

The impact of non-tariff barriers on trade and welfare*

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Abstract

Deep trade agreements (DTAs) are widespread and have taken the world beyond tariff liberalization in goods trade. As the importance of global supply chains and the services sector has increased across the world, shallow tariff reductions have given way to deeper commitments that address non-tariff barriers and behind the border barriers to trade. This paper shows that DTA commitments undertaken since the Uruguay Round have increased trade in goods by 25% and trade in services by slightly more, roughly 30%. Taking reduced-form deep trade elasticity estimates to a general equilibrium quantitative model, DTAs contributed over 40% to the welfare gains from trade globally and even more for advanced economies. China, India, and the Eastern European bloc benefited the most from trade agreements. While most of the gains in China and India came from tariff reductions, the gains to Eastern Europe came largely from deep commitments during its accession to the EU. Applying the DTA estimates to ex-ante analysis of Brexit, the losses to the UK from its departure from the deepest trade agreement in the world would not be offset by new deep trade deals with key non-EU trade partners.

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1 Introduction

Trade agreements, one of the most widely used policy tools for international economic integration, have evolved greatly both in volume and scope since the 1990s. Roughly 300 agreements are in force today, compared to only about 20 in 1990. Whereas the predominant focus of early trade arrangements was lowering tariffs and quantitative restrictions to ease trade in goods, modern trade agreements contain a range of deeper provisions beyond the narrow remit of traditional trade policy instruments. Such provisions are widespread across agreements and typically encompass measures such as mutual recognition of professional qualifications for service providers, investment liberalization, and intellectual property protection commitments. Trade agreements that include these provision types are often referred to as deep trade agreements (DTAs).

DTAs are widespread and have taken the world beyond tariff liberalization in goods trade. As the importance of global supply chains and the services sector increased across the world, shallow tariff reductions gave way to deeper commitments that address non-tariff barriers and behind-the-border barriers to trade. However, existing work on trade and welfare impacts of DTAs remains scant, and research on trade in services is still very limited. This paper examines the impacts of DTAs on trade and welfare, and it does so by expanding the scope to trade in services.

A first contribution of the paper is to provide reduced-form evidence that deep trade commitments increase trade, over and above shallow tariff reductions. DTAs, which include a wide range of non-tariff measures, have a stronger effect on gross exports than shallow agreements. Their trade-expansion effect is relatively larger for services than goods—roughly a 30% boost in gross exports for services compared to just under 25% for goods.

A second contribution of the paper is to develop a structural model that builds on these reduced-form estimates to provide general equilibrium impacts of DTAs on trade and welfare. Despite a growing literature that has examined the impact of economic integration on welfare, there is limited quantitative work studying DTAs. Our approach differs from the long tradition of computable general equilibrium models to estimate the impact of trade reforms (Anderson and Martin, 2005; Cline, 2004; Hertel, 1997). Following Kehoe et al. (2017), we use a quantitative trade model (à la Caliendo and Parro, 2015; Costinot and Rodríguez-Clare, 2014) with carefully calibrated parameters and shocks from model-consistent reduced-form estimates. As such, our model enables quantification of the aggregate trade and welfare impacts of trade agreements. We focus on two major policy events for the quantification.

In the first application, we quantify the ex-post welfare gains from trade liberalization after the Uruguay Round through tariff reductions and deeper trade policy commitments. We estimate the welfare effect of trade liberalization by feeding the actual shocks in tariffs and non-tariff provisions into our model. We also identify the major winners and the primary source of their gains by separately feeding these shocks and by differentiating across sectors. A key insight is that tariff reductions in goods contributed to welfare gains prior to the EU's 2004 expansion and for the two major economies

of China and India. After 2004, the contribution of DTAs to welfare gains from trade rises, and particularly for Eastern and Central European economies that became members of the world's deepest trade agreement, the European Union (EU). More broadly speaking, our analysis underscores that DTAs in developing economies are comprised of relatively few deep provisions and that this group has gained primarily from tariff reductions. On the other hand, welfare gains to industrialized economies, which actively engaged in comprehensive DTAs since the Uruguay round, come equally from deep commitments and tariff channels.

In the second application, we examine the trade and welfare impacts of Brexit, which reduces the United Kingdom's deep trade commitments with its largest trading partner but opens up new avenues for DTAs with economies outside the EU. Model simulations using the reduced-form estimates of the impact of DTAs on trade show welfare losses of roughly 1% for the UK in terms of real consumption per capita, even after accounting for a soft Brexit and deep NAFTA-type trade agreements with other potential partners like the United States. Moreover, these welfare losses from Brexit rise to more than double as policies with shallower trade agreements are considered in the counterfactual analysis. As the current trend towards deglobalization from political developments and more recently the Covid-19 pandemic continues, this application suggests that the unraveling of DTAs can undo some of the welfare gains from integration achieved in the past couple of decades.

This paper is related to three strands of the literature. First, we study DTAs in a quantitative framework, which is related to a vast evolving line of work providing general equilibrium welfare impacts of trade, as discussed in detail in subsequent sections. While the focus of quantitative trade models has largely been on tariff liberalization, more recent work has turned to examining non-tariff policy tools like rules of origin (Conconi et al., 2018), trade policy uncertainty (Steinberg, 2019), non-tariff barriers (Comerford and Rodríguez Mora, 2019) and preferential trade agreements (Felbermayr et al., 2015; Mayer et al., 2019). We build on the long tradition of work on trade agreements in gravity models (Baier and Bergstrand, 2007; for a survey of the literature see Limão, 2016), which have more recently been expanded in scope to incorporate elements of trade agreement depth (for example, Baier et al., 2017, 2014). We use a combination of reduced-form and structural modeling to answer distinct questions in this literature. Building on the enormous progress in measuring the content of DTAs through non-tariff provisions (Hofmann et al., 2017) and estimating their reduced-form trade impacts (Mattoo et al., 2017; Mulabdic et al., 2017; Orefice and Rocha, 2014), this paper quantifies the general equilibrium trade and welfare impacts of major DTAs of the past three decades.

Second, we examine services trade where deep commitments are a central trade policy tool. This connects our work to the growing body of research on services trade, such as Breinlich et al. (2018), Borchert et al. (2017), and Costa et al. (2019). Compared to these papers, we consider the impact of trade agreement provisions on services trade. Third, we quantify potential welfare impacts from deglobalization, which has been the focus of emerging literature, such as that on the Trump tariff war, Brexit, and, more recently, the Covid-19 pandemic. While many studies have examined recent deglobalization trends, the analysis has rarely incorporated trade elasticities from DTA provisions,

making it difficult to disentangle the relative contributions of shallow and deep commitments with the trade partner and the world economy (for example, Dhingra et al., 2017; HM Treasury, 2016; Kierzenkowski et al., 2016). Summing up, we build on the measurement and empirical progress on DTAs to estimate and quantify their trade and welfare impacts.

The rest of the paper is structured as follows. Section 2 describes the data sources used in our analysis and documents general trends in DTAs over time. Section 3 gives our empirical specification, which is motivated by the gravity equation literature, and presents reduced-form results. Section 4 walks through the quantitative framework used to estimate the effect of DTAs on living standards. Section 5 presents the results of two quantitative exercises: the welfare effects of trade liberalization after the formation of the WTO and the welfare effects from Brexit. Finally, Section 6 concludes.

2 Data and trends in modern trade agreements and tariffs

Our empirical analysis relies upon matched data on DTAs encompassing non-tariff provisions, applied tariff rates, and bilateral exports. In what follows, we describe the data sources used and discuss trends in DTAs and bilateral tariffs over time.

Information on DTAs is drawn from the World Bank (WB) Content of Deep Trade Agreements database (herein DTA database), described in Hofmann et al. (2017). This database records information on the full set of 279 trade agreements notified to the WTO between 1958 and 2015. Importantly, it identifies 52 provision categories that can exist (or co-exist) in a trade agreement. These are then broken down into two broad categories: those which fall under the current WTO mandate (WTO+ provisions) and those which extend beyond the WTO mandate (WTO-X provisions). There are 14 WTO+ provisions that cover non-tariff liberalizations embedded in modern DTAs related to customs, anti-dumping, trade-related investment measures, and public procurement, among others. The remaining 38 WTO-X provisions span a wide set of policy areas ranging from competition policy, intellectual property rights, and investment to nuclear safety, energy, and human rights.

The WB further classifies these 52 provisions as “core” versus “non-core.” Core provisions are those which the literature has identified as being most relevant in terms of easing market access (see Baldwin, 2008; Damuri, 2012). These include all WTO+ provisions as well as four WTO-X areas: competition policy, investment, movement of capital, and intellectual property rights. Table 1 presents the full set of provisions in the WB DTA database, with core provisions denoted in italics.¹

Moreover, the DTA database also relies upon expertise from legal specialists to code the enforceability of each trade agreement provision within a given bilateral agreement. A provision is classified as legally enforceable if the language used is sufficiently explicit, precise, and committing. In line with the emerging literature using this data (for example, Laget et al., 2018; Mattoo et al., 2017; Mulabdic et al., 2017), we only consider legally enforceable provisions in our baseline estimations, given that these commitments are most likely to be successfully addressed if invoked in a dispute settlement

¹See Table A1 in Hofmann et al. (2017) for a detailed description of each provisions’ definition.

proceeding. Nonetheless, we relax this requirement when conducting robustness exercises.²

Table 1: WB Content of Deep Trade Agreements Database Provisions

WTO+ provisions	WTO-X provisions		
<i>Tariffs industrial goods</i>	Anti-corruption	Cultural cooperation	Political dialogue
<i>Tariffs agricultural goods</i>	<i>Competition policy</i>	Economic policy dialogue	Public administration
<i>Customs</i>	Environmental laws	Education and training	Regional cooperation
<i>Export taxes</i>	<i>Intellectual property rights</i>	Energy	Research and technology
<i>SPS measures</i>	<i>Investment</i>	Financial assistance	SMEs
<i>TBT measures</i>	Labor market regulation	Health	Social matters
<i>State trading enterprises</i>	<i>Movement of capital</i>	Human rights	Statistics
<i>Anti-dumping</i>	Consumer protection	Illegal immigration	Taxation
<i>Countervailing measures</i>	Data protection	Illicit drugs	Terrorism
<i>State aid</i>	Agriculture	Industrial cooperation	Visa and asylum
<i>Public procurement</i>	Approximation of legislation	Information society	
<i>TRIMS</i>	Audio visual	Mining	
<i>GATS</i>	Civil protection	Money laundering	
<i>TRIPs</i>	Innovation policies	Nuclear safety	

Source: Hofmann et al. (2017). *Notes:* This table lists the full set of trade agreement provisions available and included in our analysis. WTO+ provisions are defined as those which fall under the current WTO mandate while WTO-X provisions are those which extend beyond the WTO mandate. Core provisions are in italics.

