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The depth of preferential trade agreements

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Abstract

Preferential trade agreements (PTAs) have increased rapidly in number since the 1990s, and have extended their traditional focus on tariff reduction to include deeper integration in policy areas such as competition policy, intellectual property rights, investments, and movement of capital. This paper uses a comprehensive dataset on the content of PTAs to quantify the impacts of the depth of trade agreements on bilateral trade flows and national welfare across the world for the period 1980–2015. The results indicate that agreements that are deeper (by different definitions) contribute to larger trade growth and welfare gains. Furthermore, the results imply that the depth of trade agreements also matters for the interaction between regional integration (via PTAs) and multilateral trade liberalization (via GATT/WTO).

Keywords: preferential trade agreements; deep integration; regionalism; counterfactual quantitative simulation
JEL Classification: F13; F14; F15

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1 Introduction

Formation of preferential trade agreements (PTAs) is regulated by Article XXIV of the General Agreement on Tariffs and Trade (GATT) under the conditions that the PTAs "substantially" eliminate all trade barriers between the constituent territories in the agreement, and that trade barriers to countries outside the preferential agreement "are not higher or more restrictive" than before the formation. Given their "discriminatory" nature, PTAs represent an exception to the most favored nation (MFN) principle of the GATT and its successor, the World Trade Organization (WTO).

As documented by Hofmann, Osnago and Ruta (2019), PTAs signed in recent years have gone beyond the "shallow" approach of tariff reduction and become "deeper" in the extent and scope of integration to address issues on nontariff border measures and behind-the-border domestic policy measures. This raises an important policy question: How might the depth of PTAs change the nature of their effects on trade flows and welfare? For example, if such deep agreements cover issues on domestic regulations (such as competition policy), they might create more trade relative to shallow agreements, by improving the levels of "regulatory coherence" across PTA-partner countries (Bagwell, Bown and Staiger, 2016). In addition, if these types of regulatory changes also apply to parties outside the PTA, this could potentially lead to positive spillover effects and reduced trade diversion (Baldwin and Low, 2009; Mattoo, Mulabdic and Ruta, 2022).

In this paper, we use the dataset of Hofmann, Osnago and Ruta (2019) on the content of PTAs to empirically evaluate the trade and welfare effects of deep PTA integration, and examine potential complementarity between deep PTAs and the GATT/WTO on trade liberalization and national welfare relative to shallow PTAs. The dataset of Hofmann, Osnago and Ruta (2019) explicitly tracks and catalogs the content of PTA provisions for a long time period (1958–2015). Utilizing information in this PTA dataset, we classify PTAs based on categories of policy areas included and their legal enforceability. In particular, the policy areas can be distinguished by: (i) WTO-plus or WTO-extra provisions, (ii) Core or Non-Core provisions, and (iii) within Core provisions, Border or Behind-the-Border provisions, and (iv) Preferential or MFN provisions. We define four sets of PTA category indicators by the possible combinations of these different policy areas, and characterize the depths of PTAs by the increasing coverage of the policy areas along each of these four dimensions. For example, PTAs that cover both WTO-plus and WTO-extra provisions are considered "deeper" than PTAs that cover only WTO-plus provisions, because they extend beyond the current WTO mandates (WTO-plus) and address issues that are not yet regulated by the WTO agreements (WTO-extra).

To guide our empirical estimations and structural simulation analyses, we extend the model of Melitz (2003) and derive the implied gravity equation for trade flows. The bilateral trade flows depend on directional variable/fixed trade costs, economic sizes of the trading partners, and also multilateral resistance terms to trade (with expressions that generalize the setup of Anderson and van Wincoop (2003)). We assess the effect of PTAs on trade flows (via the variable/fixed trade terms) using the gravity equation in its reduced form, in line with the literature (Head and Mayer, 2015; Limão, 2016). We conduct the analysis for a panel of 160–192 economies during the period 1980–2015. We find that PTAs promote trade on average, and the effects tend to strengthen with the depth of the PTAs, according to each of the four perspectives by which we classify the PTA policy areas and depths. In addition, in order to analyze the interaction of PTA depth and the GATT/WTO-induced trade liberalization, we also attempt to identify the direct effect of GATT/WTO on the trade costs. As highlighted by Cheong, Kwak and Tang (2014), one cannot separately identify the effects of GATT/WTO membership indicators in the reduced-form gravity framework where the exporter-year and importer-year fixed effects (FEs) are included to control for the multilateral resistance (MR) terms.[1] To overcome this difficulty, we propose an iterated regression procedure to identify the GATT/WTO membership effects consistently within the established parametric framework.

Having identified the trade-cost effects of PTAs (differentiated by their characteristics) and of GATT/WTO membership status, we conduct quantitative counterfactual analyses based on the extended Melitz framework developed above and rewritten in terms of hat algebras à la Dekle, Eaton and Kortum (2007). The framework incorporates potentially multiple margins of trade (intensive, extensive, firm entry, and roundabout input-output linkages), and is consistent with the extended version of Arkolakis, Costinot and Rodríguez-Clare (2012) with intermediate goods used in production as well as in firm entry. We take the matrices of trade-cost effects estimated due to PTA status for each country-pair in each year from the previous step as inputs for the quantitative trade models, and assess the corresponding general-equilibrium impacts. We find that countries tend to reap larger welfare gains if they have more PTA trading partnerships, and if the PTA partnerships they have in force are of the deepest forms. Furthermore, we find a potential complementary relationship between PTA deep integration and multilateral trade liberalization. The welfare benefits of PTAs would be smaller without the trade barrier reductions brought about by GATT/WTO,

[1] Define $bothwto_{ijt} = 1$ if both trading partners ij are GATT/WTO members in year t and zero otherwise; $imwto_{ijt} = 1$ if only the importing country j is a GATT/WTO member in year t and zero otherwise; and $exwto_{ijt}$=1 if only the exporting country i is a GATT/WTO member in year t and zero otherwise. It can be shown that the set of GATT/WTO membership indicators are multi-collinear with the exporter-year and importer-year FEs.

and this is more pronounced for countries with predominantly PTAs of higher provisional depth than countries with predominantly shallow agreements. The pattern also becomes increasingly relevant in recent decades. This might suggest that deep PTAs work especially effectively to reduce trade frictions across countries in a setting where the GATT/WTO regulations have cleared the ground to a large extent.

The rest of the paper is organized as follows. Section 1.1 discusses the related literature and our contributions. Section 2 documents our classification of PTAs and the corresponding PTA indicators. Section 3 establishes the structural framework and its implied gravity equation. Section 4 presents the parametric estimation methodology and estimation results. The quantitative counterfactual analyses are reported in Section 5 and Section 6 concludes.

1.1 Related Literature

Our paper contributes to the longstanding debate in the literature on whether PTAs indeed promote trade and improve welfare (Viner, 1950; Levy, 1997; Chang and Winters, 2002; Baier and Bergstrand, 2007; Caliendo and Parro, 2015; Anderson and Yotov, 2016). As first highlighted by Viner (1950), PTAs could lead to both "trade creation" and "trade diversion", where PTA member countries increase trade due to reduction in intra-PTA import barriers, but possibly divert sources of imports from lower-cost suppliers (outside the PTA) to higher-cost suppliers (inside the PTA) precisely because PTAs give preferential treatment to member countries. It is possible for the welfare loss caused by trade diversion to dominate the welfare gain due to trade creation for the member countries (Viner, 1950). Relatedly, another distinct theoretical body of literature studies whether deep integration is essential and useful for trade agreements to address global inefficiencies (Bagwell and Staiger, 2001; Antràs and Staiger, 2012; Lee, 2016).

Our analyses suggest that the depth of PTAs enhances their effects on reducing trade costs, and countries with predominantly deep PTA partnerships experience greater welfare gains than countries with predominantly shallow PTA partnerships and further greater than countries with no PTA partnerships. Although theoretically countries outside the PTA partnership could potentially lose out due to trade diversion and general-equilibrium effects, our results indicate that these negative effects are not strong and countries with zero PTA partners experience small, if any, negative welfare effects.

Our paper also contributes to another line of literature that studies how PTAs and the GATT/WTO interact to affect each other's effectiveness and momentum (Ethier, 1998; Krishna, 1998; Krueger, 1999; Estevadeordal, Freund and Ornelas, 2008; Karacaovali and Limao, 2008; Antràs and Staiger, 2012; Bagwell, Bown and Staiger, 2016). The extant

literature has tended to focus on how PTAs can affect the performance and momentum of GATT/WTO-sponsored multilateral trade liberalization. In this paper, we attempt to offer some first insights into the reverse mechanism, i.e., how GATT/WTO might facilitate/weaken the effectiveness of PTAs, and furthermore whether the findings might differ with respect to the depth of PTAs. Our analyses suggest the existence of a potential complementarity between the depth of PTAs and the GATT/WTO multilateral trade liberalization.

Our paper is directly related to two recent empirical research papers that have used the dataset of Hofmann, Osnago and Ruta (2019) to evaluate the trade/welfare effects of PTA depths (Mattoo, Mulabdic and Ruta, 2022; Dhingra, Freeman and Huang, 2023). While Mattoo, Mulabdic and Ruta (2022) focus on estimating the trade effects of PTA depth on members and non-members for the period 2002–2014, Dhingra, Freeman and Huang (2023) provide quantitative assessment of the welfare benefits of deep trade agreements following the Uruguay Round (1995–2011), and of the potential impacts of Brexit.

We contribute to this budding literature by revisiting the issue with an extended sample period (1980–2015) that includes years both before and after the major Uruguay Round trade negotiations, and also years before and after the drastic increase in the number of PTAs in the 1990s. We explore alternative definitions of PTA depth that highlight the coverage of different categories of policy areas, instead of the number counts of policy areas (as adopted in the two papers discussed above). The estimated results suggest that these defined categorical PTA indicators are informative. Within the same micro-founded estimation framework, we also develop methodologies to estimate the corresponding trade effects of GATT/WTO. With both sets of trade cost effect estimates, this allows us not only to conduct quantitative counterfactual exercises to analyze the welfare effect of PTA depth (across years and countries), but also to address the interactions/synergies between PTA depth and the GATT/WTO-induced trade liberalization — a topic of great importance as highlighted above.

2 PTA Data

For our analysis, we compile data on PTA indicators, bilateral trade flows, and trade-cost proxy variables for the period 1980–2015. This period spans the decades before and after the 1990s when the PTAs started to grow in large numbers and in depth. This sample period also covers the changes in multilateral trade environment introduced by the Tokyo Round (1973–1979) and the Uruguay Round (1986–1994) trade negotiations under the GATT, and hence, potential changes in interactions between the preferential and multilateral trade liberalizations. We document below how we construct indicators that characterize the types and

depth of PTAs. The compilations of trade flows and trade-cost proxy variables are standard, and can be found in Appendix A.

We source the PTA data from the Deep Trade Agreements Database of the World Bank,[2] developed by Hofmann, Osnago and Ruta (2019). The database contains 279 PTAs signed among 189 countries between 1958 and 2015 (that were notified to the GATT/WTO and remained in force as of December 2015). Built on the methodology developed by Horn, Mavroidis and Sapir (2010), the dataset identifies 52 policy areas and contains information on the inclusion and legal enforceability of each policy area in these PTAs.

The policy areas are conceptually classified into two broad categories: "WTO-plus" (WTO+) and "WTO-extra" (WTO-X). A policy area is considered to be a WTO+ provision if it falls under the current mandate of the WTO, and the PTA provision reconfirms existing WTO commitments, and in some cases provides for further additional obligations than under the WTO. In contrast, a policy area is classified as a WTO-X provision if it lies outside the current WTO mandate. Specifically, a total of 14 policy areas are categorized as WTO+ provisions. These include, e.g., tariffs on industrial or agricultural goods, customs administration, export taxes, antidumping and countervailing measures, where the parties reconfirm or deepen their existing commitments under the WTO. The remaining 38 policy areas, categorized as WTO-X provisions, address issues that are not yet regulated by the WTO agreements, including: e.g., competition policy, investment measures, movement of capital, and environmental laws. The policy areas can alternatively be differentiated according to their economic relevance. In particular, Hofmann, Osnago and Ruta (2019) classify all 14 WTO+ policy areas and 4 WTO-X policy areas as "Core" provisions, because they form a set of "core" rules for regulating market access and for facilitating global value chains (Damuri, 2012). The remaining 34 WTO-X policy areas are then classified as "Non-Core" provisions. The 18 "Core" provisions can be further divided into "Border" and "Behind-the-Border" measures, depending on whether they are implemented at the border or behind the border. Alternatively, the "Core" provisions can also be classified by whether they are intrinsically discriminatory (referred to as "Preferential" provisions) or applied on a most-favored-nation, nondiscriminatory, basis (referred to as "MFN" provisions). Table 1 summarizes the classification of the PTA provisions discussed above.

Given the 52 policy areas identified, the dataset provides information on whether a policy area is covered in a PTA, and if covered, the strength of its legal enforceability. In particular, Hofmann, Osnago and Ruta (2019) classify a provision as "covered," "weakly legally enforceable," or "strongly legally enforceable" based on reading of the PTA legal texts. A policy area is considered to be covered by a PTA, but not legally enforceable, if the legal

[2] http://data.worldbank.org/data-catalog/deep-trade-agreements.

language regarding the policy area is unclear or loosely formulated. In contrast, a provision is considered "weakly legally enforceable" in a PTA if the language used is sufficiently precise and binding, but the provision is excluded from the use of dispute settlement procedures. A provision is considered "strongly legally enforceable" if it has recourse to dispute settlement mechanisms. In what follows, we adopt the most stringent criterion of "strong legal enforceability" when defining the coverage of a policy area by a PTA. This highlights the importance of dispute settlement procedures in enforcing the relevant provisions.

Given the list of policy areas and their categorization, we characterize the PTAs by their coverage of: (i) WTO+ versus WTO-X policy areas; (ii) "Core" versus "Non-Core" provisions; and (iii) "Border" versus "Behind-the-Border" or (iv) "Preferential" versus "MFN" measures. Figure 1 illustrates the possible combinations of these dimensions and the corresponding PTA indicators. First, based on (i), the PTAs under study fall into three possible categories: PTA_P_X, where a PTA includes both WTO+ and WTO-X policy areas; PTA_P_nX, where a PTA includes some WTO+ provision(s), but none of the WTO-X provisions; and PTA_nP_X, where a PTA includes none of the WTO+ provisions, but covers some WTO-X provision(s). Conceptually, a PTA that covers both WTO+ and WTO-X provisions is likely to be more comprehensive and hence "deeper," compared with PTAs that address only WTO+ or only WTO-X policy areas (the third category is relatively rare in practice).

Alternatively, we can draw the line based on (ii) and categorize PTAs into those that include both "Core" and "Non-Core" policy areas (PTA_C_NC) and those that only cover "Core" policy areas but none of the "Non-Core" policy areas (PTA_C_nNC). All PTAs under study include at least some "Core" policy areas. In a similar way, we can regard PTAs that include both "Core" and "Non-Core" policy areas as being "deeper" than PTAs that include only "Core" policy areas.

We can also measure the depth of PTAs based on (iii) and regard PTAs that include "Border" and also "Behind-the-Border" policy areas (PTA_B_H) as being deeper than PTAs that include only "Border" policy areas (PTA_B_nH). Recall that the distinction of (iii) is conditional on the policy area being a "Core" policy area. Thus, we can regard PTAs that further include "Non-Core" measures in addition to both "Border" and "Behind-the-Border" policy areas as being still deeper ($PTA\_B\_H\_NC$) than without the "Non-Core" measures ($PTA\_B\_H\_nNC$), and similarly, PTAs that include some "Non-Core" measures in addition to only "Border" policy areas ($PTA\_B\_nH\_NC$) to be relatively deeper than without the "Non-Core" measures ($PTA\_B\_nH\_nNC$).

