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TRADE AND WELFARE EFFECTS OF THE WTO TRADE FACILITATION AGREEMENT *

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Trade and Welfare Effects of the WTO Trade Facilitation Agreement*

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Abstract

The WTO Trade Facilitation Agreement (TFA) has been predicted to bring about an expansion in trade flows and real income gains. To date, there is still very limited empirical evidence on the actual *post-implementation* impact of the TFA. This paper provides an assessment, combining econometric estimations from a structural gravity model with general equilibrium modelling results. The main insight is that the TFA increased trade, in particular in agriculture, between developing countries that made commitments. General equilibrium estimations indicate that agricultural trade increases by 5% worldwide, while total trade increases by 1.17% worldwide as a result of TFA implementation. Trade gains accrue in particular to LDCs, whose exports increase by 2.4% overall (17% in agriculture). Furthermore, as a result of TFA implementation, real income increases by 0.12% worldwide (0.24% for LDCs).

JEL Codes: F13, F14, F17

Keywords: Trade facilitation, Structural gravity, CGE models

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1 Introduction

The integration of the global economy has made substantial progress in reducing tariffs. Between 1994 and 2017, average tariffs worldwide fell from 8.6% to 2.6%.[1] However, significant non-tariff barriers remain, imposing considerable costs on trade. In addition, global trade has been subject to numerous shocks in recent years (e.g., the COVID-19 pandemic and the Ukraine crisis), causing disruptions to supply chains and imposing additional costs on trade. It is during these difficult times that governments must focus on further reducing the costs associated with trade barriers and regulatory differences in order to promote trade.

Trade barriers and regulatory differences are estimated to account for at least 14 per cent of total trade costs in all sectors. For low-income countries in particular, trade policy barriers are the most important component of trade costs (WTO, 2021). The distribution of these costs determines bilateral trade and investment flows, as well as the geographic distribution of production. Reducing these costs can therefore unlock significant gains for trade and welfare.

The broad definition of trade costs includes all costs arising in the delivery of a good to the final consumer, with the exception of production costs. These costs are incurred at various stages of delivery: (1) in *bringing the goods to the border*, such as costs of logistical services or financing; (2) in *costs at the border*; and lastly (3) in *behind-the-border costs*, which include regulatory measures and local barriers to doing business. *Costs at the border* are composed of *direct costs* that entail export restrictions, tariffs, or lengthy administrative procedures; *indirect costs* such as procedural delays, opportunity costs, and inventory holding; and finally, *hidden costs* such as bribery and corruption (OECD, 2018). One way to reduce such costs at the border is through trade facilitation (TF). According to the WTO definition, trade facilitation is the simplification, modernization and harmonization of export and import procedures.

Beginning in the late 1990s, policymakers placed the reduction of non-tariff trade costs on their agendas. Since then, unilateral trade facilitation efforts[2] have been undertaken, and trade

[1] Estimates are the weighted mean of the applied tariff rate across all products provided by the World Bank.

[2] Such as lowering the number of physical inspections at customs or reduction in per shipment administrative costs.

facilitation provisions were included in regional trade agreements (RTAs) (Neufeld, 2016). Harmonization of standards, reduction of unnecessary inspections, and mutual recognition of certifications are now core areas of international trade negotiations (Walmsley and Minor, 2020). As Zaki (2015) suggests, trade facilitation is a complement rather than a substitute for trade liberalization.

In the 2000s, WTO member countries also began negotiations on multilateral trade facilitation measures. The negotiations were concluded in 2013 at the Bali Ministerial Conference. The Trade Facilitation Agreement (TFA) entered into force on February 22, 2017, after being ratified by two-thirds of WTO members. It is the first multilateral trade agreement since the creation of the WTO in 1995.

There are several reasons for member countries to participate in such an agreement: (1) Countries can internalize *positive externalities*. Eliminating procedural inefficiencies at the border is costly for the implementing country but benefits both trading partners. This leads to underinvestment in trade facilitation, especially for large importing countries. A multilateral trade facilitation agreement helps countries internalize these positive externalities by requiring all trading partners to invest in trade facilitation; (2) a multilateral agreement solves a government's *credibility problem*. By committing to the TFA with enforcement tools, governments can tie their hands against anti-facilitation lobbies. These credibility issues are likely to be particularly severe in poor countries. Consistently with this insight, the empirical analysis shows that poor countries stand to gain most from participating in the TFA; (3) such an agreement solves a *coordination problem*. When countries commit to a multilateral agreement rather than conduct unilateral or bilateral trade facilitation, member states adopt common procedures that reduce the time and cost for exporters to become familiar with each trading partner's customs procedures and requirements and eliminate documentary redundancy; and finally, (4) this agreement allows for *coordination of donor support* to developing countries with capacity constraints. Without such an agreement, developing countries may not have engaged in trade facilitation to this extent.

Soon after the TFA was agreed, efforts were made to predict its possible trade and economic impacts. Notably, WTO (2015) projected that the TFA could lead to an additional average annual growth of 2.06 - 2.73% in exports and 0.34 - 0.54% in GDP up to 2030. However, to date, about five years after the TFA's entry into force, there is still very limited empirical evidence on the actual *post-implementation* impact of the TFA on trade flows and welfare. The objective of this paper is to provide a first assessment of such effects, combining econometric estimations from a structural gravity model with general equilibrium modelling results.

The main insight from the current analysis is that the TFA increased trade, in particular in agriculture, between developing countries that made commitments. We find that agricultural trade between developing countries that have made TFA commitments increases by 16-22%. This is a particularly important result, as there have been traditional obstacles to multilateral liberalization of agricultural trade, and a large number of poor countries have a comparative advantage in agriculture.

Although there is also indication of increases in manufacturing trade, and in trade between developing (TFA committing) countries and developed countries, the empirical estimates are not statistically significant, likely due to the limited post-implementation period considered (between 2017 and 2019, the last year before the COVID-19 pandemic).

General equilibrium estimations further indicate that agricultural trade increases by 5% worldwide, while total trade increases by 1.17% worldwide as a result of TFA implementation. Trade gains accrue in particular to LDCs, whose overall exports increase by 2.4% (and 17% in agriculture). We also find that implementation of the TFA is associated with real income gains. In particular, as a result of TFA implementation, total real income increases by 0.12% worldwide (0.24% for LDCs). These results are qualitatively in line with, although quantitatively lower than, the results in WTO (2015), and they are more similar to subsequent estimates by OECD (2018) and Kumar and Shepherd (2019). They further highlight the positive impact of the TFA, and will hopefully further stimulate countries to deepen and widen their commitments to the TFA.

2 Literature Review

In this section, the empirical literature on the effects of trade facilitation on trade costs, trade flows, and welfare is assessed.

2.1 Measuring Trade Facilitation

The first challenge in estimating the impact of trade facilitation on trade costs and flows, is the question of how to quantify it. Two different approaches have emerged for estimations. The first is a *top down approach* following Novy (2013). A gravity model can be used to derive an all-inclusive measure of trade costs based on observed trade and production patterns. An advantage of this method is that it does not require individual policy measures, which can be susceptible to measurement error. However, this approach provides only an overall estimate of trade costs, without the ability to differentiate the effects of trade facilitation versus other trade cost reduction measures.[3]

The alternative, *bottom-up approach*, aggregates policy measures into restrictiveness indicators. The two major indicators are the World Bank's *Logistics Performance Index* (LPI) and the OECD's *Trade Facilitation Indicators* (TFI).[4] The *LPI* is a set of six high-level indicators of a country's performance in various areas of trade logistics: customs, infrastructure, ease of arranging shipments; quality of logistics sevices; tracking and tracing; and timeliness. The six indicators are summarized into the LPI, ranging from 1 to 5.[5] The *TFIs* are intended to reflect the legal framework of administrative procedures at the border and the state of implementation of various measures. They closely follow the structure of the WTO FTA and range from 0 to 2.[6]

The bottom-up approach provides a comprehensive overview of countries' trade facilitation efforts. However, the indicators are not sufficient enough to analyse the implementation progress

[3] See Arvis et al. (2016) or Shepherd (2016) for applications.

[4] Two additional indicators, the *Doing Business* by the World Bank and the World Economic Forum *Enabling Trade Index* have also been used. See Table C.3 in WTO (2015) for more details.

[5] See Hoekman and Shepherd (2015) or Hillberry and Zhang (2018) for applications.