For the economies considered in our analysis, the deepest agreement is the EU agreement, which, after the 2004 expansion, is comprised of 40 legally enforceable provision categories.³ The second deepest agreement in our sample is NAFTA, which contains 20 legally enforceable provisions. In contrast, the shallowest agreements in our sample are the China-ASEAN and India-ASEAN agreements, with 4 and 8 legally enforceable provisions, respectively.⁴ For expositional purposes, Figure 1 plots the number of pairs of trade partners in our sample with a DTA, distinguishing those with less than 10 provisions, between 10 and 20 provisions, and more than 20 provisions. The jump in the number of pairs with more than 20 provisions in 2004 and 2007 is driven by EU expansions in those years. The steady increase in agreements with 10-20 provisions represents the entry into force of agreements such as those between the US and Australia, India, and Japan, as well as the EU and Korea, among others.

Data on applied HS 6-digit bilateral tariffs that each exporter faces when sending goods to a given partner come from UNCTAD’s Trade Analysis Information System (TRAINS), downloaded through the WB World Integrated Trade Solutions (WITS) platform. Three main steps are taken to clean and concord the data to the classification of our trade data (the ISIC Rev. 3). First, we construct a series of applied bilateral import tariffs at the HS 6-digit level, taking into account ad-valorem equivalents as provided by TRAINS where applicable.⁵ Second, we construct the tariff faced by each exporter

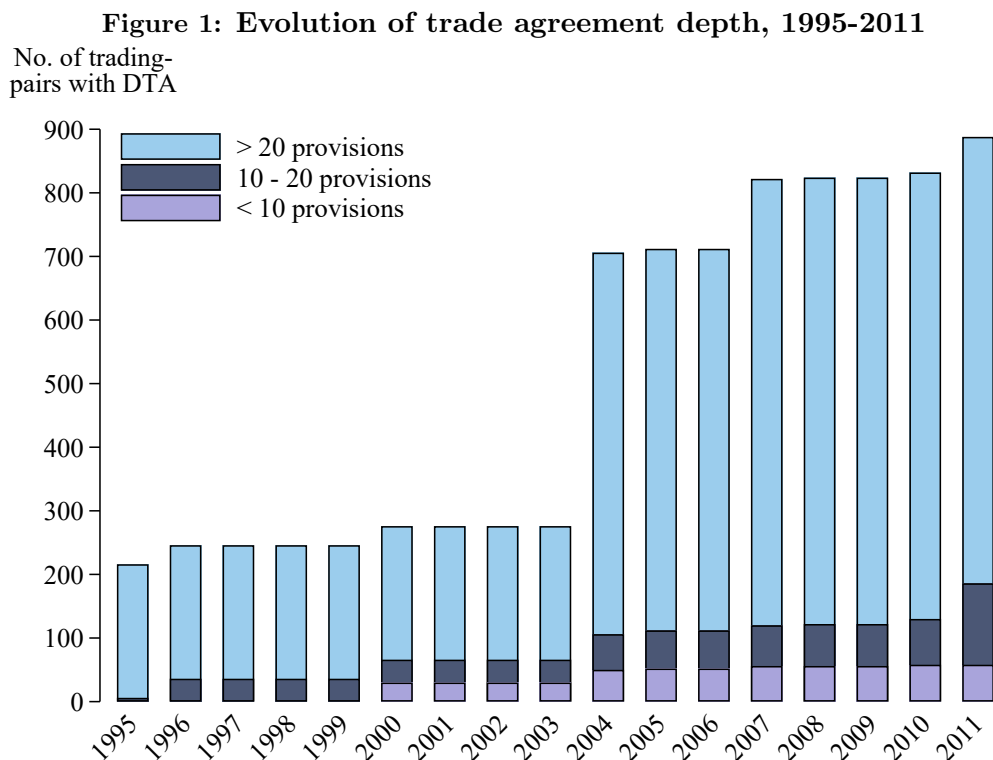
²Specifically, the DTA database distinguishes between legally enforceable provisions that are explicitly excluded by dispute settlement provision and those which are not. We consider only those which are not in the category of ‘excluded by dispute settlement’ in our baseline analysis but examine others in a robustness exercise.

³Before the 2004 expansion this agreement contained 38 provisions.

⁴The only ASEAN member included individually in our trade dataset is Indonesia. All other members are accounted for in the Rest of the World aggregate.

⁵As such, bilateral applied tariffs are constructed as the first of: preferential ad-valorem equivalent; preferential rate; MFN ad-valorem equivalent; MFN rate. In the case of Indonesia, we use the information on applied rates only due to

from each partner’s respective bilateral import tariff file.⁶ Finally, we aggregate HS 6-digit products to the relevant 2-digit industries of our trade data using a concordance between HS products for each HS classification year and ISIC Rev. 3 industries.⁷



Source: Authors’ computations based WIOD and WB DTA database. *Notes:* This figure shows the number of region pairs in our sample with a DTA, decomposed into the number of legally enforceable provisions.

Figure 2 plots the average applied tariff rates imposed by each economy in our sample on all other economies in the world (aggregated across all goods sectors). The clear messages which emerge from the figure are threefold. First, we observe large drops in India and China’s average import tariffs over the whole period. This is primarily driven by reductions in their MFN tariffs, with steady declines for India over the full period and the steepest declines for China in its lead-up to joining the WTO in 2001. Second, there is a notable drop in most Eastern European nations’ average bilateral tariffs as they prepared to join the EU, albeit to differing extents. Finally, the average applied tariffs of the US and all Western European nations are relatively low during the whole period (below 5%).

Lastly, data on bilateral exports for goods and services come from the 2013 release of the World Input-Output Database (WIOD), made available by the University of Groningen and described in Timmer et al. (2015). Bilateral exports—including intra-national flows—are available for years 1995-2011 for 40 economies and a Rest of the World (RoW) aggregate. We do not work with the newer

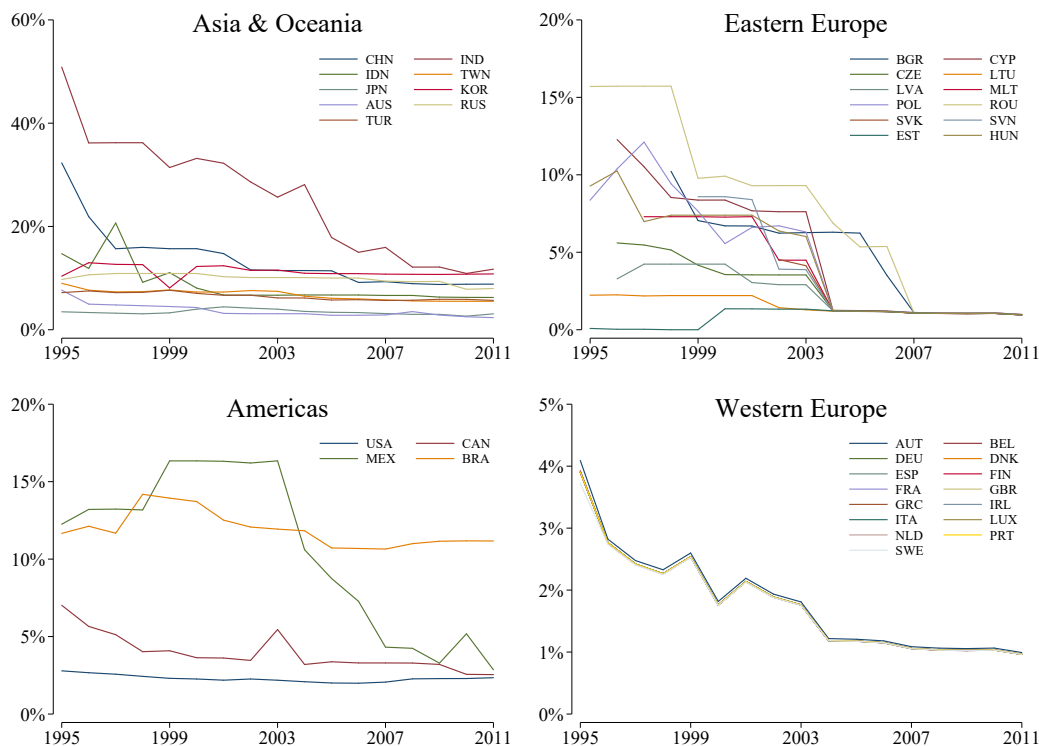
large gaps in reporting on ad-valorem equivalents (AVEs) between 1995 and 2001.

⁶For example, the tariffs faced by the United States in each respective destination to which it sends goods are simply the tariffs that each destination imposes on the US, as reported in their import tariff file.

⁷As detailed below, we source our trade data from the WIOD, which follows the ISIC Rev. 3 classification. The concordance is publicly available through the WITS platform: http://wits.worldbank.org/product_concordance.html.

release of the WIOD because it starts in year 2000, and therefore does not cover the large integration periods after the Uruguay Round (which concluded in 1994). A particularly nice feature of the WIOD is that it covers both goods and services sectors, allowing us to examine the impact of trade agreements on trade flows at various levels of disaggregation: aggregate exports; and goods versus services exports.

Figure 2: Average applied tariff rates, 1995-2011



Source: Authors' computations based WIOD and UNCTAD TRAINS Database. *Notes:* This figure shows the average tariff rates applied by each economy in our sample to all other economies in the world. Economies are denoted following standard ISO 3-digit codes.

3 Quantifying the impact of deep trade agreements

Our welfare analysis relies, in a first stage, on the gravity 'workhorse model' of international trade. We use this to capture how bilateral exports are related to changes in the level of bilateral trade costs over time. In this section, we briefly present a gravity model, which forms the basis of our reduced-form empirical analysis.⁸ We then discuss the empirical specifications implemented and present reduced-form results.