Finally, we instead distinguish the depth of PTAs based on (iv) and regard PTAs that cover both "Preferential" and "MFN" policy areas (PTA_Pref_MFN) as being deeper

than PTAs that include only "Preferential" or "MFN" policy areas (PTA_Pref_nMFN or PTA_nPref_MFN). Because the distinction in (iv) is again limited to "Core" measures, conditional on PTAs that cover both "Preferential" and "MFN" policy areas, a PTA can be regarded as being further deeper if it additionally includes "Non-Core" measures ($PTA\_Pref\_MFN\_NC$) than one without ($PTA\_Pref\_MFN\_nNC$). The PTAs under study that only include either "Preferential" or "MFN" policy areas happen to exclude "Non-Core" measures in either case (and hence PTA_Pref_nMFN is equivalent to $PTA\_Pref\_nMFN\_nNC$, and PTA_nPref_MFN is equivalent to $PTA\_nPref\_MFN\_nNC$).

In our econometric estimations, we adopt these constructed PTA indicators to analyze the effects of PTA depth on trade flows. Note that the PTA subcategories are exhaustive and mutually exclusive in each of the categorizations (a)–(d) in Figure 1. Thus, the weighted average of the effects of PTA sub-indicators in each case amounts to the overall effect of the general PTA indicator.

3 Theoretical Model

Our estimation strategy and counterfactual analysis are based on an extended Melitz (2003) model with untruncated Pareto distribution. Thus, the analysis allows for adjustment at the margins of firm entry, production and export cutoffs, and mass of firms, given changes in variable/fixed trade costs. In addition, we allow input bundles to consist of intermediates in addition to labor, and accommodate input-output linkages in a roundabout manner. Our interest is to isolate the changes in variable/fixed trade costs due to signing of PTAs (of different characteristics/depths), and the implied effects on trade flows and welfare, taking into account these margins of adjustment.

Specifically, in each country (indexed by i), firms decide to whether to enter, to produce, and to export in a forward-looking manner, anticipating the aggregate environment at the stationary equilibrium. Let c_i indicate the cost of an input bundle, in terms of which the production costs are specified. In order to enter, firms need to incur an entry cost, $c_i F_i$, equal to F_i units of the input bundle, before they learn their productivity level $1/a$, drawn from a cumulative Pareto distribution $G_i(a) = (a/\bar{a}_i)^\theta$ for $a \in [0, \bar{a}_i]$. After entry, firms decide whether to produce and serve each potential market, given the fixed production cost $c_i f_{ij}$ and marginal costs $c_i \tau_{ij} a$ for firms of productivity level $1/a$ in country i to serve market j, where $\tau_{ij} > 1$ indicates the variable trade cost factor and f_{ij} the fixed trade cost in terms of input bundles for $i \neq j$.[3]

[3]In robustness checks in Section 5.4, we allow the entry process to use input bundles with different labor intensities from those used in the production process. The modifications to the equations are shown in

Each country is endowed with L_i workers-cum-consumers. Consumers are characterized with constant-elasticity-of-substitution (CES) preferences, with an elasticity of substitution $\sigma > 1$, over the differentiated varieties supplied by firms. The same CES bundle is also used as intermediates in the production of each variety, combined with labor in a Cobb-Douglas manner, to form the input bundle.

Suppose there is an unbounded pool of potential entrants, and at equilibrium, a mass of N_i firms decide to enter. Given that each firm produces a distinct variety and the set of competing firms is dense, firms behave in a monopolistically competitive manner and charge a constant markup equal to $\frac{\sigma}{\sigma-1}$ given the CES preferences. Thus, firms in country i exit from serving market j if its cost draw is above the cutoff a_{ij} defined by the zero-profit condition:

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

where P_j and E_j refer to the aggregate price index and nominal expenditure of country j, respectively.

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

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

indicates the proportion of firms (weighted by their market shares) that export from i to j.[4]

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

$$Y_i = \sum_j X_{ij} = \left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma}N_i\sum_j\left(\tau_{ij}/P_j\right)^{1-\sigma}E_jV_{ij} \tag{3}$$

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

$$X_{ij} = \left(\frac{\tau_{ij}}{\Pi_i P_j}\right)^{1-\sigma}V_{ij}Y_iE_j, \tag{4}$$

Appendix B.

[4]As in Melitz (2003), suitable conditions are imposed such that not all firms export, a well-recognized empirical stylized fact.

$$\Pi_i^{1-\sigma} \equiv \sum_j (\tau_{ij}/P_j)^{1-\sigma} V_{ij} E_j, \tag{5}$$

$$P_j^{1-\sigma} = \sum_i (\tau_{ij}/\Pi_i)^{1-\sigma} V_{ij} Y_i. \tag{6}$$

Equation (4) resembles the structural gravity equation, and Π_i and P_j in Equations (5)–(6) the outward and inward multilateral resistance (MR) to trade proposed by Anderson and van Wincoop (2003), but with the extra term V_{ij}, which captures the margin of trade due to the mass of firms that export from country i to country j. To arrive at an implementable estimation equation, note that the definitions of a_{ij} and V_{ij} in Equations (1) and (2) imply:

$$\tau_{ij}^{1-\sigma} V_{ij} = \left({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{\theta}{\sigma-1}+1} \right) \left({P_j}^{\theta-\sigma+1} \right) \left({c_i}^{-\frac{\sigma\theta}{\sigma-1}+\sigma} \right) \left({E_j}^{\frac{\theta}{\sigma-1}-1} \right). \tag{7}$$

Using Equation (7), we can rewrite the trade flow equation (4) and the MR equations (5)–(6) in terms of variable and fixed trade costs as:

$$X_{ij} = \left(\frac{{\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{-\theta}{\sigma-1}+1}}{\bar{\chi}_i \, \zeta_j} \right) \frac{Y_i E_j}{Y_w} \tag{8}$$

$$\bar{\chi}_i = \sum_j \left({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{-\theta}{\sigma-1}+1} / \zeta_j \right) e_j \tag{9}$$

$$\zeta_j = \sum_i \left({\tau_{ij}}^{-\theta} {f_{ij}}^{-\frac{-\theta}{\sigma-1}+1} / \bar{\chi}_i \right) s_i, \tag{10}$$

where Y_w ($\equiv \sum_i Y_i$) denotes the total world output, $e_j \equiv E_j/Y_w$ denotes the expenditure share of country j, and $s_i \equiv Y_i/Y_w$ denotes the output share of country i.[5] We can regard $\bar{\chi}_i$ as the market access potential of exporter i, defined as the average of its access to each market weighted by the destination market's expenditure share e_j. Similarly, ζ_j can be regarded as the sourcing potential of importer j, with each bilateral sourcing relationship weighted by the source country's supply share s_i.

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

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

where D_j is the nominal trade deficit of country j. We assume that the input bundle combines

[5] Specifically, $\bar{\chi}_i \equiv \frac{\chi_i}{Y_w}$ and $\chi_i \equiv \Pi_i^{1-\sigma} / {c_i}^{-\frac{\sigma\theta}{\sigma-1}+\sigma}$, while $\zeta_j \equiv P_j^{-\theta} / {E_j}^{\frac{\theta}{\sigma-1}-1}$.

labor and intermediate inputs with a constant labor share b_i. Recall that intermediates comprise the full set of goods as for final demand, aggregated using the same CES function. This implies that the cost of an input bundle in country i is

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

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

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

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

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

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

4 Identifications and Estimations

4.1 Identifying Effects of PTA Depth on Trade Costs

Given the trade flow equation (8) and the panel structure of the data, we attempt to isolate the effects of PTA depth as follows. First, we control for the outward and inward MR terms $\bar{\chi}_{it}$ and ζ_{jt} by exporter-year and importer-year fixed effects. This will also absorb any other exporter-year and importer-year specific characteristics (including Y_{it} and E_{jt}). Second, we control for the unobserved trade cost factors $\left({\tau_{ijt}}^{-\theta} {f_{ijt}}^{-\frac{\theta}{\sigma-1}+1}\right)$ by observable trade cost proxies. In particular, we include exporter-importer-pair fixed effects γ_{ij}, and time-varying bilateral trade cost proxies. The pair fixed effect will absorb all country-pair observed and unobserved heterogeneity that might simultaneously affect the volume of trade and the signing of PTAs (Baier and Bergstrand, 2007). In the list of time-varying bilateral trade cost proxies, we include PTA indicators of interest, and other time-varying bilateral characteristics (such as colonial relationships, currency union, and Generalized-System-of-Preferences status) that could affect bilateral trade costs. In sum, we estimate the gravity

equation (8) based on the following specification:

$$\begin{aligned} \ln X_{ijt} &= \beta_1\, gsp_{ijt} + \beta_2\, comcur_{ijt} + \beta_3\, curheg\_o_{ijt} + \beta_4\, curheg\_d_{ijt} + \beta_5\, PTA_{ijt} \\ &\quad + \eta_{it} + \psi_{jt} + \gamma_{ij} + \epsilon_{ijt}, \end{aligned} \tag{15}$$

where in addition to the fixed effect terms introduced above, the list of time-varying bilateral trade cost proxies include: a common currency indicator $comcur_{ijt}$, which equals one if two countries use a common currency at time t; an origin-hegemony indicator $curheg\_o_{ijt}$, which equals one if exporter i is the current colonizer of importer j at time t; a destination-hegemony indicator $curheg\_d_{ijt}$, which equals one if importer j is the current colonizer of exporter i at time t; a GSP indicator gsp_{ijt}, which equals one if exporter i is granted GSP (Generalized System of Preferences) preferential treatment by importer j at time t; and a PTA indicator PTA_{ijt}, which equals one if there is at least one PTA currently in force between exporter i and importer j at time t.

The coefficient estimate ($\hat{\beta}_5$) can be regarded as the average effect of PTAs on trade flows via their impacts on variable and fixed trade costs. Our focus, however, is on the potential heterogeneous effects of PTAs conditional on their contents and depths. Hence, we will subsequently replace the general PTA indicator with the PTA sub-indicators constructed in Section 2. For instance, to examine the effects distinguished by the coverage of WTO+ and WTO-X provisions, we replace PTA_{ijt} with $PTA\_P\_X_{ijt}$, $PTA\_nP\_X_{ijt}$, and $PTA\_P\_nX_{ijt}$.

Table 2 reports the estimation results for the period 1980–2015. First, regarding the time-varying bilateral characteristics (other than PTAs), only $comcur_{ijt}$ is found to have significant and positive effects on trade flows, while the coefficient estimates of gsp_{ijt}, $curheg\_o_{ijt}$, and $curheg\_d_{ijt}$ are insignificant. Given that asymmetric country-pair fixed effects are controlled for, it requires sufficient variations across time in these bilateral characteristics to identify their effects. The insignificance finding is likely due to limited variations within country pairs in colonial relationships and in GSP status during the period studied.[6]

Next, Column (1) in Table 2 reports the coefficient estimate of the general PTA_{ijt} indicator. The result implies that a PTA promotes bilateral imports by 32.4% ($= \exp^{0.281} - 1$), all else being equal. The magnitude and significance of the PTA effect estimate are in line with the literature, as reviewed by Head and Mayer (2015) and Limão (2016). From Columns (2) to (5), the general indicator PTA_{ijt} is replaced by the list of its subcategories, following the categorization of WTO+ and WTO-X, "Core" and "Non-Core", "Border" and "Behind-the-Border", and "Preferential" and "MFN" provisions, respectively.

[6] In the existing literature, the findings on the trade effects of GSP are mixed, and depend on the empirical specification and sample used (Subramanian and Wei, 2007; Rose, 2004; Chang and Lee, 2011; Ornelas and Ritel, 2020).

In Column (2), the general PTA_{ijt} indicator is replaced by the three sub-indicators defined by a PTA's coverage of WTO+ and/or WTO-X provisions. The result indicates that a PTA that includes both WTO+ and WTO-X provisions increases bilateral imports by 33.8%, which is larger than a PTA that includes only WTO+ provisions (29.8%), while the effect of PTAs that include only WTO-X provisions is not significant (recall that this is a relatively rare category). Thus, a deeper trade agreement that builds upon and extends beyond the WTO mandates tends to reduce trade costs by more than PTAs narrowly focused on issues within the WTO mandate.

In Column (3), the PTAs are instead distinguished by their coverage of "Core" and/or "Non-Core" provisions. PTAs that are deeper by covering both "Core" and "Non-Core" provisions are found to promote bilateral imports by a greater degree (38.4%) than PTAs including only "Core" provisions (23.4%). Note also that the difference (38.4% versus 23.4%) is much more pronounced than if the distinction is drawn based on WTO+ and WTO-X (33.8% versus 29.8%). This suggests that PTAs that address issues beyond "Core" provisions are significantly more profound and comprehensive. Although some of the "Non-Core" provisions are not equally relevant from an economic perspective, compared with the "Core" provisions, they help regulate the member economies' domestic environment by improving the levels of "regulatory coherence" across countries (Bagwell, Bown and Staiger, 2016).

When we further differentiate the "Core" provisions into "Border" and "Behind-the-Border" provisions in Column (4), we find that PTAs that cover both "Border" and "Behind-the-Border" provisions promote bilateral imports by a larger extent (26.0%) than PTAs that cover only "Border" measures (20.0%), conditional on no coverage of "Non-Core" measures, and PTAs that further cover "Non-Core" measures in addition to both "Border" and "Behind-the-Border" provisions increase bilateral imports by an even larger extent (38.4%). That is, $\hat{\beta}_{PTA\_B\_H\_NC} > \hat{\beta}_{PTA\_B\_H\_nNC} > \hat{\beta}_{PTA\_B\_nH\_nNC}$. Note that the effect $\hat{\beta}_{PTA\_B\_nH\_NC}$ is not precisely estimated, as it is a rare PTA category (with a small number of observations).

Unlike the previous categorization, where more coverage of policy areas tends to enhance bilateral trade flows, it is ex ante unclear whether coverage of MFN provisions beyond "Preferential" provisions induces members of the PTAs to import more from each other. On one hand, the additional coverage of MFN provisions might erode the preferential trade status of PTA member exporters relative to non-member exporters and hence provide less stimulus to bilateral imports from PTA partners. On the other hand, the MFN provisions might enhance overall imports if they induce more trade openness. The results in Column (5) indicate that the first mechanism dominates and that PTAs that are highly discriminatory without covering any MFN policy areas tend to enhance bilateral imports among the PTA members more than PTAs that additionally include MFN provisions, conditional on no

coverage of "Non-Core" policy areas. Nonetheless, similar to the previous findings, the trade effects of PTAs that cover "Non-Core" provisions dominate those of PTAs that do not ($\hat{\beta}_{PTA\_Pref\_MFN\_NC} > \hat{\beta}_{PTA\_Pref\_nMFN\_nNC} > \hat{\beta}_{PTA\_Pref\_MFN\_nNC}$).

In sum, based on strong legally enforceable provisions, the trade-promoting effects of PTAs on members are strengthened with a broader coverage of policy areas, which helps to achieve deeper forms of integration.

