margin overall increases for the *imwto* trading relationships as well (as the *bothwto* and *exwto* trading relationships) in the presence of GATT/WTO.

Combining the patterns in trade flows and extensive margins, we can infer that for *imwto* relationships, the intensive margin would tend to increase in the counterfactual without

GATT/WTO, since trade flows tend to increase and the extensive margin tends to decrease for such trading relationships without the presence of GATT/WTO. This is indeed suggested by Figure 5. For *bothwto* and *exwto* trading relationships, trade flows and extensive margins tend to move in the same direction, as suggested by Figure 3 and Figure 4. Thus the effects on the intensive margin (the ratio of the trade flows and extensive margins) would tend to be more muted (closer to zero). For the majority of observations, however, the intensive margin X_{ijt}/V_{ijt} still tends to decrease in the counterfactual without GATT/WTO.

4.1.3 Decomposition of the Effects due to Fixed and Variable Trade Costs

Last but not least, we decompose the GATT/WTO effects due to changes in the variable trade cost and the fixed trade cost, respectively. Panels B and C of Table 7 and Table 10 summarize the effects on welfare, trade flows, extensive margin and intensive margin if we reverse the GATT/WTO-induced changes in all, variable, and fixed trade costs in 1995 and 2010, respectively. We find that the GATT/WTO implies larger welfare effects via the fixed trade cost change than via the variable trade cost change for members. For nonmembers, the effects due to the variable trade cost tend to dominate, which is in line with the discussions above that trade diversion due to negative *imwto* effects on $\tau_{ijt}^{1-\sigma}$ tends to outweigh potential trade creation due to other channels, including the effects of *imwto* and *exwto* on the fixed trade cost. Overall, when pooling across all economies, the fixed trade cost channel dominates. Table 10 indicates that the corresponding changes in the trade flow and extensive margin are also more pronounced via the fixed trade cost channel.

For the intensive margin, the ranking between fixed and variable trade costs is reversed. To understand this, note that an increase in the variable trade cost leads to a reduction in intensive margin via its direct effect on $\tau_{ijt}^{1-\sigma}$. Meanwhile, the lower revenues and profits induce exit from the destination market (of marginally less productive firms), which in turn has a positive effect on the intensive margin measure. The overall effect of the variable trade cost on the intensive margin depends on the firm productivity distribution, as suggested by Lawless (2010), Dutt, Mihov and Van Zandt (2013), and Coughlin and Bandyopadhyay (2020). On the other hand, an increase in the fixed trade cost has a direct positive effect on the intensive margin of exports, because the surviving exporters after the shock are more productive on average. However, the general equilibrium effects via income reduction may moderate downward the positive effects on the intensive margin. The results in Table 10 suggest that shutting down the GATT/WTO via the variable trade cost has a negative impact on the intensive margin X_{ijt}/V_{ijt}, implying that the direct effect of the variable trade cost (together with the income effect) dominates the indirect entry effect of the variable trade cost. The effects of shutting down the GATT/WTO on the intensive margin via the fixed

trade cost range from being negative to positive in Table 10, but overall more frequently positive compared with the impacts via the variable trade cost on the intensive margin, consistent with the theory.

In Table A.4, we report the summary statistics of the GATT/WTO effects on these variables of interest for the full sample (including trading relationships that remain active as reported above and also trading relationships that change status from active to inactive). The statistics on welfare would not change, since it is calculated at the country level. The statistics on the intensive margin do not change either since only those that remain active have observations on the intensive margin in the counterfactual. As expected, the negative effects on trade flows and extensive margins are more pronounced when taking into account trading relationships that turn inactive when shutting down the GATT/WTO system, and the difference is driven mostly by the fixed trade cost.

4.2 All Countries Became GATT/WTO Members

We also consider the counterfactual if all countries became GATT/WTO members. In this counterfactual, $bothwto_{ijt}$ takes the value 1 for all trading relationships, while all the other GATT/WTO indicators ($imwto_{ijt}$, $exwto_{ijt}$, and the excluded category $nonewto_{ijt}$ indicating whether both trading partners are nonmembers) take the value 0. By the estimates of Table 6, this implies further trade liberalization by existing members with respect to imports from previous nonmembers, and by previous nonmembers with respect to all sources of imports, where the extent of further trade liberalization differs across the types of trade costs and the previous membership status of trading partners. Note, however, that for trading relationships where both economies are already members, the trade barriers do not change relative to the status quo.

The effects on the variables of interest are evaluated relative to the status quo. The changes in welfare, trade flows, extensive margins, and intensive margins for 1995 and 2010, respectively, are reported in Table 11. In this counterfactual exercise, by turning remaining nonmembers into members, we find that the nonmembers would benefit significantly, with a gain of 4.05% at the median and 7.26% at the 75th percentile in 1995. The majority of existing members would also benefit from the accession by nonmembers, but the gains are of a smaller order of magnitude (0.07% at the median and 0.16% at the 75th percentile). The pattern of welfare effects is similar in 2010.

Table 11 further indicates that a large majority of trading relationships would experience an increase in trade flows if remaining members were to join the system, and the trade creation would be predominantly driven by the intensive margin (rather than the extensive

margin). Given the conflicting effects of fixed and variable trade costs on the intensive margin, as discussed in Section 4.1, the findings in this section suggest that the reductions in the variable trade cost in this counterfactual tend to dominate those in the fixed trade cost, such that the intensive margin of trade increases. Table 6 indicates that $\ln \tau_{ijt}^{1-\sigma}$ would change from -0.794 to 0.294 for trading relationships that turn from *imwto* to *bothwto*, while the corresponding change in $-\ln f_{ijt}$ would be much smaller (from 1.103 to 1.531). On the other hand, the parallel changes in variable and fixed trade costs from *exwto* to *bothwto* are actually in favor of the fixed trade cost channel by the estimates in Table 6, but not much more (0.0779 to 0.294 for $\ln \tau_{ijt}^{1-\sigma}$ versus 1.1711 to 1.531 for $-\ln f_{ijt}$). Third, the reductions in the fixed trade cost would be substantial relative to the variable trade cost, for trading relationships that change from *nonewto* to *bothwto*. Given the above patterns, the overall dominance of the intensive margin in this counterfactual suggests the trading relationships that switch from *imwto* to *bothwto* outnumber those that switch from *nonewto* to *bothwto*. This is indeed the case, since the set of remaining nonmembers is much smaller than that of members.

In sum, whereas the *realized* welfare and trade effects of the GATT/WTO have been facilitated mainly via the fixed trade cost channel, as shown in Section 4.1, the analysis here suggests that if remaining nonmembers were to join the system, the GATT/WTO would promote further trade (and welfare gains) predominantly via the intensive margin (given the large number of trading relationships that would turn from *imwto* to *bothwto*, and the dominance of reductions in the variable trade cost for such trading relationships).

In Table 11, we include only trading relationships that are active in the status quo in reporting the percentage changes in trade flows and margins of trade, because the hat algebra is not defined otherwise. In Figure 6, we complement the analysis of Table 11 by reporting the frequencies of changes in trade status. In this counterfactual, reductions in trade barriers help start new trading relationships. This corresponds to typically 3.01% of all bilateral relationships across years, and a max of 5.35% in 1999. In contrast, the scenario where the trade status changes from active to inactive is rare (0.00% to 0.17% across years). The pattern in Figure 6 is, as expected, the reverse of Figure 2, regarding the switch of trade status, since the current counterfactual corresponds to further lowering of trade barriers while the counterfactual in the previous section corresponds to eliminating the existing trade liberalizations induced by the GATT/WTO.

4.3 Effects of China's Accession to the GATT/WTO

We now analyze the effect of China's accession to the GATT/WTO, a significant event in 2001 given its large economic size and growing importance in the world trading system. We set up the counterfactual such that China did not enter the GATT/WTO in 2001 and redefine the membership indicators ($bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$) involving China for $t \geq 2001$. The effects on the variables of interest are evaluated relative to the status quo.

Table 12 provides the summary statistics of the corresponding welfare effects by regions in 2002 and 2010, respectively. The results indicate that China itself is the largest beneficiary of its GATT/WTO entry, followed by the countries in East and South Asia, and to a lesser extent, the OECD countries. Over time, the positive externality of China's WTO accession on the Asian economies in the region increased (from 0.22% in 2002 to 0.24% in 2010 at the median), while the benefits to itself were moderated (from 1.78% in 2001 to 1.34% in 2010). Overall, however, most of the other economies in the world would have been better off in 2002 if China had not joined the WTO, although such negative externalities of China's WTO accession have tended to moderate downward in recent years. In 2010, the majority of economies in Eastern Europe, Central Asia, Middle East and North Africa also benefited from China's membership in the WTO.

5 Effects of GATT/WTO on Firm Sales Distribution

In this section, we examine the GATT/WTO effects on firm sales distribution, by examining changes in: (i) the support of the surviving firms' productivity distribution; (ii) the macro components that scale the sales (for given firm productivity); and (iii) the mean and standard deviation of sales.

In Figure 7, we illustrate the effects of the GATT/WTO on the support of surviving firms' unit input requirement (a), i.e., the inverse measure of firm productivity. The figure uses five bilateral trading relationships in 2010 as examples, but the patterns discussed below are similarly observed in other trading relationships. In each sub-figure, the support of the distribution is shown for the factual scenario with GATT/WTO, and for the three counterfactual scenarios by shutting down the effects of GATT/WTO on the variable trade cost, on the fixed trade cost, and on both. We note that by shutting down the GATT/WTO effects, the cutoff unit input requirement a_{ijt} decreases, implying a tougher selection into exports on firms' productivity levels. Furthermore, the drop in the cutoff driven by the fixed trade cost mechanism is much more significant than due to the variable trade cost mechanism. The difference is in particular more pronounced for exports to the USA (e.g.,

Australia to USA) than American exports to its trading partners (e.g., USA to Australia). This suggests that for foreign firms exporting to the USA, the fixed trade cost represents the primary source of entry barrier, while the variable trade cost in comparison affects the export cutoff to a much smaller extent. The pattern in Figure 7 suggests that GATT/WTO has enabled more firms to enter export markets and largely done so via reductions in fixed trade costs.

Next, given the support of surviving firms' unit input requirement (a), we examine the effects of GATT/WTO on the macro components that translate the underlying productivity distribution to the firm sales distribution. Recall that for firms with a productivity level $1/a$ in country i, their sales to country j in year t are given by:

$$sales_{ijt}(a) = \left(\frac{c_{it}\tau_{ijt}a}{P_{jt}}\right)^{1-\sigma} N_{it}E_{jt}, \qquad \text{for } a \leq a_{ijt}. \tag{49}$$

We calculate the counterfactual change in the composite, $\left(\frac{\widehat{c}_{it}\widehat{\tau}_{ijt}}{\widehat{P}_{jt}}\right)^{1-\sigma} \widehat{N}_{it}\widehat{E}_{jt}$, which scales the sales for given firm productivity, and further decompose it in terms of each of its components. In a sense, this illustrates the effect on sales at the intensive margin given firm productivity levels. Tables 13 and 14 report the summary statistics of changes in these components for trading relationships that remain active both in the factual and in the counterfactual. In Table 13, we note that by reversing the changes in variable trade costs due to GATT/WTO, for the majority of the observations the general equilibrium expenditure (E_{jt}) and firm entry (N_{it}) would decrease. In contrast, input costs (c_{it}, which reflects weighted average of wages and general price index) and variable trade costs (τ_{ijt}) would increase. The higher variable trade costs would also tend to raise the general price index (P_{jt}), but the latter's increase tends to be dominated by the increase in input costs and variable trade costs, such that overall the composite $\left(\frac{c_{it}\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} N_{it}E_{jt}$ (which scales the sales) tends to decrease. This has a proportionally larger dampening effect on the sales of initially larger firms. Hence, the firm sales distribution (specific to each bilateral trading relationship) tends to become flattened without the GATT/WTO effect on the variable trade cost.

In Table 14, we note that the reverse is true when we shut down the GATT/WTO effects on the fixed trade cost. The majority of bilateral trade would experience an increase in $\left(\frac{c_{it}\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} N_{it}E_{jt}$. In this case, the general price index (P_{jt}) would increase and proportionally more so than the increase in input costs (c_{it}) such that the resulting increase in $\left(\frac{c_{it}\tau_{ijt}}{P_{jt}}\right)^{1-\sigma}$ more than offsets the decrease in the expenditure (E_{jt}) and firm entry (N_{it}). This implies that with more stringent selection into exports (due to fixed trade costs) in the scenario without GATT/WTO, the surviving firms' export sales distribution would become

more skewed, as initially bigger firms benefit more from the general equilibrium increases in the composite variable. In summary, the above analysis indicates that GATT/WTO tends to increase firm export sales dispersion via reductions in the variable trade cost, while flattening the firm export sales dispersion via reductions in the fixed trade cost, for the majority of bilateral trade flows.

In the third set of analyses, we take into account both the changes in the support of productivity distribution and the changes in the shifter that scales the sales distribution, and calculate changes in the mean and standard deviation of the sales distributions if the GATT/WTO effects on variable and/or fixed trade costs are reversed. Let μ represent the mean and *std* the standard deviation. The changes (in ratios) in the mean and standard deviation are given by:

$$\frac{\mu(sales'_{ijt})}{\mu(sales_{ijt})} \equiv \frac{\int_{a_{L_i}}^{a'_{ijt}} \left(\frac{c'_{it}\tau'_{ijt}a}{P'_{jt}}\right)^{1-\sigma} N'_{it}E'_{jt}\widetilde{G}'_{ijt}(a)da}{\int_{a_{L_i}}^{a_{ijt}} \left(\frac{c_{it}\tau_{ijt}a}{P_{jt}}\right)^{1-\sigma} N_{it}E_{jt}\widetilde{G}_{ijt}(a)da}, \tag{50}$$

$$\frac{std(sales'_{ijt})}{std(sales_{ijt})} \equiv \sqrt{\frac{\int_{a_{L_i}}^{a'_{ijt}} \left[\left(\frac{c'_{it}\tau'_{ijt}a}{P'_{jt}}\right)^{1-\sigma} N'_{it}E'_{jt} - \mu(sales'_{ijt})\right]^2 \widetilde{G}'_{ijt}(a)da}{\int_{a_{L_i}}^{a_{ijt}} \left[\left(\frac{c_{it}\tau_{ijt}a}{P_{jt}}\right)^{1-\sigma} N_{it}E_{jt} - \mu(sales_{ijt})\right]^2 \widetilde{G}_{ijt}(a)da}}, \tag{51}$$

where $\widetilde{G}_{ijt}(a) \equiv \frac{a^k - a^k_{L_i}}{a^k_{ijt} - a^k_{L_i}}$ and $\widetilde{G}'_{ijt}(a) \equiv \frac{a^k - a^k_{L_i}}{a'^k_{ijt} - a^k_{L_i}}$ are the factual and counterfactual distributions of (inverse) firm productivity. Figures 8–13 plot the histograms for (50)–(51) across trading relationships (ijt) in scenarios where the GATT/WTO effects on variable/fixed/all trade costs are reversed respectively.

Figures 8 and 9 indicate that without the GATT/WTO effects on the variable trade cost, most bilateral trade flows would see a decrease in both the mean and standard deviation. This is especially the case for trading relationships where both exporting and importing countries are members. This reinforces the finding above on changes in the sales shifter, and suggests that without the GATT/WTO effects on the variable trade cost, the distribution of firm sales would be flatter for most trading relationships (and especially so for those in which both parties are members). Figures 10 and 11 indicate that the opposite is the case when the GATT/WTO effects on the fixed trade cost are reversed. The mean and standard deviation tend to increase for most bilateral trade flows. This is again aligned with the findings above on changes in the sales shifter, where the distributions of firm sales tend to become more skewed in the scenario without the GATT/WTO effects on the fixed trade cost. Lastly, when both effects on variable and fixed trade costs are combined, Figures 12 and 13 show that the

fixed trade cost mechanism dominates, such that both mean and standard deviation tend to increase for most of the bilateral trade flows in the counterfactual without GATT/WTO. The analyses and findings in this section suggest that the GATT/WTO-induced changes in trade costs overall tend to flatten export sales distributions of existing firms, allow export entry by smaller firms, and as a result reduce the disparity of firm export sales.