3.1 Micro-foundations of the gravity equation framework

Our reduced-form empirical model is based on the gravity equation framework summarized in Head and Mayer (2014). They define general gravity in trade flows from exporter i to importer j as the set

⁸A longer discussion of the theoretical gravity model is relegated to section 4, where we discuss our quantitative model.

of models that yield a bilateral trade equation (in logs) as: $\ln X_{ij} = \ln G + \ln S_i + \ln M_j + \ln \phi_{ij} + \varepsilon_{ij}$ where G is a “gravitational constant,” S_i represents “capabilities” of exporter i as a supplier to all destinations, M_j captures all characteristics of destination market j that promote imports from all sources, and ε_{ij} is an error term. Bilateral accessibility of importer j to exporter i is captured in $0 \leq \phi_{ij} \leq 1$, which proxies for the impact of bilateral trade costs on bilateral trade flows.

As is standard, we assume that trade costs contain both a policy-related and a natural component. Adding a time dimension t to reflect the panel nature of our dataset, the impact of trade costs on accessibility is specified as $\ln \phi_{ijt} = \alpha DTA_{ijt} + \gamma \ln(1 + \tau_{ijt}) + \eta_{ij}$, where DTA_{ijt} and τ_{ijt} are the policy-related components and represent any deep trade agreement variable as described in section 3.2 and bilateral export tariffs (in the case of goods exports), respectively. The use of pairwise fixed effects, η_{ij} , addresses the natural trade cost component and has been widely shown to be the most effective method to mitigate endogeneity bias between trade agreements and trade flows, as they capture time-invariant reasons for signing trade agreements such as geographical distance and common language among trade partners.

To avoid making structural assumptions on the specific forms of the origin- and destination-specific terms, the gravity equation can be estimated with exporter and importer-specific fixed effects (or, in a panel, with exporter-time and importer-time fixed effects) which subsume the region-specific terms S_{it} and M_{jt} . These fixed effects control for time-varying factors that could influence trade (such as exchange rate shocks), and they account for the multilateral resistance terms which have been theoretically and empirically shown to bias the effects of trade agreements on trade if not controlled for (Anderson and Van Wincoop, 2003; Baldwin and Taglioni, 2006).

3.2 Empirical specification

We are interested in whether DTAs raise bilateral exports above and beyond an average trade agreement. We therefore estimate the following reduced-form equation:

$$X_{ijt} = \exp[\alpha DTA_{ijt} + \gamma \ln(1 + \tau_{ijt}) + \varphi_{jt} + \delta_{it} + \eta_{ij}] + \varepsilon_{ijt} \quad (1)$$

where X_{ijt} represents annual bilateral imports of destination j from origin i at time t . φ_{jt} and δ_{it} are importer-time and exporter-time fixed effects, respectively, and ε_{ijt} is an error term. All other variables are as described above. We estimate equation (1) for three categories of bilateral trade flows: aggregate (i.e., goods and services sectors combined); goods sectors; and services sectors. For the case of goods, we control for (the log of) applied bilateral tariffs imposed by the importer, $\ln(1 + \tau_{ijt})$, specifically.⁹

We use three different measures to capture trade agreements, each of which reflects varying types of trade agreement depth. First, we proxy DTA_{ijt} in equation (1) with a dummy variable, EIA_{ijt} ,

⁹Note that controlling for tariffs on trade in services is not applicable as bilateral tariffs only apply to goods which physically cross borders.

equal to unity if trade partners i and j have any economic integration agreement in place at time t and zero otherwise.¹⁰ Next, following Mattoo et al. (2017), we proxy DTA_{ijt} with two additional measures of trade agreement depth, based on the count of legally enforceable provisions (k) embedded in a given trade agreement. The first measure, $Core_{ijt} = \sum_{k=1}^{18} Provision_{kijt}$, captures the number of core provisions included in a bilateral trade agreement at any point in time. Noting that this trims down the full set of possible provisions as coded in the DTA database and thus might induce omitted variable bias, the second measure, $Depth_{ijt} = \sum_{k=1}^{52} Provision_{kijt}$, accounts for all potential trade agreement provisions. For ease of interpretation, we normalize these indices between 0 and 1, where 1 refers to the agreement with the maximum number of provisions, and 0 refers to the absence of an agreement.¹¹

In our sample, certain trade agreements, such as the EU agreement, become deeper over time by introducing additional provisions. The main sources of variation thus come from the entry into force of a new DTA and adding provisions to pre-existing trade agreements. In equation (1), the estimated coefficient of interest is α , which gives the extent to which DTAs raise bilateral trade flows, holding economy-wide outcomes fixed. In line with the latest techniques in the literature, we apply the Poisson pseudo maximum-likelihood (PPML) estimation technique proposed by Silva and Tenreyro (2006, 2011) as a way to account for the presence of zero trade flows between bilateral partners, as well as to control for potential heteroskedasticity in our trade data.¹²

Finally, we estimate our baseline specification using annual data. Given our main goal to examine the welfare effects of DTAs, this is our preferred approach for two main reasons. First, we map our reduced-form estimates to annual frequency data in the quantitative model. Therefore, using annual data in our gravity specifications keeps the two parts of our analysis consistent. Second, relative to most gravity model studies that consider trade in goods data starting in the 1960s, the WIOD provides greater disaggregation between goods and services sectors at the expense of a relatively short (16 year) panel. Thus, proceeding with annual data allows us to retain a maximum amount of observations for each export category. Recent work by Egger et al. (2020) lends support to this approach, showing that the use of annual data in gravity estimates improves the efficiency of estimates due to the use of more data.¹³

3.3 Reduced-form results

Table 2 presents the results of equation (1) for aggregate, goods, and services exports.¹⁴ Three main observations are noteworthy. First, the magnitude of the trade agreement variable at hand

¹⁰For the economies covered in our sample, the relevant EIA types are free trade agreements or customs unions.

¹¹In the case of $Core_{ijt}$ the maximum number of provisions is 18. In the case of $Depth_{ijt}$ —for our sample at hand—the maximum number of provisions is 40.

¹²We implement these regressions in Stata using the regression command `ppmlhdfe` by Correia et al. (2019).

¹³Using annual versus interval data—and the appropriate length of intervals—is a widely discussed issue in the gravity literature. We address this through robustness exercises, whereby we re-estimate our empirical specifications using 2-year and 4-year interval data.

¹⁴In all reduced-form specifications presented, we exclude the RoW aggregate as it contains some economies with which economies in our sample have an agreement. Nonetheless, including the RoW aggregate only changes results trivially.

increases with agreement depth, irrespective of the type of trade flow in question. More specifically, the point estimates on EIA_{ijt} , which capture the average effect of any bilateral agreement irrespective of the number of provisions, suggests that bilateral exports between partners that sign an agreement increase by 33.8% (column 1a for aggregate exports).¹⁵ This is lower than the overall impact of $Core_{ijt}$ (38.4%, column 1b) and $Depth_{ijt}$ (43.9%, column 1c). This pattern of increasing magnitude across depth variables confirms results from Mattoo et al. (2017), although they find an even larger (and, as they note, somewhat puzzling) jump in magnitude between $Core_{ijt}$ and $Depth_{ijt}$.

From a policy standpoint, our results provide empirical backing to the notion that DTAs, which include a wide range of non-tariff provisions, have a stronger effect on exports than shallow agreements, given their ability to address behind-the-border trade barriers in addition to the reduction of tariffs. Moreover, our results underscore that provisions which might seem less direct as trade policy instruments (such as clauses on education and training or health) do in fact play a role as non-tariff measures.

Second, comparing results from columns 2a-2c with results from columns 3a-3c suggests that the effect of DTAs is larger for trade in services than trade in goods. The point estimate on $Depth_{ijt}$ in column 3c suggests that trade in services between partners that sign an agreement with the highest depth increases by 29.6%. This result—which is not well documented in the literature—provides evidence that DTAs that include substantive non-tariff provisions play an important role in services trade overall.¹⁶ This underscores that DTAs can be a powerful policy tool by which to boost services exports.

Table 2: Baseline results: Aggregate, goods, and services exports

	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
	Aggregate Exports			Goods Exports			Services Exports		
EIA_{ijt}	0.094*** (0.041)			0.123** (0.050)			0.183*** (0.034)		
$Core_{ijt}$		0.112** (0.044)			0.180*** (0.057)			0.237*** (0.037)	
$Depth_{ijt}$			0.138*** (0.043)			0.221*** (0.056)			0.259*** (0.039)
$\ln(1 + \tau_{ijt})$	-0.230*** (0.038)	-0.229*** (0.038)	-0.226*** (0.037)	-0.272*** (0.039)	-0.265*** (0.038)	-0.261*** (0.037)			
FEs (it, jt, ij)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,200	27,200	27,200	26,434	26,434	26,434	27,200	27,200	27,200

Notes: This table shows the estimation results for equation (1) for aggregate gross exports, goods exports, and services exports. Data is for years 1995-2011 (annual). RoW aggregate excluded. SEs clustered by ij -pair are in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1% levels, respectively.

Finally, while the overall effect of DTAs is relatively larger for trade in services, our results also suggest that such agreements positively impact goods exports, even after controlling for bilateral tariffs. This is seen in column 2c, where the point estimate on $Depth_{ijt}$ indicates that trade in goods between partners that sign an agreement with the highest depth increases by 24.7% (versus 13.1%

¹⁵The overall percentage change in exports resulting from any given agreement proxy is calculated as $exp(\alpha) - 1$.

¹⁶Looking at global value chain trade, Laget et al. (2018) find that the impact of DTAs is typically higher for value-added trade in services compared to value-added trade in goods.

when examining the point estimate on EIA_{ijt} in column 2a). This again supports the role of non-tariff provisions in fostering deeper trade links which engender bilateral goods exports in a meaningful way, beyond the pure reduction of tariffs.

3.4 Reduced-form robustness

We run two main checks to ensure the robustness of equation (1). First, we relax the requirement that legally enforceable provisions must include dispute settlement, thus expanding the number of underlying provisions included in both $Core_{ijt}$ and $Depth_{ijt}$. Results are presented in Table A1, where the variables $CoreAll_{ijt}$ and $DepthAll_{ijt}$ refer to the expanded set of provisions. While results are similar and the trends described above hold, overall magnitudes are slightly lower across the board. These smaller magnitudes are in line with results in Mattoo et al. (2017) and, if anything, provide merit to the approach of considering legally enforceable provisions which can be resolved through dispute settlement. In effect, clauses which are strictly legally binding give a stronger boost to bilateral exports than those which might not hold up in dispute settlement.