4.2 Identifying Effects of GATT/WTO Membership on Trade Costs

Notably missing from the list of trade-cost proxies included in Equation (15) is the joint GATT/WTO membership status of the exporting and importing countries. The GATT/WTO membership effects are however absorbed by the exporter-year and importer-year fixed effects, as noted by Cheong, Kwak and Tang (2014). In particular, define $bothwto_{ijt}$, $imwto_{ijt}$, and $exwto_{ijt}$ to indicate whether both trading partners are GATT/WTO members, whether only the importer is a GATT/WTO member, and whether only the exporter is a GATT/WTO member, respectively. Cheong, Kwak and Tang (2014) showed that these GATT/WTO membership indicators are jointly multicollinear with the set of exporter-year and importer-year indicators, and thus their effects cannot be separately identified by estimation of Equation (15). In one of our counterfactual analyses, because we are interested in the interaction of PTAs and GATT/WTO, we require partial/direct effects of GATT/WTO on trade flows (via variable/fixed trade costs). We propose the following procedure to identify the GATT/WTO effects. In essence, we (i) regress the combined exporter-year and importer-year fixed effects on the GATT/WTO membership indicators among other terms that are absorbed by the fixed effects (such as the MR terms), (ii) update the trade cost estimates to include the effects of GATT/WTO, (iii) update the structural MR terms given the updated trade cost estimates, and repeat the procedure until convergence. The coefficient estimates of GATT/WTO membership indicators in Step (i) are then taken to be the direct effects of GATT/WTO on trade flows via variable/fixed trade costs.

To start, following the estimation of Equation (15), we can obtain a first-cut estimate of the trade cost term as:

$$\begin{aligned} \ln\left(\tilde{\tau}_{ijt}^{-\theta}\tilde{f}_{ijt}^{-\frac{-\theta}{\sigma-1}+1}\right)^{0} \equiv\ & \hat{\beta}_1\, gsp_{ijt} + \hat{\beta}_2\, comcur_{ijt} + \hat{\beta}_3\, curheg\_o_{ijt} + \hat{\beta}_4\, curheg\_d_{ijt} \\ +\ & \hat{\beta}_5\, PTA_{ijt} + \tilde{\gamma}_{ij}, \end{aligned} \tag{16}$$

which includes the direct effect of the time-varying trade-cost proxies, and also the time-invariant exporter-importer FEs ($\tilde{\gamma}_{ij}$). The latter is included to capture the potential effects

of time-invariant determinants (such as bilateral distance) on bilateral variable/fixed trade costs. Given the trade cost effect estimate by Equation (16) and observables on the output and expenditure shares (s_{it}, e_{jt}), we can then impute the MR terms $\bar{\chi}_{it}$ and ζ_{jt} using the structural relationships in Equations (9) and (10). We then isolate the GATT/WTO effects by estimating the following specification:

$$\begin{aligned} \tilde{\eta}_{it} + \tilde{\psi}_{jt} &= \alpha_1\, bothwto_{ijt} + \alpha_2\, imwto_{ijt} + \alpha_3\, exwto_{ijt} + \alpha_4 \ln Y_{it} + \alpha_5 \ln E_{jt} \\ &- \alpha_6 \ln \tilde{\bar{\chi}}_{it} - \alpha_7 \ln \tilde{\zeta}_{jt} - \alpha_8 \ln Y_{wt} + \epsilon_{ijt}, \end{aligned} \tag{17}$$

where $\tilde{\eta}_{it} + \tilde{\psi}_{jt}$ is the sum of the exporter-year and importer-year FEs estimated from Equation (15), while the controls included on the right-hand side correspond to the underlying structural determinants of $\tilde{\eta}_{it} + \tilde{\psi}_{jt}$ according to Equation (8). The GATT/WTO membership indicators are included to extract the GATT/WTO membership effects absorbed by the combination of the exporter-year and importer-year FEs.

Given the coefficient estimates ($\hat{\alpha}_1$, $\hat{\alpha}_2$ and $\hat{\alpha}_3$) from Equation (17), the trade-cost term is updated to incorporate the estimated effects of the three GATT/WTO indicators on trade costs:

$$\begin{aligned} \left(\ln \tilde{\tau}_{ijt}{}^{-\theta} \tilde{f}_{ijt}{}^{-\frac{-\theta}{\sigma-1}+1}\right)^1 &= \left(\ln \tilde{\tau}_{ijt}{}^{-\theta} \tilde{f}_{ijt}{}^{-\frac{-\theta}{\sigma-1}+1}\right)^0 + \hat{\alpha}_1^0\, bothwto_{ijt} + \hat{\alpha}_2^0\, imwto_{ijt} \\ &+ \hat{\alpha}_3^0\, exwto_{ijt}, \end{aligned} \tag{18}$$

where the superscript '1' indicates the updated estimate and '0' the existing estimate. Given the updated trade cost effect estimate, we then repeat the iteration procedure, by updating the MR terms by Equations (9) and (10), and the GATT/WTO membership effect estimates by Equation (17), until convergence.

The results are reported in Table 3. First, we find that joint GATT/WTO membership $bothwto_{ijt}$ raises bilateral imports by 15.7%. This is consistent with the ex ante expectation, since when a country becomes a GATT/WTO member, it must apply the tariff-bindings and nontariff commitments negotiated (in its accession package or in general trade negotiation sessions) by the MFN principle to all other GATT/WTO members. This is expected to lower the variable/fixed trade costs for imports by members from other members. Second, the *bothwto* effect is further larger than the *imwto* and *exwto* effects ($\hat{\alpha}_1 > \hat{\alpha}_2$; $\hat{\alpha}_1 > \hat{\alpha}_3$). The insignificant estimate of the *imwto* effect suggests that members do not extend their policy liberalization to imports from nonmembers on average. Third, we find that *exwto* has a small and negative effect (−2.1%) on bilateral trade flows from member exporters to nonmember importers. We interpret this finding as a result of the GATT/WTO regulations on its

members' use of export and production subsidies, by prohibiting, regulating, or phasing-out such subsidies on industrial or agricultural goods. Member exports in affected sectors are likely to decrease when not offset by trade policy liberalization in the destination markets of the nonmembers.

5 General Equilibrium Effects

In this section, we evaluate the general-equilibrium effects of PTAs, and their interaction with the GATT/WTO multilateral trading system. We then verify the robustness of the benchmark findings to the choice of parameter values, and changes in the theoretical setup.

5.1 Counterfactual Analytical Framework

We rewrite the system of structural equations introduced in Section 3 and transform the variables in levels to variables in ratios à la the hat algebra of Dekle, Eaton and Kortum (2007).[7] In particular, let x' denote the counterfactual value of a variable x, and $\widehat{x} \equiv x'/x$ the ratio of the counterfactual to the factual value of the variable. This allows us to analyze arbitrary shocks to the economy (say, shutting down all PTAs) and the resulting equilibrium in the counterfactual scenario relative to the factual one.

First, by the labor market-clearing condition in Equation (14), we have:

$$\widehat{Y}_i = \widehat{w}_i. \tag{19}$$

Next, by the aggregate budget constraint in Equation (11), it follows that:

$$\widehat{E}_i = \frac{Y_i}{E_i}\widehat{Y}_i + \frac{D_i}{E_i}\widehat{Y}_w, \tag{20}$$

where $\widehat{Y}_w = \sum_i s_i \widehat{Y}_i$. In deriving Equation (20), we have assumed that the ratio of a country's nominal trade deficit to the world gross output is fixed in the counterfactual as in the factual scenario ($\widehat{D}_i = \widehat{Y}_w$), following Caliendo and Parro (2015).

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

$$\widehat{c}_i = \widehat{w}_i^{b_i} \widehat{P}_i^{1-b_i}. \tag{21}$$

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

Further, the free-entry condition (13) implies that:

$$\widehat{N}_i = \widehat{Y}_i / \widehat{c}_i. \tag{22}$$

Next, note that given Equation (7) for the trade margins, we have:

$$\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} = \left(\widehat{\tau}_{ij}^{-\theta} \widehat{f}_{ij}^{-\frac{\theta}{\sigma-1}+1} \right) \left(\widehat{P}_j^{\theta-\sigma+1} \right) \left(\widehat{c}_i^{-\frac{\sigma\theta}{\sigma-1}+\sigma} \right) \left(\widehat{E}_j^{\frac{\theta}{\sigma-1}-1} \right). \tag{23}$$

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

$$\widehat{\Pi}_i^{1-\sigma} = \sum_j \rho_{ij} \left(\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} / \widehat{P}_j^{1-\sigma} \right) \widehat{E}_j, \tag{24}$$

$$\widehat{P}_j^{1-\sigma} = \sum_i \lambda_{ij} \left(\widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij} / \widehat{\Pi}_i^{1-\sigma} \right) \widehat{Y}_i, \tag{25}$$

where $\rho_{ij} \equiv X_{ij}/Y_i$ is the share of country i's sales that go to destination j, and $\lambda_{ij} \equiv X_{ij}/E_j$ is the share of country j's expenditure that is spent on goods from source i.

Finally, the market-clearing condition in Equation (3) and the definition of the outward MR term in Equation (5) imply that:

$$\widehat{Y}_i = \widehat{N}_i \, \widehat{c}_i^{1-\sigma} \, \widehat{\Pi}_i^{1-\sigma}. \tag{26}$$

The system above can be solved in terms of $\{\widehat{w}_i\}$ and $\left\{\widehat{P}_j\right\}$, given exogenous shocks to the trade costs $\left\{\widehat{\tau}_{ij}^{-\theta} \widehat{f}_{ij}^{-\frac{-\theta}{\sigma-1}+1}\right\}$. In particular, given some initial guess of $\{\widehat{w}_i\}$ and $\left\{\widehat{P}_j\right\}$, the system of equations (19)–(25) can be used in the listed order to update the ratios of variables $\left\{\widehat{Y}_i, \widehat{E}_i, \widehat{c}_i, \widehat{N}_i, \widehat{\tau}_{ij}^{1-\sigma} \widehat{V}_{ij}, \widehat{\Pi}_i^{1-\sigma}, \widehat{P}_j^{1-\sigma}\right\}$, and in turn, Equation (26) can be used to update $\widehat{w}_i$ $(=\widehat{Y}_i)$. This procedure is repeated until convergence in terms of $\{\widehat{w}_i\}$ and $\left\{\widehat{P}_j\right\}$. The welfare effects given exogenous changes in trade cost can then be measured by:

$$\widehat{W}_i = \widehat{w}_i / \widehat{P}_i. \tag{27}$$

This formula evaluates the welfare effect based on changes in the real output, although in principle we can also examine changes in the real expenditure (the two could differ due to the presence of trade deficits).

To illustrate the algorithm, suppose the coefficient estimate of a PTA indicator is β from Section 4. By eliminating the pertinent PTAs in the counterfactual, this introduces shocks to

the trade-cost term by $\left\{\widehat{\tau}_{ijt}{}^{-\theta}\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\right\} = \exp(-\beta)$ for country-pair-years where the PTA indicator equals one. The shock $\left\{\widehat{\tau}_{ijt}{}^{-\theta}\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\right\}$ can then be fed into the system (19)–(26) to derive the counterfactual equilibrium relative to the factual, and the corresponding effects of the PTA indicator on the welfare (27) and other endogenous variables. Similarly, we can calculate how changes in trade costs due to other changes in PTA status and/or GATT/WTO membership status affect the endogenous variables in the economy, taking into account general equilibrium adjustments.

Implementing the algorithm requires inputs on the parameter values for the elasticity of substitution σ, the Pareto distribution dispersion parameter θ, and the value-added share $\{b_{it}\}$. We set $\sigma = 5$, which lies within the range of trade elasticity often reported in the gravity literature; see Head and Mayer (2015) for a meta-analysis. For θ, we choose the value based on the estimate of $\theta - (\sigma - 1)$ in Helpman, Melitz and Yeaple (2004). Most of their estimates fall in the range of $[0.5, 1.5]$. We adopt $\theta - (\sigma - 1) = 1$ as the benchmark; i.e., $\theta = 5$ when $\sigma = 5$.[8] For $\{b_{it}\}$, we use the share of value added in gross output, calculated for each country-year, as elaborated in Appendix A. The value $\{b_{it}\}$ varies in the range of $[0.26, 0.62]$ across country-years for the period of study.

The implementation also requires inputs on the shares $\{\rho_{ijt}, \lambda_{ijt}\}$, which can be imputed from data on trade and gross output. In the data, a country does not necessarily trade with every potential trading partner. Such trading relationships will be reflected by $\rho_{ijt} = 0$ and $\lambda_{ijt} = 0$. All counterfactual changes in the trade costs calculated for these country pairs are multiplied by zero shares and hence do not affect the counterfactual results. In a sense, this is internally consistent, since the current framework cannot explain zero trade and counterfactual changes in the occurrence of zero trade. It is best to leave out zero-trade relationships from the analysis. Thus, whatever counterfactual effects we obtain using the current framework are conditional on the positive trading relationships. This also suggests that the regression estimates we obtained in Section 4 based on positive trade flows are consistent with the design of the counterfactual analysis.

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

5.2 General Equilibrium Effects of PTA and PTA Subcategories

For the counterfactual analysis, we drop countries with poor data quality, and adjust the set of countries until the implied expenditure and domestic trade share of all countries are positive. We call this set of countries the pseudo world, and calculate the supply and expenditure shares of each country relative to the pseudo world. The characteristics of the countries included in the counterfactual analysis are reported in Table 4 and Table 5. As shown in Table 4, the coverage of the pseudo world in terms of GDP share and import share is very close to that of the actual world. In Table 5, we characterize the pseudo world import flows by the PTA status or GATT/WTO membership status. As indicated, countries with PTAs in force have surged in numbers since the 1990s. Correspondingly, the import flows covered by PTAs have increased substantially, from 21.5% in 1980 to 50.5% in 2015. In sum, the pseudo world covers a total of 244 PTAs for the period 1980–2015. A detailed list of these PTAs is provided in Table 6.

Given the set of countries, we conduct counterfactual analysis for the period 1980–2015 based on the Melitz framework laid out in Section 5.1. We consider the counterfactual if all PTAs were eliminated. The shocks to the trade costs $\left\{\widehat{\tau}_{ijt}{}^{-\theta}\widehat{f}_{ijt}{}^{-\frac{\theta}{\sigma-1}+1}\right\}$ for each country-pair-year observation are calculated given the coefficient estimates of PTA indicators in Table 2.[9] The effects of PTAs on a variable of interest x are then imputed as: $(1-\widehat{x})\times 100\%$.

We start by studying the welfare effects of PTAs, based on the estimated effect of the general PTA indicator in Column (1) of Table 2. Figure 2 summarizes the findings. In order to better present the results, we classify the countries by the number of trading relationships they have where a PTA is in force in a year: zero, greater than zero but fewer than the median, or greater than or equal to the median of the year across countries. Due to space constraints, we report the results for every five-year interval. Figure 2 shows that the distribution of PTA welfare effects becomes increasingly more dispersed with a longer right tail over the decades. The countries with more PTA partners tend to gain more in terms of welfare relative to countries with fewer or no PTA partners. In early years, the mass of countries with PTA partners is small, and the welfare effects are concentrated around zero; countries with above-the-median number of PTA partners gain in the range of $[0, 3\%]$. The distribution of PTA welfare effects starts to become more dispersed in 2000, especially for those countries with above-the-median number of PTA partners, with welfare gains sometimes in the range of $[5\%, 10\%]$. Although theoretically countries outside the PTA partnership could potentially lose out due to trade diversion and general-equilibrium effects, Figure 2 shows that these negative effects are not strong and countries with zero PTA partners experience small, if

[9] Only significant PTA effect estimates are used as inputs for the counterfactual analyses; insignificant estimates are taken to be zeros.

any, negative welfare effects.

Table 7 summarizes the welfare effects by geographical region of the countries. We see that all OECD countries have gained, and in 2015 the mean and median gains of the OECD countries ($\sim$ 2%) are the greatest compared with the other regions. In 2015, East and South Asia, and Eastern Europe and Central Asia have some very big winners (7.09%) and some small losers (-0.11%), leaving an overall positive welfare impact. Latin American and Caribbean countries have experienced relatively homogeneous and positive welfare effects, with a mean or median gain of $\sim$ 0.7%. Sub-Saharan Africa is the region that has seen generally smaller positive effects from PTAs. The remaining 'Other' region has experienced on average moderately positive welfare effects from PTAs.