6 Conclusion

In this paper, we develop an estimation procedure to identify the changes in variable and fixed trade costs in bilateral trading relationships due to GATT/WTO membership for the period 1991–2017. Specifically, the information on trade incidence, trade volume, firm sales distribution parameters and multilateral resistance are used to isolate these two trade cost factors.

The estimation results show that GATT/WTO membership has reduced the fixed trade cost much more than the variable trade cost. In particular, the benchmark estimates suggest that the fixed trade cost is lower by 78.37% for trading relationships where both economies are members (*bothwto*), lower by 66.81% if only the importing country is a member (*imwto*), and lower by 69.00% if only the exporting country is a member (*exwto*). In comparison, the effect of *bothwto* and *exwto* on the variable trade cost is one order of magnitude smaller (by 7.09% and 1.93%, respectively). In fact, the variable trade cost for the *imwto* trading relationships tends to increase by 21.96%.

In other words, the impacts on each type of trade cost are the largest if both trading partners are members (relative to the scenarios where only the importing or the exporting country is a member). GATT/WTO members tend to extend their reductions in fixed import barriers (but not in variable import barriers) to nonmember sources of imports. In contrast, members tend to lower their export barriers (fixed or variable) with respect to both member and nonmember destinations of exports. Thus, nonmembers tend to free ride on members' liberalizations that reduce fixed trade costs (in both members' outward and inward trade flows), and also to a very small degree in variable trade costs with respect to members' outward exports, but face higher variable barriers in accessing the members' markets.

We then conduct counterfactual analyses to study the effects of GATT/WTO memberships on national welfare, bilateral trade status, trade flows, extensive margins and intensive margins, given the estimated trade cost shocks associated with membership status. We find that the GATT/WTO has larger impacts on members' welfare via the fixed trade cost channel than via the variable trade cost channel, given the dominance and prevalence of reductions in the fixed trade cost (over the variable trade cost) in members' inward and

outward trade flows. For the nonmembers, however, the welfare effects tend to be dominated by the variable trade cost channel, suggesting that the negative impacts of the higher variable trade barriers nonmembers face in accessing the members' markets tend to outweigh any potential positive welfare effects of lower fixed trade barriers that nonmembers face in their trade with members. Overall, when pooling across all economies, the fixed trade cost channel dominates.

As discussed in the introduction, the fact that trade flow is truncated at zero has prevented most work of the previous literature from studying the change in bilateral trade status in the counterfactual analysis. This paper proposes a structural framework to simulate counterfactual trade incidence and volume for both active and inactive trading relationships, taking into account general equilibrium adjustments of firm-level and aggregate variables, thus filling a gap in the literature. Our analysis suggests that in the counterfactual without GATT/WTO (an increase in trade costs), a sizable fraction of bilateral trading relationships would change from being active to inactive (6.69%–13.73% across years). On the other hand, if all remaining nonmembers were to join the GATT/WTO relative to the status quo, this would help further generate new trading relationships, amounting to 3.01% of all potential trading relationships across years, and a max of 5.35% in year 1999.

We subsequently analyze the distribution of changes in extensive margins (V_{ijt}) and intensive margins (X_{ijt}/V_{ijt}) across trading relationships in the counterfactual without GATT/WTO. For observations where the trade status remains active, the extensive margin V_{ijt} tends to decrease across all trading relationships involving a member, including *imwto*. Recall that all three GATT/WTO indicators (*bothwto*, *imwto*, and *exwto*) lower the fixed trade cost, which promotes trade flows via the extensive margin. Lower variable trade costs for the *bothwto* and *exwto* trading relationships further enhance the extensive margin. Higher variable trade costs for the *imwto* trading relationships, in contrast, diminish the extensive margin. The results here suggest that the fixed trade cost channel dominates the variable trade cost channel such that the extensive margin overall increases in the presence of GATT/WTO for the *imwto* trading relationships as well as the *bothwto* and *exwto* trading relationships. As expected, if we also include trading relationships that change status from being active to inactive (in addition to those that remain active), the negative effects of shutting down the GATT/WTO system on trade flows and extensive margins would be more pronounced, with the difference being driven mostly by the fixed trade cost.

Given that variable trade costs increase while fixed trade costs decrease for *imwto* relationships, the intensive margin tends to decrease for such trading relationships in the presence of GATT/WTO. In contrast, for *bothwto* and *exwto* trading relationships, both variable and fixed trade costs decrease. While the latter may exert countervailing effects on the intensive

margin via general equilibrium adjustment in the aggregate variables, the former plays a pivotal role in driving the intensive margin. Thus, the intensive margin tends to increase for such trading relationships in the presence of GATT/WTO. Overall, for the majority of the observations (dominated by *bothwto* and *exwto* trading relationships), the intensive margin X_{ijt}/V_{ijt} tends to increase with GATT/WTO.

Last but not least, we examine the GATT/WTO effects on firm sales distribution, by investigating changes in: (i) the support of the surviving firms' productivity distribution; (ii) the macro components that scale the sales (for given firm productivity); and (iii) the mean and standard deviation of sales. We find that the fixed trade cost mechanism dominates, such that GATT/WTO-induced changes in trade costs overall tend to flatten export sales distributions of existing firms, allow export entry by smaller firms, and as a result reduce the disparity of firm export sales.

While this paper focuses on the impacts of GATT/WTO, the estimation strategies proposed can be used to identify/isolate the effects of alternative policies on the variable/fixed trade costs. The procedure can be further simplified when the multicollinearity issue is not present in the context studied. The general equilibrium framework proposed (which explicitly models changes in the trade status) can also be applied to evaluate the effects of alternative policy shocks. Although not explicitly reported/discussed, changes in the aggregate and firm-level variables, such as the mass of entry, domestic cutoff, export cutoff, count of products exported per trading relationship, and multilateral resistance to export and import, are also simulated in the counterfactual analysis and could be of interest in alternative contexts. The analytical framework can be extended in several ways to further enhance understanding of the GATT/WTO system, for example: (1) by incorporating input-output linkages across sectors and conducting the analysis at the exporter-importer-sector-year level; (2) by extending the current framework to a dynamic general equilibrium analysis using the dynamic hat algebra (Caliendo, Dvorkin and Parro, 2019); and (3) by studying the GATT/WTO effects on trade in services in recent decades. We leave these potential extensions for future research.

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A Math Appendix

Proof of Equations (43)–(44). The free entry condition in (14) can be rewritten as follows, by using the other conditions in the system:

$$\begin{aligned}
\frac{1}{\sigma}Y_i - \sum_j N_{ij}c_i f_{ij} &= N_i c_i F_i \\
\Rightarrow \frac{1}{\sigma}Y_i - \frac{1}{\sigma}\sum_j N_{ij}\left(\frac{\sigma}{\sigma-1}\frac{\tau_{ij}c_i a_{ij}}{P_j}\right)^{1-\sigma} E_j &= N_i c_i F_i \quad \text{by (6)} \\
\Rightarrow \frac{1}{\sigma}Y_i - \frac{1}{\sigma}\sum_j G_i(a_{ij})N_i\left(\frac{\sigma}{\sigma-1}\frac{\tau_{ij}c_i a_{ij}}{P_j}\right)^{1-\sigma} E_j &= N_i c_i F_i \\
\Rightarrow \frac{1}{\sigma}Y_i - \frac{1}{\sigma}\sum_{j:z^*_{ij}>0} G_i(a_{ij})(a_{ij})^{1-\sigma}X_{ij}/V_{ij} &= N_i c_i F_i \quad \text{by (8)} \\
\Rightarrow \frac{1}{\sigma}Y_i - \frac{1}{\sigma}\sum_{j:z^*_{ij}>0} X_{ij}/\nu_{ij} &= N_i c_i F_i
\end{aligned}$$

where ν_{ij} is as defined in (44) by the definition of G_i in (4) and of the extensive margin V_{ij} in (7). For the counterfactual, the above relation also holds. The expression for (43) therefore follows by the definition of the hat algebra. □

B Counterfactual/Calibration Appendix

B.1 Computation of a'_{ijt} and a_{ijt}, and Calibration of a_{H_i} and a_{L_i}

The (inverse) productivity cutoff a_{ijt} can be inferred by (19), given the definition of the latent variable Z_{ijt} and the estimates of $Z_{ijt} = \exp(s_\eta z^*_{ijt})$. Similarly, we can obtain a'_{ijt} given the counterfactual value of Z'_{ijt}.

We estimate the parameters a_{L_i} and a_{H_i} for the support of the (inverse) productivity distributions using ORBIS firm-level data for the period 2008–2018 (dictated by data availability to us). In view of the fact that the quality of the firm-level data is the best for European countries in the ORBIS dataset (Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych and Yesiltas, 2015), we estimate the firm productivity based on the firm-level data of 15 European countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Sweden. The production functions are estimated by sector (defined at the NACE sector level), using the method of Wooldridge (2009).

Given the productivity estimates of all firms across all sectors, we define $TFP^{99\%}_{it}$ as the

99th-percentile firm productivity level of all firms in each country and year. We regress this variable $TFP_{it}^{99\%}$ on GDP per capita for the panel of 15 European countries, and extrapolate/predict this variable for all the 185 economies in our sample for the period 2008–2018. We then take the average across years to measure the upper bound of the productivity support of a country ($1/a_{L_i}$). The lower bound of the productivity support of a country ($1/a_{H_i}$) is constructed in the same way but based on the 1st-percentile productivity estimates. We use the 99th and 1st percentiles instead of the maximum and minimum productivity estimates literally, to minimize the influence of outliers and measurement errors. The estimates of a_{L_i} and a_{H_i} are reported in Table A.3.

B.2 Calibration of N_{it}, and Computation of N'_{ijt} for Inactive Trading Relationship

The mass of entrants N_{it} is required in the estimation of the GATT/WTO effects on the total trade cost in (32). In this appendix, we explain how we estimate N_{it}, and subsequently use it to impute N'_{ijt} for $z^*_{ijt} \leq 0$.

Given the values of a_{L_i}, a_{H_i}, a_{ijt}, and k (e.g., $k = 5.6$ if $\frac{k}{\sigma-1} = 1.4$ and $\sigma = 5$), we estimate N_{it} based on (15). The proposed method is to divide N_{ijt} by $\frac{a_{L_i}^k}{a_{H_i}^k - a_{L_i}^k}\left[\left(\frac{a_{ijt}}{a_{L_i}}\right)^k - 1\right]$, and then to take the average of the results within each it to obtain an estimate of N_{it}.

To impute N'_{ijt} for $z^*_{ijt} \leq 0$, we first obtain $N'_{it} = N_{it}\widehat{N}_{it}$ given $\widehat{N}_{it}$ from the counterfactual analysis. Using the relationship between N'_{ijt} and N'_{it} by (15) again, and a'_{ijt} from the counterfactual analysis as explained in Section B.1, we impute the value of N'_{ijt} for $z^*_{ijt} \leq 0$. The summary statistics of N'_{ijt} for $z^*_{ijt} \leq 0$ are reported in Table A.5 for the counterfactual without GATT/WTO. Note that without GATT/WTO, trade barriers would increase in general. Thus, if the factual trade flows are already zero ($z^*_{ijt} \leq 0$), the counterfactual N'_{ijt} without GATT/WTO rarely turns positive (except when the general equilibrium effects dominate in favor of trade creation). This explains the negligible magnitudes of N'_{ijt} reported in the table.

C Data Appendix

The country-level data used in this paper comprise three main components: trade flows, GDP, and trade-cost proxy variables. These data are compiled for the period 1991–2017. In addition, we use global firm-level data for the period 2008–2018 to estimate the productivity distribution parameters as documented in Section B.1.

C.1 Bilateral Trade Flow

Bilateral merchandise trade flows are retrieved from the UN Comtrade Database at the HS 6-digit level. We measure N_{ijt} by the number of HS 6-digit products exported by country i to country j in year t. The trade flow X_{ijt} is measured by the sum of the CIF import values of all HS 6-digit products exported by country i to country j in year t.

C.2 GDP, Value-added Share, and Gross Output

We use the GDP data from the CEPII's Gravity dataset,[45] and supplement the missing entries with the GDP data from the World Bank's World Development Indicators (WDI).[6] We construct the gross output Y_i by taking the ratio of GDP and the value-added share α_{it} in gross output: $Y_{it} = GDP_{it}/\alpha_{it}$.

The data on value-added share α_{it} are compiled from several sources. The first option is "STAN STructural ANalysis Database,"[7] which covers 37 countries for 1970–2017. We take the ratio of "*Value added, current prices*" and "*Production (gross output), current prices*" for "*Industry: Total*."[8] The second option is the WIOD Socio-Economic Accounts.[9] It has had three releases at the start of the current project: November 2016 release (with data for 2000–2014), July 2014 release (with data for 1995–2011), and February 2012 release (with data for 1995–2009). We take the figures from the latest available release for a given country and year. The third option is the input-output tables (IOTs) from the OECD Input-Output database.[10] There have been four editions of these tables released: 2018 edition (ISIC Rev.4), 2015 edition (ISIC Rev.3), 2002 edition (ISIC Rev.3), and 1995 edition (ISIC Rev.2). Again, we take the figures from the latest available edition for a given country and year. For example, given the 2018 edition IOTs, we aggregate the entries of "*Value added at basic prices*" and "*Output at basic prices*", respectively, across sectors; and compute the ratio of the two. Despite all these alternatives, some countries may have no data in some years. In that case, we fill in the missing entries as follows: (1) $\alpha_{it} = \alpha_{i,T_i^e}$ for all $t > T_i^e$, where T_i^e is the latest year with data on value-added share for country i; (2) $\alpha_{it} = \alpha_{i,T_i^s}$ for all $t < T_i^s$, where T_i^s is the earliest year with data on value-added share for country i; (3) $\alpha_{it} = (\alpha_{i,t_i^1} + \alpha_{i,t_i^2})/2$ for $t_i^1 < t < t_i^2$, where t_i^1 and t_i^2 are the two years nearest to t and with data available. For countries without any information, we use the value-added shares of the rest of the world

[4] `http://www.cepii.fr/CEPII/en/bdd\_modele/presentation.asp?id=8`.
[5] `http://sites.google.com/site/hiegravity/data-sources`.
[6] `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators`.
[7] `https://www.oecd.org/industry/ind/stanstructuralanalysisdatabase.htm`.
[8] `https://stats.oecd.org/Index.aspx?DataSetCode=STANI4_2016`.
[9] `http://www.wiod.org/database/seas16`.
[10] `https://www.oecd.org/sti/ind/input-outputtables.htm`.

(ROW), available in the 2015 edition IOTs.

We use the population data from the CEPII's Gravity dataset, and supplement the missing entries with the population data from the WDI and the International Monetary Fund's International Financial Statistics (IFS).[11] The data on GDP per capita are also obtained from the CEPII's Gravity dataset. When it is missing in CEPII, we replace the missing entry by the ratio of GDP and population as compiled above.

C.3 Expenditure

Based on bilateral trade flow, we construct the trade deficit of a country by: $\bar{D}_{jt} = \sum_i X_{ijt} - \sum_i X_{jit}$. However, the world trade deficit $\bar{D}_{wt}$ does not always add to zero, due to data measurement errors and also due to omitted countries from the sample. We allocate the discrepancy $\bar{D}_{wt}$ to each country in proportion to its output share of the world, i.e., $D_{jt} = \bar{D}_{jt} - \frac{Y_{jt}}{Y_{wt}}\bar{D}_{wt}$. The gross expenditure of a country is then constructed as $E_{jt} = Y_{jt} + D_{jt}$.