[6] OECD TFIs have been used in several papers, including Kumar and Shepherd (2019), López González and Sorescu (2019), Fontagné et al. (2020), and Beverelli and Ticku (2022).

of an agreement at a more granular level. The WTO has created the *Trade Facilitation Agreement Database* which tracks the progress on the TFA implementation at the individual commitment level. Hence, it provides a complete breakdown of each developing country's commitments at a given point in time.[7] This new type of data has so far only been used by Hillberry and Zurita (2022) to assess the factors that determine the implementation behavior of different member countries. This paper is the first to evaluate the impact of the TFA on trade flows using this data set on commitments.

2.2 Impact of Trade Facilitation on Trade Costs

Trade costs are a major barrier to trade (see Box 1 for more details on mechanisms). Trade facilitation measures aim to reduce *trade costs at the border*, and it is important to understand the channels through which they operate: the *direct cost reduction channel* lowers fixed and variable costs, allowing trade flows to increase at both the extensive and intensive margins (see Box 1); the *uncertainty reduction channel* helps expand trade flows by reducing the cost of uncertainty at the border (Fontagné et al., 2020); and lastly, the *red tape barriers reduction channel* operates through the dampening impact of trade facilitation on policy-induced trade barriers that do not generate revenue or rents.[8]

Moreover, trade facilitation has spillover effects, as it can lead to a reduction in *hidden trade costs* as well. Trade facilitation measures lead to a higher border integrity and more efficient border processes, which reduces border-related corruption (Moïsé and Sorescu, 2019). In addition, the simplification of customs procedures (ex-ante provision of information and measures to streamline legal procedures) has a dampening effect on customs evasion (Beverelli and Ticku, 2022).

[7] Developed countries were required to commit to all articles during the ratification process, while developing countries had the option to gradually add commitments depending on their ability to implement them.

[8] While trade facilitation leads to a reduction in red tape barriers (RTBs), tariff reductions can be associated with protectionist backlashes through increases in RTBs (Maggi et al., 2022). See also Beverelli et al. (2019) for a more general analysis of 'trade policy substitution', defined as the use of non-tariff measures (NTMs) to restore former levels of tariff protection.

Box 1 - *Economics of Trade Costs*

Trade theory has identified several mechanisms by which trade costs disrupt international trade flows: (1) they drive a wedge between the relative prices of two trading partners by simultaneously raising the price that domestic consumers pay for imports and lowering the price that foreign exporters receive *(Classical General Equilibrium Models of Trade)*; moreover, (2) small (developing) countries are disproportionately affected as the production of goods is shifted to large (developed) countries *(New Trade Theory - Monopolistic Competition)*; and finally, (3) small and less productive firms are prevented from becoming exporters. These cannot offer their products at a lower price than domestic producers and are therefore unable to compete in a foreign market where they face additional costs *(New Trade Theory - Heterogeneous Firms)*.

Trade costs can be categorized as either variable or fixed costs. Variable trade costs are paid for each unit exported, while fixed costs are incurred regardless of volume. In general (see for instance Chaney, 2008) a reduction in variable costs affects trade flows both at the intensive (traded volume of old goods) and extensive (range of traded goods) margin. Fixed costs only affect the extensive trade margin by allowing new exporters to enter the market.

There is substantial empirical evidence of the positive impact of trade facilitation on reducing trade costs. An analysis covering 234 RTAs finds a robust and statistically significant relationship between the inclusion of TF provisions in RTAs and the reduction of trade costs (Duval et al., 2015). The authors highlight that reducing transit time and increasing transparency are the most effective measures. In addition, Piermartini and Maggi (2022) estimate trade costs for a sample of 118 economies based on the latest version of the GTAP database. They show that there is a significant negative correlation between trade costs and OECD TFIs. This implies that countries with lower trade facilitation face higher international trade costs. Using Spanish shipment-level export data, Hornok and Koren (2015) estimate that a 50% reduction in administrative costs per shipment is equivalent to a 9% reduction in tariffs.[9]

[9]The results of Shepherd (2016) however call for some caution on the impact of TF on trade costs. He

2.3 Impact of Trade Facilitation on Trade Flows

As trade costs decrease due to trade facilitation, trade is expected to increase. Several studies point to the expansion of trade flows due to improvements in trade facilitation. The importance of reducing customs transit times for exports is highlighted by Volpe Martincus et al. (2015). They use transaction-level customs data from Uruguay to estimate the impact of control-related delays on exports. Exploiting information on the exact timing of delays, they find that a 10% increase in customs delays results in a 3.8% decrease in exports. The resulting costs are borne by sellers, who face a decline or even a complete stop in demand for their exports. Heid et al. (2021) estimate the impact of a country-specific "time to export" index in a structural gravity model. Consistent with this literature the estimates are negative and statistically significant. Using customs data for Egypt, Hendy and Zaki (2021) confirm that administrative barriers which prolong time at customs affect both the intensive (value of exports) and the extensive (number of products and number of destinations) margins of trade. Evidence for export diversification due to trade facilitation is provided by Beverelli et al. (2015), while Fernandes et al. (2021), exploiting a sharp drop in physical inspections in Albania, document a significant impact on import diversification.

Examining a wide range of developing and developed countries, López González and Sorescu (2019) assess the relationship between the trade facilitation and international trade participation at firm level. They conclude that trade facilitation enables SMEs in both developed and developing countries to expand their export and import activities at the intensive as well as extensive margins. Studies have also shown that trade facilitation measures affect firms differently across the size distribution. While the availability of information benefits all firms, other measures such as advance rulings, appeal procedures, and automation of border formalities tend to favor large firms (Fontagné et al., 2020). Supporting evidence is provided by Carballo et al. (2021), who show that large firms benefit relatively more from fast processing times. This is because they are more sensitive to border processing time, since they manage

concludes that the two regional agreements targeting a 10% reduction in trade costs have had little impact, as trade costs in both agriculture and manufacturing in the APEC region and other regions of the world fell at similar rates between 2002 and 2010.

more complicated supply chains and shipping systems than smaller firms.

In addition, trade facilitation fosters the integration of firms into global value chains (GVCs): countries into which inputs can be imported rapidly and reliably are attractive to companies looking to establish or integrate into GVCs. A 0.1-unit increase in OECD TFIs can lead to a 1.5% to 3.5% increase in value-added imports (OECD, 2018). Using firm-level data for Peru, Lee et al. (2021) shows that trade facilitation in preferential trade agreements leads to an expansion of imports and exports. This is particularly beneficial for companies integrated into GVCs, as they benefit through improved efficiency in sourcing foreign inputs and simplified procedures for exporting.

2.4 Specific Impact of the WTO TFA

The ratification of the TFA has attracted much attention, with several studies forecasting the potential impact for various levels of implementation. Moïsé and Sorescu (2013) forecasted that full implementation of the TFA would reduce trade costs by 14.3% on average. Economies with the biggest pre-implementation deficiencies would profit the most. Similar estimates were provided by OECD (2018). However the first post-implementation study provides estimates that are significantly lower. Duval and Utoktham (2022) find evidence that implementation of the WTO TFA reduces trade costs by 1- 4% on average.

Ex ante estimates of trade and GDP gains have been obtained using computable general equilibrium (CGE) models. However, it is difficult to compare the results as they may vary due to different underlying assumptions and parameters used for the estimates. In addition, comparability is further hampered by different defined scenarios. Nevertheless, some trends can be detected. Using a Dynamic Computable Equilibrium Model, WTO (2015) estimates an addition of 2.06 - 2.73% to the average annual percentage export growth between 2015-2030 due to the implementation of the TFA. Estimates of similar magnitude are provided by Walmsley and Minor (2020). They develop a new estimation approach, which views trade facilitation as an increase in consumers willingness to pay, rather then a reduction in trade costs.[10] They esti-

[10]The newly developed alternative approach holds that consumers prefer goods delivered more quickly and

mate a 1.96% increase in global trade due to full TFA implementation. Much smaller estimates are provided by OECD (2018). Using a computable general equilibrium model, it is estimated that full implementation of the TFA can increase world trade by 0.6%. Kumar and Shepherd (2019) use a general equilibrium structural gravity approach and also predict relatively small gains. Taking the perspective of an importing country, they show that full implementation of the TFA can increase bilateral trade flows by 0.2%.

Estimates of GDP growth are also mixed. WTO (2015) predicts an annual additional growth of 0.34 - 0.54% in GDP, depending on the extent of TFA implementation. The predictions of OECD (2018) are significantly lower in magnitude. The increased efficiency of border procedures from full implementation of the TFA could potentially add between 0.04% and 0.41% to countries' GDP, depending on the level of development. The estimates of Kumar and Shepherd (2019) are in between: full implementation of the TFA would result in a 0.15% increase in global real output.