In Figure 3 to Figure 6, we differentiate PTAs by their depths, and apply the heterogeneous trade-cost effect estimates in Columns (2)–(5) of Table 2 for each country-pair-year observation according to the type of PTAs that are in force for each country-pair-year observation (as inputs for the counterfactual analyses). To summarize the welfare effects across countries, we classify countries by the predominant type of PTAs that are in force in a country's trading partnerships. For example, in Figure 3, which allows for differential trade-cost effect estimates of PTAs according to their coverage of WTO+ and/or WTO-X provisions, a country is classified to be in the group "PTA_nP_X", "PTA_P_nX" and "PTA_P_X", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others.[10]

Figure 3 suggests that countries with a dominant number of PTAs that are in deeper forms of integration tend to gain more in welfare relative to countries with a dominant number of shallower PTAs. In particular, the welfare effect distribution of the country group "PTA_P_X" tends to dominate that of the country group "PTA_P_nX", and further dominates the remaining groups of countries. This to a large extent reflects the hierarchy in the trade-cost effect estimates of PTAs that increase in magnitude with the depth of the PTAs (cf. Column (2) of Table 2). In general, the overall effects on a country's trade and welfare might also depend on the prevalence of deep PTAs (beyond being dominant) across all trading partnerships of a country, and the strength of complementarity between deep PTAs and the existing bilateral trade volumes. Interestingly, despite these additional considerations, the heterogeneity in the PTA welfare effects at the country level preserves the hierarchy in the trade-cost effect estimates of PTA depths, by simply grouping countries according to the predominant type of PTAs that a country signs.

[10]Note that to simplify notations, we have used the same symbols for the country grouping as the PTA subcategory indicators, PTA_nP_X, PTA_P_nX and PTA_P_X, respectively. Refer to Figure 1 for more details on the differentiation and combination of the subsets.

In Figure 4, the counterfactual analysis instead applies the trade-cost effect estimates of PTAs differentiated by their coverage of Core and/or Non-Core provisions, as reported in Column (3) of Table 2. Based on a similar approach, a country is classified to be in the group "PTA_C_nNC" and "PTA_C_NC", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others. We observe a similar pattern as previously noted: countries with a dominant number of deeper PTAs (covering both Core and Non-Core provisions) tend to gain more in terms of welfare, relative to countries with a dominant number of shallower PTAs (covering only Core provisions), and further more than countries with no PTAs.

Figure 5 repeats a similar analysis but applies the trade-cost effect estimates of PTAs from Column (4) of Table 2, differentiated by their coverage of Border/Behind-the-Border Core provisions and Non-Core provisions. A country is classified to be in the group "PTA_B_nH_nNC", "PTA_B_nH_NC", "PTA_B_H_nNC", and "PTA_B_H_NC", respectively, in a year if the number of its trading partnerships belonging to each of these categories dominates the others. In this case, the welfare-effect distribution of countries with a predominant number of the deepest type of PTAs ("PTA_B_H_NC") still clearly dominates those of countries with a predominant number of shallower types of PTAs. However, the distinction is not as clear-cut between the two groups of countries with a predominant number of either shallower PTAs ("PTA_B_nH_nNC" versus "PTA_B_H_nNC"), although $PTA\_B\_H\_nNC$ has a larger effect than $PTA\_B\_nH\_nNC$ on trade costs (cf. Column (4) of Table 2). Thus, in this case, the composition and prevalence of PTA types in a country's trading partnerships (as well as the other considerations discussed above) blurs the distinction at the country level for countries having predominantly shallower PTAs.

Finally, based on distinctions drawn with respect to PTAs' coverage of preferential/MFN Core provisions and Non-Core provisions, Figure 6 suggests a similar pattern as previously noted: countries with a dominant number of deeper PTAs (covering both Core and Non-Core provisions, "PTA_Pref_MFN_NC") tend to gain more in terms of welfare, relative to countries with a dominant number of shallower PTAs (covering only Core provisions). In turn, countries with a dominant number of shallower PTAs that exclude MFN provisions ("PTA_Pref_nMFN_nNC") tend to gain more in terms of welfare, relative to countries with a dominant number of shallower PTAs that include MFN provisions ("PTA_Pref_MFN_nNC"). This hierarchy in welfare gains across countries by the predominant type of PTAs that countries sign is in line with the ranking of these PTA subcategories in lowering bilateral trade costs (i.e., $\hat{\beta}_{PTA\_Pref\_MFN\_NC} > \hat{\beta}_{PTA\_Pref\_nMFN\_nNC} > \hat{\beta}_{PTA\_Pref\_MFN\_nNC}$) as reported in Column (5) of Table 2.

In sum, the trade-promoting and welfare-enhancing effects of PTAs are greater, the more

prevalent deeper PTAs are in a country's trading partnerships. Countries with predominantly deeper PTAs that include both WTO+ and WTO-X provisions, Core and Non-Core provisions, Border, Behind-the-Border and Non-Core provisions, or alternatively, Preferential, MFN, and Non-Core provisions tend to experience larger gains. Given that PTAs have become more prevalent and deeper over the decades, the distribution of PTA welfare effects has become more dispersed with thicker right tails. PTAs thus have played increasingly important role in deepening trade integration and creating welfare gains beyond the conventional WTO mandates and scopes.

5.3 Interaction of PTA and GATT/WTO

The tension and interaction between the preferential approach to trade liberalization (via PTAs) and the multilateral approach (via GATT/WTO) have been a hotly debated theoretical and policy question in the literature. Baldwin (2008) identifies three perspectives on how PTA and GATT/WTO could interact: (i) a PTA could affect the performance and momentum of GATT/WTO-sponsored multilateral trade liberalization; (ii) GATT/WTO could faciliate/weaken the effectiveness and formation of PTAs, or (iii) the momentum and outcome of both could be driven by some third factors. The literature has studied the first perspective extensively (Bagwell, Bown and Staiger, 2016; Antràs and Staiger, 2012; Karacaovali and Limao, 2008; Estevadeordal, Freund and Ornelas, 2008; Krueger, 1999; Krishna, 1998; Ethier, 1998). In this section, we attempt to offer some insights into the second perspective, by quantifying the role of GATT/WTO in facilitating/weakening the effectiveness of PTAs, and examining whether the answer depends on the depth of PTAs. In particular, we evaluate the welfare effects of PTAs and PTA depth in the counterfactual scenario without GATT/WTO, and compare the results with those under factual GATT/WTO membership status as studied in Section 5.2.

Figure 7 summarizes the results, where Panels (a)–(e) are based on the PTA trade-cost effect estimates in Columns (1)–(5) of Table 2, respectively, and the GATT/WTO membership effect estimates in Table 3. Panel (a) indicates that the welfare-promoting effects of PTAs are lower in the counterfactual without GATT/WTO. Thus, GATT/WTO-induced trade liberalization reinforces that of PTAs. The complementarity tends to be stronger for countries with a larger number of PTA partnerships (cf. Panel (a)), and more pronounced in recent decades.

Panels (b)–(e) suggest that countries benefit less from PTAs (both shallow and deep) in a world without GATT/WTO. In earlier decades, the complementarity of GATT/WTO for PTAs tends to be stronger for countries with predominantly shallow PTAs. However, starting

1995, the synergy between GATT/WTO and deep PTAs becomes stronger. Countries with predominantly the deepest forms of PTAs ("PTA_P_X", "PTA_C_NC", "PTA_B_H_NC", or "PTA_Pref_MFN_NC") would have experienced much lower welfare gains from their PTAs, in the absence of the multilateral trade liberalization. The period since 1995 was also a period when PTAs surged in numbers, and when the GATT/WTO membership size expanded significantly following the Uruguay Round negotiations.

In sum, the findings in this section provide supporting evidence of the potential complementarity between GATT/WTO and PTAs (and in particular, the deeper forms of PTAs). As highlighted by Figure 7, without the trade barrier reductions brought about by GATT/WTO, countries with predominantly PTAs of higher provisional depth would have gained much less (more so than countries with predominantly shallow agreements), and this is increasingly the case in recent decades. This might suggest that deep PTAs work especially effectively to reduce trade frictions across countries in a setting where the GATT/WTO regulations have cleared the ground to a large extent.

5.4 Robustness Checks

In this section, we conduct several sensitivity analyses. First, we allow θ to vary within a range of values suggested by the literature (discussed in Footnote 8). A higher θ is expected to lower the welfare effects in the Melitz model, since the same observed changes in trade flows $\left({\tau_{ijt}}^{-\theta} {f_{ijt}}^{-\frac{\theta}{\sigma-1}+1}\right)$ imply smaller changes in the underlying trade costs. Indeed, Table 8 indicates that the median welfare effects of PTAs across countries monotonically decreases as θ increases, from 4.5 to 10, given $\sigma = 5$. We then experiment by raising the elasticity of substitution to an extremely high value ($\sigma = 10$). We expect this to lower the welfare effects of PTAs, because varieties in consumer preferences become closer substitutes. Given the constraint $\theta > (\sigma - 1)$ required for well-defined aggregate price indices, we also modify θ upward to $\theta = 10$ when setting $\sigma = 10$. These parameter values are close to the upper bound used in the literature, so we can take the associated welfare effects under this setting as the lower-bound predictions. Across this range of parameter values, countries with more than the median number of PTAs in 2015 enjoy median welfare gains in the range of [0.44%, 1.61%], while countries with fewer than the median number of PTAs in 2015 experience much smaller median welfare gains, in the range of [0.06%, 0.24%].

Next, we allow the entry process in the Melitz model to use input bundles that have higher labor intensity than the input bundles used in the production process, following Bollard, Klenow and Li (2016) [BKL] and Arkolakis, Costinot and Rodríguez-Clare (2012). The modifications to the counterfactual equations are shown in Appendix B. Let κ denote

the value-added share in the entry process. The mean value-added share across the entry and the production process is then: $\bar{b}_{it} \equiv b_{it}\left(1-\frac{\sigma-1}{\sigma\theta}\right)+\kappa\left(\frac{\sigma-1}{\sigma\theta}\right)$. The value $\bar{b}_{it}$ corresponds to the value-added share observed in the data. Since the maximum value-added share observed across country-years in the data is 0.62, we set κ to take on values in $[0.8, 1]$ and calibrate b_{it} for given κ and observed $\bar{b}_{it}$. The effects on firm entry are summarized in Table 9, where we also include the benchmark case (when $\kappa = b_{it} = \bar{b}_{it}$). Consistent with theoretical implications, the relatively larger increase in wages relative to aggregate prices (for countries that gain in real wages with PTAs) implies a higher entry cost as κ increases, and hence weakens the incentive for entry. To the limit when $\kappa = 1$, the mass of firms remains constant, as in the original Melitz model. This pattern (weaker entry effects as κ increases) holds across different parameter values for σ and θ.

In spite of the impacts on firm entry as κ changes, Table 8 indicates that the impact of varying κ on welfare is negligible. To understand this result, note that we calibrate the parameter to imply the same mean value-added share as observed in the data. As κ increases in the entry process, for a given observed value-added share $\bar{b}_{it}$, this implies smaller b_{it} in the production process. A larger κ reduces the welfare effects (via weaker firm entry effects), but a smaller b_{it} amplifies them (since the multiplier effect via the use of intermediates in production is stronger). The simulation results suggest that these two countervailing effects exactly cancel out.

6 Conclusion

In this paper, we use a Melitz-type model to guide our analysis of the relationship between the depth of PTAs and trade flows. We provide a comprehensive analysis of the effects of PTA depths on trade flows and national welfare for a panel of 160–192 economies during the period 1980–2015. We explore alternative definitions of PTA depth that highlight the coverage of different categories of policy areas. The results suggest that countries with more PTA partnerships and with predominantly deep PTA partnerships experience larger welfare gains. The welfare benefits of deep PTAs become more pronounced in recent decades when the PTAs surge in number and increase in depth. Countries outside PTA alliances experience small, if any, welfare losses. Welfare effects are heterogeneous across geographical regions, with disproportionately larger gains accruing to Europe and Asia. We also develop methodologies to estimate the GATT/WTO membership effects on trade costs within the same structural framework, and compare the welfare effects of PTA depths in a world with and without the GATT/WTO-induced trade liberalization. The findings indicate a positive synergy between the two distinct approaches to trade liberalization, and suggest that the

GATT/WTO framework of regulations enhances the welfare benefits of PTAs, and this is especially the case with deep PTAs.

For future work, several lines of investigation are of potential interest. First, we have defined the depth of PTAs based on coverage of different categories of policy areas. It would be interesting to investigate what provisions in each category are critical and whether comprehensive coverage of policy areas within each category matters. This investigation can help identify the specific channel(s) through which the depth of PTAs affects trade flows. Second, based on general-equilibrium counterfactual analyses, we do not find significant trade diversion or negative welfare effects on countries without PTAs. Although theories abound on how PTAs can divert trade that would otherwise have occurred between PTA-partner countries and third countries, and hence impose negative TOT externalities on third countries, the increasing prevalence of PTA partnerships and the increasing depths of PTAs might have changed the premise fundamentally. It would be interesting in future work to assess whether and how the depth of PTAs might moderate trade diversion and the TOT impacts of PTAs, by zooming in to different types of PTAs and conducting counterfactual analyses specific to each type of PTA (in contrast to an overall elimination of all PTA partnerships, as is done in our counterfactual analysis here). Last but not least, given the welfare benefits of deep PTAs documented in this paper, it is of policy interest to examine the mechanism design of PTA negotiations that would result in successively deeper integrations, in a parallel way as the GATT's foundation principles (such as reciprocity) have helped foster successive rounds of tariff reductions and regulatory harmonization on domestic, behind-the-border, policies. The findings that the GATT/WTO complements deep PTAs also suggest that the two approaches to trade liberalization might need to be brought under the same umbrella with increased dialogues and coherence in their negotiation protocols.

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A Data Appendix

A.1 Bilateral Trade Flows

Bilateral merchandise trade flows are obtained from the Correlates of War (COW) project.[11] Since the data on trade were reported only up to 2014, we construct the merchandise trade flows for 2015 using the IMF Direction of Trade Statistics (DOTS),[12] based on the COW's method.

We also attempt to incorporate bilateral commercial services trade. We first source the data from the "WTO-UNCTAD-ITC annual trade in services dataset".[13] We combine the information from its two databases: "Trade in commercial services, 2005–onwards (BPM6)" and "Trade in commercial services, 1980–2013 (BPM5)". Specifically, we take the series "*Memo item: Total services*" (with product code "*S200*") from BPM6 and supplement it with the corresponding series from BPM5. For remaining missing entries, we further supplement with the series "*Total EBOPS Services*" from the World Bank's "Trade in Services Database" available for the period 1985–2011.[14]

The total bilateral trade across country pairs is constructed as the sum of bilateral merchandise trade and bilateral commercial services trade for the period 1980–2015.

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

We use the GDP data from the World Bank's World Development Indicators (WDI),[15] and supplement the missing entries with the GDP data from the CEPII's gravity dataset.[16,17] We construct the gross output Y_{it} data by taking the ratio of GDP and the value-added share b_{it} in gross output: $Y_{it} = GDP_{it}/b_{it}$.