C.4 Proxies for Asymmetric Bilateral Trade Cost

The trade cost variables are taken from CEPII's Gravity dataset and GeoDist dataset, except as otherwise noted below.[12] 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 $bothwto_{ijt}$, $imwto_{ijt}$ and $exwto_{ijt}$ are constructed from the CEPII variables *gatt_o* and *gatt_d* (which equals one if the exporting country is a GATT/WTO member, and respectively if the importing country is a GATT/WTO member).[13]

The other variables used include population-weighted bilateral distance ($wdist_{ij}$); two common language indicators, where the first indicator equals one if a language is the official or primary language in both countries ($comlang_{ij}$), and the second indicator equals one if a language is spoken by at least 9% of the population in both countries ($comlang2_{ij}$); a common border indicator, which equals one if two countries are contiguous ($contig_{ij}$); a common colonizer indicator, which equals one if two countries have had a common colonizer after 1945 ($comcol_{ij}$); the 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

[11] `http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B`.

[12] `http://www.cepii.fr/CEPII/en/bdd\_modele/presentation.asp?id=6`.

[13] We also make some corrections of GATT/WTO membership in CEPII's dataset with the information from the WTO's website whenever we find strong evidence. For example, Madagascar has been a member of GATT since 1963 and a member of WTO since 1995, as indicated at the WTO's website, whereas it is always listed as a nonmember in CEPII's gravity dataset.

years in the twentieth century, 75 years in the nineteenth century, or 100 years before the nineteenth century; $smctry_{ij}$); a regional trade agreement indicator, which equals one if a regional trade agreement is in force between two countries (rta_{ijt}); a common currency indicator, which equals one if two countries use a common currency ($comcur_{ijt}$); an indicator of whether exporter i has ever been a colonizer of importer j (heg_o_{ij}) and an indicator of whether importer j has ever been a colonizer of exporter i (heg_d_{ij}).

Because the identity of a colonizer versus a colony never switched in the period of our study, we constructed 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 heg_o_{ij}: $curheg\_o_{ijt} = 1$ if $curcol_{ijt} = 1$ and $heg\_o_{ij} = 1$. The indicator for whether importer j is currently a colonizer of exporter i is constructed in a similar way: $curheg\_d_{ijt} = 1$ if $curcol_{ijt} = 1$ and $heg\_d_{ij} = 1$.

We supplement the legal origin data from CEPII with the information from La Porta, de Silanes, Shleifer and Vishny (1999), La Porta, de Silanes and Shleifer (2008), and CIA's *World Factbook* website,[14] 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 ($land_{ij}$, $island_{ij}$) is obtained from Andrew Rose,[15] supplemented with information from the CIA *World Factbook* website. The data on the common currency indicator ($comcur_{ijt}$) are from de Sousa,[16] and supplemented with CEPII's Gravity dataset.

The data on the regional trade agreement indicator (rta_{ijt}) are from the Database on Economic Integration Agreements (April 2017) constructed by Scott Baier and Jeffrey Bergstrand.[17] We supplement the missing rta_{ijt} data with the information from WTO Regional Trade Agreements Database.[18]

The data on whether importer j offers GSP preferential treatment to exporter i (GSP_{ijt}) are from the Database on Economic Integration Agreements (April 2017) constructed by Scott Baier and Jeffrey Bergstrand.[19] To supplement the missing GSP_{ijt} entries, we first use the information from the WTO's Database on Preferential Trade Agreements.[20] If the information on GSP_{ijt} is still missing, we compile the data manually from the "Generalized

[14] `http://www.cia.gov/library/publications/the-world-factbook`.
[15] `http://faculty.haas.berkeley.edu/arose/RecRes.htm`.
[16] `http://jdesousa.univ.free.fr/data.htm`.
[17] `https://www3.nd.edu/~jbergstr/`. Ornelas and Ritel (2020) provide a detailed introduction to this database.
[18] `https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx`.
[19] `https://www3.nd.edu/~jbergstr/`.
[20] `http://ptadb.wto.org/`.

System of Preferences: List of Beneficiary Countries" reported by the UNCTAD.[21] The UNCTAD updates the information on the GSP schemes from time to time, but not annually. The information on the GSP schemes is only available for years 2001, 2005, 2006, 2008, 2009, 2011, and 2015. We fill in remaining missing entries with those from the nearest previous year.

C.5 Classification of Countries by Income Levels

Countries are classified as high-income, upper-middle-income, lower-middle-income and low-income by the World Bank.[22] This information is available from 1987 onwards. We group the upper-middle-income and lower-middle-income countries together as middle-income countries.

C.6 Pseudo World

We trim the data as follows to arrive at a sample we call the pseudo world for the analysis. 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 in each year. 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 when their implied internal trade is negative: $X_{iit} \equiv Y_{it} - \sum_{j \neq i} X_{ijt} < 0$. 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 the resulting set of countries the pseudo world, and calculate the supply and expenditure shares of each country relative to the pseudo world.

The numbers of countries in the raw data and in the pseudo world are reported in Table 1. The number of countries included in the pseudo world increased from 38 in 1991 to 163 in 2007, and 107 in 2017. The set of countries in the pseudo world (determined based on the iteration procedure explained above) does not differ significantly from that in the raw data, except for years 2001, 2002, 2010, and 2011. 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, when the membership size was small, about 92.39% of the world import flows were covered under

[21] http://unctad.org/en/Pages/DITC/GSP/GSP-List-of-Beneficiary-Countries.aspx.

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

the GATT/WTO treaties, with another 5.42% imported by members from nonmembers. With the membership size continuing to grow, the import flows among members increased to 99.61% by 2017, while those by members from nonmembers fell to 0.19% in 2017.

C.7 ORBIS Data

We downloaded from ORBIS the firm-level variables on operating revenues, total assets, number of employees, material costs, cost of goods sold, cost of employees, NACE sector name, and BvD sector name for the period 2008–2018.[23] When data on material costs are missing, we replace the missing entries by the difference between the cost of goods sold and the cost of employees. Data were downloaded in US dollars and deflated into 2008 PPP dollars as documented next.

C.8 Deflator for Firm-level Variables

Let $E_{c,t}$ indicate the exchange rate of country c in year t (in terms of local currency/USD), and let $deflator_{c,t} \equiv P_{c,t}/P_{c,2008}$ denote country c's local deflator relative to year 2008. The current values of firm-level revenues and other input expenditures (in USD) are converted to 2008 PPP dollars by $deflator\_2008\_ppp_{c,t} \equiv deflator_{c,t}/(E_{c,t}/E_{c,2008})$. The local GDP deflators $\frac{P_{c,t}}{P_{c,2008}}$ are retrieved from the World Bank Development Indicators.[24] The exchange rate deflator $\frac{E_{c,t}}{E_{c,2008}}$ is obtained from the Penn World Table version 9.1,[25] and supplemented by World Bank Development Indicators.

D Empirical Validity of the Truncated Pareto Distribution

As highlighted in Fernandes et al. (2022), intensive margin accounts for a significant portion of variations in bilateral trade flows in the data, which cannot be reconciled with the Melitz model if one assumes a non-truncated Pareto distribution for firm productivity. The resulting model predicts that intensive margin remains constant and does not vary with bilateral trade flows. Generalizing the model in terms of fixed cost specifications might alter the prediction and introduce variations in the intensive margin, but requires yet another counter-intuitive condition that fixed trade costs be negatively correlated with distance. They show that a Melitz model with log-normal distribution generates predictions consistent with the

[23] https://www.bvdinfo.com/en-gb/our-products/data/international/orbis.
[24] https://databank.worldbank.org/reports.aspx?source=world-development-indicators.
[25] https://www.rug.nl/ggdc/productivity/pwt/.

stylized facts (positive elasticity of intensive margins; and intensive margins that decrease with distance). The same model also implies that fixed trade costs increase with distance.

In this section, we show that the Melitz model with truncated Pareto distribution (used in our analysis) can generate trade patterns that are consistent with the stylized facts noted above. In particular, we conduct regression analysis based on the model-simulated (or model-estimated) variations in intensive/extensive margins, trade flows, and variable/fixed trade costs, to verify that: (i) the elasticities of the extensive and intensive margins (with respect to trade flow) are both positive; (ii) changes in extensive and intensive margins are negatively correlated with changes in bilateral distance; and (iii) higher variable and fixed trade costs are associated with longer distances.

First, unlike the previous studies, our methodologies proposed in Section 2.2 offer direct estimates of variable and fixed trade costs. We take advantage of these estimates and regress them, respectively, on weighted bilateral distance between trading partners (controlling for exporter-year and importer-year FEs). The results in Table A.6 show that longer distance is associated with larger variable and fixed trade costs.

Next, we conduct a counterfactual analysis in which the logarithm of bilateral distance between trading partners is reduced by 0.5%, and simulate the changes in the trade margins. We regress changes in extensive and intensive margins, respectively, on changes in distance. Table A.7 indicates that both extensive and intensive margins decrease with distance.

Third, still based on the counterfactual outcome with the logarithm of bilateral distance reduced by 0.5%, we evaluate the extensive margin elasticity and intensive margin elasticity (with respected to trade flow). Table A.8 indicates that both elasticities are positive.

We also conduct another counterfactual analysis in which the logarithm of bilateral distance between trading partners is reduced by 0.1%, as a robustness check. The regression results of trade margins on distance, and trade margins on trade flows, are shown in Tables A.9 and A.10, respectively. The signs of the regression coefficient estimates remain the same as in the previous counterfactual scenario.

In sum, we demonstrate in this section that a Melitz model with truncated Pareto distribution can generate patterns of trade flows (and trade costs) consistent with those documented in Fernandes et al. (2022).

Table 1: Characteristics of countries included in the analysis

Year	(a) No. of countries in the raw data	(b) No. of countries in the pseudo world	(c) No. of obs. with positive bilateral imports	(d) No. of obs. with zero bilateral imports
1991	38	38	1,294	150
1992	52	52	2,423	281
1993	66	66	3,585	771
1994	89	89	6,021	1,900
1995	107	107	8,253	3,196
1996	115	115	9,713	3,512
1997	125	125	11,222	4,403
1998	129	129	11,974	4,667
1999	138	138	13,498	5,546
2000	151	151	16,286	6,515
2001	154	153	16,907	6,502
2002	155	154	17,140	6,576
2003	156	156	17,722	6,614
2004	159	159	17,967	7,314
2005	159	159	18,339	6,942
2006	158	158	18,614	6,350
2007	163	163	19,807	6,762
2008	159	159	19,189	6,092
2009	159	159	18,947	6,334
2010	163	162	19,971	6,273
2011	160	159	19,571	5,710
2012	158	158	19,517	5,447
2013	157	157	19,559	5,090
2014	152	152	18,587	4,517
2015	146	146	17,620	3,696
2016	143	143	17,147	3,302
2017	107	107	10,005	1,444

Note:
(a) refers to the number of countries: (i) with at least one non-missing bilateral import and one non-missing bilateral export entry in WITS, (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 C.6 to ensure that every country has positive expenditure and internal trade.
(c) refers to the number of trading relationships in the pseudo world with positive bilateral imports.
(d) refers to the number of trading relationships in the pseudo world with zero bilateral imports.

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

Year	(a) No. of countries	(b) No. of members	(c) No. of nonmembers	(d) Import share of members	(e) Import share of nonmembers	(f) Import share of *bothwto* obs.	(g) Import share of *imwto* obs.
1991	38	33	5	0.9781	0.0219	0.9239	0.0542
1992	52	43	9	0.9512	0.0488	0.8622	0.0890
1993	66	56	10	0.9478	0.0522	0.8524	0.0954
1994	89	74	15	0.9593	0.0407	0.8851	0.0742
1995	107	85	22	0.9575	0.0425	0.8831	0.0745
1996	115	90	25	0.9473	0.0527	0.8598	0.0875
1997	125	96	29	0.9475	0.0525	0.8642	0.0833
1998	129	96	33	0.9399	0.0601	0.8520	0.0880
1999	138	104	34	0.9470	0.0530	0.8576	0.0894
2000	151	120	31	0.9424	0.0576	0.8352	0.1072
2001	153	127	26	0.9710	0.0290	0.9305	0.0406
2002	154	127	27	0.9688	0.0312	0.9284	0.0405
2003	156	128	28	0.9661	0.0339	0.9218	0.0443
2004	159	130	29	0.9648	0.0352	0.9157	0.0490
2005	159	130	29	0.9689	0.0311	0.9271	0.0418
2006	158	129	29	0.9683	0.0317	0.9235	0.0449
2007	163	135	28	0.9675	0.0325	0.9284	0.0392
2008	159	133	26	0.9689	0.0311	0.9261	0.0427
2009	159	133	26	0.9700	0.0300	0.9321	0.0379
2010	162	133	29	0.9682	0.0318	0.9216	0.0466
2011	159	131	28	0.9674	0.0326	0.9195	0.0479
2012	158	135	23	0.9863	0.0137	0.9721	0.0141
2013	157	136	21	0.9869	0.0131	0.9744	0.0125
2014	152	135	17	0.9858	0.0142	0.9700	0.0159
2015	146	133	13	0.9907	0.0093	0.9848	0.0059
2016	143	132	11	0.9906	0.0094	0.9855	0.0050
2017	107	102	5	0.9980	0.0020	0.9961	0.0019

Note:
(a) refers to the number of countries in the pseudo world.
(b) refers to the number of GATT/WTO member countries in the pseudo world.
(c) refers to the number of nonmember countries in the pseudo world.
(d) refers to the total imports of GATT/WTO member countries relative to the total imports of the pseudo world.
(e) refers to the total imports of nonmember countries relative to the total imports of the pseudo world.
(f) refers to the total imports of country pairs where both are GATT/WTO members relative to the total imports of the pseudo world.
(g) 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: Definition of (asymmetric) trade cost proxies

Variables	Definition
$bothwto_{ijt}$	whether both the importing and the exporting country are GATT/WTO members
$imwto_{ijt}$	whether only the importing country is a GATT/WTO member
$exwto_{ijt}$	whether only the exporting country is a GATT/WTO member
rta_{ijt}	whether a regional trade agreement is in force between two countries
gsp_{ijt}	whether the importing country offers a Generalized System of Preference (GSP) to the exporting country
$comcur_{ijt}$	whether two countries use a common currency
$curheg\_o_{ijt}$	whether the exporting country is currently a colonizer of the importing country
$curheg\_d_{ijt}$	whether the importing country is currently a colonizer of the exporting country
$comlanguage_{ij}$	whether two countries use the same language as the official or primary language
$comlanguage2_{ij}$	whether the same language is spoken by at least 9% of the population in both countries
$comcol_{ij}$	whether two countries have had a common colonizer after 1945
$comleg_{ij}$	whether two countries have a common legal origin
$smctry_{ij}$	whether two countries were or are the same state or the same administrative entity for a long period of time
heg_o_{ij}	whether the exporting country has ever been a colonizer of the importing country
heg_d_{ij}	whether the importing country has ever been a colonizer of the exporting country
$contig_{ij}$	whether two countries are contiguous
$bothisland_{ij}$	whether both countries are island countries
$bothlandlock_{ij}$	whether both countries are landlocked
$\ln wdistance_{ij}$	logarithm of population-weighted bilateral distance (km)

Note: This table provides the definition of each of the (asymmetric) trade cost proxies we use in Equations (24) and (30). These trade cost proxies include both time-variant and time-invariant variables.

Table 4: Summary statistics of (asymmetric) trade cost proxies

Variables	No. of obs.	Mean	Std.	Min	Max	Unit of obs.
$bothwto_{ijt}$	518,322	0.6884	0.4632	0	1	i, j, t
$imwto_{ijt}$	518,322	0.1378	0.3447	0	1	i, j, t
$exwto_{ijt}$	518,322	0.1378	0.3447	0	1	i, j, t
rta_{ijt}	518,322	0.2092	0.4067	0	1	i, j, t
gsp_{ijt}	518,322	0.1229	0.3284	0	1	i, j, t
$comcur_{ijt}$	518,322	0.0206	0.1421	0	1	i, j, t
$curheg\_o_{ijt}$	518,322	0.0002	0.0154	0	1	i, j, t
$curheg\_d_{ijt}$	518,322	0.0002	0.0154	0	1	i, j, t
$comlanguage_{ij}$	33,643	0.1553	0.3622	0	1	i, j
$comlanguage2_{ij}$	33,643	0.1511	0.3581	0	1	i, j
$comcol_{ij}$	33,643	0.1143	0.3182	0	1	i, j
$comleg_{ij}$	33,643	0.3403	0.4738	0	1	i, j
$smctry_{ij}$	33,643	0.0141	0.1177	0	1	i, j
heg_o_{ij}	33,643	0.0059	0.0767	0	1	i, j
heg_d_{ij}	33,643	0.0059	0.0767	0	1	i, j
$contig_{ij}$	33,643	0.0152	0.1222	0	1	i, j
$bothisland_{ij}$	33,643	0.0522	0.2224	0	1	i, j
$bothlandlock_{ij}$	33,643	0.0322	0.1764	0	1	i, j
$\ln wdistance_{ij}$	33,643	8.7597	0.8120	0.6316	9.8902	i, j

Note: This table provides the summary statistics of the asymmetric observable trade proxies we use in Equations (24) and (30).