The results discussed above are based on assumed reductions in trading costs that would result from the TFA. Therefore, the corresponding general equilibrium results are to some extent also assumed. In contrast, the analysis conducted in this study is based on actual estimates of trade cost reductions that occurred after the ratification of the TFA.

3 Descriptive Analysis of the TFA Commitments

The analysis in this study is based on detailed information about the individual commitments of WTO member countries under the Trade Facilitation Agreement contained in the Trade Facilitation Agreement Database (TFAD).[11] Countries could make commitments in twelve articles, and in a number of sub-articles within each article (see Table 1), summing up to 238 possible commitments. While developed countries were required to commit to all 238

are willing to pay more for them. This is true not only for final products, but also for intermediate goods throughout the supply chain. From the perspective of firms, the ability to defer import decisions until better market knowledge is obtained, and then to receive those imports quickly once a decision has been made, has distinct advantages for retailers and importers (Walmsley and Minor, 2020).

[11] Available at `https://tfadatabase.org/en`.

Table 1: Number of Sub-Articles by TFA Article

Article	Title	No. of Sub-Articles
Art. 1	*Publication and Availability of Information*	22
Art. 2	*Opportunity to Comment, Information Before Entry Into Force and Consultations*	4
Art. 3	*Advance Rulings*	19
Art. 4	*Appeal or Review Procedures*	9
Art. 5	*Other Measures to Enhance Impartiality, Non-Discrimination, and Transparency*	8
Art. 6	*Disciplines on Fees and Charges Imposed on or in Connection With Importation and Exportation*	14
Art. 7	*Release and Clearance of Goods*	55
Art. 8	*Boarder Agency Cooperatio*n	6
Art. 9	*Movement of Goods Under Customs Control Intended for Import*	1
Art. 10	*Formalities Connected With Importation, Exportation and Transit*	30
Art. 11	*Freedom of Transit*	21
Art. 12	*Customs Cooperation*	49

sub-articles during the ratification process, developing countries had the option to gradually add commitments depending on their ability to implement them, as described in Box 2. The TFAD provides a breakdown of each developing country's commitments at a given point in time. A total of 121 developing countries have made commitments under the Trade Facilitation Agreement.

Box 2 - *Commitment Types in WTO TFA*

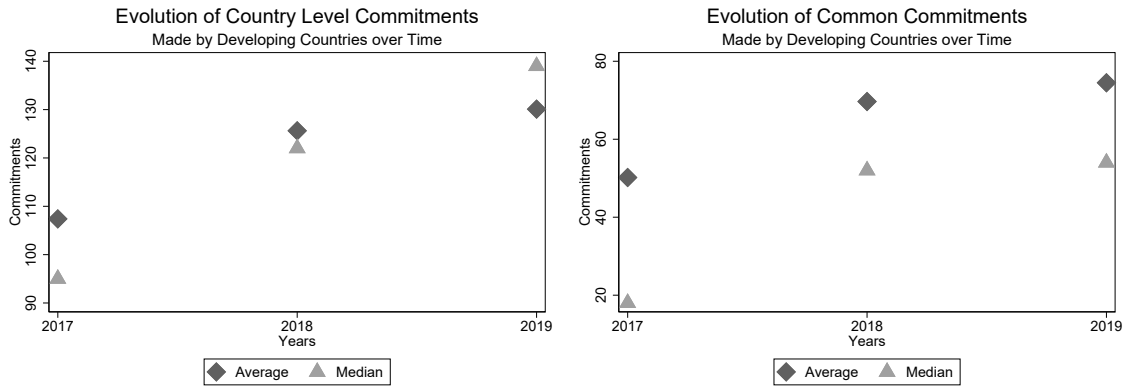
The novel structure of the TFA allows developing countries to make commitments on a measure-by-measure basis. There are three different types of commitments: *Type A* are binding commitments, which the respective governments had to implement within one year of the agreement's entry-into-force in 2017. *Type B* commitments allow countries to delay their implementation until such time that they have the capacity to implement them. Lastly, *Type C* commitments are those that the country believes will require both additional time and substantial financial and/or technical assistance before they can be implemented. The analysis in this study is based on all commitments that have been made, independent of the type.

According to TFAD, until November 2022 50% of commitments were made during the ratification process (Type A), while 18% of the sub-articles were committed to later (Type B). For 27% of the commitments countries have requested financial or technical assistance (Type C) and for 4% of commitments no notification had been made yet. (See Chart 6 in WTO, 2021a, for similar analysis).

The development of the commitments made by developing countries during the study period is depicted in Figure 1. Figure 1a shows how the average and median number of commitments for the 121 developing countries evolved between 2017 (year of TFA ratification) and 2019 (last year in the sample in the empirical analysis). An interesting pattern can be observed, with the median growing faster (from 95 to 138) than the average (from 107 to 130). This means that the number of commitments of each country was skewed to the right at the beginning. Many countries made few commitments, while only some pledged a large number of trade facilitation measures from the start. By the end of the observation period, the distribution shifted. This indicates that the majority of countries increased the number of commitments considerably, while some countries remained at a low number.

Since the empirical analysis is based on bilateral data, it will consider common commitments within a given country pair. In particular, an indicator variable equal to one if both trading

Figure 1: Evolution of TFA Commitments



(a) By Country **(b)** By Trading Partners

Notes: Figure 1a shows the evolution of the average and median number of commitments made by countries between 2017 and 2019. The minimum number of commitments a TFA committing country could have made is 1 and the maximum is 238. Figure 1b depicts the development of common commitments across pairs of TFA committing countries. The minimum number of common commitments within a pair of TFA committing countries is 0 and the maximum is 238.

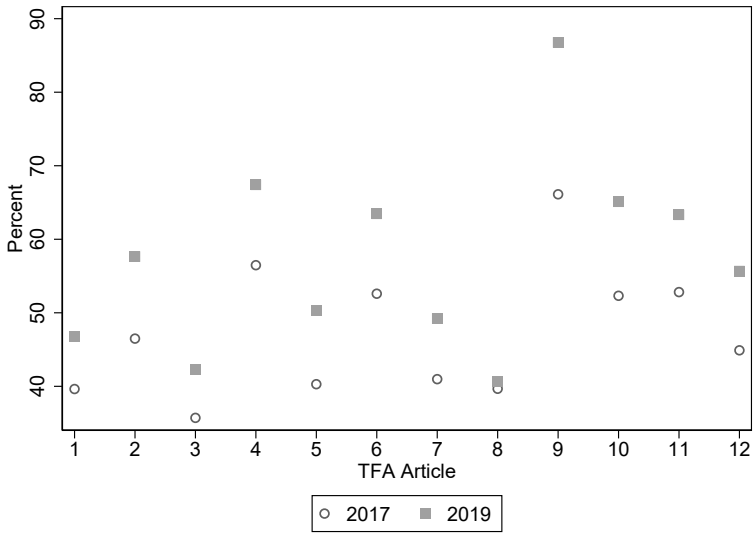
partners have made commitments will be used as a measure of the *extensive margin* of commitments, and the number of common commitments within each given country pair will be used as a measure of the *intensive margin* of commitments. The rise of the average and median number of common commitments between bilateral trading partners is depicted in Figure 1b.[12] A steady increase of the average number of common commitments can be observed, while the median increases by almost three-fold between 2017 and 2018. This indicates that the number of common commitments is rising faster among trading pairs with a low number of commitments than in trading pairs with a high initial number of common commitments.

The evolution of the average share of commitments made by countries by article is presented in Figure 2.[13] With the exception of Article 8, it can be seen that commitments have deepened for all articles. On average, the number of commitments within each article increased by 20%. As also pointed out by WTO (2021a) and Hillberry and Zurita (2022), certain TFA articles are easier to implement than others. For example, as shown in Figure 2, it appears to be easier to

[12] The moments of the distribution of the other explanatory variable, a dummy variable indicating whether both trading partners have made commitments, are not shown here because they are not particularly informative.

[13] The share of commitments by article is calculated as the ratio between a country's number of commitments in that article and the total number of sub-articles where commitments can be made in that article (displayed in the last column of Table 1). In Figure 2, each point (for year 2017) or square (for year 2019) is the average share across all the 121 TFA committing countries.