The data on value-added share b_{it} are sequentially sourced from several databases as follows. The first source is the "STAN STructural ANalysis Database",[18] which covers 37 countries for years from 1970 to 2017. We take the ratio of "*Value added, current prices*" and "*Production (gross output), current prices*" for "*Industry: Total*".[19] The next alternative source is the WIOD Socio-Economic Accounts: November 2016 release (with data for 2000–2014); July 2014 release (with data for 1995–2011); and February 2012 release (with data for

[11] http://www.correlatesofwar.org/data-sets/bilateral-trade.
[12] http://www.imf.org/en/Data.
[13] https://www.wto.org/english/res_e/statis_e/trade_datasets_e.htm.
[14] https://datacatalog.worldbank.org/dataset/trade-services-database.
[15] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.
[16] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8.
[17] http://sites.google.com/site/hiegravity/data-sources.
[18] https://www.oecd.org/industry/ind/stanstructuralanalysisdatabase.htm.
[19] https://stats.oecd.org/Index.aspx?DataSetCode=STANI4_2016.

1995–2009).[20] We use the later release as much as possible. The third source is the Input-Output Tables (IOTs) from the OECD Input-Output database,[21] with four editions available: 2018 edition (ISIC Rev.4), 2015 edition (ISIC Rev.3), 2002 edition (ISIC Rev.3), 1995 edition (ISIC Rev.2). We use the later edition as much as possible. For example, given the 2018 edition of IOTs, we calculate the value-added share by aggregating the "*Value added at basic prices*" and "*Output at basic prices*", respectively, across all sectors (from "*Agriculture, forestry and fishing*" to "*Private households with employed persons*") and taking their ratio. We fill in the remaining missing entries as follows: (1) $b_{it} = b_{i,T_i^e}$ for all $t > T_i^e$, where T_i^e is the latest year with data on value-added share for country i; (2) $b_{it} = b_{i,T_i^s}$ for all $t < T_i^s$, where T_i^s is the earliest year with data on value-added share for country i; (3) $b_{it} = (b_{i,t_i^1} + b_{i,t_i^2})/2$ 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 data on value-added shares, we use the value-added shares of the rest of the world (ROW) from the 2015 edition of IOTs.

A.3 Expenditures

Based on data on bilateral trade flows, we construct the trade deficit of a country by: $\tilde{D}_{jt} = \sum_i X_{ijt} - \sum_i X_{jit}$. If the world trade deficit $\tilde{D}_{wt}$ is not equal to zero exactly, we allocate the discrepancy $\tilde{D}_{wt}$ to each country in proportion to its output share of the world, i.e., $D_{jt} = \tilde{D}_{jt} - s_j \tilde{D}_{wt}$. The gross expenditure of a country is then constructed as $E_{jt} = Y_{jt} + D_{jt}$.

A.4 Proxies for Asymmetric Bilateral Trade Cost

Other than the PTA indicators documented in the main text, the remaining trade cost proxy variables are mostly taken from CEPII's gravity dataset and GeoDist dataset.[22] 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 based on the CEPII variables *gatt_o* and *gatt_d* (which equal one if the exporting country or the importing country is a GATT/WTO member, respectively). We cross-check and correct the WTO membership entries in the CEPII dataset, with reference to the WTO website.[23]

The other variables taken from CEPII include the common currency indicator, $comcur_{ijt}$, which equals one if two countries share a common currency in year t; and the colonial

[20] http://www.wiod.org/database/seas16.

[21] https://www.oecd.org/sti/ind/input-outputtables.htm.

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

[23] For example, Madagascar has been a member of GATT since 1963 and a member of WTO since 1995 according to the WTO website, but it is listed as a nonmember in CEPII's gravity dataset.

relationship indicators: heg_o_{ij}, indicator for whether exporter i has ever been a colonizer of importer j, and heg_d_{ij}, indicator for whether importer j has ever been a colonizer of exporter i. Because the identity of a colonizer versus a colony did not switch during the period of our study, we construct the indicator for whether exporter i is currently a colonizer of importer j based on the CEPII variable $curcol_{ijt}$ (whether i is currently a colony of j or vice versa) and 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 $heg\_d_{ij} = 1$.

The data on the GSP indicator, gsp_{ijt}, for whether importer j offers exporter i GSP preferential treatment are sourced from the Database on Economic Integration Agreements (April 2017).[24] We supplement the first source with information from the WTO's Database on Preferential Trade Agreements.[25] For remaining missing entries, we compile the data manually from the "Generalized System of Preferences: List of Beneficiary Countries" reported by the UNCTAD.[26] The UNCTAD updates the information on the GSP schemes from time to time, but not annually (available for years 2001, 2005, 2006, 2008, 2009, 2011, and 2015).

A.5 Pseudo World

For the counterfactual analysis, we drop countries with poor data quality. First, we drop countries that do not have GDP data. We also drop countries that do not import or export to any other countries. Given the set of remaining countries, we construct trade deficits and expenditures as discussed above, and drop countries if the constructed expenditure is negative. We also drop countries if its domestic 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 domestic trade of all countries are positive. We call this set of countries the pseudo world, and calculate the supply and expenditure shares of each country relative to the pseudo world. The characteristics of the countries included in the counterfactual analysis are documented in Table 4 and Table 5.

[24] https://www3.nd.edu/~jbergstr/.
[25] http://ptadb.wto.org/.
[26] http://unctad.org/en/Pages/DITC/GSP/GSP-List-of-Beneficiary-Countries.aspx.

B Math Appendix

B.1 Alternative Formulations of the Input Bundle

This appendix modifies the theoretical setup for the input bundle and allows the entry process to use input bundles whose labor intensity differs from that in the production process. Let Equation (12) continue to characterize the cost of the input bundle used in the production process. Let the entry process use input bundles with labor intensity κ such that the cost of the input bundle used in the entry process is:

$$c_i^e = w_i^\kappa \, P_i^{1-\kappa}. \tag{28}$$

The free-entry condition in Equation (13) is modified as:

$$\frac{\sigma-1}{\sigma\theta} Y_i = N_i F_i c_i^e, \tag{29}$$

and the labor-market clearing condition is instead:

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

These translate into counterfactual conditions for the entry cost bundle:

$$\widehat{c}_i^e = \widehat{w}_i^\kappa \, \widehat{P}_i^{1-\kappa}, \tag{31}$$

for free entry:

$$\widehat{Y}_i = \widehat{N}_i \, \widehat{c}_i^e, \tag{32}$$

and for labor-market clearing, which remains the same as Equation (19). Thus, we have one extra set of variables $\{\widehat{c}_i^e\}$ to determine but also one extra set of conditions in (31).

Define $\bar{b}_{it} \equiv b_{it}\left(1 - \frac{\sigma-1}{\sigma\theta}\right) + \kappa\left(\frac{\sigma-1}{\sigma\theta}\right)$. The value $\bar{b}_{it}$ corresponds to the value-added share observed in the data. The assumption $\kappa = b_{it}$ corresponds to the case where $\bar{b}_{it} = b_{it}$. Following Bollard, Klenow and Li (2016), we allow for the scenarios where the input bundle used for entry is more labor intensive than in production, i.e., $\kappa > b_{it}$. Thus, we set κ to take on values greater than $\max_{it}\{\bar{b}_{it}\}$, where $\max_{it}\{\bar{b}_{it}\}$ is the maximum value-added share observed across country-years in the data (0.62). In particular, we allow κ to take on values in $[0.8, 1]$. Given $\bar{b}_{it}$ and κ, we then back out the values for b_{it}.

Table 1: Classification of PTA provisions

WTO+ (P)	Core (C)	Border (B)	Preferential (Pref)	Tariffs on industrial goods Tariffs on agricultural goods Anti-dumping Countervailing measures Export taxes
			MFN	TRIMS measures TRIPS SPS measures TBT measures Customs administration
		Behind-the-Border (H)	Preferential (Pref)	Public procurement
			MFN	State-owned enterprises GATS State aid
WTO-X (X)				Competition policy IPR Investment measures
		Border (B)	MFN	Movement of capital
	Non-Core (NC)	Non-Core (NC)	Non-Core (NC)	Anti-corruption Environmental laws Labor market regulation Consumer protection Data protection Agriculture Approximation of legislation Audiovisual Civil protection Innovation policies Cultural cooperation Economic policy dialogue Education and training Energy Financial assistance Health Human rights Illegal immigration Illicit drugs Industrial cooperation Information society Mining Money laundering Nuclear safety Political dialogue Public administration Regional cooperation Research and technology SMEs Social matters Statistics Taxation Terrorism Visa and asylum

Note: The classification is based on Hofmann, Osnago and Ruta (2019). "P", "X", "C", "NC", "B", "H" and "Pref" are abbreviations for "WTO+", "WTO-X", "Core", "Non-Core" ,"Border", "Behind-the-Border" and "Preferential" provisions, respectively.

Table 2: Effects of PTA and PTA depths (1980–2015)

	(1)	(2)	(3)	(4)	(5)
	Bilateral imports (in log, million USD)				
gsp	0.002	0.003	0.005	0.005	0.002
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
comcur	0.527***	0.528***	0.517***	0.518***	0.516***
	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)
curheg_o	0.489	0.488	0.487	0.486	0.487
	(0.333)	(0.333)	(0.332)	(0.332)	(0.333)
curheg_d	0.045	0.043	0.043	0.042	0.043
	(0.530)	(0.530)	(0.530)	(0.529)	(0.531)
PTA	0.281***				
	(0.023)				
PTA_nP_X		-0.105			
		(0.330)			
PTA_P_nX		0.264***			
		(0.045)			
PTA_P_X		0.291***			
		(0.024)			
PTA_C_nNC			0.210***		
			(0.033)		
PTA_C_NC			0.325***		
			(0.026)		
PTA_B_nH_nNC				0.182***	
				(0.052)	
PTA_B_nH_NC				0.362	
				(0.228)	
PTA_B_H_nNC				0.231***	
				(0.041)	
PTA_B_H_NC				0.325***	
				(0.026)	
PTA_nPref_MFN_nNC					-0.104
					(0.330)
PTA_Pref_nMFN_nNC					0.317***
					(0.074)
PTA_Pref_MFN_nNC					0.180***
					(0.035)
PTA_Pref_MFN_NC					0.322***
					(0.026)
No. of Observations	670,360	670,360	670,360	670,360	670,360
R^2	0.866	0.866	0.866	0.866	0.866
Adjusted R^2	0.857	0.857	0.857	0.857	0.857
Exporter-Year FE	Yes	Yes	Yes	Yes	Yes
Importer-Year FE	Yes	Yes	Yes	Yes	Yes
Exporter-Importer FE	Yes	Yes	Yes	Yes	Yes

Note:
(a) Estimation of Equation (15). Refer to Figure 1 for the definition of the PTA indicators.
(b) Robust standard errors are clustered at the exporter-importer level and indicated in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3: GATT/WTO membership effects (by iterated estimation procedure)

	(1) $\tilde{\eta}_{it} + \tilde{\psi}_{jt}$
WTO_BOTH	0.146***
	(0.007)
WTO_IM	-0.006
	(0.007)
WTO_EX	-0.021***
	(0.007)
$\ln \bar{\chi}_{it}$	-0.198***
	(0.004)
$\ln \zeta_{jt}$	-0.213***
	(0.004)
$\ln Y_{it}$	0.931***
	(0.001)
$\ln E_{jt}$	0.903***
	(0.001)
$\ln Y_{wt}$	-1.080***
	(0.001)
No. of Observations	670,360
R^2	0.876
Adjusted R^2	0.876

Note:
(a) Estimation of Equation (17). "WTO_BOTH", "WTO_IM" and "WTO_EX" in the table correspond to *bothwto*, *imwto* and *exwto* in the equation, respectively.
(b) $\tilde{\eta}_{it} + \tilde{\psi}_{jt}$ is the sum of the exporter-year and importer-year FEs estimated from Equation (15). Robust standard errors are in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4: Characteristics of countries included in the pseudo world

	(a)	(b)	(c)	(d)	(e)
year	No. of countries in the raw data	No. of countries in the pseudo world	GDP share of the pseudo world	Import share of the pseudo world	No. of obs. with positive bilateral imports
1980	161	160	0.996	0.979	11,363
1985	164	163	0.997	0.987	11,960
1990	166	165	0.988	0.986	13,776
1995	186	184	0.999	0.996	18,348
2000	192	192	0.998	0.996	22,132
2005	195	191	0.999	0.996	23,360
2010	193	191	0.998	0.992	24,271
2015	189	188	0.999	0.991	26,286

Note:
(a) refers to the number of countries: (i) with at least one non-missing bilateral import observation and one non-missing bilateral export observation in a year, (ii) with data on trade cost proxy variables, and (iii) with GDP data.
(b) refers to the number of countries in the pseudo world following the iterated adjustment procedure described in Section A.5.
(c) refers to the total GDP of the countries in the pseudo world relative to the world GDP (of the 224 CEPII countries).
(d) refers to the total imports of the countries in the pseudo world relative to the world imports (of the 224 CEPII countries).
(e) refers to the number of observations in the pseudo world with positive bilateral imports.

Table 5: Characteristics of countries included in the pseudo world (by PTA and GATT/WTO membership status)

	(a)	(b)	(c)	(d)	(e)	(f)
year	No. of countries in the pseudo world	No. of countries with PTAs	No. of PTAs in force	No. of observations with PTA=1	Import share of observations with PTA=1	Import share of countries with PTAs
1980	160	34	6	272	0.215	0.450
1985	163	39	9	336	0.200	0.618
1990	165	45	11	402	0.266	0.659
1995	184	107	37	1,168	0.366	0.758
2000	192	137	73	1,882	0.385	0.774
2005	192	172	124	3,133	0.459	0.989
2010	191	180	192	4,607	0.468	0.993
2015	188	178	244	5,401	0.505	0.996

	(g)	(h)	(i)	(j)	(k)	(l)
year	No. of countries in GATT/WTO	Import share of GATT/WTO members	Import share of nonmembers	Import share of *bothwto* observations	Import share of *imwto* observations	Import share of *exwto* observations
1980	83	0.860	0.140	0.672	0.188	0.121
1985	88	0.863	0.137	0.724	0.139	0.117
1990	98	0.920	0.080	0.819	0.101	0.072
1995	125	0.919	0.081	0.818	0.101	0.066
2000	138	0.908	0.092	0.794	0.115	0.075
2005	147	0.968	0.032	0.925	0.043	0.026
2010	151	0.965	0.035	0.921	0.044	0.031
2015	158	0.985	0.015	0.972	0.012	0.015

Note:
(a) refers to the number of countries in the pseudo world.
(b) refers to the number of countries with at least one PTA currently in force (signed with trading partners in the pseudo world).
(c) refers to the number of PTAs currently in force in the pseudo world.
(d) refers to the number of country-pair observations whose PTA indicator equals one in the pseudo world.
(e) refers to the total imports of country-pair observations whose PTA indicator equals one, relative to the total imports of the pseudo world.
(f) refers to the total imports of countries with at least one PTA currently in force (signed with trading partners in the pseudo world), relative to the total imports of the pseudo world.
(g) refers to the number of GATT/WTO member countries in the pseudo world.
(h) refers to the total imports of GATT/WTO member countries relative to the total imports of the pseudo world.
(i) refers to the total imports of nonmember countries relative to the total imports of the pseudo world.
(j) refers to the total imports of country-pair observations where both trading partners are GATT/WTO members, relative to the total imports of the pseudo world.
(k) refers to the total imports of country-pair observations where only the importer is a GATT/WTO member, relative to the total imports of the pseudo world.
(l) refers to the total imports of country-pair observations where only the exporter is a GATT/WTO member, relative to the total imports of the pseudo world.