Second, we pool our data over two-year and four-year intervals. This is motivated by the argument that using interval data in gravity specifications is the best approach to isolate results from year to year variability and to account for the fact that trade agreement effects might not adjust in a single year’s time (see Yotov et al., 2016 for a thorough discussion).¹⁷ Our main results continue to hold when using data over two- or four-year intervals, as shown in Table A2 and Table A3, respectively. Overall we observe the same trends, while the magnitude of our point estimates increases slightly with larger intervals. As such, we posit that if anything, our main results provide a lower bound of the overall effect of DTAs.

4 Quantitative framework

To estimate the welfare effect of DTAs, we use a quantitative trade model of the global economy, which predicts the gravity equation and incorporates various welfare channels of trade. We follow Costinot and Rodríguez-Clare (2014) and Caliendo and Parro (2015) to set up a general equilibrium multi-sector model with trade in intermediate inputs and input-output linkages. Arkolakis et al. (2012) show that many workhorsetrade models deliver the same predictions of “gains from trade.” Our model belongs to this class of models. More importantly, these models enable the “hat algebra approach” (Dekle et al., 2008) which provides a mapping of the data to the model and allows us to perform counterfactual trade policy simulations with relatively few requirements for the estimation of model parameters.

We contribute to this literature by introducing two important differences in our approach, as compared to Costinot and Rodríguez-Clare (2014). First, while they focus on hypothetical shocks

¹⁷The literature cited typically uses panel data for long time periods over four-year or five-year intervals (e.g. Anderson and Yotov, 2016; Baier and Bergstrand, 2007; Baier et al., 2014).

to tariffs and non-tariff barriers, we examine the welfare effects of actual changes in observed tariffs and non-tariff provisions in DTAs since the Uruguay Round. Otherwise stated, we use reduced form estimates of the impact of observed tariffs and DTA provisions to inform which shocks to feed into our quantitative model. Second, juxtaposing this information with 1995 levels allows us to estimate a series of welfare changes due to trade liberalization across our whole sample period.¹⁸

In what follows, we first present our multi-sector model with trade in intermediate inputs and input-output linkages. We apply the “hat algebra approach” to such a model and then describe our model-based accounting approach to simulate the welfare effect of DTAs.

4.1 Model

Demand Side. Suppose there are N countries, indexed by $j = 1, \dots, N$, and S sectors, indexed by $s = 1, \dots, S$. In each country, the representative household maximizes the following two-tier utility:

$$u_i = \prod_{s=1}^S C_{i,s}^{\beta_{i,s}}, \quad (2)$$

while $\beta_{i,s}$ is the Cobb-Douglas expenditure share of sector s in country i satisfying $\sum_s \beta_{i,s} = 1$, and $C_{i,s}$ is total consumption of composite good s given by a CES aggregator:

$$C_{i,s} = \left(\int_{\omega \in \Omega_{i,s}} c_{i,s}(\omega)^{(\sigma_s-1)/\sigma_s} d\omega \right)^{\sigma_s/(\sigma_s-1)}, \quad (3)$$

where $\sigma_s > 1$ is the sector-specific elasticity of substitution and $\Omega_{i,s}$ is the set of available differentiated good variety.

Production and Trade. Suppose each country is endowed with a measure L_i unit of labor. The production of final goods variety requires both labor inputs and composite intermediate goods. To be specific, we assume that the unit cost function of a variety ω of sector s in country i is given by:

$$c_{i,s} = w_i^{\alpha_{i,s}} \prod_{n=1}^S P_{i,n}^{\alpha_{i,ns}}, \quad (4)$$

where w_i is the wage rate of labor in country i , $\alpha_{i,s}$ is the share of labor inputs, $\alpha_{i,ns}$ are the sectoral intermediate input expenditure shares such that $\alpha_{i,s} + \sum_{n=1}^S \alpha_{i,ns} = 1$, and $P_{i,n}$ is the price of the composite intermediate inputs given by:

$$P_{i,n} = \left(\sum_{j=1}^N P_{j,i,n}^{1-\sigma_n} \right)^{\frac{1}{1-\sigma_n}}, \quad (5)$$

where $P_{j,i,n}$ is the price index of intermediate good n sourced from country j .

¹⁸Our model does not include dynamics such as Caliendo et al. (2019), but it does use observed tariff and DTA changes in each year to examine welfare changes over a 16-year time span.

Trade is costly. To deliver one unit of goods from i to j , $d_{ij,s} \geq 1$ units have to be shipped. Therefore, $d_{ij,s}$ represents iceberg trade costs (Samuelson, 1954) which capture all non-tariff barriers of trade, which are shaped by DTAs. In addition, there are tariffs imposed by governments on foreign imports. The *ad-valorem* tariff rate imposed by country j on good s from country i is $\tau_{ij,s}$. Taking both non-tariff barriers and tariffs into account, and under the assumption that markets are perfectly competitive, the price index of intermediate goods in country j sector s sourced from country i is given by:

$$P_{ij,s} = d_{ij,s}(1 + \tau_{ij,s})c_{i,s}. \quad (6)$$

Trade flows include both final and intermediate goods. Under our assumption that they share the same CES elasticity, the aggregate trade flow follows the gravity equation such that

$$X_{ij,s} = \frac{P_{ij,s}^{1-\sigma_s}}{P_{j,s}^{1-\sigma_s}} E_{j,s}, \quad (7)$$

where $E_{j,s}$ is the total expenditure of country j on goods in sector s , which we specify below. Therefore, the expenditure share on goods in sector s produced by country i is given by:

$$\lambda_{ij,s} \equiv \frac{X_{ij,s}}{E_{j,s}} = \frac{P_{ij,s}^{1-\sigma_s}}{P_{j,s}^{1-\sigma_s}}. \quad (8)$$

Trade Balance and Total Expenditure. Due to the Cobb-Douglas preference, without trade in intermediate goods and input-output linkages, sectoral expenditure is simply $E_{j,s} = \beta_{j,s}(Y_j + T_j + D_j)$, where $Y_j = w_i L_j$ is total factor income, T_j is total tariff revenues, and D_j is the exogenous aggregate trade imbalance.¹⁹ With input-output linkages, sectoral expenditure is given by:

$$E_{j,s} = \beta_{j,s}(Y_j + T_j + D_j) + \sum_{n=1}^S \alpha_{j,sn} R_{j,n}, \quad (9)$$

where $T_j = \sum_{i=1, s=1}^{N,S} \frac{\tau_{ij,s}}{1+\tau_{ij,s}} X_{ij,s}$ is the aggregate tariff revenue, $R_{j,n} = \sum_{i=1}^N \frac{X_{ji,n}}{1+\tau_{ji,n}}$ is the sectoral revenue, and $Y_j = \sum_{s=1}^S \alpha_{i,s} R_{j,s}$ is the aggregate labor income.

Competitive Equilibrium. Given the preference parameters $(\beta_{i,s}, \sigma_s)$, technology parameters $(\alpha_{i,s}, \alpha_{i,ns})$, trade deficits (D_j) , tariffs $(\tau_{ij,s})$ and non-tariff barriers $(d_{ij,s})$, the competitive equilibrium is determined by Equations (4)-(9).

4.2 Hat Algebra and Welfare

In general, to simulate the welfare impact of any trade policy reform requires solving the system of equations (4)-(9). But this would rely on knowing the level of all model primitives, which might

¹⁹Endogenizing trade imbalances requires to model the aggregate saving and investment decision of a given agent (Dix-Carneiro et al., 2021). To keep our model simple, we take trade imbalance as exogenously given in our model. We also follow Costinot and Rodríguez-Clare (2014) to remove the trade imbalances from the data and conduct the counterfactual analysis in a model with balanced trade. Nevertheless, the results are quantitatively close to our baseline results without removing trade imbalances from the data.

be difficult to estimate. We instead adopt the ‘‘Hat Algebra’’ approach (Dekle et al., 2008). This approach solves the model in terms of changes, thus eliminating the need to incorporate information on the full set of parameters discussed above. Defining $\hat{x} = x'/x$, where x' is the level of x after a (trade policy) shock, we can rewrite equations (4)-(9) as follows:

$$\hat{c}_{i,s} = \hat{w}_i^{\alpha_{i,s}} \prod_{n=1}^S \hat{P}_{i,n}^{\alpha_{i,ns}}, \quad (10)$$

$$\hat{P}_{i,n} = \left(\sum_{j=1}^N \hat{P}_{j,i,n}^{1-\sigma_n} \lambda_{ji,n} \right)^{\frac{1}{1-\sigma_n}}, \quad (11)$$

$$\hat{P}_{ij,s} = \hat{d}_{ij,s} \frac{1 + \tau'_{ij,s}}{1 + \tau_{ij,s}} \hat{c}_{i,s}, \quad (12)$$

$$\hat{\lambda}_{ij,n} = \frac{\hat{P}_{ij,n}^{1-\sigma_n}}{\sum_{k=1}^N \hat{P}_{kj,n}^{1-\sigma_n} \lambda_{kj,n}}, \quad (13)$$

$$\hat{E}_{j,s} E_{j,s} = \frac{\beta_{j,s}}{1 - \sum_{i=1, s=1}^{N,S} \frac{\tau'_{ij,s}}{1 + \tau'_{ij,s}} \hat{\lambda}_{ij,n} \lambda_{ij,n} \beta_{j,s}} (Y'_j + D'_j + T'_j) + \sum_{n=1}^S \alpha_{j,sn} R'_{j,n}, \quad (14)$$

where $Y'_j = \sum_{s=1}^S \alpha_{i,s} R'_{j,s}$, $R'_{j,s} = \sum_{k=1}^N \frac{\hat{\lambda}_{kj,s} \lambda_{kj,s}}{1 + \tau'_{kj,s}} \hat{E}_{k,s} E_{k,s}$, and $T'_j = \sum_{i=1, s=1}^{N,S} \frac{\tau'_{ij,s}}{1 + \tau'_{ij,s}} \hat{\lambda}_{ij,s} \lambda_{ij,s} \hat{E}_{j,s} E_{j,s}$.