Figure 2: Average Share of Sub-Articles Committed To, by Article



Notes: This figure shows the average share of sub-article commitments made by article in 2017 and 2019. Authors' elaboration based on WTO Trade Facilitation Agreement Database.

implement commitments in articles 4 or 10 than in articles 3 or 8.[14]

4 Trade Effects of the TFA

This section provides the trade effects of the TFA estimated using a theory-based gravity equation. It includes three sub-sections: (i) Description of the data and sources used (Section 4.1); (ii) Description of the econometric model that we employed to obtain the main estimates (Section 4.2); and (iii) Discussion of our main findings (Section 4.3).

4.1 Data and Sources

To perform the estimation analysis, we rely on the newest (second) edition of the International Trade and Production Database for Estimation (ITPD-E-R02). This dataset is developed by Borchert et al. (2022b) and it is hosted and maintained by the U.S. International Trade Commission (US ITC).[15] The ITPD-E-R02 has several advantages for our purposes. First, it covers many countries (256), including all WTO members. Second, it includes consistently con-

[14]Note that Art. 9 only has one sub-article as shown in Table 1. Therefore, for this article, the average share of sub-article commitments is equal to the average share of article commitments.

[15]For summary statistics and further details on the ITPD-E-R02, including gravity estimations, see Borchert et al. (2021, 2022a,b).

structed domestic and international trade flows.[16] Third, the ITPD-E-R02 is constructed from raw administrative data that have not been manipulated with statistical methods. Thus, ITPD-E-R02 is suitable for estimations. Fourth, the ITPD-E-R02 includes many industries (170), which can be classified in four broad sectors, including Agriculture, Mining, Manufacturing and Services. Our analysis will focus on Agriculture and Manufacturing, but we will exploit the most disaggregated industry dimension of the ITPD-E-R02. This is particularly important in the current setting, since the TFA entered into force only recently (i.e., in 2017), limiting the variability of the data over time and increasing the importance of sectoral disaggregation.[17]

4.2 Econometric Specification

To quantify the impact of the TFA, we rely on the workhorse model of trade, the gravity equation. In addition to having many and solid theoretical foundations (e.g. Anderson, 1979; Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Arkolakis et al., 2012; Allen et al., 2020), the gravity system would enable us to obtain both the partial and the general equilibrium effects of the TFA within the same structural framework. The following econometric specification is based on the theoretical gravity model:

$$\begin{aligned} X^j_{in,t} &= \exp[\alpha_0 + \alpha_1 WTO_{in,t} + \mathbf{TFA}_{in,t} + INTBRDR^j_{in,t}] \\ &\quad \times \exp[\mu^j_{in} + \pi^j_{i,t} + \chi^j_{n,t}] + \epsilon^j_{in,t}, \end{aligned} \tag{1}$$

where $X^j_{in,t}$ are nominal trade flows (Baldwin and Taglioni, 2006) from exporter i to importer n in industry j at time t.[18] To specify and estimate equation (1), we follow the latest developments and best practices from the related literature (e.g. Yotov et al., 2016).

The dependent variable $X^j_{in,t}$ denotes trade in levels (rather than in logs) because, following

[16] As demonstrated in Dai et al. (2014), the inclusion of domestic trade flows is important for quantifying the effects of trade agreements. More recently, Larch et al. (2018) use domestic trade flows to solve the puzzle of missing WTO effects (Rose, 2004).

[17] The ITPD-E-R02 covers a long period of time (1986-2019 for agriculture and 1988-2019 for manufacturing). Given the purposes of our study, however, we limit the estimating sample to the period 2014-2019, which is centered around the year 2017, when the TFA entered into force.

[18] The use of the subscript n for the importing country and of the superscript j for the industry is to keep notation in line with the notation of Section 5.

Santos Silva and Tenreyro (2006, 2011), we will use the Poisson Pseudo Maximum Likelihood (PPML) as our preferred estimator. $X^j_{in,t}$ includes domestic trade flows, which would enable us to capture possible trade diversion effects from domestic sales (Dai et al., 2014; Larch et al., 2018; Yotov, 2022).

Based on the recent analysis of Egger et al. (2022), we will use data for consecutive years, instead of data with intervals (Cheng and Wall, 2005). This is particularly important in our setting, because the TFA entered into force only recently (i.e., in 2017). To improve estimation efficiency, we will pool together (rather than aggregate) the industries that are available from the ITPD-E within the broad sectors of agriculture and manufacturing. Specifically, we will pool 28 industries in Agriculture and 118 industries in Manufacturing.

The pooling of multiple industries implies that in order to account for the structural multilateral resistances of Anderson and van Wincoop (2003), we should use exporter-industry-time and importer-industry-time fixed effects ($\pi^j_{i,t}$ and $\chi^j_{n,t}$, respectively). Motivated by Baier and Bergstrand (2007) we will also include pair fixed effects, which, due to our disaggregated specification, will also vary by industry (μ^j_{in}).[19]

Following the recommendations of Bergstrand et al. (2015), who argue that the effects of trade agreements may be biased upward because they may be capturing common globalization effects, we will also include a set of industry- and year-specific international border dummies ($INTBRDR^j_{in,t}$), i.e., dummy variables that are equal to one for international trade and zero for domestic sales for each year in our sample. Furthermore, we will control for WTO membership with an indicator that is equal to one if i and n are both WTO members at time t.[20]

The main objective is to estimate equation (1) to obtain estimates of the impact of the TFA. To this end, we will experiment with several variables that are captured in the vector $\mathbf{TFA}_{in,t}$. Specifically, we will distinguish TFA effects by group and at the extensive and intensive mar-

[19] Following Baier et al. (2019), the industry-pair fixed effects will be asymmetric ($\overrightarrow{\mu^j_{in}}$), i.e., depending on the direction of trade flows.

[20] We do note, however, that due to the combination of recent and short sample period and the use of pair fixed effects, our WTO estimates would be identified of very few observations due to new joiners.

gins using the following variables:

- *Both_commit_ext* is a dummy variable equal to one if both countries i and n are in the set of the 121 WTO members who made any TFA commitment and zero otherwise.
- *One_commit_ext* is equal to one if one of the countries is one of the 121 WTO members who made any TFA commitment and the other country is a developed country, and zero otherwise.
- *#commitments* captures the number of common commitments made simultaneously by countries i and n.
- *Both_commit_int* is the interaction of *#commitments* and *Both_commit_ext*, and it captures the effect at the intensive margin of the TFA for the 121 WTO members who made any TFA commitment.
- Similarly, *One_commit_int* is the interaction between *#commitments* and the variable *One_commit_ext*, and it captures the effect at the intensive margin of the TFA if one of the countries is one of the 121 WTO members who made any TFA commitment and the other country is a developed country.

4.3 Estimation Results

This section describes the results based on the econometric model described in the previous section. Our main findings appear in Tables 2 and 3. As noted earlier, we focus on Agriculture and Manufacturing.

Despite the relatively short period of investigation and the rich structure of fixed effects, in Table 2 we obtain a positive, sizable, and statistically significant estimate of the impact of the TFA on agricultural trade among the less developed members of the TFA agreement. The estimates imply an about 22% increase in trade flows ($[\exp(0.201) - 1] \times 100$). We view this result as particularly encouraging, due to the traditional difficulties in liberalizing trade in

Table 2: Estimating The Effects of TFA at the Extensive Margin

	Agriculture (1)	Manufacturing (2)
WTO	0.145	0.058
	(0.169)	(0.124)
Both_commit_ext	0.201**	0.041
	(0.071)	(0.026)
One_commit_ext	0.012	0.027
	(0.031)	(0.020)
No. of observations	890,626	10,100,038

Notes: This table reports estimation results from econometric models that study the impact of the extensive margin of the TFA on international trade. The dependent variable is bilateral trade in levels. All estimates are obtained in panel settings with the PPML estimator, exporter-sector-time and importer-sector-time fixed effects, industry-specific time-varying international border variables, as well as industry-specific asymmetric country-pair fixed effects. For presentation purposes, we omit the estimates of all fixed effects, including the constant, as well as of the industry-specific time-varying international border variables. Standard errors are multi-way clustered by exporter, importer, and year and are reported in parentheses. $^{+}$ $p < 0.10$, * $p < .05$, ** $p < .01$. See main text for further details.

agriculture and to the fact that a large number of poor countries have a comparative advantage in agriculture. The corresponding estimate for manufacturing is positive, but very small in magnitude and not statistically significant. Thus, at least in the couple of years after its implementation, the TFA has not been able to stimulate additional manufacturing trade among its less developed members. The last row of Table 2 shows that, at least in the couple of years after its implementation, the TFA did not lead to increases in either agriculture nor manufacturing trade between less developed and the richer WTO members.[21]

Moving to the intensive margin results (Table 3), the estimates for Agriculture suggest that more commitments (as measured by their count) have led to deeper liberalization and more trade among the developing TFA members. This result is consistent with the corresponding result on the extensive margin from Table 2. Note that the number of commitments ranges from

[21] In the first row of Table 2, we do not obtain significant estimates of the effects of the WTO. This is not surprising because during the short period of investigation there were only a few new joiners (Yemen in 2012, Seychelles and Kazakhstan in 2015, Liberia and Afghanistan in 2016). We do note, however, that both of the estimates of the WTO effects are positive. A possible explanation for the insignificant results is that it may take time for the WTO effects to kick in.