Table 6: List of Agreements

agreement	entry into force
Armenia - Kazakhstan	2001
Armenia - Moldova	1995
Armenia - Russian Federation	1993
Armenia - Turkmenistan	1996
Armenia - Ukraine	1996
ASEAN free trade area	1992
ASEAN-Australia-New Zealand	2010
ASEAN-India	2010
ASEAN-Korea	2010
Australia-New Zealand (ANZCERTA)	1983
Australia-Singapore	2003
Australia-Thailand	2005
Brunei Darussalam - Japan	2008
CAFTA-DR	2006
CAN	1988
Canada - Chile	1997
Canada - Colombia	2011
Canada - Costa Rica	2002
Canada - Honduras	2014
Canada - Israel	1997
Canada - Jordan	2012
Canada - Panama	2013
Canada - Rep. of Korea	2015
Canada-EFTA	2009
Canada-Peru	2009
Carribean Community and Community Market (CARICOM)	1973
CEFTA	2007
CEZ	2004
Chile - Colombia	2009
Chile - Costa Rica (Chile - Central America)	2002
Chile - El Salvador (Chile - Central America)	2002
Chile - Guatemala (Chile - Central America)	2010
Chile - Honduras (Chile - Central America)	2008
Chile - Malaysia	2012
Chile - Mexico	1999
Chile - Nicaragua (Chile - Central America)	2012
Chile - Viet nam	2014
Chile-Australia	2009
Chile-China	2006
Chile-Japan	2007
Chile-Korea	2004
China - Costa Rica	2011
China - Macao, China	2003
China-ASEAN	2005
China-Hong Kong	2004
China-New Zealand	2008
China-Pakistan	2007
China-Peru	2010
China-Singapore	2009
CIS	1994
Colombia - Mexico	1995
Colombia - Northern Triangle (El Salvador, Guatemala, Honduras)	2009
COMESA	1994
Costa Rica - Peru	2013
Costa Rica - Singapore	2013
Dominican Republic - Central America	2001
EAEC	1997
East African Community (EAC)	2000
East African Community (EAC) - Accession of Burundi	2007
East African Community (EAC) - Accession of Rwanda	2007
EC (10) Enlargement	1981
EC (9) Enlargement	1973
EC Enlargement (12)	1986
EC Enlargement (15)	1995
EC Enlargement (25)	2004
EC Enlargement (27)	2007
EC Treaty	1958
EC-Albania	2006
EC-Algeria	2005
EC-Bosnia Herzegovina	2008
EC-Cameroon	2009
EC-CARIFORUM	2008
EC-Chile	2003
EC-Cote d'Ivoire	2009
EC-Croatia	2002
EC-Egypt	2004
EC-Faroe Islands	1997
EC-FYR Macedonia	2001
EC-Iceland	1973
EC-Israel	2000
EC-Jordan	2002
EC-Lebanon	2003
EC-Mexico	2000
EC-Morocco	2000
EC-Norway	1973
Economic and Monetary Community of Central Africa (CEMAC)	1999
ECOWAS	1993
EC-Palestinian Authority	1997
EC-South Africa	2000
EC-Switzerland Liechtenst0	1973
EC-Tunisia	1998
EC-Turkey	1996
EEA	1994
EFTA - Albania	2010
EFTA - Bosnia and Herzegovina	2015
EFTA - Central America (Costa Rica and Panama)	2014
EFTA - Chile	2004
EU - Republic of Moldova	2014
EU (28) Enlargement	2013
Eurasian Economic Union (EAEU)	2015
Eurasian Economic Union (EAEU) - Accession of Armenia	2015
Eurasian Economic Union (EAEU) - Accession of Kyrgyz Republic	2015
EU-San Marino	2002
GCC	2003
Georgia - Armenia	1998
Georgia - Azerbaijan	1996
Georgia - Kazakhstan	1999
Georgia - Russian Federation	1994
Georgia - Turkmenistan	2000
Georgia - Ukraine	1996
Guatemala - Chinese Taipei	2006
Gulf Cooperation Council (GCC) - Singapore	2013
Hong Kong, China - Chile	2014
Hong Kong, China - New Zealand	2011
Iceland - China	2014
Iceland - Faroe Islands	2006
India - Bhutan	2006
India-Japan	2011
India-Malaysia	2011
India-Singapore	2005
India-Sri Lanka	2001
Israel - Mexico	2000
Japan - Australia	2015
Japan - Peru	2012
Japan-ASEAN	2008
Japan-Indonesia	2008
Japan-Malaysia	2006
Japan-Mexico	2005
Japan-Philippines	2008
Japan-Singapore	2002
Japan-Switzerland	2009
Japan-Thailand	2007
Japan-Viet Nam	2009
Jordan - Singapore	2005
Korea, Republic of - Australia	2014
Korea, Republic of - Turkey	2013
Korea, Republic of - US	2012
Korea, Republic of-India	2010
Korea, Republic of-Singapore	2006
Kyrgyz Republic - Armenia	1995
Kyrgyz Republic - Kazakhstan	1995
Kyrgyz Republic - Moldova	1996
Kyrgyz Republic - Russian Federation	1993
Kyrgyz Republic - Ukraine	1998
Kyrgyz Republic - Uzbekistan	1998
Malaysia - Australia	2013
MERCOSUR	1991
Mexico - Central America	2012
Mexico - Uruguay	2004
NAFTA	1994
New Zealand - Chinese Taipei	2013
New Zealand - Malaysia	2010
New Zealand - Singapore	2001
Nicaragua - Chinese Taipei	2008
Pacific Island Countries Trade Agreement (PICTA)	2003
PAFTA	1998
Pakistan - Malaysia	2008
Pakistan - Sri Lanka	2005
Panama - Chile	2008
Panama - Chinese Taipei	2004
Panama - Costa Rica (Panama - Central America)	2008
Panama - El Salvador (Panama - Central America)	2003
Panama - Guatemala (Panama - Central America	2009
Panama - Honduras (Panama - Central America)	2009
Panama - Nicaragua (Panama - Central America)	2009
Panama - Peru	2012
Panama - Singapore	2006
Peru - Chile	2009
Peru - Korea, Republic of	2011
Peru - Mexico	2012
Peru - Singapore	2009
Russian Federation - Azerbaijan	1993
Russian Federation - Belarus	1993
Russian Federation - Belarus - Kazakhstan	1997
Russian Federation - Kazakhstan	1993
Russian Federation - Republic of Moldova	1993
Russian Federation - Tajikistan	1993
Russian Federation - Turkmenistan	1993
Russian Federation - Uzkbekistan	1993
Russian Federation-Ukraina	1994
SACU	2004
SAFTA	2006
Singapore - Chinese Taipei	2014
Southern African Development Community	2000
Switzerland - China	2014
Thailand - New Zealand	2005
Trans-Pacific Strategic Economic Partnership	2006
Treaty on a Free Trade Area between members of the Commonwealth of Independent States (CIS)	2012
Turkey - Albania	2008
Turkey - Bosnia and Herzegovina	2003
Turkey - Chile	2011
Turkey - Former Yugoslav Republic of Macedonia	2000
Turkey - Georgia	2008
Turkey - Israel	1997
Turkey - Jordan	2011

EFTA - Colombia	2011	Turkey - Mauritius	2013
EFTA - Egypt	2007	Turkey - Morocco	2006
EFTA - Former Yugoslav Republic of Macedonia	2002	Turkey - Palestinian Authority	2005
EFTA - Hong Kong, China	2012	Turkey - Tunisia	2005
EFTA - Jordan	2002	Turkey-EFTA	1992
EFTA - Lebanon	2007	Ukraine - Azerbaijan	1996
EFTA - Mexico	2001	Ukraine - Former Yugoslav Republic of Macedonia	2001
EFTA - Morocco	1999	Ukraine - Moldova	2005
EFTA - Palestinian Authority	1999	Ukraine - Uzbekistan	1996
EFTA - Peru	2011	Ukraine Tajikistan	2002
EFTA - SACU	2008	Ukraine-Belarus	2006
EFTA - Singapore	2003	Ukraine-Kazakhstan	1998
EFTA - Tunisia	2005	Ukraine-Turkmenistan	1995
EFTA - Ukraine	2012	US - Colombia	2012
EFTA-Israel	1993	US - Panama	2012
EFTA-Korea	2006	US-Australia	2005
Egypt - Turkey	2007	US-Bahrain	2006
El Salvador - Honduras - Chinese Taipei	2008	US-Chile	2004
EU - Central America	2013	US-Israel	1985
EU - Colombia and Peru	2013	US-Jordan	2001
EU - Eastern and Southern Africa States Interim EPA	2012	US-Morocco	2006
		US-Oman	2009
EU - Georgia	2014	US-Peru	2009
EU - Korea, Republic of	2011	US-Singapore	2004
EU - Papua New Guinea/Fiji	2009	West African Economic and Monetary Union (WAEMU)	2000

Note: Based on the dataset constructed by Hofmann, Osnago and Ruta (2019), which includes all PTAs that have been notified to the GATT/WTO and remained in force as of December 2015. The table lists the 244 PTAs signed by the set of countries in the pseudo world during 1980–2015.

Table 7: Welfare effects of PTAs by regions

	Mean	Median	Min	Max	Countries
Panel A. Ex-post welfare effects of PTA (Melitz, 1980)					
OECD	0.70	0.59	-0.01	2.54	23
East and South Asia	-0.01	0.00	-0.03	0.00	21
East. Europe and Cent. Asia	-0.01	-0.01	-0.02	0.00	5
Latin America and Caribbean	0.18	0.00	-0.04	1.06	32
Middle East and North Africa	0.02	-0.02	-0.03	0.67	19
Sub-Saharan Africa	-0.01	-0.01	-0.10	0.06	46
Other	0.05	0.00	-0.07	0.79	14
Panel B. Ex-post welfare effects of PTA (Melitz, 2015)					
OECD	2.54	1.87	0.23	15.00	23
East and South Asia	1.41	0.79	-0.11	5.67	25
East. Europe and Cent. Asia	2.45	1.85	0.12	7.09	15
Latin America and Caribbean	0.79	0.57	-0.01	2.64	32
Middle East and North Africa	0.84	0.56	0.06	3.18	23
Sub-Saharan Africa	0.52	0.18	-0.13	3.22	46
Other	1.55	0.71	-0.11	5.04	24

Note: Based on the estimates in Column (1) of Table 2, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. The welfare effect of PTAs (based on real output) is calculated given the observed PTA status relative to the counterfactual had PTA not existed ($PTA = 0$ for all ijt). Figures shown are % change in welfare.

Table 8: Welfare effects of PTAs (Melitz vs. BKL; median effects)

Parameters	PTA status	Year 1980 Melitz	Year 1980 BKL $\kappa = 0.8$	Year 1980 BKL $\kappa = 1$	Year 2015 Melitz	Year 2015 BKL $\kappa = 0.8$	Year 2015 BKL $\kappa = 1$
1. σ=5, θ=4.5	0	-0.0069	-0.0069	-0.0069	-0.0092	-0.0092	-0.0092
	1	0.3193	0.3193	0.3193	0.2362	0.2362	0.2362
	2	0.7488	0.7488	0.7488	1.6071	1.6071	1.6071
2. σ=5, θ=5 (benchmark)	**0**	**-0.0068**	**-0.0068**	**-0.0068**	**-0.0102**	**-0.0102**	**-0.0102**
	1	**0.2891**	**0.2891**	**0.2891**	**0.2087**	**0.2087**	**0.2087**
	2	**0.6740**	**0.6740**	**0.6740**	**1.4410**	**1.4410**	**1.4410**
3. σ=5, θ=5.5	0	-0.0065	-0.0065	-0.0065	-0.0107	-0.0107	-0.0107
	1	0.2641	0.2641	0.2641	0.1860	0.1860	0.1860
	2	0.6127	0.6127	0.6127	1.3060	1.3060	1.3060
4. σ=5, θ=6	0	-0.0062	-0.0062	-0.0062	-0.0107	-0.0107	-0.0107
	1	0.2430	0.2430	0.2430	0.1679	0.1679	0.1679
	2	0.5617	0.5617	0.5617	1.1954	1.1954	1.1954
5. σ=5, θ=8	0	-0.0041	-0.0041	-0.0041	-0.0097	-0.0097	-0.0097
	1	0.1285	0.1285	0.1285	0.0812	0.0812	0.0812
	2	0.2995	0.2995	0.2995	0.6337	0.6337	0.6337
6. σ=5, θ=10	0	-0.0039	-0.0039	-0.0039	-0.0094	-0.0094	-0.0094
	1	0.1223	0.1223	0.1223	0.0769	0.0769	0.0769
	2	0.2846	0.2846	0.2846	0.6015	0.6015	0.6015
7. σ=10, θ=10	0	-0.0031	-0.0031	-0.0031	-0.0076	-0.0076	-0.0076
	1	0.0912	0.0912	0.0912	0.0561	0.0561	0.0561
	2	0.2108	0.2108	0.2108	0.4438	0.4438	0.4438

Note:
(a) Based on the estimates in Column (1) of Table 2, given the Melitz or BKL framework. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual without PTAs.
(b) The PTA status classifies countries into three groups, based on the number of trading partnerships a country has where a PTA is in force in a year: (0) zero, (1) greater than zero but fewer than the median, or (2) greater than or equal to the median of the year across countries.

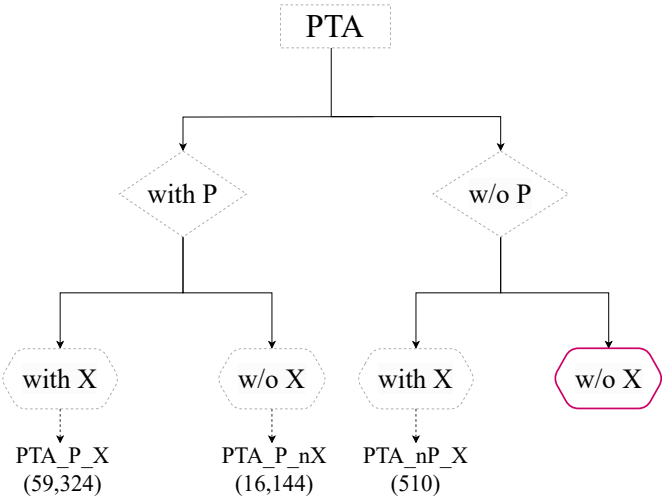
Table 9: Firm entry effects of PTAs (Melitz vs. BKL; median effects)

Parameters	PTA status	Year 1980 Melitz	Year 1980 BKL $\kappa = 0.8$	Year 1980 BKL $\kappa = 1$	Year 2015 Melitz	Year 2015 BKL $\kappa = 0.8$	Year 2015 BKL $\kappa = 1$
1. σ=5, θ=4.5	0	0.00	0.00	0	0.00	0.00	0
	1	0.16	0.06	0	0.12	0.05	0
	2	0.38	0.15	0	0.80	0.32	0
2. σ=5, θ=5 (benchmark)	0	**0.00**	**0.00**	**0**	**-0.01**	**0.00**	**0**
	1	**0.15**	**0.06**	**0**	**0.11**	**0.04**	**0**
	2	**0.34**	**0.13**	**0**	**0.72**	**0.29**	**0**
3. σ=5, θ=5.5	0	0.00	0.00	0	-0.01	0.00	0
	1	0.13	0.05	0	0.09	0.04	0
	2	0.31	0.12	0	0.65	0.26	0
4. σ=5, θ=6	0	0.00	0.00	0	-0.01	0.00	0
	1	0.12	0.05	0	0.09	0.03	0
	2	0.29	0.11	0	0.60	0.24	0
5. σ=5, θ=8	0	0.00	0.00	0	0.00	0.00	0
	1	0.07	0.03	0	0.04	0.02	0
	2	0.15	0.06	0	0.32	0.13	0
6. σ=5, θ=10	0	0.00	0.00	0	0.00	0.00	0
	1	0.06	0.02	0	0.04	0.02	0
	2	0.15	0.06	0	0.30	0.12	0
7. σ=10, θ=10	0	0.00	0.00	0	0.00	0.00	0
	1	0.05	0.02	0	0.03	0.01	0
	2	0.11	0.04	0	0.22	0.09	0

Note:
(a) Based on the estimates in Column (1) of Table 2, given the Melitz or BKL framework. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual without PTAs.
(b) The PTA status classifies countries into three groups, based on the number of trading partnerships a country has where a PTA is in force in a year: (0) zero, (1) greater than zero but fewer than the median, or (2) greater than or equal to the median of the year across countries.