Table 5: Summary statistics of $\tilde{\delta}$ and $\tilde{s}_\eta$ across years ($\frac{k}{\sigma-1} = 1.4$)

when $k/(\sigma-1) = 1.4$	Min	Median	Max
$\tilde{\delta}$	0.67	0.87	1.28
$\tilde{s}_\eta$	1.68	2.18	3.19

Note: This table provides the summary statistics of $\tilde{\delta}$ and $\tilde{s}_\eta$. $\tilde{\delta}$ is estimated from Equation (30). $\tilde{s}_\eta$ is calculated from Equation (26), given $k/(\sigma-1) = 1.4$. $\tilde{\delta}$ and $\tilde{s}_\eta$ are year-specific because the estimations of Equations (24) and (30) are done year by year.

Table 6: GATT/WTO effects on the variable, total and fixed trade cost factors ($\frac{k}{\sigma-1} = 1.4$; $\sigma = 5$)

	(1)	(2)	(3)
GATT/WTO effects identified	$\ln \tau_{ijt}^{1-\sigma}$	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$
Dependent variables	$\tilde{\theta}_{it} + \tilde{\lambda}_{jt}$	$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$	
$bothwto_{ijt}$	0.294***	1.825***	1.531***
	(0.0375)	(0.0416)	(0.0560)
$imwto_{ijt}$	-0.794***	0.309***	1.103***
	(0.0349)	(0.0307)	(0.0465)
$exwto_{ijt}$	0.0779**	1.249***	1.1711***
	(0.0391)	(0.0432)	(0.0583)
$\ln \Pi_{it}^{1-\sigma}$	-0.206***	-0.0511***	
	(0.0148)	(0.0132)	
$\ln P_{jt}^{1-\sigma}$	-0.115***	0.179***	
	(0.00595)	(0.00671)	
$\ln s_{it}$	3.188***	2.671***	
	(0.0301)	(0.0255)	
$\ln e_{jt}$	0.787***	0.610***	
	(0.00368)	(0.00491)	
$\ln Y_{wt}$	1.993***	1.255***	
	(0.0242)	(0.0161)	
$\ln N_{it}$		0.298***	
		(0.00515)	
Exporter FE	✓	✓	
Observations	390,878	505,996	
R^2	0.971	0.871	

Note: Given $k/(\sigma-1) = 1.4$ and $\sigma = 5$, Column (1) and Column (2) report the estimation results of GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma}$ and $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$, respectively. Estimations in Column (1) and Column (2) are based on regression equations (31) and (32), respectively. Column (3) provides the calculated GATT/WTO effects on $-\ln f_{ijt}$. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7: Welfare effects of GATT/WTO by membership status (shutting down GATT/WTO)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Welfare effects of GATT/WTO				
1995				
Members	85	-2.26	-1.26	-0.76
Nonmembers	22	0.84	1.55	2.45
All	107	-1.84	-0.93	-0.40
2010				
Members	133	-1.84	-1.35	-0.98
Nonmembers	29	0.07	0.74	1.76
All	162	-1.64	-1.20	-0.70
Panel B. Welfare effects of GATT/WTO via variable trade cost				
1995				
Members	85	-1.12	-0.57	-0.32
Nonmembers	22	1.62	2.53	3.63
All	107	-0.87	-0.42	-0.18
2010				
Members	133	-0.99	-0.60	-0.38
Nonmembers	29	0.41	1.61	2.73
All	162	-0.86	-0.50	-0.18
Panel C. Welfare effects of GATT/WTO via fixed trade cost				
1995				
Members	85	-1.65	-0.88	-0.57
Nonmembers	22	-0.12	0.44	0.91
All	107	-1.54	-0.71	-0.34
2010				
Members	133	-1.48	-1.00	-0.69
Nonmembers	29	-0.42	0.08	0.86
All	162	-1.28	-0.86	-0.51

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income) by membership in the counterfactual if the GATT/WTO effects on all, variable and fixed trade costs, respectively, are rescinded relative to the factual. The effects reported are in terms of percentage change.

Table 8: Welfare effects of GATT/WTO by regions (shutting down GATT/WTO)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Welfare Effects of GATT/WTO (1995)				
OECD	21	-0.99	-0.72	-0.51
East. Europe and Central Asia	6	-2.65	-1.67	1.65
East and South Asia	11	-1.51	-0.81	-0.44
Latin America and Caribbean	25	-2.78	-1.14	-0.87
Middle East and North Africa	11	-0.86	-0.50	1.02
Sub-Saharan Africa	22	-2.68	-1.82	-1.28
Other	11	-0.03	1.41	2.49
Panel B. Welfare Effects of GATT/WTO (2010)				
OECD	23	-2.23	-1.35	-0.98
East. Europe and Central Asia	11	-2.65	-1.30	-0.10
East and South Asia	23	-2.02	-0.99	-0.76
Latin America and Caribbean	30	-1.95	-1.34	-0.96
Middle East and North Africa	21	-1.39	-0.81	0.11
Sub-Saharan Africa	35	-1.62	-1.24	-0.77
Other	19	-1.46	-1.04	0.91

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income) by region in the counterfactual if the GATT/WTO effects are rescinded relative to the factual. The effects reported are in terms of percentage change.

Table 9: Welfare effects of GATT/WTO by income levels (shutting down GATT/WTO)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Welfare Effects of GATT/WTO (1995)				
High Income	29	-1.01	-0.72	-0.43
Middle Income	52	-2.24	-0.88	0.29
Low Income	26	-2.51	-1.75	-1.26
Panel B. Welfare Effects of GATT/WTO (2010)				
High Income	50	-2.23	-1.35	-0.74
Middle Income	88	-1.54	-1.08	-0.45
Low Income	24	-1.63	-1.27	-0.80

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income) by income level in the counterfactual if the GATT/WTO effects are rescinded relative to the factual. The effects reported are in terms of percentage change.

Table 10: GATT/WTO effects via all, variable, and fixed trade cost (shutting down GATT/WTO)

		No. of obs.	25th percentile	Median	75th percentile
Panel A. GATT/WTO effects on trade flow X_{ijt} (active to active)					
	via all trade costs	7,008	-76.72	-64.61	-42.67
1995	via variable trade costs	8,192	-39.01	-31.75	-2.54
	via fixed trade costs	7,052	-63.84	-53.51	-41.90
	via all trade costs	17,637	-77.86	-64.23	-40.73
2010	via variable trade costs	20,282	-40.55	-30.92	-14.54
	via fixed trade costs	17,774	-64.31	-53.06	-41.05
Panel B. GATT/WTO effects on extensive margin V_{ijt} (active to active)					
	via all trade costs	7,008	-64.64	-54.52	-42.03
1995	via variable trade costs	8,192	-15.69	-10.58	2.49
	via fixed trade costs	7,052	-60.40	-50.97	-44.39
	via all trade costs	17,637	-64.55	-53.55	-41.75
2010	via variable trade costs	20,282	-16.42	-10.11	-1.75
	via fixed trade costs	17,774	-59.64	-50.45	-43.84
Panel C. GATT/WTO effects on intensive margin X_{ijt}/V_{ijt} (active to active)					
	via all trade costs	7,008	-33.07	-20.22	-0.62
1995	via variable trade costs	8,192	-26.81	-22.94	-7.14
	via fixed trade costs	7,052	-9.52	-3.04	7.87
	via all trade costs	17,637	-37.70	-20.88	3.96
2010	via variable trade costs	20,282	-28.68	-22.67	-12.45
	via fixed trade costs	17,774	-13.88	-2.73	9.66

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in trade flow, extensive margin, and intensive margin in the counterfactual if the GATT/WTO effects on all, variable and fixed trade costs, respectively, are rescinded relative to the factual. The effects reported are in terms of percentage change.

Table 11: GATT/WTO effects (if all countries became members)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. GATT/WTO effects on welfare Y_{it}/P_{it}				
1995				
Members	85	-0.04	0.07	0.16
Nonmembers	22	2.85	4.05	7.26
All	107	-0.02	0.12	0.46
2010				
Members	133	-0.08	0.13	0.33
Nonmembers	29	1.70	3.25	6.42
All	162	-0.02	0.22	0.65
Panel B. GATT/WTO effects on trade flow X_{ijt}(active to active)				
1995	8,355	2.00	7.36	90.32
2010	20,590	0.68	8.87	48.42
Panel C. GATT/WTO effects on extensive margin V_{ijt} (active to active)				
1995	8,355	-1.19	1.59	38.40
2010	20,590	-1.91	1.68	18.45
Panel D. GATT/WTO effects on intensive margin X_{ijt}/V_{ijt} (active to active)				
1995	8355	3.17	6.00	30.70
2010	20590	2.32	7.28	17.07

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income) by membership, trade flow, extensive margin, and intensive margin in the counterfactual if all countries became members, relative to the factual. The effects reported are in terms of percentage change.

Table 12: Welfare effects by regions (if China had not joined the GATT/WTO in 2001)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Welfare Effects of GATT/WTO (2002)				
China	1	-1.78	-1.78	-1.78
OECD	23	-0.17	-0.09	-0.01
East. Europe and Central Asia	11	-0.07	0.06	1.74
East and South Asia	16	-0.53	-0.22	0.15
Latin America and Caribbean	31	-0.12	-0.01	0.10
Middle East and North Africa	19	-0.09	0.07	0.97
Sub-Saharan African	37	-0.08	0.07	0.20
Other	16	0.03	0.12	0.88
Total	154	-0.13	0.00	0.20
Panel B. Welfare Effects of GATT/WTO (2010)				
China	1	-1.34	-1.34	-1.34
OECD	23	-0.14	-0.09	-0.05
East. Europe and Central Asia	11	-0.11	-0.09	0.83
East and South Asia	22	-0.43	-0.24	-0.07
Latin America and Caribbean	30	-0.13	0.00	0.12
Middle East and North Africa	21	-0.15	-0.04	0.27
Sub-Saharan African	35	-0.04	0.06	0.23
Other	19	-0.01	0.27	0.71
Total	162	-0.15	-0.03	0.23

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income) by region in the counterfactual if China had not joined the GATT/WTO in 2001 relative to the factual. The effects reported are in terms of percentage change.

Table 13: Changes in the sales' components given a (shutting down GATT/WTO effects on variable trade cost)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Changes in Sales' Components given a (1995)				
$\widehat{P}_{jt}^{\sigma-1}$	8,085	0.9804	1.0205	1.0603
$\widehat{E}_{jt}$	8,085	0.9850	0.9967	1.0124
$\widehat{N}_{it}$	8,085	0.9977	0.9990	1.0009
$\widehat{c}_{it}^{1-\sigma}$	8,085	0.9461	0.9979	1.0433
$\widehat{\tau}_{ijt}^{1-\sigma}$	8,085	0.7453	0.7453	0.9251
$(\widehat{c}_{it}\widehat{\tau}_{ijt}/\widehat{P}_{jt})^{1-\sigma}\widehat{N}_{it}\widehat{E}_{jt}$	8,085	0.7283	0.7895	1.0549
Panel B. Changes in Sales' Components given a (2010)				
$\widehat{P}_{jt}^{\sigma-1}$	20,120	0.9587	1.0220	1.0847
$\widehat{E}_{jt}$	20,120	0.9807	0.9987	1.0155
$\widehat{N}_{it}$	20,120	0.9964	0.9986	1.0020
$\widehat{c}_{it}^{1-\sigma}$	20,120	0.9274	0.9945	1.0604
$\widehat{\tau}_{ijt}^{1-\sigma}$	20,120	0.7453	0.7453	0.9251
$(\widehat{c}_{it}\widehat{\tau}_{ijt}/\widehat{P}_{jt})^{1-\sigma}\widehat{N}_{it}\widehat{E}_{jt}$	20,120	0.7117	0.7978	0.9417

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the 25th percentile, median, and 75th percentile of the changes in the components of sales for years 1995 and 2010, in the counterfactual if the GATT/WTO effects on the variable trade cost are rescinded relative to the factual. Only the observations that remain active in both the factual and counterfactual worlds are included.

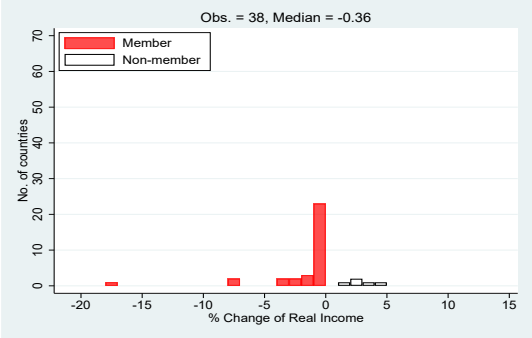
Table 14: Changes in the sales' components given a (shutting down GATT/WTO effects on fixed trade cost)

	No. of obs.	25th percentile	Median	75th percentile
Panel A. Changes in Sales' Components given a (1995)				
$\widehat{P}_{jt}^{\sigma-1}$	6,945	0.9429	1.0441	1.1185
$\widehat{E}_{jt}$	6,945	0.9753	0.9994	1.0169
$\widehat{N}_{it}$	6,945	0.9962	0.9981	0.9994
$\widehat{c}_{it}^{1-\sigma}$	6,945	0.9256	0.9787	1.0915
$\widehat{\tau}_{ijt}^{1-\sigma}$	6,945	1	1	1
$(\widehat{c}_{it}\widehat{\tau}_{ijt}/\widehat{P}_{jt})^{1-\sigma}\widehat{N}_{it}\widehat{E}_{jt}$	6,945	0.8861	1.0286	1.1789
Panel B. Changes in Sales' Components given a (2010)				
$\widehat{P}_{jt}^{\sigma-1}$	17,612	0.9282	1.0545	1.1849
$\widehat{E}_{jt}$	17,612	0.9719	0.9952	1.0281
$\widehat{N}_{it}$	17,612	0.9945	0.9965	0.9992
$\widehat{c}_{it}^{1-\sigma}$	17,612	0.8799	0.9913	1.1249
$\widehat{\tau}_{ijt}^{1-\sigma}$	17,612	1	1	1
$(\widehat{c}_{it}\widehat{\tau}_{ijt}/\widehat{P}_{jt})^{1-\sigma}\widehat{N}_{it}\widehat{E}_{jt}$	17,612	0.8539	1.0313	1.2294

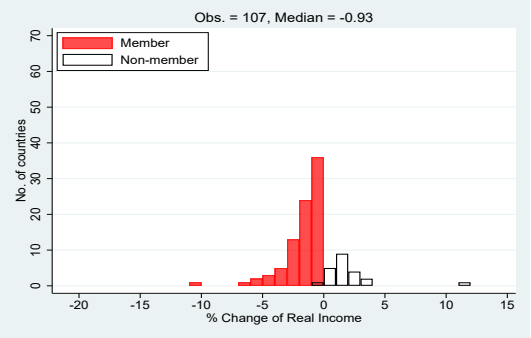
Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the 25th percentile, median, and 75th percentile of the changes in the components of sales for years 1995 and 2010, in the counterfactual if the GATT/WTO effects on the fixed trade cost are rescinded relative to the factual. Only the observations that remain active in both the factual and counterfactual worlds are included.