Table 3: Estimating The Effects of TFA at the Extensive and Intensive Margin

	Agriculture (1)	Manufacturing (2)
WTO	0.153	0.095
	(0.179)	(0.113)
#commitments	-0.0004	-0.0006**
	(0.0003)	(0.0002)
Both_commit_ext	0.011	-0.160
	(0.079)	(0.099)
Both_commit_int	0.001^{+}	0.0009*
	(0.0007)	(0.0004)
One_commit_ext	-0.0005	-0.201**
	(0.075)	(0.077)
One_commit_int	0.00008	0.001**
	(0.0004)	(0.0003)
No. of observations	890,626	10,100,038

Notes: This table reports estimation results from econometric models that study the impact of the extensive and intensive margin of the TFA on international trade. The dependent variable is bilateral trade in levels. All estimates are obtained in panel settings with the PPML estimator, exporter-sector-time and importer-sector-time fixed effects, industry-specific time-varying international border variables, as well as industry-specific asymmetric country-pair fixed effects. For presentation purposes, we omit the estimates of all fixed effects, including the constant, as well as of the industry-specific time-varying international border variables. Standard errors are multi-way clustered by exporter, importer, and year and are reported in parentheses. $^{+}$ $p < 0.10$, * $p < .05$, ** $p < .01$. See main text for further details.

0 to 238, with a mean of around 150 commitments for country-pairs where both countries are developing countries, and around 100 commitments when one of the countries is one of the 121 WTO members who made any TFA commitment as of 2017 and the other country is a developed country. Hence, the marginal effect at the mean is about 16% ($(\exp(0.001 \times 150) - 1) \times 100$), which is similar to the effect that we obtained in Table 1 when not distinguishing between extensive and intensive margin. Hence, the positive gains seem to stem from the intensive margin.

We obtain more mixed results in the Manufacturing sector. Specifically, similar to Agriculture, we obtain a positive and statistically significant estimate on the intensive margin of trade among developing countries, as captured by the estimate on Both_commit_int. In addition,

we also obtain a highly significant estimate on One_commit_int. However, the estimates on the overall number of commitments and the extensive margin for trade between the developed and the developing countries (One_commit_ext) are negative and statistically significant.

In sum, based on the analysis that performed in this section, the most robust and important finding is that the TFA has promoted agricultural trade among committing developing countries. We also obtain positive but small and not statistically significant estimates of the TFA effects in Manufacturing and for trade between poor and rich countries in both agriculture and manufacturing. A possible explanation for the insignificant results is the relatively short period of time since the TFA entered into force. Based on the analysis of the evolution of the effects of trade agreements from Egger et al. (2022), we expect that the TFA impact would follow an upward trajectory and that stronger effects may be detected with data that cover more years after its implementation.

5 General Equilibrium Effects of the TFA

In this section, based on the empirical estimates in the previous section, we quantify the aggregate trade and real income effects of the TFA implementation by means of a counterfactual analysis based on a computable general equilibrium model. We start describing the model (Section 5.1), its mechanisms (Section 5.2), and its calibration (Section 5.3). In Section 5.4 we then quantify the trade cost effects of the estimations obtained in Section 4, and use these effects as inputs for the model. Section 5.5 discusses the results of the counterfactual analysis.

5.1 Description of the Model

The theoretical framework is based on Caliendo and Parro (2015), who provide a multi-sector version of the Ricardian trade model by Eaton and Kortum (2002) with input-output linkages. We follow previous work (see Aichele and Heiland 2018; Felbermayr and Steininger 2019; Felbermayr et al. 2022) in modelling non-tariff barriers to trade (NTBs) explicitly. The model features a theoretically founded gravity equation at its core and, thus, permits integrating the

partial trade effects estimated with the empirical gravity model in the previous section.

The comparative statics exercises we conduct compare the baseline equilibrium before the implementation of the TFA to the counterfactual long-run equilibrium featuring lower levels of NTBs that are consistent with the trade-enhancing effects estimated in the empirical section. The new simulated equilibrium is a counterfactual one because to isolate the effects of the TFA we hold all other variables constant at their baseline level.[22] In what follows, we present a non-technical summary of the model environment and the adjustment mechanisms that are at work in our general equilibrium framework. Analytical details, which closely track Caliendo and Parro (2015), are relegated to Appendix A.

The model features multiple countries and multiple sectors that are connected via input-output linkages. Each country produces an aggregate good in every sector that consists of domestic and imported varieties. Each country also produces varieties of each sectoral good (or service) using labor and a bundle of intermediate inputs. The intermediate input bundle contains the aggregate goods from other sectors, with input shares that reflect the sectoral input-output linkages in each economy. The input shares vary by country and sector of demand as well as by sector of supply, exactly as observed in a classical input-output table. The aggregate sectoral goods are also sold to domestic consumers, which spend a constant share of their income on each sectoral good.

Demand for imported varieties in each sector follows a gravity equation:

$$X_{in}^{j} = \pi_{in}^{j} X_{n}^{j}, \qquad \text{where} \qquad \pi_{in}^{j} = \frac{\lambda_{i}^{j} \left[c_{i}^{j} \kappa_{in}^{j} \right]^{-\frac{1}{\theta^{j}}}}{\sum_{i=1}^{N} \lambda_{i}^{j} \left[c_{i}^{j} \kappa_{in}^{j} \right]^{-\frac{1}{\theta^{j}}}} \tag{2}$$

denotes the share of total expenditure X_n^j that consumers and producers in country n spend on varieties from sector j produced in country i. Import shares π_{in}^j reflect the relative competitiveness of a source country in producing and shipping varieties to a specific destination. Such relative competitiveness is determined by a source country- and sector-specific aver-

[22] The model is static and assumes that technology is fixed. Short-run effects and the adjustment path are thus not considered.

age productivity level λ_i^j and bilateral sector-specific trade costs κ_{in}^j. In addition, a country's competitiveness depends on the cost of inputs c_i^j, including the cost of labor and the prices of intermediate goods.

Bilateral trade cost are modelled as

$$\kappa_{in}^j = (1 + t_{in}^j) \exp\left[\mathbf{GRAV}_{in}\boldsymbol{\beta}^j + \mathbf{Z}_{in}\boldsymbol{\delta}^j\right], \tag{3}$$

where $t_{in}^j \geq 0$ denotes ad-valorem tariffs, $\mathbf{GRAV}_{in}$ is a vector of proxies for bilateral NTBs that are common in the empirical gravity literature and $\mathbf{Z}_{in}$ is a vector collecting trade policy variables such as an indicator for whether two countries have jointly committed to the implementation of the TFA.

Total exports and imports by sector are given by

$$EX_i^j = \sum_{n \neq i} X_{in}^j \qquad \text{and} \qquad IM_n^j = \sum_{i \neq n} X_{in}^j, \tag{4}$$

respectively. Real GDP, our measure of welfare, is given by

$$RGDP_n = \frac{VA_n}{P_n}, \tag{5}$$

where VA_n measures value added of country n. Value added is given by labor income $VA_n = w_n L_n$, where w_n and L_n denote the wage and the labor force of country n, respectively. $P_n = \Pi_{j \in J}(p_n^j)^{\alpha_n^j}$ is the consumer price index in country n, with α_n^j reflecting the share of expenditure devoted to goods from sector j.

The model is closed with an income-equals-expenditure condition that pins down the wage in every country. The model allows for unbalanced trade, treating trade surpluses as transfers. Following Caliendo and Parro (2015), we hold trade surpluses constant in the counterfactual equilibrium.