According to Equations (10)-(14), given the preference and technological parameters and shocks on tariffs ($\tau_{ij,s} \rightarrow \tau'_{ij,s}$), non-tariff barriers ($d_{ij,s} \rightarrow d'_{ij,s}$), or trade imbalances ($D_j \rightarrow D'_j$), we only need to observe the status quo trade share $\{\lambda_{ij,s}\}$, $i, j = 1, \dots, N; s = 1, \dots, S$ to solve the model in terms of changes. Given the preference specified in Equation (2), the changes in consumer welfare can be evaluated by changes in real consumption:

$$\hat{u}_j = \hat{c}_j = \frac{Y_j + \widehat{D_j + T_j}}{\widehat{P_j}}, \quad (15)$$

where $Y_j + \widehat{D_j + T_j}$ is the change in total income and $\widehat{P_j} = \prod_{i=1, s=1}^{N,S} \hat{P}_{i,s}^{\beta_{j,s}}$.²⁰

Adopting the method above, we can compute the change in real consumption for any period t relative to a benchmark period, \hat{c}_{jt} . To account for the impact of a trade policy reform that makes bilateral trade costs (including tariff and non-tariff barriers) evolve over time, we need to evaluate the discounted value of real consumption flows. To do so, we assume that the representative household has a lifetime utility function given by:

$$U_j = \sum_{t=0}^{\infty} \beta^t \ln(u_{jt}),$$

²⁰We follow Costinot and Rodríguez-Clare (2014) to normalize the world GDP to one.

where u_{jt} has the same specification as equation (2), and $\beta \in (0, 1)$ is the discount factor. We measure the welfare impact of a trade policy reform in terms of equivalent variations. To be specific, it is the permanent proportional change in real consumption that would keep the household's lifetime utility the same with or without the trade policy reform. Suppose $\{c_{jt}\}_{t=0}^{\infty}$ and $\{c'_{jt}\}_{t=0}^{\infty}$ are the real consumption flows with and without the trade policy reform, respectively, and that Δ_j , the consumption equivalent of country j , is defined as:

$$\sum_{t=0}^{\infty} \beta^t \ln(\Delta_j \cdot c_{jt}) = \sum_{t=0}^{\infty} \beta^t \ln(c'_{jt}).$$

Then, the consumption equivalent Δ_j satisfies:

$$\ln(\Delta_j) = (1 - \beta) \sum_{t=0}^{\infty} \beta^t \ln(\hat{c}_{jt}), \quad (16)$$

while $\hat{c}_{jt} \equiv c'_{jt}/c_{jt}$ is the counterfactual change in real consumption, which we can estimate using the hat algebra approach for each period.

5 Quantitative Results

We use the model described above and data from the WIOD to simulate the welfare effect of two major changes in trade policy. Following Costinot and Rodríguez-Clare (2014), the WIOD data is aggregated to 31 regions and 31 sectors.²¹ Data on sectoral and regional output expenditure shares and the share of intermediate inputs sourced from each other in production are taken from the WIOD. Trade elasticities are from estimates provided in Caliendo and Parro (2015).²²

We examine two major trade policy changes. First, we estimate the ex-post welfare gains which ensued from widespread trade liberalization that took place following the conclusion of the Uruguay Round and the formation of the WTO in 1995. Following historical developments in the world trade landscape, the years 1995-2011 saw a rapid decline in tariff barriers, the signature of several DTAs, and the deepening of some pre-existing trade agreements.

Second, we use our framework to simulate welfare changes following Brexit under different policy scenarios of DTAs with the EU and with economies outside the EU. The UK's departure from the EU is the largest DTA reversal in recent history. Brexit is a fracture in the world's deepest trade agreement and arises in a setting where services trade and deep commitments are key components of aggregate economic impacts. While a number of studies have examined its tariff implications, an understanding of non-tariff barriers, particularly in the services sector, is less well-understood. The

²¹This approach is taken because some sectors in some economies are associated with both zero output and consumption in the WIOD due to differences in sector classifications across economies. Following Costinot and Rodríguez-Clare (2014), we thus aggregate to 31 sectors, all with non-zero outputs and consumption in all economies. This allows us to keep the data as disaggregated as possible. For further details, see pp. 14 of the Online Appendix of Costinot and Rodríguez-Clare (2014). See Appendix 2 for a list of economies and sectors and the aggregations included in our analysis.

²²The aggregation scheme for economies is provided in Tables A4 and that for sectors and corresponding trade elasticities is provided in Table A5.

reduced form deep trade agreement estimates and the structural model provide new results for the evolution and deepening of UK’s trade relationships within and outside the EU.

5.1 Trade liberalization after the WTO is formed: 1995-2011

The world experienced significant progress in trade liberalization from around the time the WTO was formed in 1995 through the end of our data sample in 2011. This is highlighted in Figures 1 and 2, which show an uptick in DTAs and a considerable decline in applied tariff rates, respectively. Two notable developments were the expansion of the largest customs union in the world, the EU, and large tariff reductions by two of the largest developing economies, China and India.

How much did the world benefit from this round of trade liberalization? We answer this question by feeding estimated changes in DTAs and observed tariff reductions into our quantitative trade model. We proceed as follows. First, setting year 1995 as the base year, we infer the change in non-tariff barriers of trade due to DTAs from equation (1) as:

$$\widehat{d}_{ij,st} = \exp \left[-\frac{\widetilde{\alpha}_s}{\theta} (DTA_{ij,t} - DTA_{ij,1995}) \right], \quad (17)$$

where $\widetilde{\alpha}_s$ is the point estimate of α in equation (1) for sector s (goods or services) and θ is the trade elasticity for each individual WIOD sector from Caliendo and Parro (2015), listed in Table A5. Then, the change in the bilateral trade costs in sector s is given by:

$$\widehat{\phi}_{ij,st} = \widehat{d}_{ij,st} \frac{1 + \tau_{ij,st}}{1 + \tau_{ij,s1995}}, \quad (18)$$

where $\tau_{ij,st}$ is the tariff imposed by country i on sector s imports from country j .²³ Therefore, $\widehat{\phi}_{ij,st}$ measures overall changes in trade costs (including tariff and non-tariff barriers) between country i and country j from the year 1995 to year t . Finally, we feed the shocks of each year into the model together with data from the year 1995 to estimate changes in real consumption induced by the shocks.

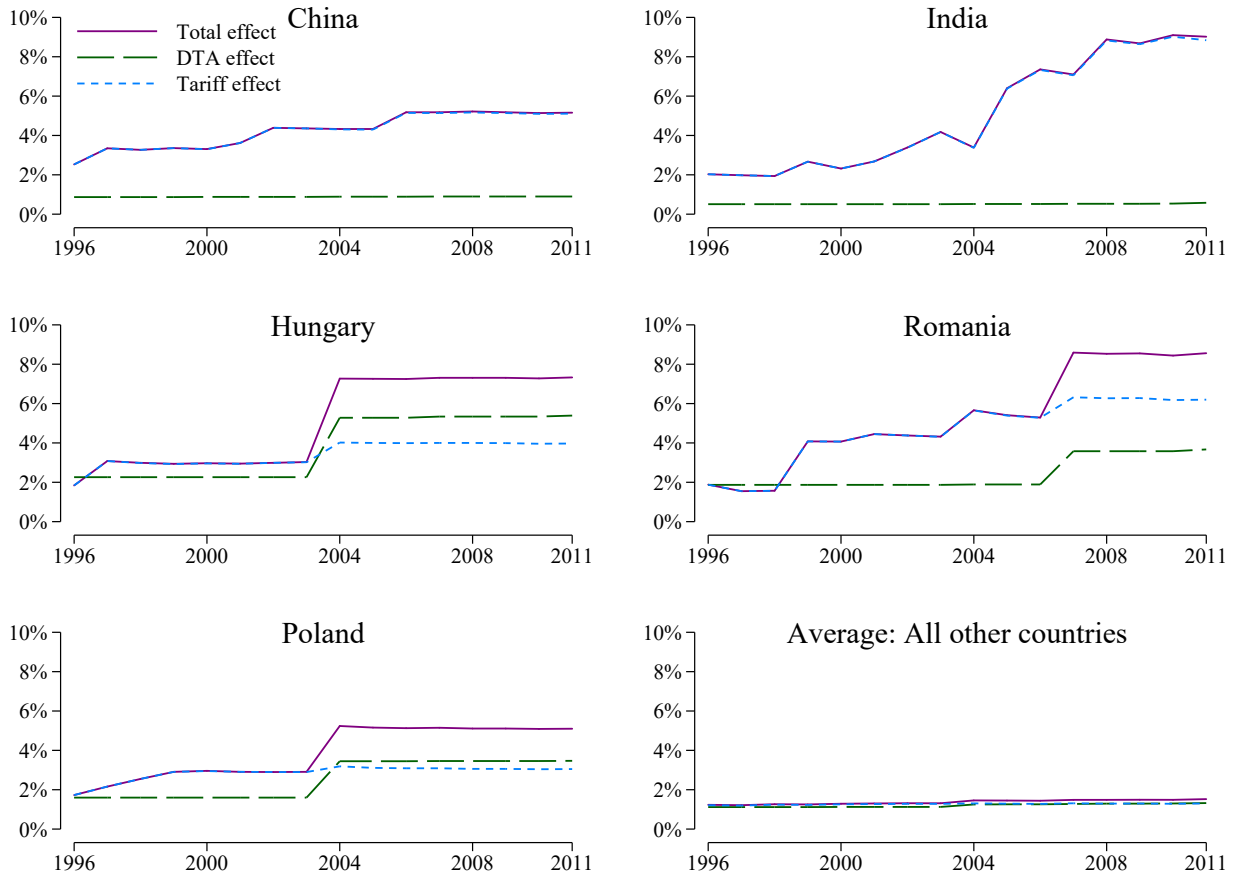
Figure 3 plots the estimated changes in real consumption for each year, which are further decomposed into DTA and tariff effects.²⁴ A few economies are noteworthy in terms of overall welfare gains. First, Eastern European economies, including Romania, Hungary, and Poland, all of which joined the EU during its 2004 enlargement, experienced high overall welfare gains. These gains were predominantly driven by tariff reductions prior to EU accession. After 2004, there is a notable rise in their welfare gains stemming from DTAs. Second, economies that cut their tariffs significantly, including China and India, stand out as well. For example, India’s real consumption rose by almost 10% in 2011

²³For services sectors, there is no second term which captures changes in tariffs.