Figure 1: Effects of GATT/WTO on welfare (shutting down GATT/WTO)

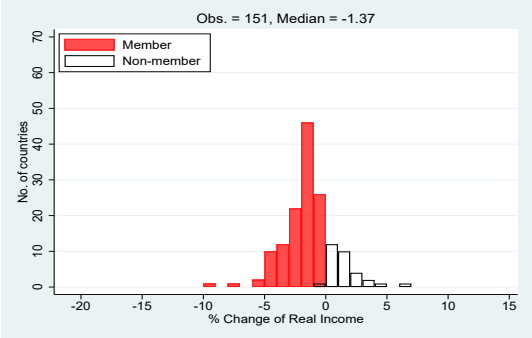
(a) 1991



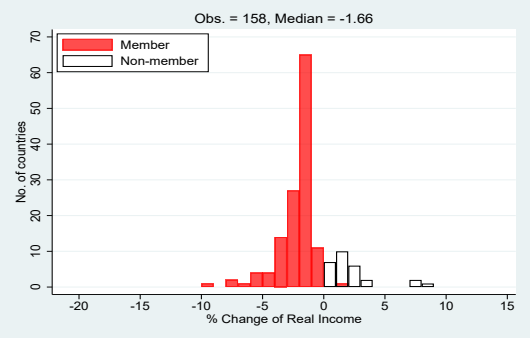
(b) 1995



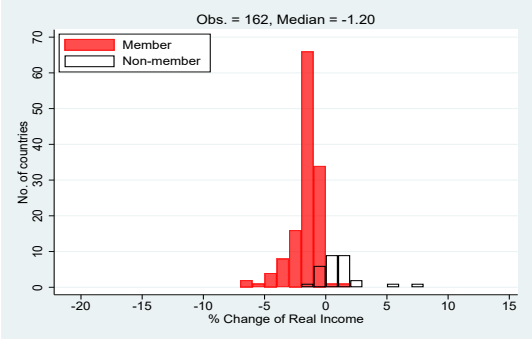
(c) 2000



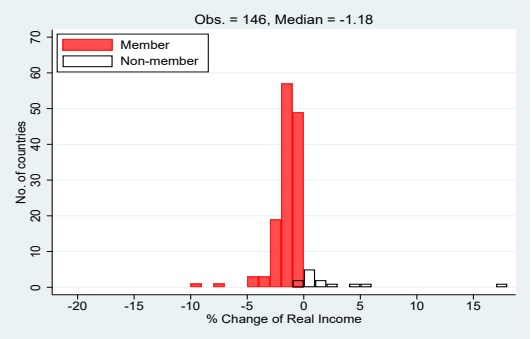
(d) 2005



(e) 2010



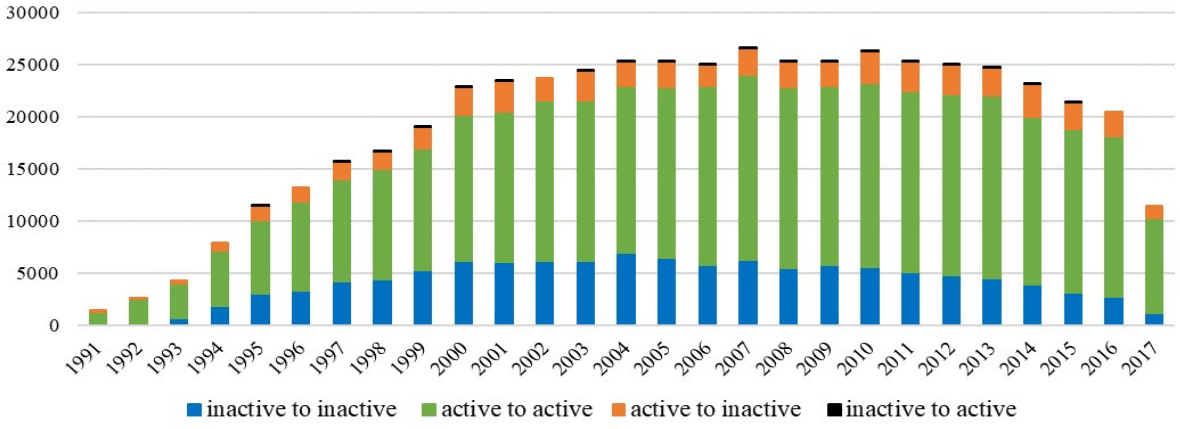
(f) 2015



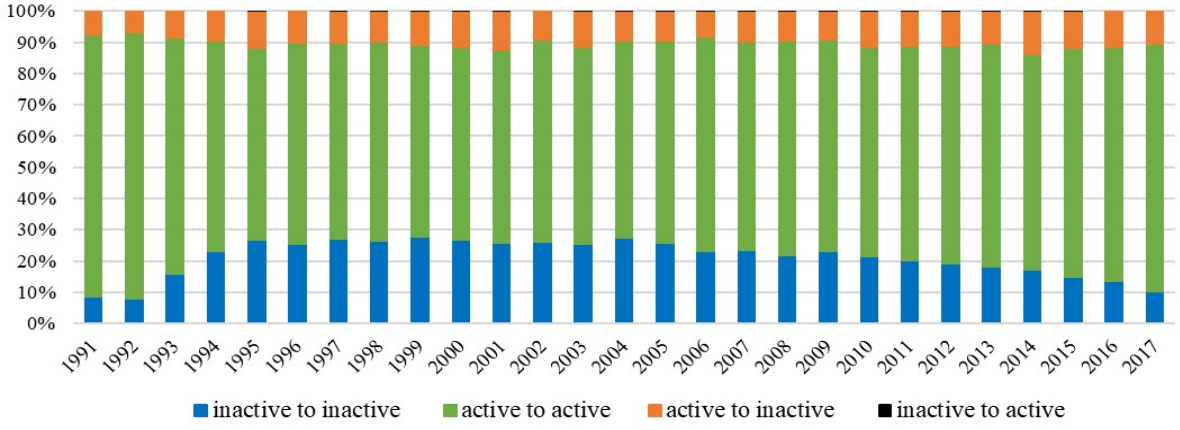
Note: Based on estimates in Table 6, this set of analyses evaluates changes in welfare in the counterfactual if the GATT/WTO effects on variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of countries, and the x-axis the % change in welfare (real income). Outliers are omitted.

Figure 2: Effects of GATT/WTO on trade status (shutting down GATT/WTO)

Panel A. Changes in trade status: frequencies



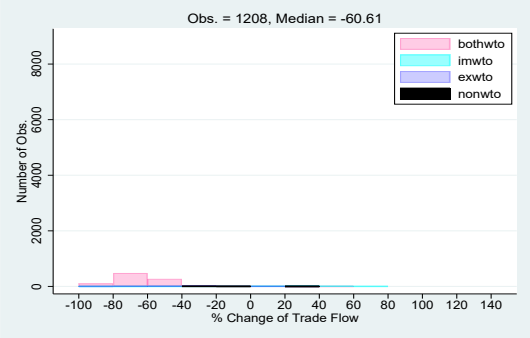
Panel B. Changes in trade status: fractions



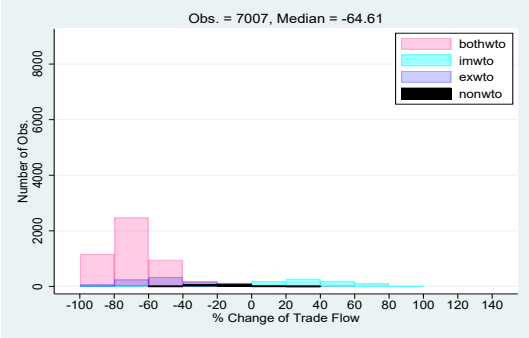
Note: Based on estimates in Table 6, this set of analyses evaluates changes in trade status in the counterfactual if the GATT/WTO effects on variable and fixed trade costs are rescinded relative to the factual.

Figure 3: Effects of GATT/WTO on trade flow (shutting down GATT/WTO)

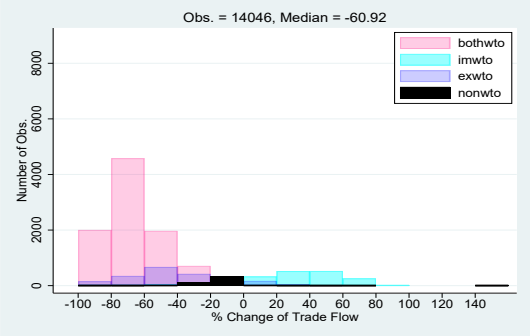
(a) 1991



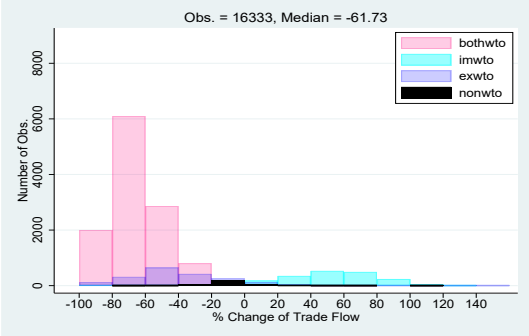
(b) 1995



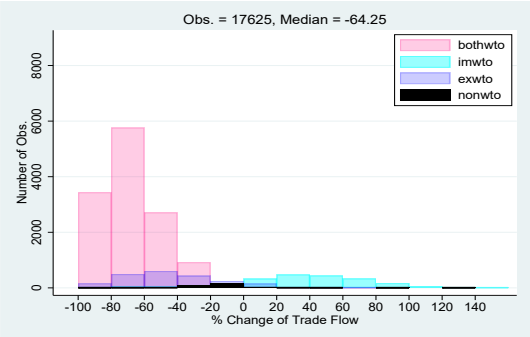
(c) 2000



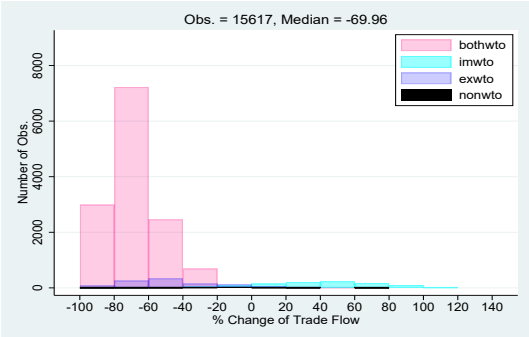
(d) 2005



(e) 2010



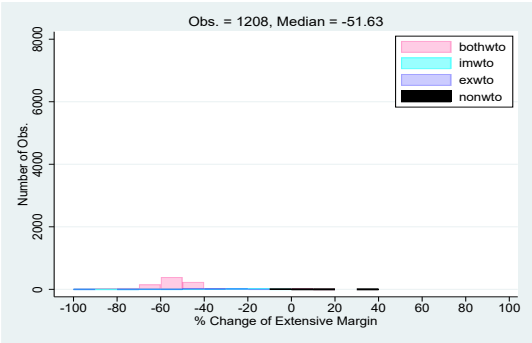
(f) 2015



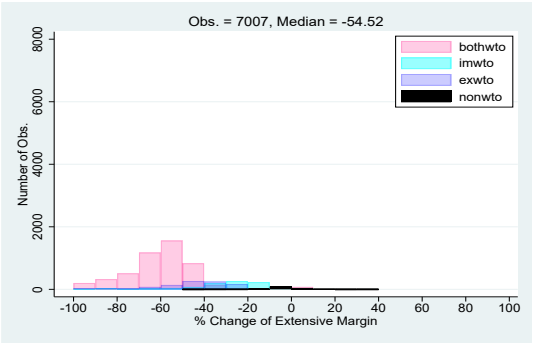
Note: Based on estimates in Table 6, this set of analyses evaluates changes in trade flow in the counterfactual if the GATT/WTO effects on variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of countries, and the x-axis the % change in trade flow. Outliers are omitted.

Figure 4: Effects of GATT/WTO on extensive margin V_{ijt} (shutting down GATT/WTO)

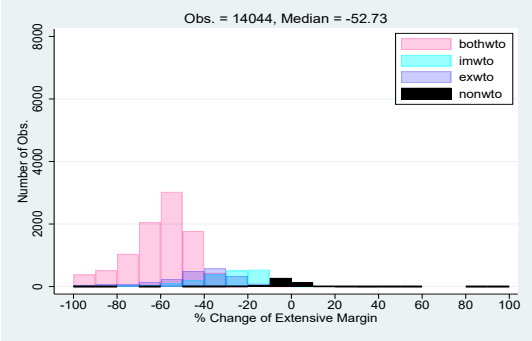
(a) 1991



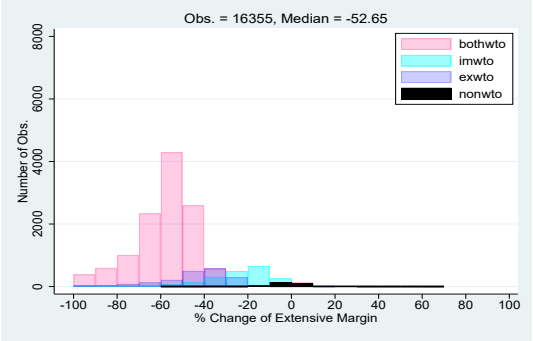
(b) 1995



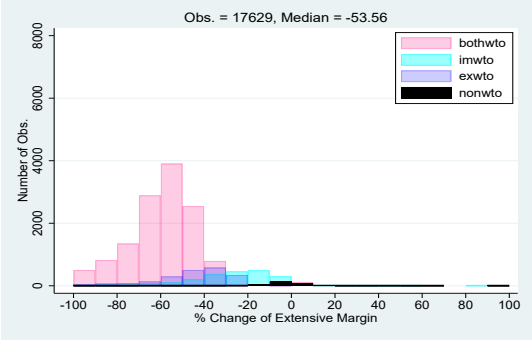
(c) 2000



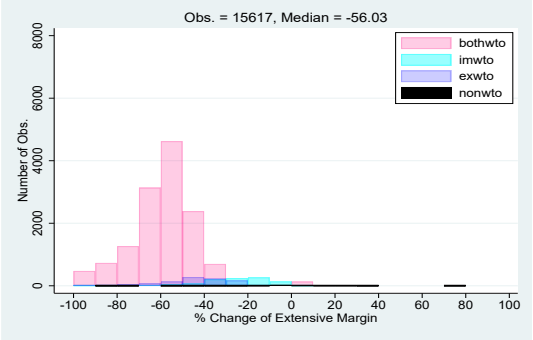
(d) 2005



(e) 2010



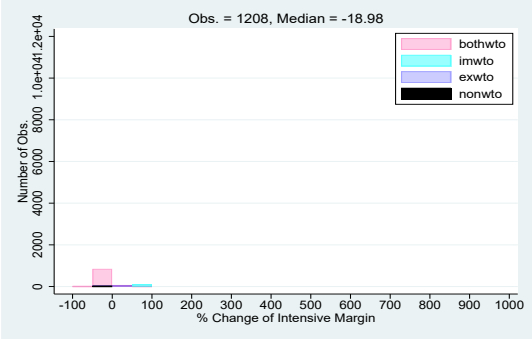
(f) 2015



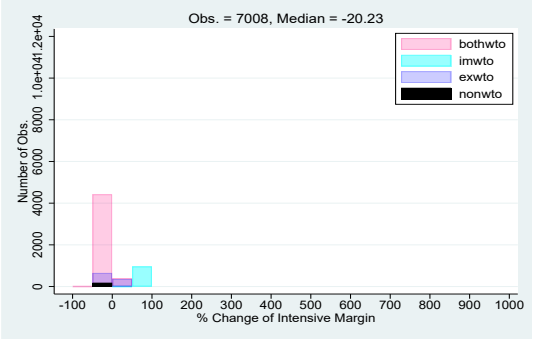
Note: Based on estimates in Table 6, this set of analyses evaluates changes in extensive margin V_{ijt} in the counterfactual if the GATT/WTO effects on variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of countries, and the x-axis the % change in extensive margin. Outliers are omitted.