5.2 Model mechanisms

To quantify the general equilibrium trade and welfare effects of the TFA agreement, we simulate the responses of the model outcomes to a change in NTBs that is consistent with the empirical estimates in the previous section. Before turning to the quantification of the NTB changes and the calibration of the model, we discuss the adjustment mechanisms that are at work in the model.

The direct and indirect effects induced by trade cost shocks are manifold. Consider a decrease in bilateral trade costs between origin i and destination n for varieties of sector j, $\hat{\kappa}_{in}^{j} < 1$. As a direct consequence, country i's relative competitiveness in serving market n with sector-j goods improves. Hence, the trade share increases. Furthermore, there are multiple second-round adjustments. First, lower prices for imported intermediate inputs reduce the production cost of all sectors in the importing country. These cost reductions are passed on further along the value chain to all sectors in all countries, with the strength of the effect determined by the intensity of the input-output relationship. The resulting differential cost changes feed back into relative competitiveness changes of all sectors from all countries in all destination markets. Second, countries experiencing greater gains in competitiveness experience an increase in demand for their goods, which leads to higher wages. Exports decrease as higher wages partly undo the gains in competitiveness and imports increase due to higher incomes until the initial deficit is restored. Third, income changes and output changes caused by changes in relative competitiveness spill over to other countries via changes in demand for imports. Given the richness of direct and indirect mechanisms, general equilibrium adjustments to a trade cost shock are very diverse. Yet, as a general tendency, a country experiencing a negative trade cost shock sees wages increase. Third countries tend to lose market shares but may also gain if they rely strongly on inputs or demand from the directly affected countries.

5.3 Model calibration

Following Caliendo and Parro (2015) and Dekle et al. (2008), we solve for the model in global changes. This procedure has the advantage that several constant model parameters that are difficult to calibrate, like the elasticity of substitution between varieties, drop out. The only deep parameter that needs to be calibrated is the sectoral trade elasticity. Moreover, the data requirements for calibrating the baseline and for solving the model in changes are modest; we only need initial trade flows, tariffs, final goods expenditure shares, input-output coefficients, and sectoral value added. We do not need to calibrate productivity levels, initial prices or wages, nor do we need to know the initial levels of NTBs. We choose US value added as the numeraire. Hence, all changes in nominal variables, for example, exports, are measured relative to the change in US value added.

We calibrate the baseline equilibrium to the year 2016 based on data from the EORA database. We match the consumption, production and trade patterns of 175 countries (plus an aggregate region representing the rest of the world) and 17 sectors (agriculture, mining, 8 manufacturing sectors and 7 services sectors). Specifically, we perfectly match bilateral sectoral trade flows, sectoral value added, sectoral final goods expenditure shares and cross-sectoral intermediate input coefficients in all countries. Moreover, we use tariffs from the WITS database for the calibration of the baseline trade shares including tariffs and initial tariff revenues. Finally, in line with the extant literature we set the trade cost elasticity $-1/\theta$ equal to -5. This is motivated by the median value of -3.78 of the price elasticities $\left(1-\left(-\frac{1}{\theta}\right)\right)$ for structural gravity estimates reported in Table 3.5 in Head and Mayer (2014).

5.4 NTB reductions associated with TFA implementation

Equations (2) and (3) imply that the estimated partial effects of the TFA on trade can be translated into changes in ad-valorem equivalents of NTBs according to

$$\hat{\kappa}_{in}^{j,Both\_commit\_ext} = exp\left[\frac{\hat{\delta}^{j,Both\_commit\_ext}}{(1-\theta)}\right] - 1 \tag{6}$$

and

$$\hat{\kappa}_{in}^{j,One\_commit\_ext} = exp\left[\frac{\hat{\delta}^{j,One\_commit\_ext}}{(1-\theta)}\right] - 1, \tag{7}$$

for $j \in (Agriculture,\ Manufacturing)$. The coefficients $\hat{\delta}^{j,Both\_commit\_ext}$ and $\hat{\delta}^{j,One\_commit\_ext}$ respectively correspond to the estimated effects of the variable *Both_commit_ext* and of the variable *One_commit_ext* in Table 2.

The implied NTB changes corresponding to the estimates are diplayed in Table 4.

Table 4: Implied NTB changes from the estimates in Table 2

	Agriculture	Manufacturing
$\hat{\kappa}_{in}^{j,Both\_commit\_ext}$	-4.9%	-1.0%
$\hat{\kappa}_{in}^{j,One\_commit\_ext}$	-0.3%	-0.7%

These cost effects are fed into the model, which yields the general equilibrium adjustments in bilateral sectoral exports and imports, as well as in real income. Moreover, we bootstrap confidence bounds for our model predictions. To that end, we use a parametric bootstrap to obtain a distribution of NTB changes that is centered around the mean estimates and reflects the uncertainty surrounding the estimated parameters. We simulate the counterfactual equilibrium for each draw from the distribution of NTB changes and report the 90% confidence bounds for the model outcomes of interest obtained from the bootstrapped distribution of the model predictions.

5.5 Results

5.5.1 Trade effects

In accordance with the partial trade effects estimated in Section 4, we find that the TFA agreement promoted trade especially in the agricultural sector.

Figure 3 plots the change in exports for the four aggregate economic sectors (agriculture, mining, manufacturing, and services). Table 5 provides the same information, and it also includes, in the last row, global results.

As shown in the last row of Table 5, agricultural exports globally increase by 5%. The results grouped by geographical regions suggests that agricultural exports increase by more than 10% for the countries in Africa, South and Central America and the Caribbean, Asia and the Middle East.[23] When grouping the results by income level, it is apparent that the increase in agricultural trade is entirely driven by the Least Developed Countries and Developing Countries. Moreover, Least Developed Countries also account for the largest statistically significant increase in total exports (2.4%). Other Developing countries experience sizeable trade increases as well (2.2%), while the aggregate effects for the other groups are not statistically significant.

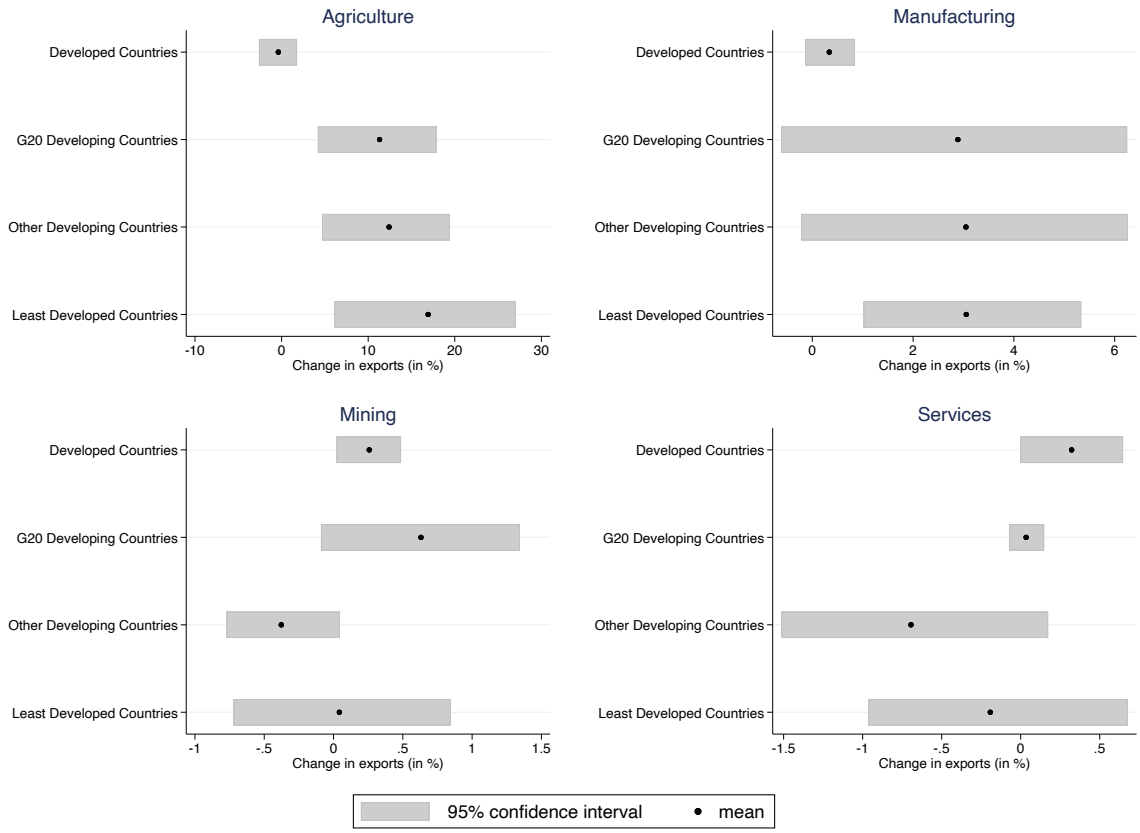
Manufacturing exports also increase, albeit by a smaller amount: by 3% in Asia and above 2% in Africa and in South and Central America and the Caribbean. As shown in Figure 3, the confidence bounds for the predictions for export changes in manufacturing are also much wider, reflecting the larger degree of parameter uncertainty surrounding the partial trade effects.