²⁴Note that a general feature of this type of exercise is that the sum of the decomposition effects is typically larger than the total effect. This is explained by the fact that the baseline model accounts for a high-dimensional shock representing changes in both tariffs and DTAs. During the model simulation, these two components interact with one another, generating general equilibrium effects running in potentially different directions. When included in isolation, this potential interaction is not present. For other studies for which decomposition effects exhibit this feature, see Dhingra et al. (2017) and Tombe and Zhu (2019).

compared to 1995 as a result of trade liberalization during this period. Unlike the Eastern European economies, China and India’s welfare gains were driven predominantly by tariff reductions. All other economies in our sample experienced relatively small welfare gains over the period.²⁵

Figure 3: Evolution of overall welfare gains from trade liberalization, 1996-2011



Notes: This figure shows the estimated change in real consumption for each economy and each year by feeding the observed changes in tariffs and estimated non-tariff barriers as compared to year 1995 into the quantitative model.

Next, we use equation (16) to compute the consumption equivalent of welfare gains from trade liberalization. Results are reported in Table 3. Column 1 presents our results assuming that $\beta = 0.96$ and that no further trade liberalization occurred after 2011. Following Costinot and Rodríguez-Clare (2014), we ensure consistency with the theoretical model by performing simulations after having removed trade imbalances from the data. Note that this correction is made alongside an assumption of zero status quo tariffs (i.e., in 1995). In terms of the DTA variable, we assume that the “rest of the world” belongs to an agreement equal to the average depth with all other economies in our sample. In line with the picture painted by Figure 3, we find that China, India, and the Eastern European bloc

²⁵Appendix 2 presents all economies used in the quantitative analysis. Individual results for all economies not named in Figure 3 are averaged for readability and are available upon request.

benefited the most, enjoying a welfare gain ranging from roughly 4% to 7%. Other regions experienced modest welfare gains.

To understand the source of the welfare gain, Columns 2-5 conduct two additional exercises. First, in columns 2 and 3, we isolate the effects of DTA provisions from tariff shocks, and present the share attributable to each (i.e. columns 2 and 3 sum to 100%). Overall, we observe that gains from both types of trade liberalization are comparable. China and India are the main exceptions, as their gains from tariff liberalization are much bigger than those from deep clauses in trade agreements. This is not surprising: as we can see from Figure 2, these two economies undertook the largest import tariff cuts in our sample. Moreover, our results support the findings of Goldberg et al. (2010) and Yu (2015), who also show that reductions in China's and India's import tariffs contributed to aggregate gains.

Subsequently, columns 4 and 5 decompose total welfare gains into gains from goods versus services sectors, respectively (where now columns 4 and 5 sum to 100%). This exercise reveals that, in most cases, welfare gains from goods liberalization outweigh those from services liberalization. This is particularly evident for Eastern European economies (Hungary, Poland, and Romania) and emerging economies such as China and India and others like Mexico and Indonesia. On the other hand, the gains from goods versus services sectors are comparable for industrialized economies such as the US and early EU members.²⁶

These results track well with intuition: industrialized economies exhibited low tariffs during the full sample period, and thus their gains from reductions in barriers to trade in goods are likely to be linked mostly to liberalization of non-tariff barriers to trade. On the other hand, developing and emerging market economies drastically cut their tariffs during the sample period and undertook deeper liberalizations, and thus their gains from trade in goods are likely to capture both effects. Moreover, welfare gains from services sectors are non-trivial, which speaks to the importance of deep commitments in services trade. It is also noteworthy that welfare gains from column 5 tend to be smaller than those in column 2. This is rationalized by the fact that results in column 2 account for DTA effects for all sectors over time, whereas those in column 5 isolate DTA effects for services sectors only.

Finally, columns 6 and 7 present the results of two robustness exercises. First, in column 6 we re-estimate our baseline specification from column 1, but instead of assuming zero status quo tariffs when removing trade imbalances in the year 1995, we now impose actual applied tariff rates in this year. The resulting welfare gains remain very close to those in the baseline. In column 7, we use a discount factor $\beta = 0.99$, which raises welfare gains slightly.

5.2 Brexit and post-Brexit trade deals

The United Kingdom's decision to withdraw from the EU is an unprecedented instance of trade de-integration: it is the first time in modern history that an economy has sought to leave a deeply

²⁶For ease of discussion, columns 2-3 and 4-5 break down DTA and tariff results, and goods and services results, as shares. Appendix Table A6 presents full results in terms of values.

Table 3: Welfare Effect of Trade Liberalization: 1995-2011

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline	DTA & tariff split		Goods & services split		Robustness	
	DTAs and tariffs	DTA share	Tariff share	Goods share	Services share	Actual '95 tariffs	Discount rate $\beta = 0.99$
AUS	1.97%	45.08%	54.92%	59.06%	40.94%	1.96%	2.11%
AUT	0.98%	53.44%	46.56%	56.59%	43.41%	0.96%	1.07%
BEL	1.41%	55.13%	44.87%	54.17%	45.83%	1.35%	1.53%
BRA	0.47%	51.02%	48.98%	50.51%	49.49%	0.49%	0.49%
CAN	1.54%	42.78%	57.22%	57.71%	42.29%	1.54%	1.61%
CHN	4.46%	16.21%	83.79%	84.10%	15.90%	4.80%	4.97%
DEU	1.08%	53.74%	46.26%	53.31%	46.69%	1.03%	1.14%
DNK	1.35%	50.82%	49.18%	56.42%	43.58%	1.34%	1.47%
ESP	0.72%	55.49%	44.51%	52.31%	47.69%	0.70%	0.76%
FIN	1.10%	51.91%	48.09%	56.04%	43.96%	1.08%	1.17%
FRA	0.81%	52.80%	47.20%	53.62%	46.38%	0.79%	0.86%
GBR	1.24%	52.00%	48.00%	53.47%	46.53%	1.20%	1.30%
GRC	0.65%	48.46%	51.54%	62.37%	37.63%	0.66%	0.71%
HUN	5.82%	55.20%	44.80%	70.13%	29.87%	5.90%	6.91%
IDN	2.09%	43.61%	56.39%	65.68%	34.32%	2.16%	2.40%
IND	6.61%	7.51%	92.49%	93.01%	6.99%	6.82%	8.33%
IRL	1.86%	52.18%	47.82%	52.34%	47.66%	1.83%	1.95%
ITA	0.96%	54.96%	45.04%	51.37%	48.63%	0.93%	1.00%
JPN	0.85%	51.17%	48.83%	49.57%	50.43%	0.80%	0.84%
KOR	2.29%	44.37%	55.63%	58.32%	41.68%	2.34%	2.36%
MEX	1.09%	38.33%	61.67%	66.56%	33.44%	1.14%	1.28%
NLD	1.67%	54.69%	45.31%	51.81%	48.19%	1.59%	1.76%
POL	4.23%	50.13%	49.87%	71.54%	28.46%	4.23%	4.86%
PRT	0.70%	60.63%	39.37%	50.50%	49.50%	0.68%	0.74%
ROU	6.53%	36.22%	63.78%	77.31%	22.69%	6.64%	7.98%
RUS	2.40%	49.79%	50.21%	51.67%	48.33%	2.30%	2.58%
SWE	1.06%	51.79%	48.21%	54.53%	45.47%	1.03%	1.13%
TUR	1.51%	56.68%	43.32%	59.06%	40.94%	1.52%	1.55%
TWN	3.03%	46.25%	53.75%	54.29%	45.71%	3.14%	3.23%
USA	0.84%	51.57%	48.43%	49.20%	50.80%	0.80%	0.86%
RoW	2.38%	38.97%	61.03%	73.35%	26.65%	2.56%	2.75%
average	2.05%	44.04%	55.96%	64.24%	35.76%	2.07%	2.31%

Notes: This table presents the welfare effect of trade liberalization during 1995-2011 in terms of equivalent variation for each economy and the RoW region. Column 1 is the baseline result from simulations which feed the estimated DTAs and observed changes in tariffs of each economy during 1995-2011 to the model, assuming the discount factor $\beta = 0.96$. Here, we follow Costinot and Rodríguez-Clare (2014) by removing trade imbalances from the data and assuming zero status quo tariffs (i.e., in 1995). Columns 2 and 3 feed the DTA and tariffs shocks in isolation, respectively, and present results in terms of shares. Similarly, columns 4 and 5 decompose the effects of DTA provisions and tariff reductions into gains from goods versus services sectors, respectively, and present results in terms of shares. Column 6 uses data which removes trade imbalances, but assumes the underlying status-quo tariffs are actual tariffs. Column 7 uses a discount factor $\beta = 0.99$. The last row of the table computes the simple average of welfare gains across economies.

integrated trading bloc. As such, Brexit represents a potentially significant re-shaping of the UK’s future trading relationships with both the EU itself and the rest of the world. In addition, leaving the EU affords the UK the opportunity to independently negotiate trade agreements with non-EU countries, which it was unable to do while within the EU. Although it remains unclear which countries these might be, the US and the UK’s Commonwealth trading partners are frequently cited as potential candidates. The depth of any possible new trade agreements with non-EU countries remains uncertain.

The importance of this policy question and the uncertainty surrounding any outcome has sparked several investigations into the potential consequences of Brexit, including Dhingra et al. (2017), Born et al. (2019), Steinberg (2019), and Mayer et al. (2019), among others. In this subsection, we pick up on this debate, and focus on the welfare effect of Brexit and post-Brexit trade agreements. Importantly, our analysis differs from those mentioned above in two main ways. First, instead of proxying any new deal with a binary trade agreement variable, we use information from our reduced-form estimates in equation (1), which account for the depth of agreements based on non-tariff provisions. Second, we incorporate the actual information about potential tariff shocks based on pre-existing bilateral tariff rates between trade partners.