Figure 5: Effects of GATT/WTO on intensive margin X_{ijt}/V_{ijt} (shutting down GATT/WTO)

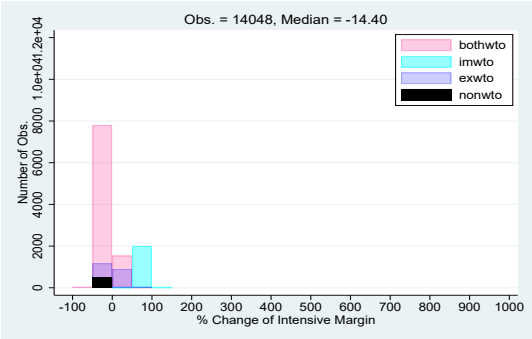
(a) 1991



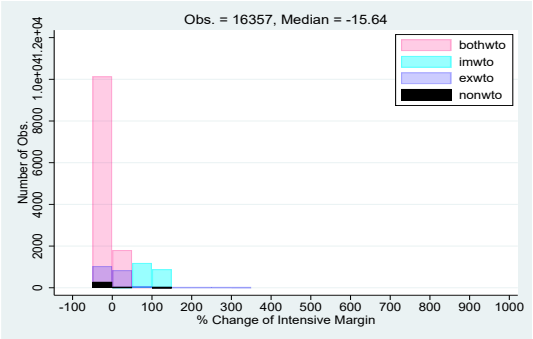
(b) 1995



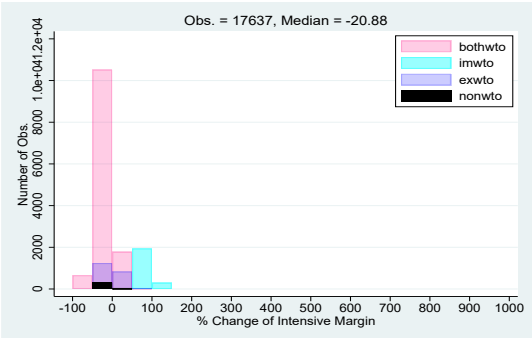
(c) 2000



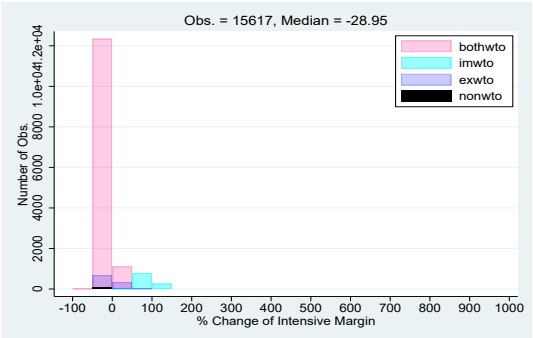
(d) 2005



(e) 2010



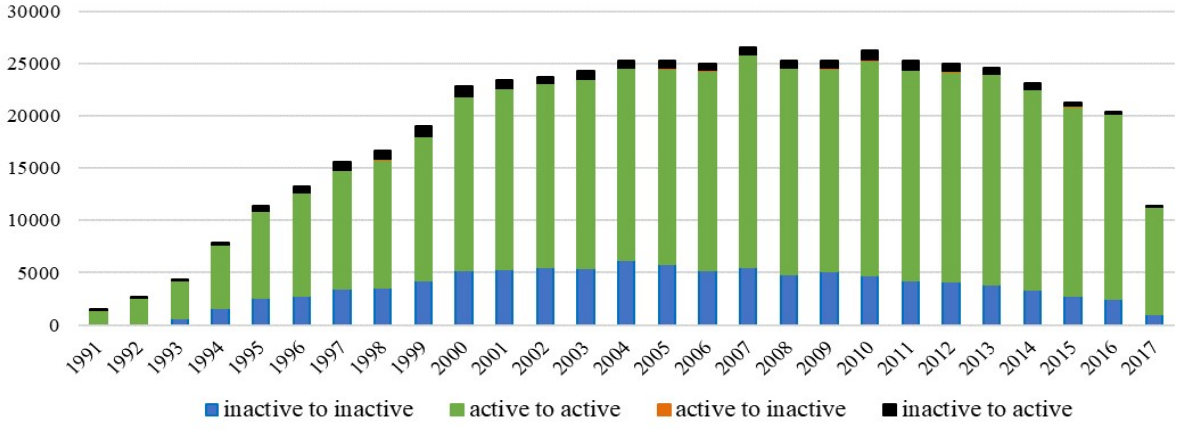
(f) 2015



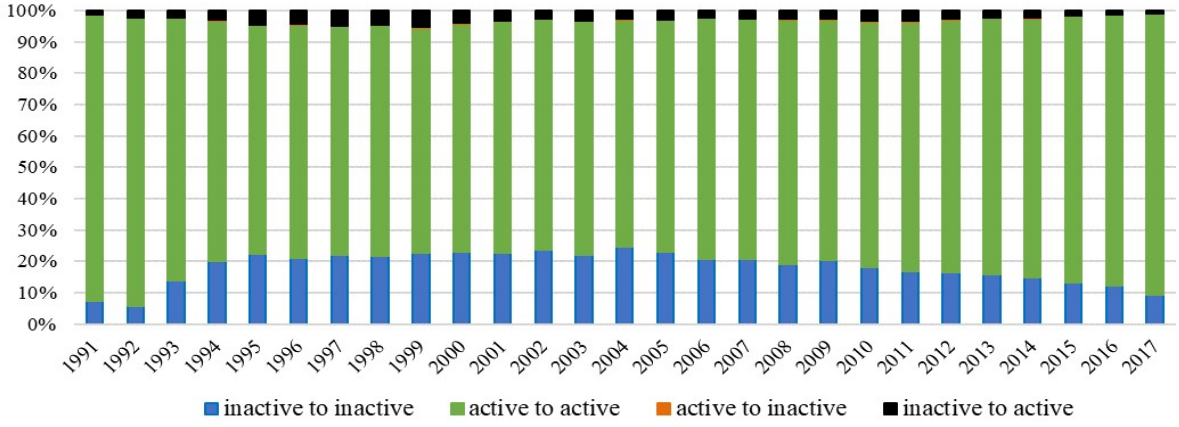
Note: Based on estimates in Table 6, this set of analyses evaluates changes in intensive margin X_{ijt}/V_{ijt} in the counterfactual if the GATT/WTO effects on variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of countries, and the x-axis the % change in intensive margin. Outliers are omitted.

Figure 6: Effects of GATT/WTO on trade status (if all countries became members)

Panel A. Changes in trade status: frequencies



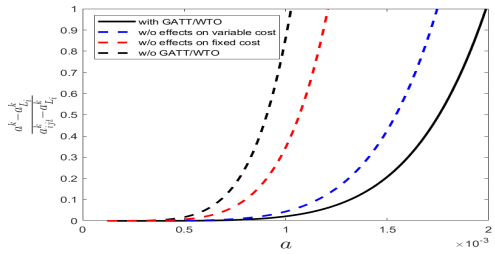
Panel B. Changes in trade status: fractions



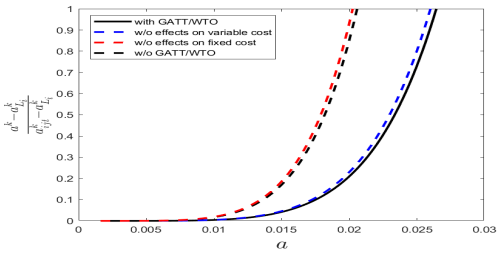
Note: Based on estimates in Table 6, this set of analyses evaluates changes in trade status in the counterfactual if all countries became members relative to the factual.

Figure 7: Effects of GATT/WTO on the support of (inverse) firm productivity distribution

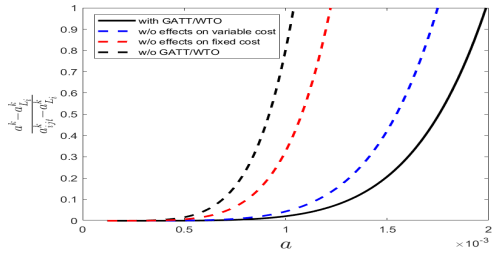
(a) USA to CHN



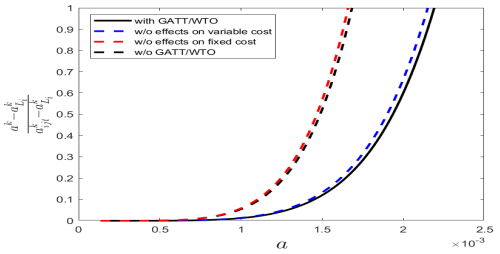
(b) CHN to USA



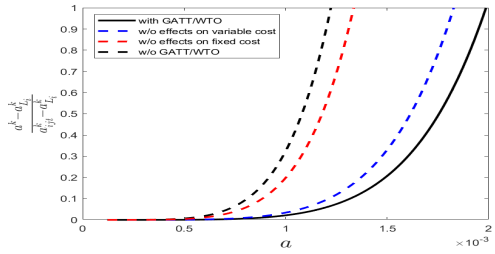
(c) USA to JPN



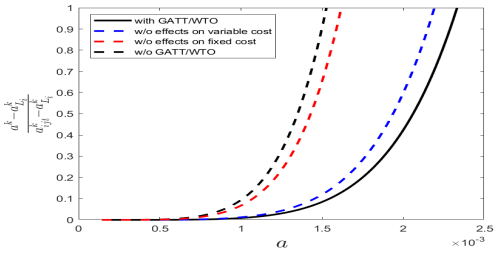
(d) JPN to USA



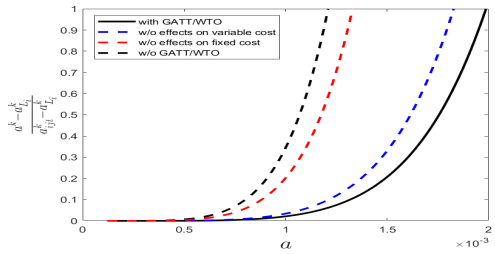
(e) USA to GBR



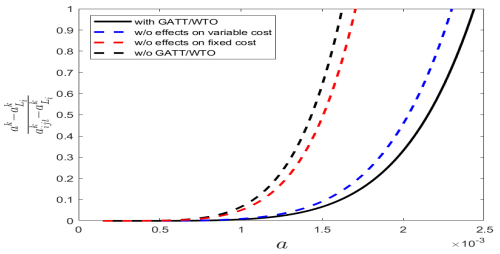
(f) GBR to USA



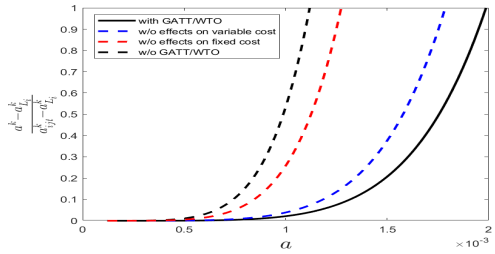
(g) USA to CAN



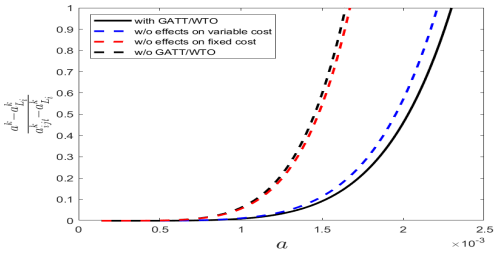
(h) CAN to USA



(h) USA to AUS



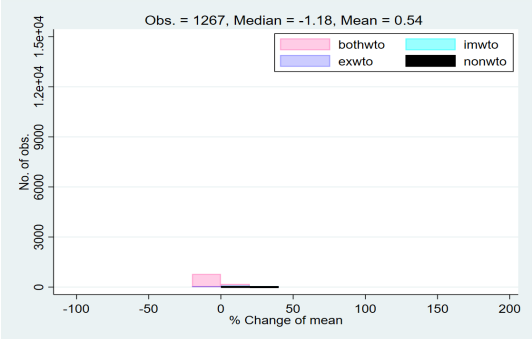
(i) AUS to USA



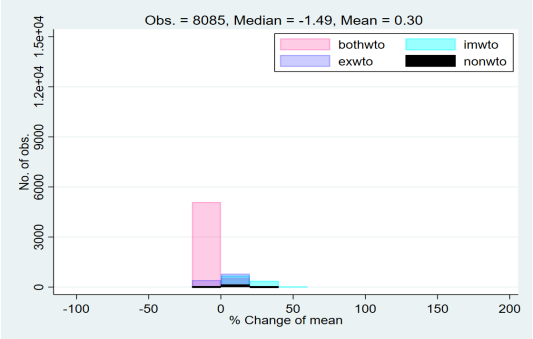
Note: This figure shows the support of (inverse) firm productivity distribution for the factual scenario with GATT/WTO, and for the three counterfactual scenarios by shutting down the effects of GATT/WTO on the variable trade cost, on the fixed trade cost, and on both. The parameters of the distribution for a (firm's unit input requirement) are based on the estimated a_{L_i} and a_{ijt} from the data, and simulated a'_{ijt} from the counterfactual analysis.

Figure 8: Effects of GATT/WTO on the mean of export sales distribution (shutting down GATT/WTO via the variable trade cost mechanism)

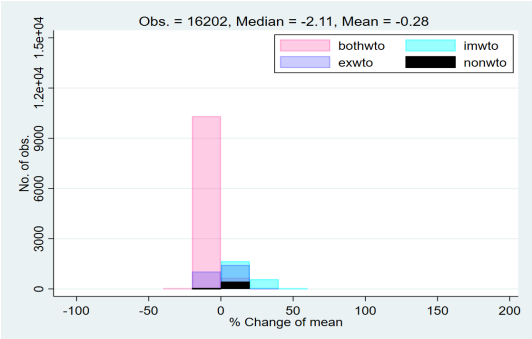
(a) 1991



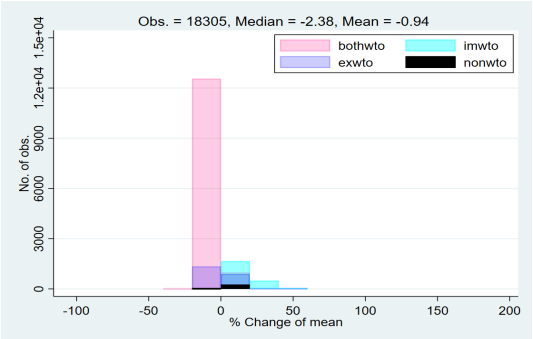
(b) 1995



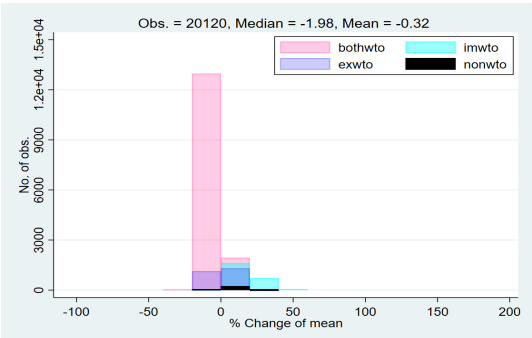
(c) 2000



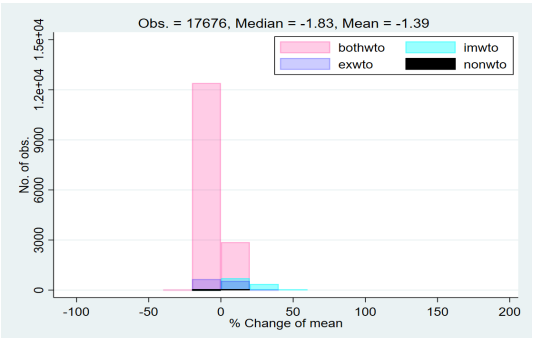
(d) 2005



(e) 2010



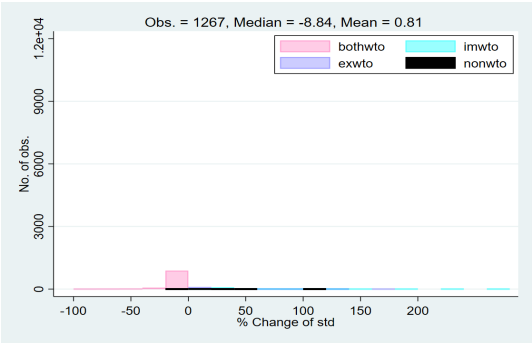
(f) 2015



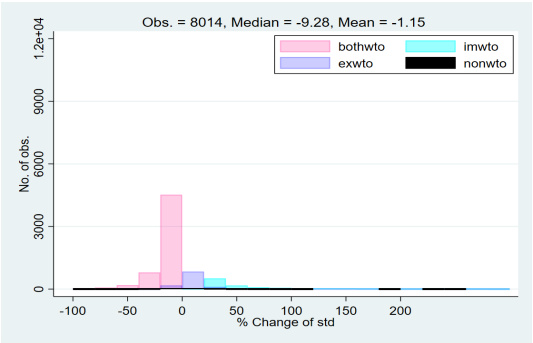
Note: Based on estimates in Table 6, this set of analyses evaluates changes in the mean of the export sales distribution in the counterfactual if the GATT/WTO effects on the variable trade cost are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in mean. Outliers are omitted.