The changes in exports in the mining and services sectors, which did not benefit from direct NTB reductions, are driven by indirect effects. As described in Section 5.2, one crucial spillover channel are input-output linkages. Manufacturing, and to a lesser extend agriculture, use imported and domestic intermediates from all sectors. Hence, export-driven output growth in the directly affected sectors generates trade in all sectors. Europe and North America are major services exporters and benefit from the increased demand from the manufacturing sector. A second spillover effect that benefits in particular services exporters is due to the increase in income in the liberalising countries, which is largely spent on services, some of which are imported. Thirdly, there are relative competitiveness effects. In the regions where agriculture and manufacturing are growing, factor prices increase and resources are reallocated to expanding sectors – at the expense of services and mining.

Column (5) of Table 5 shows aggregate trade effects. Asia experiences the largest increase

[23] As indicated above, export changes are measured in units of US value added (our choice of the numeraire). That is, they correspond to nominal export changes under the assumption that the price of US value added does not change. Since the US is not particularly strongly affected by the TFA agreement, the predicted nominal trade increase is expected to be close to the actual increase in nominal trade. *Relative* export changes (e.g., changes in agriculture vs. mining or trade effects in Africa vs. trade effects in North America) are independent of the choice of the numeraire.

Figure 3: Export Effects (in %)



Notes: Confidence bounds are based on 200 draws from a parametric bootstrap of the estimated partial trade effects. Trade changes are measured relative to the change in US value added.

(2.5%), followed by South and Central America and the Caribbean (2%) and Africa (1.9%). Table 6 shows the TFA-induced increases in bilateral exports between regions. The largest trade increase occurs between the Middle East, Asia and Africa, within Africa, and within South and Central America and the Caribbean. Exports to and from Europe and North America grow by much less. Finally, Table 7 reports the absolute nominal trade changes. It can be seen that, globally, trade increases by US$ 231 billion.

Table 5: Effects on Real GDP and Exports (in %)

	Exports					
	Agric. (1)	Mining (2)	Manuf. (3)	Services (4)	Total (5)	Real GDP (6)
By region						
Africa	**14.60**	-0.51	**2.35**	-0.43	**1.85**	**0.15**
Asia	**11.14**	0.72	3.20	0.02	**2.48**	**0.20**
Commonwealth of Indep. States	1.68	**-0.06**	1.31	0.38	1.07	0.09
Europe	0.07	**0.13**	0.17	0.22	0.18	0.06
Middle East	**10.43**	**-1.36**	1.92	**-0.79**	**1.40**	**0.15**
North America	0.60	**0.13**	0.85	0.08	0.69	0.05
S. and C. America, Caribbean	**13.49**	0.16	2.48	**-0.20**	**2.02**	**0.11**
By income level						
Developed Countries	-0.38	**0.26**	0.34	0.32	0.31	0.04
G20 Developing Countries	**11.32**	0.63	2.89	0.03	2.51	0.16
Least Developed Countries	**17.03**	0.04	**3.06**	-0.19	**2.40**	**0.24**
Other Developing Countries	**12.42**	-0.38	3.05	-0.69	**2.21**	**0.28**
Total						
World	**5.02**	0.30	1.46	**0.07**	1.17	**0.12**

Notes: Bold values indicate statistical significance at the 10% level or higher. Inference based on 200 draws from a parametric bootstrap of the estimated partial trade effects. Trade changes are measured relative to the change in US value added. Real value added effects at the regional/income group/world level are aggregated using PPP-adjusted real GDP in 2016 as weights.

Table 6: Bilateral Export Changes (%)

	Importer						
Exporter	Africa	Asia	C.I.S.	Europe	Middle East	North America	S./C. Amer. & Carribean
Africa	**4.22**	**2.46**	**1.10**	1.05	**2.12**	0.95	**2.86**
Asia	**4.51**	**2.94**	2.05	1.81	**1.63**	1.79	**2.42**
C.I.S.	**2.41**	2.00	1.89	0.48	**1.43**	0.47	**1.86**
Europe	0.89	1.64	**0.06**	-0.24	0.88	0.13	1.68
Middle East	**5.49**	**2.17**	**0.45**	0.79	**1.26**	0.74	**1.66**
North America	0.59	1.35	-0.52	-0.52	0.62	0.63	1.85
S/C. Amer., Caribbean	**2.58**	**2.30**	0.94	1.24	**1.24**	1.19	**3.57**

Notes: Bold values indicate statistical significance at the 10% level or higher. Inference based on 200 draws from a parametric bootstrap of the estimated partial trade effects. Trade changes are measured relative to the change in US value added.

Table 7: Absolute Changes in Exports (in Mio. 2016 USD)

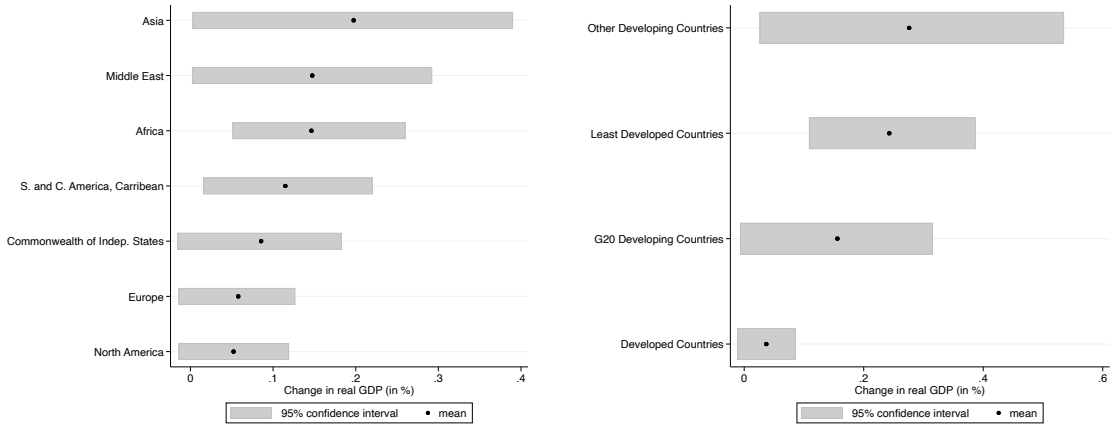
	Agric.	Mining	Manuf.	Services	Total
By region					
Asia	19,639	3,011	128,440	282	151,372
S. and C. America, Caribbean	3,239	44	12,423	-417	15,289
Middle East	2,971	-543	11,711	-1,657	12,482
Africa	1,892	-64	8,352	-593	9,587
North America	474	301	24,025	417	25,216
Commonwealth of Indep. States	349	-4	3,342	362	4,048
Europe	153	474	8,318	4,348	13,292
By income level					
G20 Developing Countries	17,637	1,924	93,061	281	112,904
Other Developing Countries	11,459	-418	73,926	-6,399	78,568
Least Developed Countries	798	2	4,081	-107	4,775
Developed Countries	-1,178	1,711	25,541	8,966	35,040
Total					
World	28,651	3,246	196,046	3,160	231,104

Notes: Trade changes are normalized by the change in US value added.

5.5.2 Real income effects

The trade cost reductions achieved through the TFA brought about significant real income gains. Real GDP at the world level increases by 0.12% (see Column (6) of Table 5). The gains are concentrated among the Least Developed and Developing Countries, with the largest effects accruing to countries in Asia (0.2%), Africa (0.15%) and the Middle East (.15%) and South and Central America and the Caribbean (0.11%) (see Figure 4). We find increases in real GDP for the other world regions as well, but the effects are not significant. The real income gains reflect changes in a flow variable (annual real GDP). Hence, the 0.12% increase at the world level means that in every year following the TFA implementation, real GDP is 0.12 higher than it would have been if the agreement had not been implemented.