Overall, we consider four potential Brexit outcomes, summarized in Table 4.²⁷ While the UK’s future tariffs with the EU have been specified in the new EU-UK Trade and Cooperation Agreement (TCA), its implications for non-tariff barriers, particularly in the services sectors, are not fully specified. We therefore consider different degrees of depth in the UK’s trading relationship within and outside the EU.

Table 4: Brexit scenarios

Scenario	(a) UK: Soft Brexit with the EU	(b) UK: Hard Brexit with the EU
1	<i>NAFTA-depth deal with EU</i>	<i>No deal with the EU; MFN rules</i>
2	<i>Scenario (1a) plus NAFTA-depth trade deal with the United States</i>	—
3	<i>Scenario (2a) plus NAFTA-depth trade deal with Canada and Australia</i>	—

Notes: This table describes the four different Brexit scenarios considered in our counterfactual exercises. In all scenarios, we assume that current FTAs with non-EU members remain in place.

The first three scenarios relate to a “Soft Brexit” case, in which the UK and EU are assumed to negotiate a trade deal of equivalent depth and tariff rates as the North American Free Trade Agreement (NAFTA). NAFTA is a relatively deep agreement, encompassing 0% preferential tariff rates on nearly all goods and a range of non-tariff provisions. The main difference between this Soft Brexit outcome and the UK’s EU membership is thus a shift in non-tariff barriers.²⁸ For example, according to the

²⁷In all scenarios, we assume that the UK rolls over its pre-existing trade deals with non-EU members. These are less important here, as most agreements are relatively shallow in nature.

²⁸There are some differences in tariff rates on individual products, but the main differences come in terms of non-tariff barriers to trade.

DTA database, the EU agreement contains provisions on areas like competition policy, anti-corruption, and visa and asylum, while NAFTA does not. The remaining two Soft Brexit scenarios layer additional NAFTA-depth agreements (including NAFTA tariff rates) on top of the assumed UK-EU relationship. First, we allow for such an agreement between the UK and US, the UK’s next largest trading partner. Second, we consider additional agreements between the UK and its largest Commonwealth trading partners, Canada and Australia.

The final scenario relates to a benchmark “Hard Brexit”, whereby the UK trades on MFN terms with the entire EU bloc: bilateral tariffs revert to MFN rates, and trade agreement depth drops to zero. This is a useful benchmark with which to compare our estimates because previous work has typically reported a Hard Brexit scenario, as the chance of a no deal remained on the table until the UK actually left the EU in 2021. In all cases, we choose the final year of our data as the base year of Brexit and feed the data from this year into the model alongside the shocks from the four different Brexit scenarios.

Table 5 presents the welfare effects in terms of changes in real consumption from different Brexit and post-Brexit trade deals.²⁹ Columns 1-3 present results relating to the various Soft Brexit outcomes, and columns 4-6 present results relating to the various Hard Brexit outcomes. We discuss these outcomes in turn.

UK: Soft Brexit with the EU. Column 1 of Table 5 presents results from our most basic Soft Brexit scenario, whereby we assume that the UK reaches a NAFTA-depth agreement with the EU and implements NAFTA tariff rates. In this case, we infer the associated change in DTA provisions using the estimated $\hat{\alpha}_s$ point estimate from equation (1) and the difference between the depth of NAFTA and the EU.³⁰ Under this scenario, we find that UK welfare would drop by 1.02%. Ireland experiences the next biggest welfare reduction, 0.59%. Other EU members are also left worse off, but the hit to their welfare is about one order of magnitude smaller. Economies outside the EU gain slightly from Brexit due to trade diversion effects. Column 2 presents results when layering a NAFTA-depth UK-US trade deal and NAFTA-level UK-US tariff rates on top of Soft Brexit with the EU. This reduces the UK’s welfare loss by about a third. The US’ welfare is only slightly raised, and the welfare of most of the other regions remains almost unchanged. Finally, column 3 allows for NAFTA-like DTAs between the UK and the US, Canada, and Australia.

The main takeaways from the Soft Brexit counterfactuals are twofold. Even with this relatively deep post-Brexit trade agreement with the EU, UK welfare declines as a result of leaving the EU. Furthermore, additional DTAs with non-EU members do little to mitigate this loss. In the best-case scenario (column 3), the UK still experiences a welfare loss of 0.67% (over two-thirds of the loss without the extra deals).

UK: Hard Brexit with the EU. Column 4 of Table 5 presents results from our baseline Hard Brexit scenario, whereby we assume that no trade deal is reached between the UK and the EU. In

²⁹We assume that the Brexit shock is permanent. Therefore, computing the consumption equivalent would deliver the same result.

³⁰In the year 2011, the EU’s depth index is 1, while that of NAFTA is 0.5.

Table 5: Welfare effects of Brexit

	(1)	(2)	(3)	(4)
	UK: Soft Brexit with the EU			Hard Brexit
	<i>+ NAFTA-depth</i>			
	<i>DTA with:</i>			
	US	US, CAN, AUS		
AUS	0.02%	0.02%	0.02%	0.02%
AUT	-0.07%	-0.07%	-0.07%	-0.13%
BEL	-0.21%	-0.22%	-0.22%	-0.40%
BRA	0.00%	0.00%	0.00%	0.00%
CAN	0.03%	0.03%	0.11%	0.03%
CHN	0.00%	0.00%	0.00%	0.01%
DEU	-0.15%	-0.16%	-0.16%	-0.30%
DNK	-0.11%	-0.11%	-0.11%	-0.23%
ESP	-0.08%	-0.08%	-0.08%	-0.14%
FIN	-0.09%	-0.09%	-0.09%	-0.15%
FRA	-0.09%	-0.09%	-0.09%	-0.17%
GBR	-1.02%	-0.70%	-0.67%	-2.24%
GRC	-0.04%	-0.04%	-0.04%	-0.08%
HUN	-0.12%	-0.13%	-0.13%	-0.25%
IDN	0.00%	0.00%	0.00%	0.00%
IND	0.00%	0.00%	0.00%	0.00%
IRL	-0.59%	-0.60%	-0.61%	-1.21%
ITA	-0.06%	-0.06%	-0.06%	-0.11%
JPN	0.00%	0.00%	0.00%	0.00%
KOR	0.00%	0.00%	0.00%	0.01%
MEX	0.00%	0.00%	0.00%	0.00%
NLD	-0.17%	-0.18%	-0.18%	-0.35%
POL	-0.09%	-0.09%	-0.09%	-0.18%
PRT	-0.07%	-0.07%	-0.07%	-0.14%
ROU	-0.08%	-0.08%	-0.08%	-0.14%
RUS	0.00%	0.00%	0.00%	0.00%
SWE	-0.13%	-0.13%	-0.13%	-0.23%
TUR	0.00%	0.00%	0.00%	0.02%
TWN	0.00%	0.00%	0.00%	0.01%
USA	0.01%	0.04%	0.04%	0.02%
RoW	0.00%	0.00%	0.00%	0.01%

Notes: This table shows the impact of the following scenarios on the welfare (in terms of real consumption) of each economy: (1) Soft Brexit. The UK and the EU reach a NAFTA-depth trade deal (including NAFTA tariff rates). (2) In addition, a NAFTA-depth and NAFTA-tariff rate deal is reached with the United States. (3) In addition, a NAFTA-depth and NAFTA-tariff rate deal is reached with Canada and Australia. (4) Hard Brexit. There is no deal between the UK and the EU: depth is zero, and each apply MFN tariffs. (5) In addition, a NAFTA-depth and NAFTA-tariff rate deal is reached with the United States. (6) In addition, a NAFTA-depth and NAFTA-tariff rate deal is reached with Canada and Australia with NAFTA tariff rates.

such a world, the depth between the UK and all EU trade partners would drop to zero, and MFN tariffs would be implemented. Compared to our baseline Soft Brexit scenario (column 1), the hit to welfare more than doubles reaching a total loss of 2.24%. This shows that substantial losses to the UK economy which could have emerged under a Hard Brexit outcome have been avoided through the new EU-UK TCA, but the losses nonetheless remain substantive under Soft Brexit. For example, even the losses under Soft Brexit are an order of magnitude higher than those estimated for the US economy from the Trump tariff war (0.04% of GDP, Fajgelbaum et al. 2020).

Clearly, the main takeaway from these exercises is that signing deep trade deals with non-EU members will not make up for the overall loss from leaving the EU. Admittedly, a welfare loss of around 1% (Soft Brexit) to 2% (Hard Brexit) might seem modest, but they are incurred annually and cumulate over time.³¹ To put these numbers in perspective, we can compare with column 1 of Table 3, which shows that total UK welfare gains from trade liberalization over the 1995-2011 period were just over 1.2%. Therefore, we conclude that Brexit losses are of a similar magnitude as the gains from trade liberalization accumulated over nearly two decades.

6 Conclusion

This paper has examined the impact of deep trade agreements (DTAs) on trade and welfare. The reduced-form estimates show that deep trade policy commitments have given an extra boost to trade in goods, which amounted to a 25% increase after the conclusion of the Uruguay Round. A less well-known finding is that deep trade policy commitments increase trade in services, and the elasticity of services trade flows to DTAs is 30%. These reduced-form estimates provide direct evidence for the role of DTAs in fostering international economic integration. To examine the welfare effect of DTAs, the paper develops a structural model that builds on the reduced-form estimates to determine the aggregate welfare impacts of deep trade policy commitments.

The structural model enables an understanding of the aggregate contribution of DTAs to the welfare gains from trade in the last couple of decades. We find that the tariff reductions and deepening of trade policy commitments since the Uruguay Round increased welfare by over 2% on average. DTAs contributed over 40% to the gains from trade, and even more so in advanced economies and 2004 EU-accession members.

A key advantage of structural modeling is the ability to conduct counterfactual scenario analysis. Applying the reduced-form estimates and the structural model to Brexit, we find that the UK economy experiences a welfare loss ranging from roughly -1% to over -2%. While signing deep agreements with the EU and key trading partners like the United States, Canada, and Australia reduces the magnitude of the welfare losses, it is not enough to overcome the loss of deep trade policy commitments that EU membership provides. Welfare losses in this soft Brexit scenario continue to be negative. The annual welfare losses under our baseline Soft Brexit scenario amount to over 80% of the UK's annual gains

³¹Our Hardr Brexit numbers are similar to those from Dhingra et al. (2017) and a wide range of other studies. See Sampson (2017) for a survey.

from trade liberalization accumulated in the 16 years following the conclusion of the Uruguay Round.