Figure 9: Effects of GATT/WTO on the standard deviation of export sales distribution (shutting down GATT/WTO via the variable trade cost mechanism)

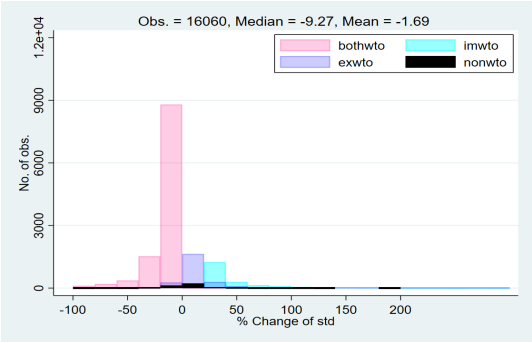
(a) 1991



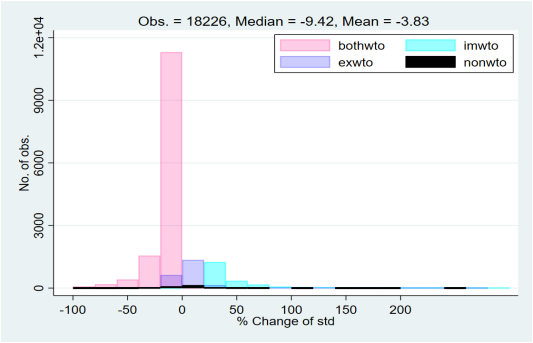
(b) 1995



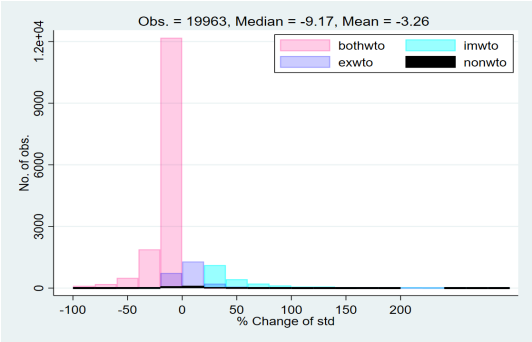
(c) 2000



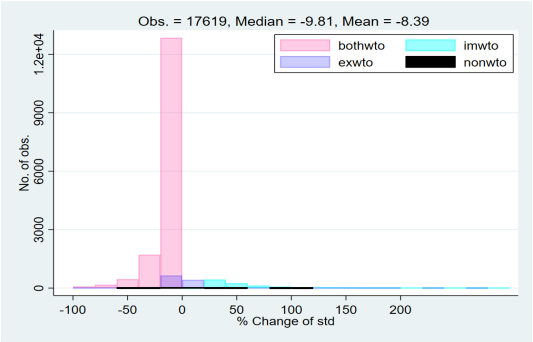
(d) 2005



(e) 2010



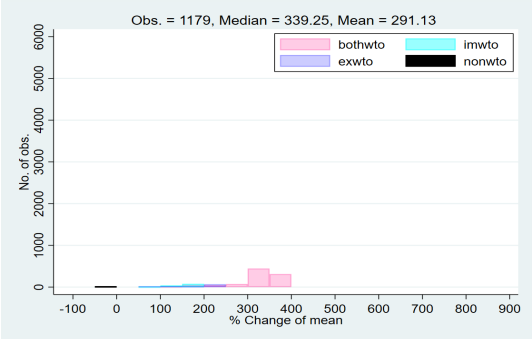
(f) 2015



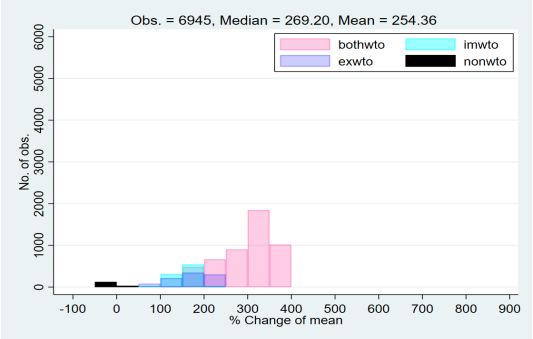
Note: Based on estimates in Table 6, this set of analyses evaluates changes in the standard deviation of the export sales distribution in the counterfactual if the GATT/WTO effects on the variable trade cost are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in standard deviation. Outliers are omitted.

Figure 10: Effects of GATT/WTO on the mean of export sales distribution (shutting down GATT/WTO via the fixed trade cost mechanism)

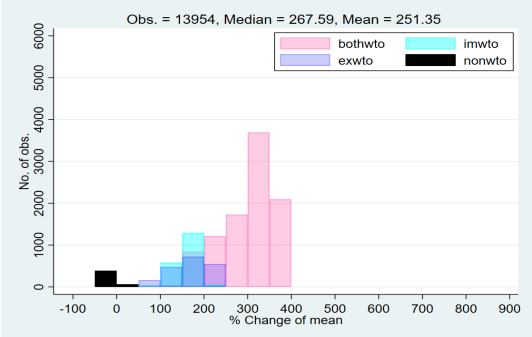
(a) 1991



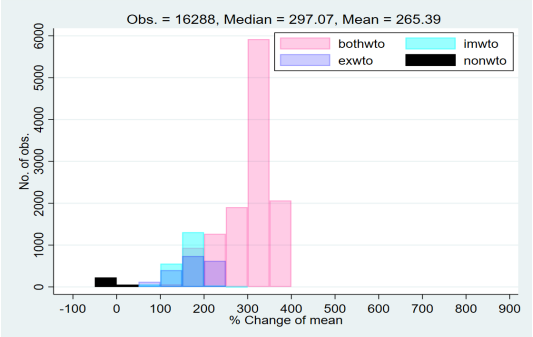
(b) 1995



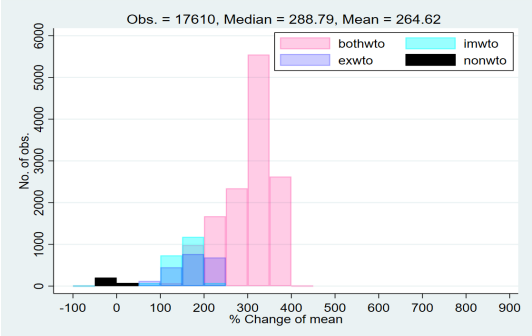
(c) 2000



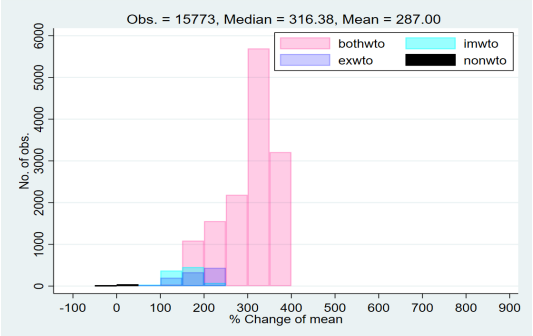
(d) 2005



(e) 2010



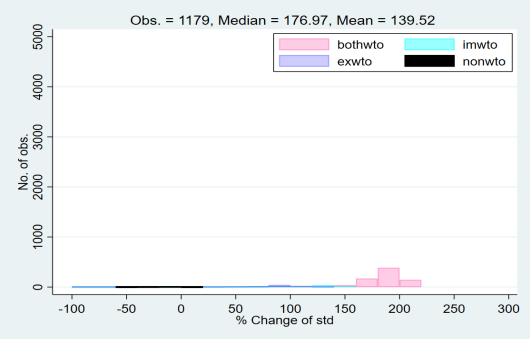
(f) 2015



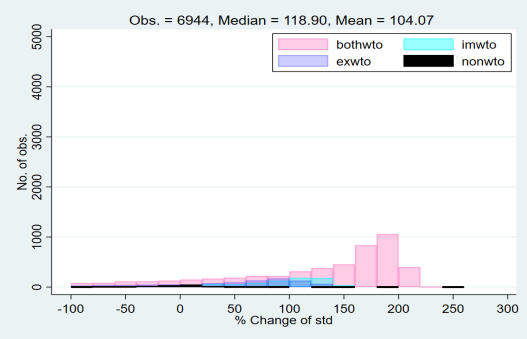
Note: Based on estimates in Table 6, this set of analyses evaluates changes in the mean of the export sales distribution in the counterfactual if the GATT/WTO effects on the fixed trade cost are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in mean. Outliers are omitted.

Figure 11: Effects of GATT/WTO on the standard deviation of export sales distribution (shutting down GATT/WTO via the fixed trade cost mechanism)

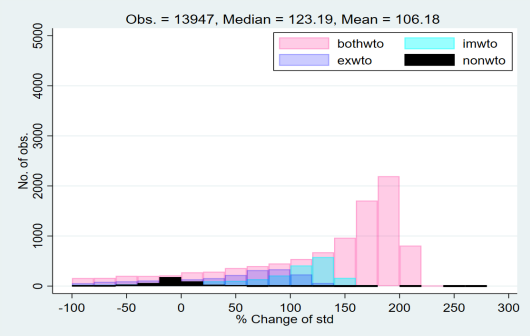
(a) 1991



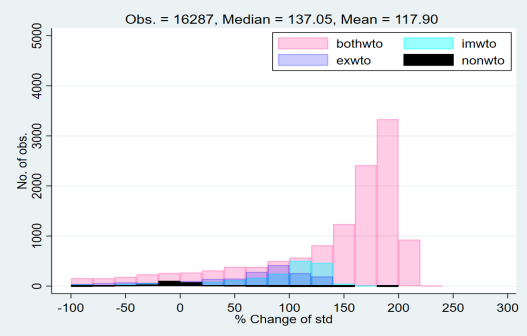
(b) 1995



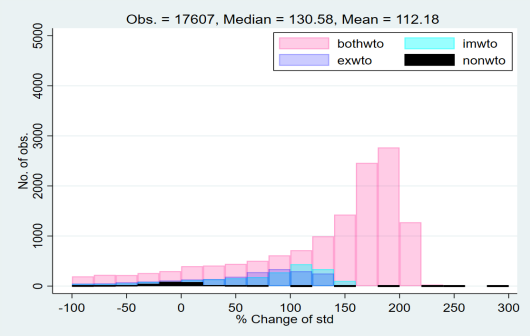
(c) 2000



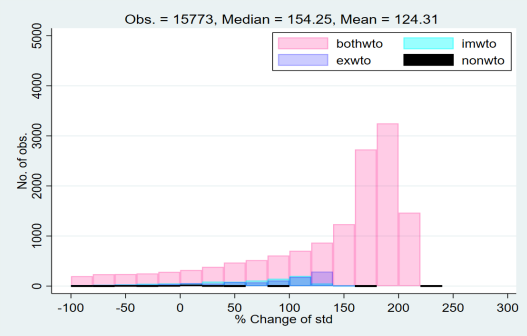
(d) 2005



(e) 2010



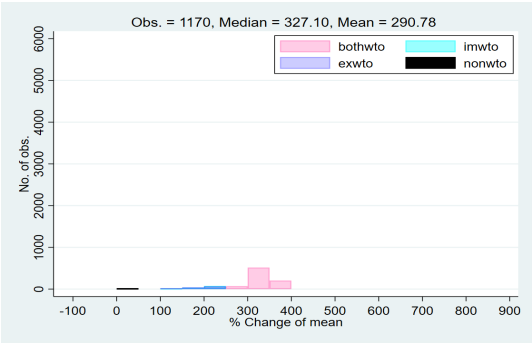
(f) 2015



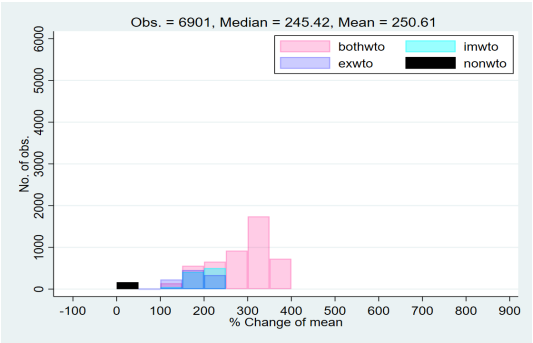
Note: Based on estimates in Table 6, this set of analyses evaluates changes in the standard deviation of the export sales distribution in the counterfactual if the GATT/WTO effects on the fixed trade cost are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in standard deviation. Outliers are omitted.

Figure 12: Effects of GATT/WTO on the mean of export sales distribution (shutting down GATT/WTO)

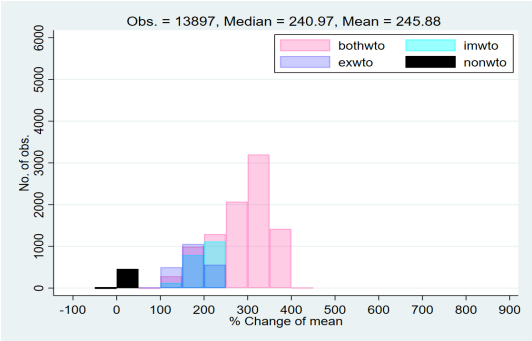
(a) 1991



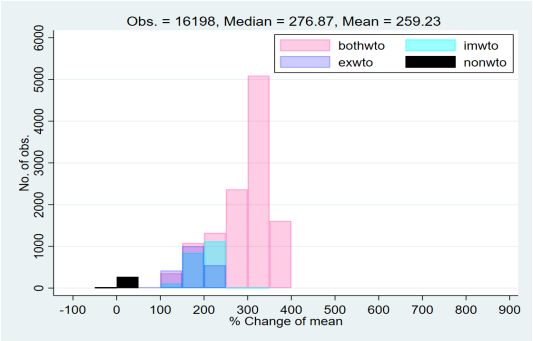
(b) 1995



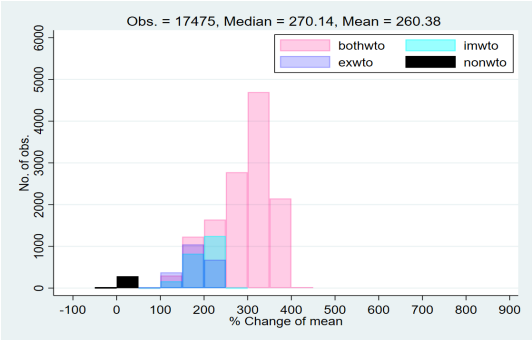
(c) 2000



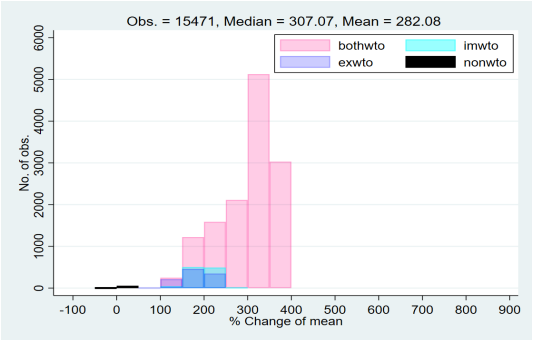
(d) 2005



(e) 2010



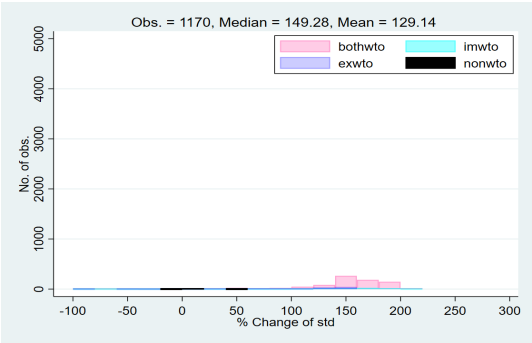
(f) 2015



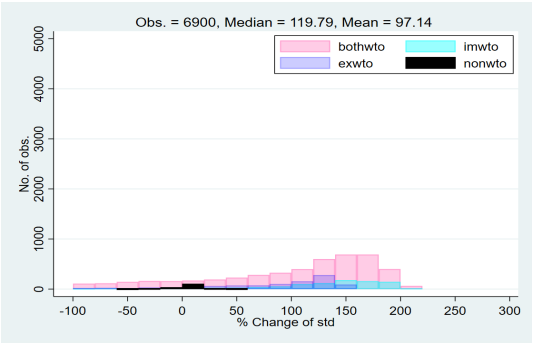
Note: Based on estimates in Table 6, this set of analyses evaluates changes in the mean of the export sales distribution in the counterfactual if the GATT/WTO effects on the variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in mean. Outliers are omitted.