Figure 4: Real GDP Effects (in %)



Notes: Confidence bounds are based on 200 draws from a parametric bootstrap of the estimated partial trade effects. Real value added changes at the regional/income level are aggregated using PPP-adjusted real GDP in 2016 as weights.

6 Conclusions

The Trade Facilitation Agreement is the first multilateral trade agreement since the creation of the WTO in 1995. It is an important step for member countries to further reduce costs associated with trade barriers and regulatory differences in order to promote trade. To date, about five years after the TFA's entry into force, there is still very limited empirical evidence on the actual post-implementation impact of the TFA on trade flows and welfare. This paper has provided a first comprehensive assessment of such effects. This study is based on the WTO TFA Database, which provides a breakdown of each developing country's commitments at a given point in time, and combines econometric estimations from a structural gravity model with general equilibrium modelling results.

The impact of TFA commitments on bilateral trade flows has been assessed using the structural gravity model. Both the effects of the extensive margin (impact of bilateral commitments to implement) and the intensive margin (impact of making common commitments) have been assessed for the agricultural and manufacturing sectors. The main insight is that the TFA increased trade, in particular in agriculture, between developing countries that made commitments. In particular, we have found that agricultural trade between developing countries that have made TFA commitments increases by 16-22%. Although there is also indication of in-

creases in manufacturing trade, and in trade between developing (TFA committing) countries and developed countries, the empirical estimates are not statistically significant, likely due to the limited post-implementation period considered.

Furthermore the study has quantified the aggregate trade and real income effects of the TFA commitments by means of a counterfactual analysis based on a multi-sector and -country computable general equilibrium model. These estimations indicate that agricultural trade increases by 5% worldwide and manufacturing trade by 1.5%, while total trade increases by 1.17% worldwide as a result of TFA implementation. Trade gains accrue in particular to LDCs, whose overall exports increase by 2.4% overall (and 17% in agriculture). We have also found that implementation of the TFA is associated with real income gains, in the order of 0.12% worldwide (0.24% for LDCs).

These are very early estimates of the impact of the TFA. In the future, as the effects of this agreement are fully realized, the trade and welfare gains are likely to expand. Likewise, as more data on the post-implementation period become available, a more granular assessment of the impact of different types of trade facilitation measures on trade flows will become feasible. This will complement the results presented in this study, and help policymakers better plan for future trade facilitation reforms.

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Appendix

A Theoretical Model

There are N countries indexed by i and n, as well as J sectors indexed by j and k. Sectoral goods are either used as inputs in production or consumed, with the representative consumer having Cobb-Douglas preferences over consumption C_n^j of sectoral final goods with expenditure shares $\alpha_n^j \in (0,1)$ and $\sum_j \alpha_n^j = 1$.

In each sector j, there is a continuum of intermediate goods producers indexed $\omega^j \in [0,1]$ who combine labor and composite intermediate input and who differ with respect to their productivity $z_i^j(\omega^j)$. Intermediate goods are aggregated into sectoral composites using CES production functions with elasticity η^j. There is perfect competition and labor L_n is mobile across sectors but not between countries.

A firm in country i can supply its output at price

$$p_{in}^j(\omega^j) = \kappa_{in}^j \frac{c_i^j}{z_i^j(\omega^j)} \text{ with } c_i^j = \Upsilon_i^j (w_i)^{\beta_i^j} \left[\prod_{k=1}^{J} \left(p_i^k\right)^{\gamma_i^{k,j}}\right]^{(1-\beta_i^j)}. \tag{A-1}$$

The minimum cost of an input bundle is c_i^j, where Υ_i^j is a constant, w_i is the wage rate in country i, p_i^k is the price of a composite intermediate good from sector k, $\beta_i^j \geq 0$ is the value added share in sector j in country i and $\gamma_i^{k,j}$ denotes the cost share of source sector k in sector j's intermediate costs, with $\sum_{k=1}^{J} \gamma_i^{k,j} = 1$. κ_{in}^j denotes trade costs of delivering sector j goods from country i to country n such that

$$\kappa_{in}^j = (1 + t_{in}^j) D_{in}^{\rho^j} e^{\delta^j \mathbf{Z}_{in}}, \tag{A-2}$$

where $t_{in}^j \geq 0$ denotes ad-valorem tariffs, D_{in} is bilateral distance, and $\mathbf{Z}_{in}$ is a vector collecting trade cost shifters (such as FTAs or other trade policies).

Productivity of intermediate goods producers follows a Fréchet distribution with a location parameter $\lambda_n^j \geq 0$ that varies by country and sector (a measure of absolute advantage) and shape parameter θ^j that varies by sector (and captures comparative advantage).[24]

Producers of sectoral composites in country n search for the supplier with the lowest cost such that $p_n^j = \min_i \left\{p_{in}^j(\omega^j); i = 1, \ldots, N\right\}$. Caliendo and Parro (2015) show that it is possible to derive a closed form solution of composite intermediate goods price

$$p_n^j = A^j \left(\sum_{i=1}^{N} \lambda_i^j \left(c_i^j \kappa_{in}^j\right)^{\frac{-1}{\theta^j}}\right)^{-\theta^j}, \tag{A-3}$$

where $A^j = \Gamma\left[1 + \theta^j(1-\eta^j)\right]^{\frac{1}{1-\eta^j}}$ is a constant.

[24] Convergence requires $1 + \theta^j > \eta^j$.

Similarly, a country n's expenditure share π_{in}^j for source country i's goods in sector j is

$$\pi_{in}^j = \frac{\lambda_i^j \left[c_i^j \kappa_{in}^j\right]^{\frac{-1}{\theta^j}}}{\sum_{i=1}^N \lambda_i^j \left[c_i^j \kappa_{in}^j\right]^{\frac{-1}{\theta^j}}}, \tag{A-4}$$

which forms the core of a gravity equation.

A.1 General Equilibrium

Let Y_n^j denote the value of gross production of varieties in sector j. For each country n and sector j, Y_n^j has to equal the value of demand for sectoral varieties from all countries $i = 1, \ldots, N$.[25] The goods market clearing condition is given by

$$Y_n^j = \sum_{i=1}^N \frac{\pi_{ni}^j}{(1+t_{ni}^j)} X_i^j \qquad \text{with} \qquad X_i^j = \sum_{k=1}^J \gamma_i^{j,k}(1-\beta_i^k) Y_i^k + \alpha_i^j I_i, \tag{A-5}$$

where national income consists of labor income, tariff rebates R_i and the (exogenous) trade surplus S_i, i.e. $I_i = w_i L_i + R_i - S_i$ and X_i^j is country i's expenditure on sector j goods. The first term on the right-hand side gives demand of sectors k in all countries i for intermediate usage of sector j varieties produced in country n, the second term denotes final demand. Tariff rebates are $R_i = \sum_{j=1}^J X_i^j \left(1 - \sum_{n=1}^N \frac{\pi_{ni}^j}{(1+t_{ni}^j)}\right)$.

The second equilibrium condition requires that for each country n, the value of total imports, domestic demand and the trade surplus has to equal the value of total exports including domestic sales, which is equivalent to total output Y_n:

$$\sum_{j=1}^J \sum_{i=1}^N \frac{\pi_{in}^j}{(1+t_{in}^j)} X_n^j + S_n = \sum_{j=1}^J \sum_{i=1}^N \frac{\pi_{ni}^j}{(1+t_{ni}^j)} X_i^j = \sum_{j=1}^J Y_n^j \equiv Y_n. \tag{A-6}$$

Conditions (A-5) and (A-6) close the model.

Following Caliendo and Parro (2015) and Dekle et al. (2008), we solve the model in changes. Let z denote the initial level of a variable and z' its counterfactual level. Then, trade cost shocks are given by $\hat{\kappa}_{in}^j = \frac{1+t_{in}^{j'}}{1+t_{in}^j} e^{\delta^j (Z'_{in} - Z_{in})}$.

The change in real GDP, our measure of welfare, is given by

$$\widehat{RGDP}_n = \frac{\widehat{VA}_n}{\prod_{j=1}^J \left(\widehat{p}_n^j\right)^{\alpha_n^j}}. \tag{A-7}$$

[25] Our exposition differs from Caliendo and Parro (2015) in that they use total expenditure on composite goods instead of total production of varieties as endogenous variable. So in Caliendo and Parro (2015) the value of gross production comprises all foreign varieties that are bundled into the composite good without generation of value added.