Figure 1: Categorization of PTAs and corresponding indicators

(a) "WTO+" and "WTO-X"



(b) "Core" and "Non-Core"

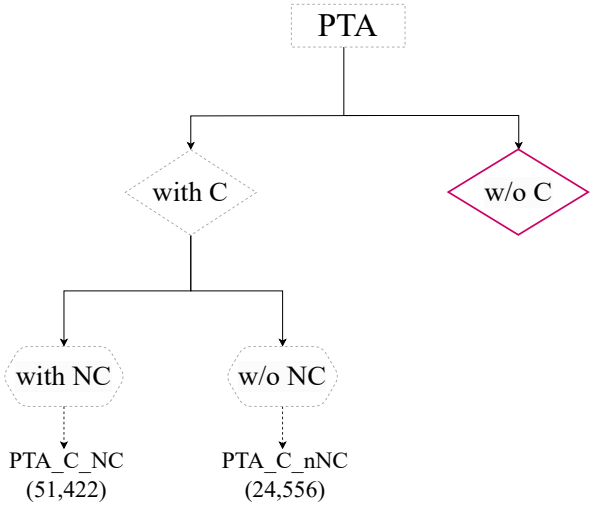
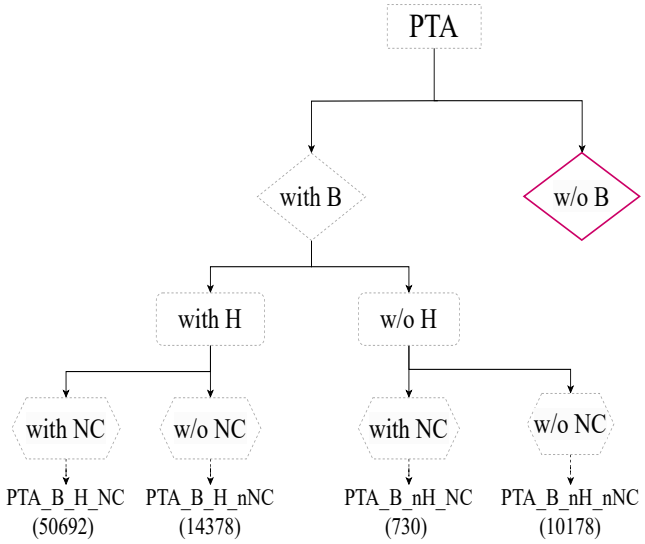
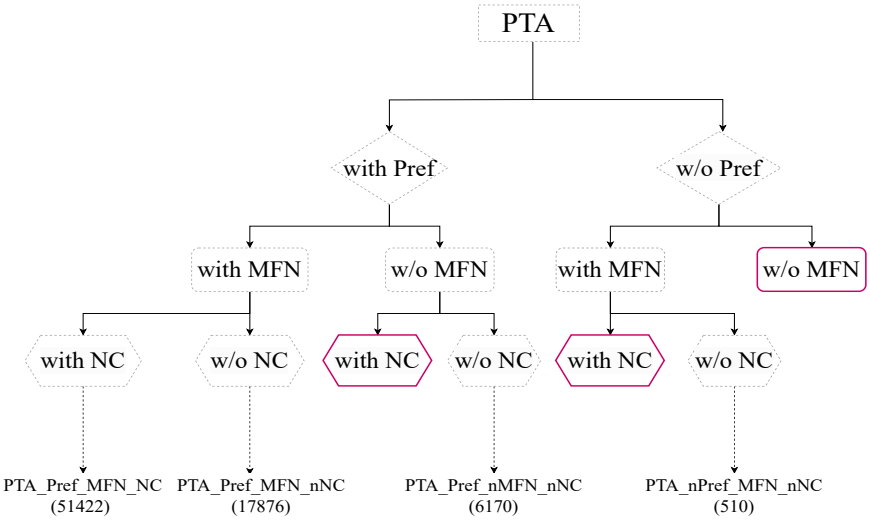


Figure 1: Categorization of PTAs and corresponding indicators (continued)

(c) "Border" and "Behind-the-Border"

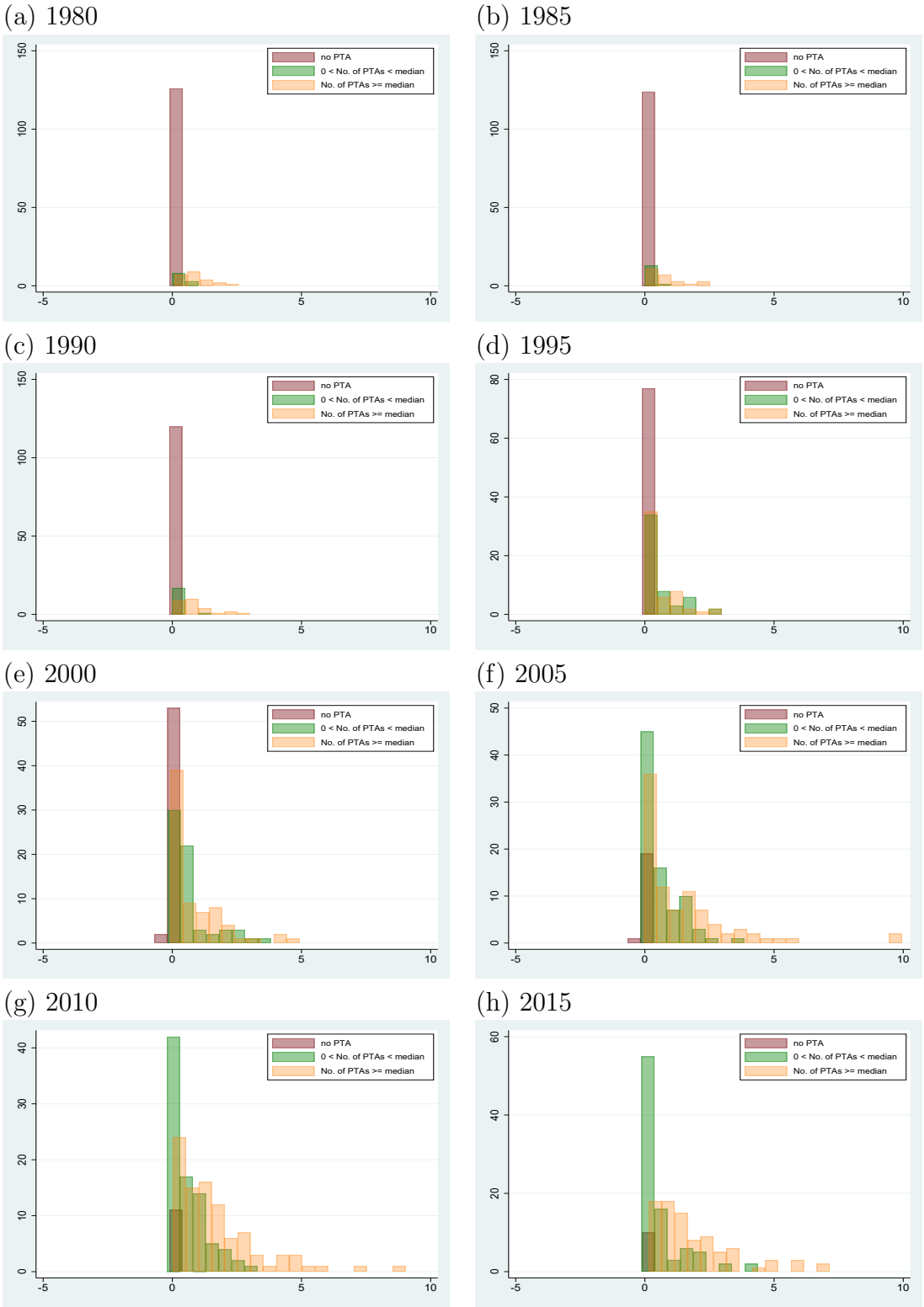


(d) "Preferential" and "MFN"



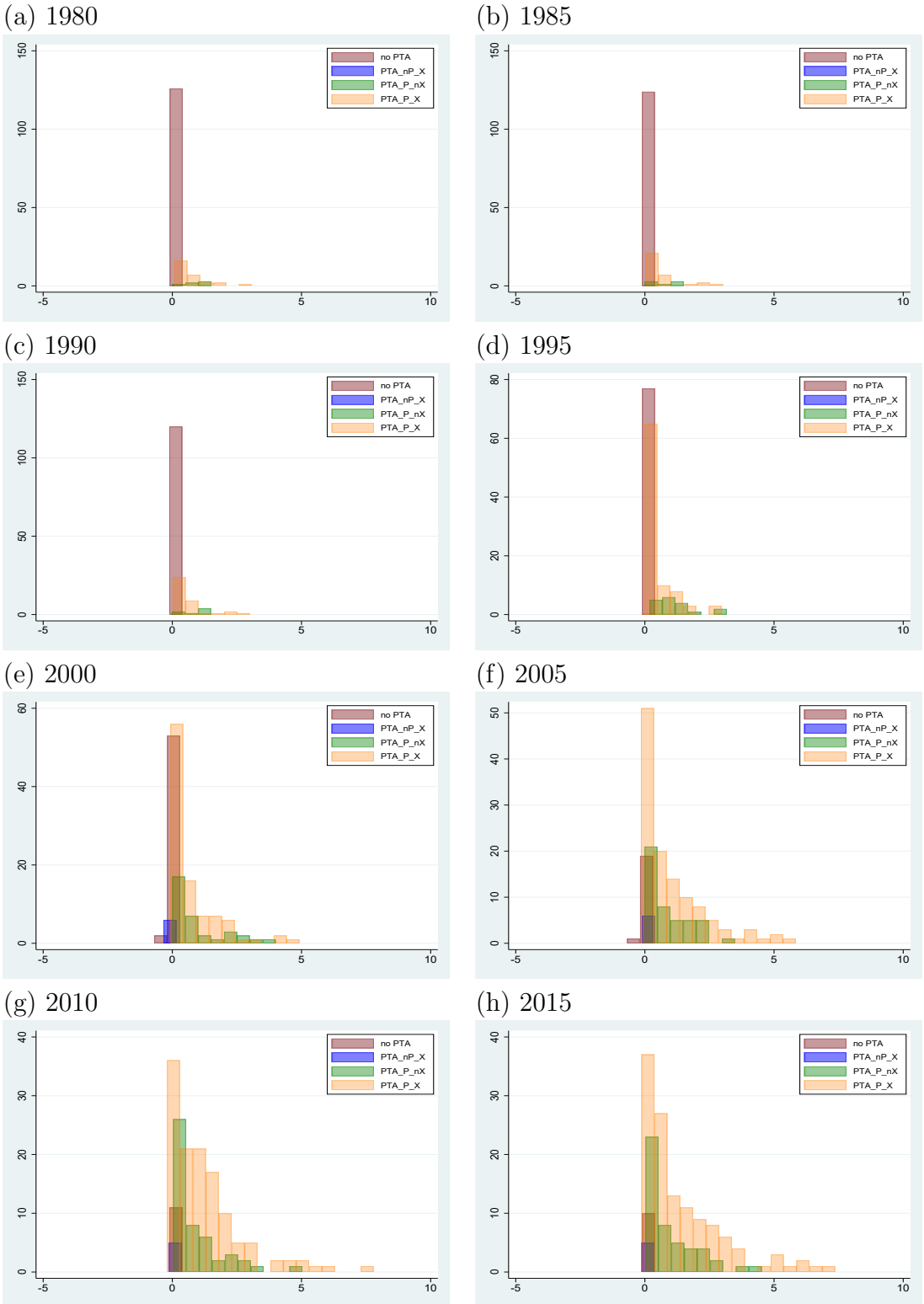
Note:
(a)"P" and "X" are abbreviations for "WTO+" and "WTO-X" provisions, respectively; "C" and "NC" are abbreviations for "Core" and "Non-Core" provisions, respectively; "B" and "H" are abbreviations for "Border" and "Behind-the-Border" provisions, respectively; and "Pref" is the abbreviation for "Preferential" provisions.
(b) Nodes where there are no PTAs with the indicated combinations of policy areas are highlighted in red.
(c) The number of observations (across country-pairs and years) for each PTA subcategory is indicated in the parentheses.

Figure 2: Welfare effects of PTAs



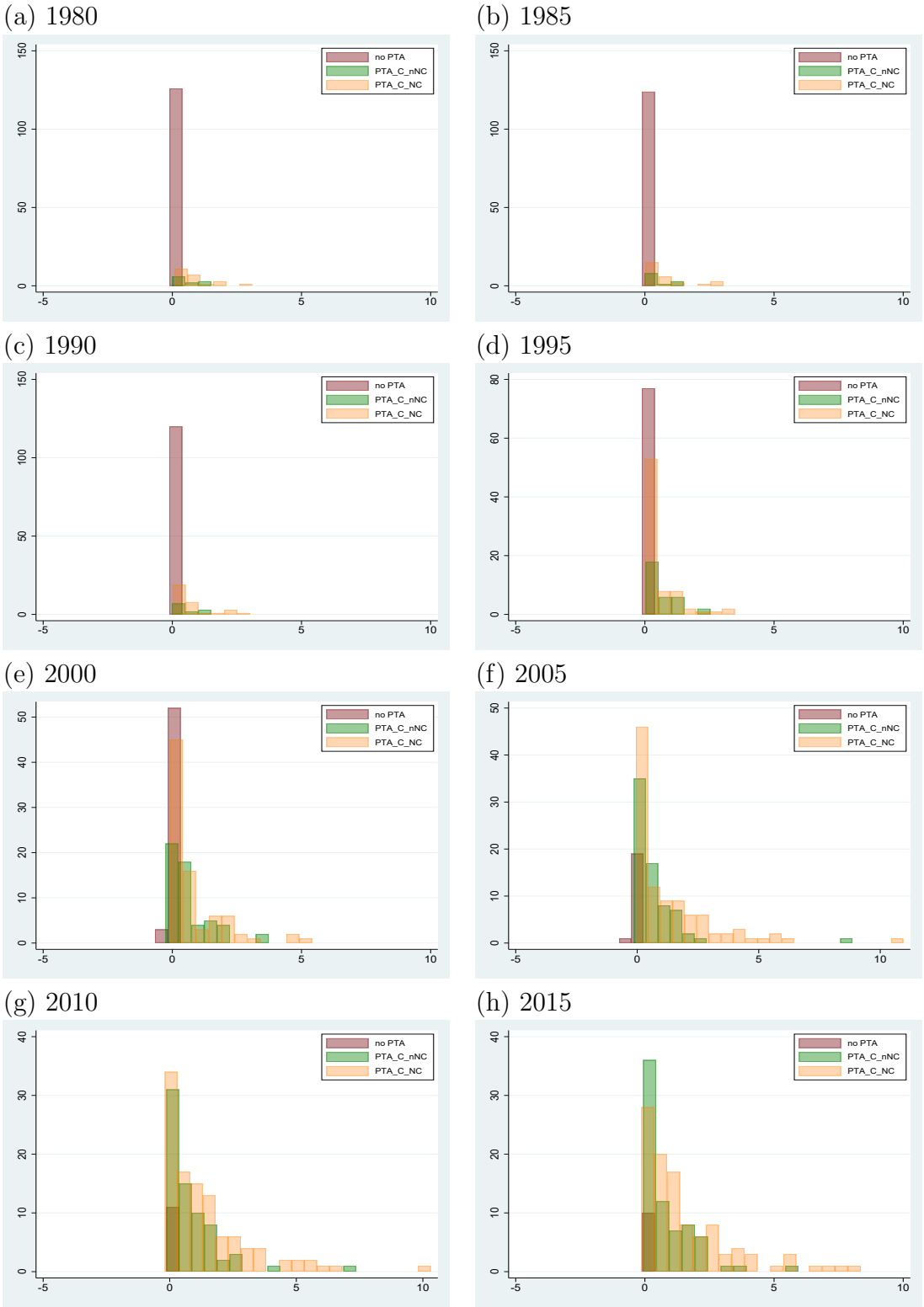
Note: Based on the PTA estimates in Column (1) of Table 2, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual had PTAs not existed ($PTA = 0$ for all ijt). The y-axis indicates the number of countries, and the x-axis the % change in welfare (real output). Outliers are omitted. No. of PTAs refers to the number of trading partnerships a country has where a PTA is in force in a year.