This paper quantifies the trade and welfare gains from deep trade policy commitments. DTAs have contributed substantially to the overall gains from trade and continue to be important for many economies, particularly as tariffs have reached low levels. As trends towards deglobalization continue, precise quantification of the potential aggregate gains from deep trade agreements—as provided by this paper—is essential to enable a thorough assessment of alternative trade policies and their concomitant trade-offs.

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Appendix 1 Reduced-form robustness

Table A1: Additional provision category

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	Aggregate Exports		Goods Exports		Services Exports	
<i>CoreAll_{ijt}</i>	0.307*** (0.025)		0.164*** (0.055)		0.220*** (0.035)	
<i>DepthAll_{ijt}</i>		0.344*** (0.022)		0.202*** (0.055)		0.232*** (0.038)
<i>ln(1 + τ_{ijt})</i>			-0.266*** (0.038)	-0.261*** (0.038)		
FEs (<i>it, jt, ij</i>)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,200	27,200	26,434	26,434	27,200	27,200

Notes: This table shows the estimation results for equation (1) for aggregate gross exports, goods exports, and services exports. Data is for years 1995-2011 (annual). We now include provisions which are weakly legally enforceable, i.e., do not include dispute settlement. RoW aggregate excluded. SEs clustered by *ij*-pair are in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1% levels, respectively.

Table A2: 2-year intervals

	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
	Aggregate Exports			Goods Exports			Services Exports		
<i>EIA_{ijt}</i>	0.304*** (0.024)			0.108** (0.048)			0.223*** (0.038)		
<i>Core_{ijt}</i>		0.341*** (0.025)			0.162*** (0.055)			0.280*** (0.041)	
<i>Depth_{ijt}</i>			0.379*** (0.022)			0.199*** (0.056)			0.295*** (0.042)
<i>ln(1 + τ_{ijt})</i>				-0.290*** (0.037)	-0.283*** (0.037)	-0.280*** (0.036)			
FEs (<i>it, jt, ij</i>)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,400	14,400	14,400	13,917	13,917	13,917	14,400	14,400	14,400

Notes: This table shows the estimation results for equation (1) for aggregate gross exports, goods exports, and services exports. Data is for years 1995-2011 in two-year intervals. RoW aggregate excluded. SEs clustered by *ij*-pair are in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1% levels, respectively.

Table A3: 4-year intervals

	Aggregate Exports			Goods Exports			Services Exports		
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
<i>EIA_{ijt}</i>	0.357*** (0.022)			0.087* (0.046)			0.223*** (0.046)		
<i>Core_{ijt}</i>		0.414*** (0.024)			0.148*** (0.054)			0.274*** (0.050)	
<i>Depth_{ijt}</i>			0.458*** (0.024)			0.176*** (0.056)			0.279*** (0.051)
<i>ln(1 + τ_{ijt})</i>				-0.348*** (0.034)	-0.340*** (0.034)	-0.339*** (0.033)			
FEs (<i>it, jt, ij</i>)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,000	8,000	8,000	7,677	7,677	7,677	8,000	8,000	8,000

Notes: This table shows the estimation results for equation (1) for aggregate gross exports, goods exports, and services exports. Data is for years 1995-2011 in four-year intervals. RoW aggregate excluded. SEs clustered by *ij*-pair are in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1% levels, respectively.

Appendix 2 WIOD Regions and Sectors

Table A4: WIOD economies and aggregation

WIOD Region	WIOD Code	Quantitative model aggregation
Australia	AUS	AUS
Austria	AUT	AUT
Belgium	BEL	BEL
Brazil	BRA	BRA
Canada	CAN	CAN
China	CHN	CHN
Denmark	DNK	DNK
Finland	FIN	FIN
France	FRA	FRA
Germany	DEU	DEU
Greece	GRC	GRC
Hungary	HUN	HUN
India	IND	IDN
Indonesia	IDN	IND
Ireland	IRL	IRL
Italy	ITA	ITA
Japan	JPN	JPN
Korea	KOR	KOR
Mexico	MEX	MEX
Netherlands	NLD	NLD
Poland	POL	POL
Portugal	PRT	PRT
Romania	ROU	ROU
Russia	RUS	RUS
Spain	ESP	ESP
Sweeden	SWE	SWE
Taiwan	TWN	TWN
Turkey	TUR	TUR
United Kingdom	GBR	GBR
United States	USA	USA
Bulgaria	BGR	
Cyprus	CYP	
Czech Republic	CZE	
Estonia	EST	
Latvia	LVA	
Lithuania	LTU	RoW
Luxembourg	LUX	
Malta	MLT	
Slovak Republic	SVK	
Slovenia	SVN	
Rest of World	RoW	

Notes: We aggregate economies shown in columns 1 and 2 into those in column 3 for the estimation of the quantitative model.

Table A5: WIOD sectors, trade elasticities and sector aggregation used in analysis

WIOD Sector	WIOD Sector Description	Detailed Sector Aggregation	Trade Elasticity	Aggregate Sectors (Goods vs. Services)
1	Agriculture, Hunting, Forestry and Fishing	1	8.11	Goods
2	Mining and Quarrying	2	15.72	Goods
3	Food, Beverages and Tobacco	3	2.55	Goods
4	Textiles and Textile Products	4	5.56	Goods
5	Leather, Leather and Footwear	5	10.83	Goods
6	Wood and Products of Wood and Cork	6	9.07	Goods
7	Pulp, Paper, Paper Printing and Publishing	7	51.08	Goods
8	Coke, Refined Petroleum and Nuclear Fuel	8	4.75	Goods
9	Chemicals and Chemical Products	9	1.66	Goods
10	Rubber and Plastics	10	2.76	Goods
11	Other Non-Metallic Mineral	11	7.99	Goods
12	Basic Metals and Fabricated Metal	12	1.52	Goods
13	Machinery, Nec	13	10.6	Goods
14	Electrical and Optical Equipment	14	0.37	Goods
15	Transport Equipment	15	5	Goods
16	Manufacturing, Nec; Recycling	16	5	Services
17	Electricity, Gas and Water Supply	17	5	Services
18	Construction	18	5	Services
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	19	5	Services
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	20	5	Services
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	21	5	Services
22	Hotels and Restaurants	22	5	Services
23	Inland Transport	23	5	Services
24	Water Transport	24	5	Services
25	Air Transport	25	5	Services
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	26	5	Services
27	Post and Telecommunications	27	5	Services
28	Financial Intermediation	28	5	Services
29	Real Estate Activities	29	5	Services
30	Renting of M&Eq and Other Business Activities	30	5	Services
32	Education	32	5	Services
33	Health and Social Work	33	5	Services
31	Public Admin and Defence; Compulsory Social Security	31	5	Services
34	Other Community, Social and Personal Services	34	5	Services
35	Private Households with Employed Persons	35	5	Services

Notes: The detailed sector aggregation follows that in Costinot and Rodríguez-Clare (2014). Trade elasticities are from Caliendo and Parro (2015).

Appendix 3 Additional welfare results

This appendix presents additional welfare results, whereby we present values associated with columns 2-5 of Table 3. As discussed in the main text, a general feature of this type of exercise is that the sum of the decomposition effects is typically larger than the total effect (corresponding to column 1 of Table 3). This is explained by the fact that the baseline model accounts for a high-dimensional shock representing changes in both tariffs and DTAs. During the model simulation, these two components interact with one another, generating general equilibrium effects running in potentially different directions. When included in isolation, this potential interaction is not present.³²

³²For other studies for which decomposition effects exhibit this feature, see Dhingra et al. (2017) and Tombe and Zhu (2019).

Table A6: Welfare Effect of Trade Liberalization: 1995-2011

	(1)	(2)	(3)	(4)
	DTA & tariff split		Goods & services split	
	DTAs only	Tariffs only	Goods only	Services only
AUS	1.48%	1.81%	1.95%	1.35%
AUT	0.90%	0.78%	0.95%	0.73%
BEL	1.41%	1.15%	1.39%	1.17%
BRA	0.47%	0.45%	0.47%	0.46%
CAN	1.14%	1.53%	1.54%	1.13%
CHN	0.86%	4.43%	4.45%	0.84%
DEU	1.08%	0.93%	1.07%	0.94%
DNK	1.21%	1.17%	1.34%	1.03%
ESP	0.76%	0.61%	0.71%	0.65%
FIN	1.01%	0.93%	1.08%	0.85%
FRA	0.80%	0.71%	0.81%	0.70%
GBR	1.20%	1.11%	1.23%	1.07%
GRC	0.50%	0.53%	0.65%	0.39%
HUN	4.32%	3.51%	5.62%	2.39%
IDN	1.37%	1.77%	2.07%	1.08%
IND	0.53%	6.51%	6.58%	0.49%
IRL	1.83%	1.68%	1.84%	1.67%
ITA	1.02%	0.84%	0.95%	0.90%
JPN	0.87%	0.83%	0.85%	0.86%
KOR	1.73%	2.17%	2.28%	1.63%
MEX	0.62%	0.99%	1.07%	0.54%
NLD	1.73%	1.43%	1.64%	1.52%
POL	2.83%	2.81%	4.12%	1.64%
PRT	0.84%	0.54%	0.69%	0.68%
ROU	2.89%	5.09%	6.41%	1.88%
RUS	2.30%	2.32%	2.38%	2.23%
SWE	0.99%	0.92%	1.04%	0.87%
TUR	1.45%	1.11%	1.51%	1.05%
TWN	2.58%	2.99%	3.02%	2.54%
USA	0.88%	0.83%	0.84%	0.87%
RoW	1.24%	1.93%	2.34%	0.85%
average	1.38%	1.76%	2.03%	1.13%

Notes: This table presents the welfare effect of trade liberalization during 1995-2011 in terms of equivalent variation for each economy and the RoW region. In all columns, we assume a discount factor $\beta = 0.96$ and follow Costinot and Rodríguez-Clare (2014) by removing trade imbalances from the data and assuming zero status quo tariffs (i.e., in 1995). Columns 1 and 2 feed the DTA and tariffs shocks in isolation, respectively. Columns 4 and 5 decompose the effects of DTA provisions and tariff reductions into gains from goods versus services sectors, respectively.