Figure 13: Effects of GATT/WTO on the standard deviation of export sales distribution (shutting down GATT/WTO)

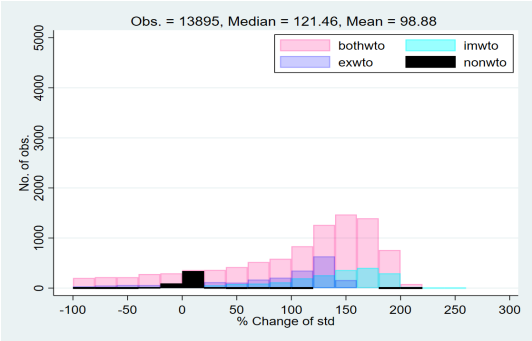
(a) 1991



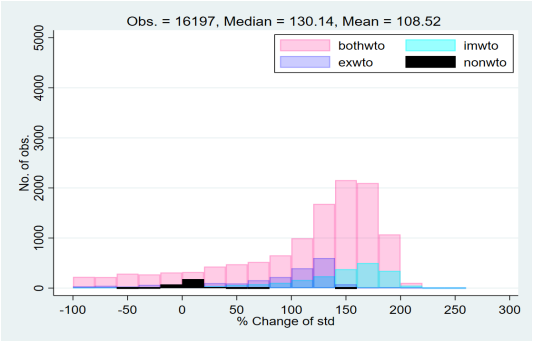
(b) 1995



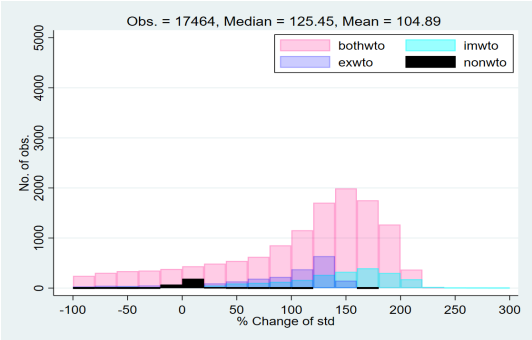
(c) 2000



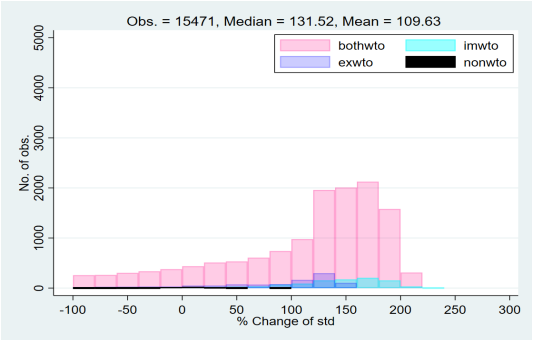
(d) 2005



(e) 2010



(f) 2015



Note: Based on estimates in Table 6, this set of analyses evaluates changes in the standard deviation of the export sales distribution in the counterfactual if the GATT/WTO effects on the variable and fixed trade costs are rescinded relative to the factual. The y-axis indicates the number of observations, and the x-axis the % change in standard deviation. Outliers are omitted.

Table A.1: GATT/WTO effects on the total and fixed trade cost factors ($\frac{k}{\sigma-1} = 1.35, 1.38, 1.42, 1.45$)

	(1) $\frac{k}{\sigma-1} = 1.35$		(2) $\frac{k}{\sigma-1} = 1.38$	
GATT/WTO effects identified	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$
Dependent variables	$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$		$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$	
$bothwto_{ijt}$	2.131***	1.837***	1.938***	1.644***
	(0.0476)	(0.0606)	(0.0438)	(0.0577)
$imwto_{ijt}$	0.343***	1.137***	0.322***	1.116***
	(0.0352)	(0.04957)	(0.0324)	(0.0476)
$exwto_{ijt}$	1.463***	1.3851***	1.328***	1.2501***
	(0.0494)	(0.063)	(0.0455)	(0.060)
	(3) $\frac{k}{\sigma-1} = 1.42$		(4) $\frac{k}{\sigma-1} = 1.45$	
GATT/WTO effects identified	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$
Dependent variables	$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$		$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$	
$bothwto_{ijt}$	1.723***	1.429***	1.586***	1.292***
	(0.0396)	(0.0545)	(0.0369)	(0.0526)
$imwto_{ijt}$	0.299***	1.093***	0.284***	1.078***
	(0.0292)	(0.0455)	(0.0272)	(0.0442)
$exwto_{ijt}$	1.177***	1.0991***	1.081***	1.0031***
	(0.0411)	(0.0567)	(0.0383)	(0.0547)

Note: Given $\sigma = 5$, Panels (1)–(4) report the estimation results of GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$ and the calculated GATT/WTO effects on $-\ln f_{ijt}$ with $\frac{k}{\sigma-1} = 1.35, 1.38, 1.42, 1.45$, respectively. The estimations include the same list of controls as their counterparts in Table 6. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.2: GATT/WTO effects on the total and fixed trade cost factors ($\sigma = 3, 4, 6, 7$)

	(1) $\sigma = 3$		(2) $\sigma = 4$	
GATT/WTO effects identified	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$
Dependent variables	$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$		$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$	
$bothwto_{ijt}$	1.854***	1.560***	1.842***	1.548***
	(0.0415)	(0.0559)	(0.0416)	(0.056)
$imwto_{ijt}$	0.313***	1.107***	0.310***	1.104***
	(0.0307)	(0.0465)	(0.0307)	(0.465)
$exwto_{ijt}$	1.276***	1.1981***	1.264***	1.1861***
	(0.0431)	(0.0582)	(0.0432)	(0.0583)

	(3) $\sigma = 6$		(4) $\sigma = 7$	
GATT/WTO effects identified	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$	$\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$	$-\ln f_{ijt}$
Dependent variables	$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$		$\tilde{\zeta}_{it} + \tilde{\xi}_{jt}$	
$bothwto$	1.805***	1.511***	1.783***	1.489***
	(0.0415)	(0.0559)	(0.0415)	(0.0559)
$imwto$	0.311***	1.105***	0.315***	1.109***
	(0.0307)	(0.0465)	(0.0306)	(0.0464)
$exwto$	1.232***	1.1541***	1.212***	1.1341***
	(0.0432)	(0.0583)	(0.0432)	(0.0583)

Note: Given $\frac{k}{\sigma-1} = 1.4$, Panels (1)–(4) report the estimation results of GATT/WTO effects on $\ln \tau_{ijt}^{1-\sigma} - \ln f_{ijt}$ and the calculated GATT/WTO effects on $-\ln f_{ijt}$ with $\sigma = 3, 4, 6, 7$, respectively. The estimations include the same list of controls as their counterparts in Table 6. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.3: Estimates of a_{L_i} and a_{H_i} for selected economies

Country Name	$1/a_{L_i}$	Country Name	$1/a_{H_i}$
Luxembourg	17750.93	Luxembourg	19.72
Bermuda	14123.83	Bermuda	15.69
Norway	12510.89	Norway	13.90
Switzerland	11547.02	Switzerland	12.83
Qatar	11275.35	Qatar	12.52
Denmark	8898.96	Denmark	9.89
Sweden	8299.71	Sweden	9.22
United States of America	8221.40	United States	9.14
Iceland	8180.08	Iceland	9.09
Ireland	8132.53	Ireland	9.04
Netherlands	7683.31	Netherlands	8.54
Belgium	7584.64	Belgium	8.43
Austria	7537.03	Austria	8.37
Japan	7463.14	Japan	8.29
United Arab Emirates	7431.83	United Arab Emirates	8.26
Australia	7119.02	Australia	7.91
Finland	7084.58	Finland	7.87
United Kingdom	7010.39	United Kingdom	7.79
Germany	6884.30	Germany	7.64
Singapore	6797.29	Singapore	7.55
⋮	⋮	⋮	⋮
Uganda	82.06	Uganda	0.09
Guinea-Bissau	77.83	Guinea-Bissau	0.09
Central African Republic	68.30	Central African Republic	0.08
Madagascar	64.26	Madagascar	0.07
Malawi	58.07	Malawi	0.06
Ethiopia	56.86	Ethiopia	0.06
Niger	54.95	Niger	0.06
Eritrea	46.11	Eritrea	0.05
Chad	40.91	Chad	0.05
Burundi	38.38	Burundi	0.04

Note: This table reports the estimated upper-bound and lower-bound productivity levels ($1/a_{L_i}$ and $1/a_{H_i}$) for the top 20 and the bottom 10 economies in terms of each measure.

Table A.4: GATT/WTO effects via all, variable, and fixed trade cost (shutting down GATT/WTO)

		No. of obs.	25th percentile	Median	75th percentile
Panel A. GATT/WTO effects on welfare Y_{it}/P_{it}					
	via all trade costs	107	-1.84	-0.93	-0.40
1995	via variable trade costs	107	-0.87	-0.42	-0.18
	via fixed trade costs	107	-1.54	-0.71	-0.34
	via all trade costs	162	-1.64	-1.20	-0.70
2010	via variable trade costs	162	-0.86	-0.50	-0.18
	via fixed trade costs	162	-1.28	-0.86	-0.51
Panel B. GATT/WTO effects on trade flow X_{ijt} (full sample)					
	via all trade costs	8,365	-84.82	-69.71	-48.72
1995	via variable trade costs	8,365	-39.43	-32.12	-3.58
	via fixed trade costs	8,365	-75.70	-57.31	-44.55
	via all trade costs	20,634	-84.75	-69.27	-46.67
2010	via variable trade costs	20,634	-41.07	-31.28	-15.37
	via fixed trade costs	20,634	-73.37	-56.39	-43.45
Panel C. GATT/WTO effects on extensive margin V_{ijt} (full sample)					
	via all trade costs	8,365	-77.66	-58.00	-45.38
1995	via variable trade costs	8,365	-16.06	-10.80	1.70
	via fixed trade costs	8,365	-74.33	-53.59	-45.73
	via all trade costs	20,634	-74.61	-57.13	-44.21
2010	via variable trade costs	20,634	-16.88	-10.33	-2.00
	via fixed trade costs	20,634	-70.16	-52.75	-45.01
Panel D. GATT/WTO effects on intensive margin X_{ijt}/V_{ijt} (active to active)					
	via all trade costs	7,008	-33.07	-20.22	-0.62
1995	via variable trade costs	8,192	-26.81	-22.94	-7.14
	via fixed trade costs	7,052	-9.52	-3.04	7.87
	via all trade costs	17,637	-37.70	-20.88	3.96
2010	via variable trade costs	20,282	-28.68	-22.67	-12.45
	via fixed trade costs	17,774	-13.88	-2.73	9.66

Note: Based on the estimates of GATT/WTO effects in Table 6, this table reports the changes in welfare (real income), trade flow, extensive margin, and intensive margin in the counterfactual if the GATT/WTO effects on all, variable and fixed trade costs, respectively, are rescinded relative to the factual. The effects reported are in terms of percentage change.

Table A.5: Summary statistics of N'_{ijt} for $z^*_{ijt} \leq 0$ (shutting down GATT/WTO)

No. of obs.	Mean	Min	Max
115,726	1.05e-04	0	1.96

Note: This table provides the summary statistics of N'_{ijt} for $z^*_{ijt} \leq 0$ based on the estimation method of N_{it} as documented in Appendix B.2.

Table A.6: Trade cost on distance

Dependent variables	(1) $\ln \tau_{ijt}$	(2) $\ln f_{ijt}$
$\ln wdistance_{ijt}$	0.296***	0.350***
	(0.000918)	(0.00416)
Exporter-Year FE	✓	✓
Importer-Year FE	✓	✓
Observations	516,784	516,784
R^2	0.983	0.922

Note: Column (1) and Column (2) report the estimation results of distance effects on the variable trade cost $\ln \tau_{ijt}$ and the fixed trade cost $\ln f_{ijt}$, respectively. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.7: Margins of trade on distance ($\ln wdistance_{ijt}$ reduced by 0.5%)

Dependent variables	(1) $\ln \widehat{N}_{ijt}$	(2) $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$
$\ln\left(\widehat{wdistance}_{ijt}\right)$	-1.922***	-0.212**
	(0.0493)	(0.0859)
Exporter-Year FE	✓	✓
Importer-Year FE	✓	✓
Observations	399,473	399,473
R^2	0.724	0.912

Note: Column (1) and Column (2) report the estimation results of regressing changes in extensive margin $\ln \widehat{N}_{ijt}$ and intensive margin $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$, respectively, on changes in distance, where changes in extensive and intensive margins are model-simulated by reducing the logarithm of weighted distance by 0.5% in the counterfactual relative to the factual. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.8: Trade margin elasticity regression ($\ln wdistance_{ijt}$ reduced by 0.5%)

Dependent variables	(1) $\ln \widehat{N}_{ijt}$	(2) $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$
$\ln \widehat{X}_{ijt}$	0.629***	0.371***
	(0.00698)	(0.00698)
Exporter-Year FE	✓	✓
Importer-Year FE	✓	✓
Observations	399,473	399,473
R^2	0.905	0.947

Note: Column (1) and Column (2) report the estimation results of regressing changes in extensive margin $\ln \widehat{N}_{ijt}$ and intensive margin $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$, respectively, on changes in trade flows, where changes in extensive/intensive margins and trade flows are model-simulated by reducing the logarithm of weighted distance by 0.5 % in the counterfactual relative to the factual. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.9: Margins of trade on distance ($\ln wdistance_{ijt}$ reduced by 0.1%)

Dependent variables	(1) $\ln \widehat{N}_{ijt}$	(2) $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$
$\ln\left(\widehat{wdistance}_{ijt}\right)$	-2.086***	-1.528***
	(0.243)	(0.430)
Exporter-Year FE	✓	✓
Importer-Year FE	✓	✓
Observations	399,246	399,246
R^2	0.719	0.913

Note: Column (1) and Column (2) report the estimation results of regressing changes in extensive margin $\ln \widehat{N}_{ijt}$ and intensive margin $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$, respectively, on changes in distance, where changes in extensive and intensive margins are model-simulated by reducing the logarithm of weighted distance by 0.1% in the counterfactual relative to the factual. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.10: Trade margin elasticity regression ($\ln wdistance_{ijt}$ reduced by 0.1%)

Dependent variables	(1) $\ln \widehat{N}_{ijt}$	(2) $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$
$\ln \widehat{X}_{ijt}$	0.624***	0.376***
	(0.00682)	(0.00682)
Exporter-Year FE	✓	✓
Importer-Year FE	✓	✓
Observations	399,246	399,246
R^2	0.902	0.948

Note: Column (1) and Column (2) report the estimation results of regressing changes in extensive margin $\ln \widehat{N}_{ijt}$ and intensive margin $\ln \frac{\widehat{X}_{ijt}}{\widehat{N}_{ijt}}$, respectively, on changes in trade flows, where changes in extensive/intensive margins and trade flows are model-simulated by reducing the logarithm of weighted distance by 0.1% in the counterfactual relative to the factual. The robust standard errors are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.