Figure 3: Welfare effects of PTAs ("WTO+" and "WTO-X")



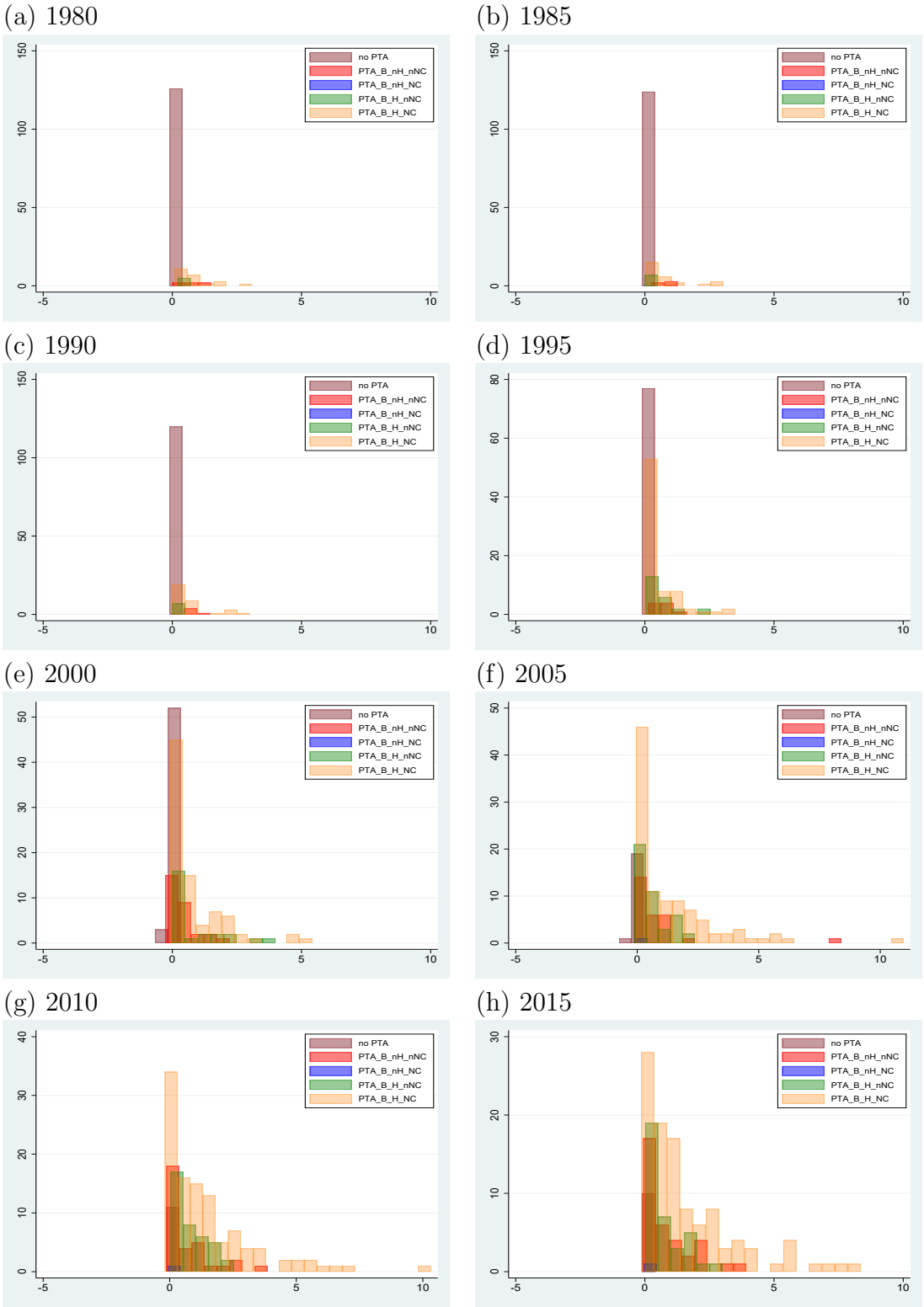
Note: Based on the PTA estimates in Column (2) of Table 2, using the Melitz framework with parameter values $\sigma = 5$, and $\theta = 5$. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual had PTAs not existed. The y-axis indicates the number of countries, and the x-axis the % change in welfare (real output). Outliers are omitted. A country is classified to be in the group "PTA_nP_X", "PTA_P_nX" and "PTA_P_X", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others.

Figure 4: Welfare effects of PTAs ("Core" and "Non-Core")



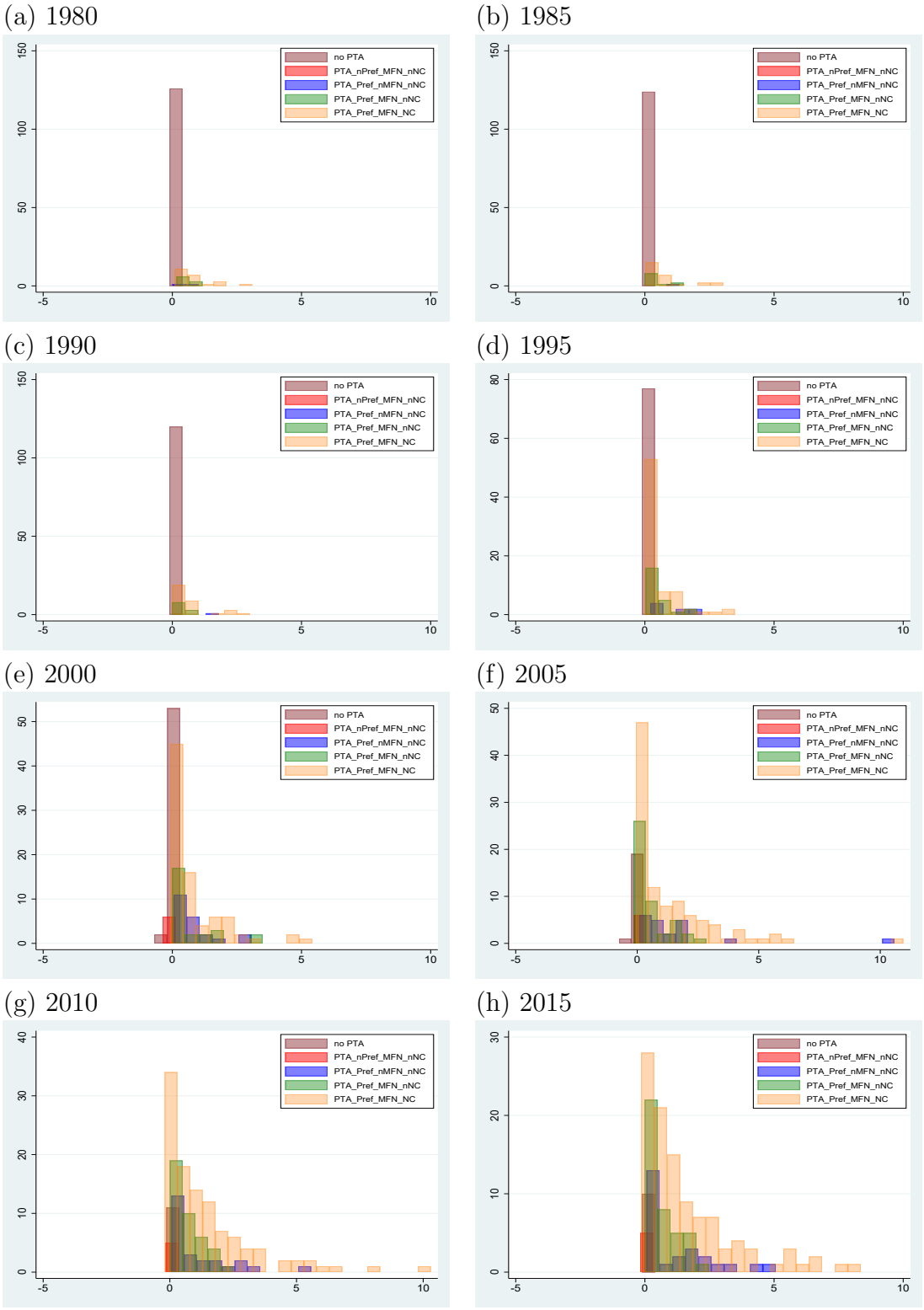
Note: Based on the PTA estimates in Column (3) of Table 2, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual had PTAs not existed. The y-axis indicates the number of countries, and the x-axis the % change in welfare (real output). Outliers are omitted. A country is classified to be in the group "PTA_C_nNC" and "PTA_C_NC", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others.

Figure 5: Welfare effects of PTAs ("Border" and "Behind-the-Border")



Note: Based on the PTA estimates in Column (4) of Table 2, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual had PTAs not existed. The y-axis indicates the number of countries, and the x-axis the % change in welfare (real output). Outliers are omitted. A country is classified to be in the group "PTA_B_nH_nNC", "PTA_B_nH_NC", "PTA_B_H_nNC", and "PTA_B_H_NC", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others.

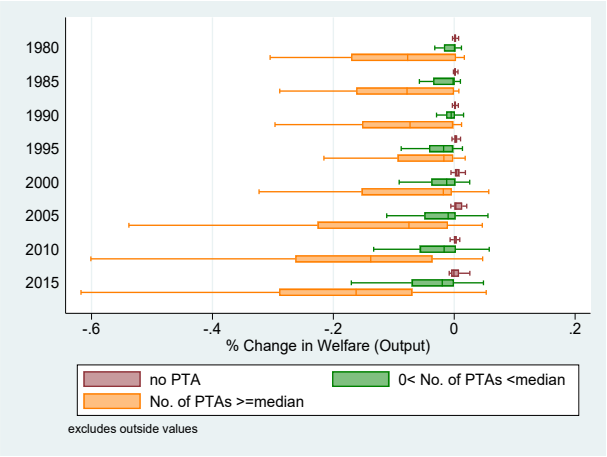
Figure 6: Welfare effects of PTAs ("Preferential" and "MFN")



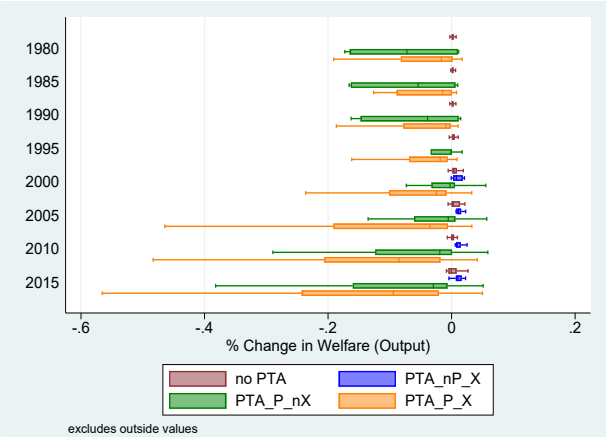
Note: Based on the PTA estimates in Column (5) of Table 2, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. This set of analyses evaluates the effects of PTAs given the observed PTA status relative to the counterfactual had PTAs not existed. The y-axis indicates the number of countries, and the x-axis the % change in welfare (real output). Outliers are omitted. A country is classified to be in the group "PTA_nPref_MFN_nNC", "PTA_Pref_nMFN_nNC", "PTA_Pref_MFN_nNC", and "PTA_Pref_MFN_NC", respectively, in a year if the number of its trading partnerships that belong to each of these categories dominates the others.

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

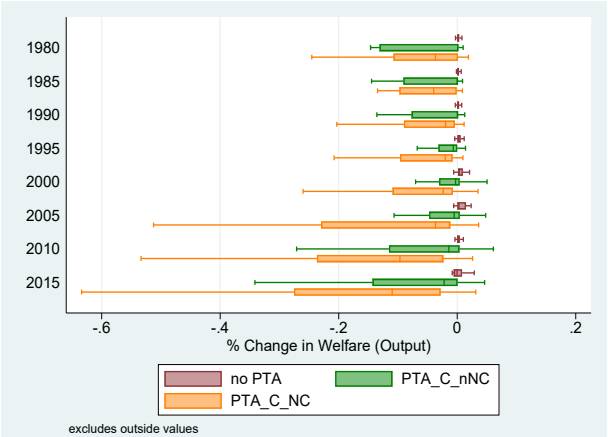
(a) PTA



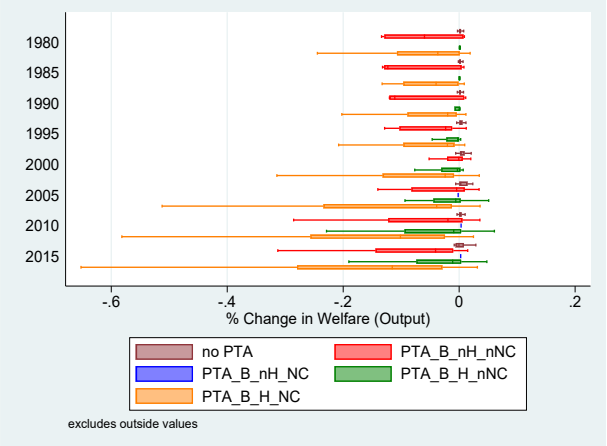
(b) "WTO+" and "WTO-X"



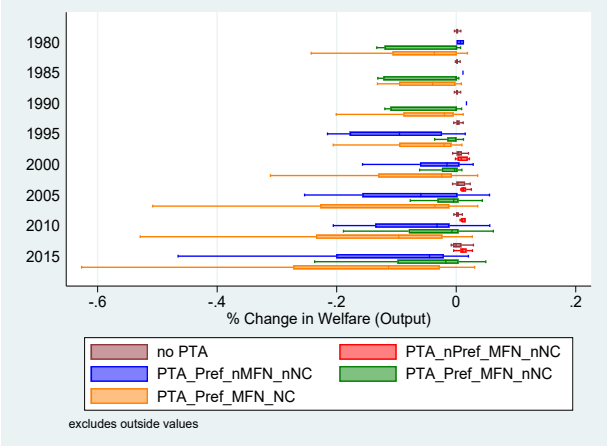
(c) "Core" and "Non-Core"



(d) "Border" and "Behind-the-Border"



(e) "Preferential" and "MFN"



Note: Panels (a)–(e) are based on the PTA effect estimates in Columns (1)–(5) of Table 2, respectively, and the GATT/WTO membership effect estimates in Table 3, using the Melitz framework with parameter values $\sigma = 5$ and $\theta = 5$. This set of analyses evaluates the effects of PTAs without GATT/WTO, relative to those under factual GATT/WTO membership status. Outliers are omitted. The grouping of countries is as defined in Figure 2 to Figure 6.