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The layers of the IT Agreement's trade impact

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The Layers of the IT Agreement's Trade Impact

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The Layers of the IT Agreement's Trade Impact

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Abstract

The WTO's plurilateral Information Technology Agreement (ITA) reduced tariffs to zero on many IT products. This paper presents a comprehensive study of its trade impacts by incorporating recent insights from both the global value chain (GVC) and time in trade literatures. Inserting tariffs directly into the gravity equation breaks the ITAs impact down into four layers. Import demand elasticities are found to be non-linear: Tariff reduction (layer 1) has relatively small impacts, while complete tariff elimination (layer 2) has high impacts, especially for intermediate goods. Beyond that, ITA accession has positive non-tariff effects on both imports (layer 3) and exports (layer 4). These commitment effects suggest that higher trade policy certainty affects investment and sourcing decisions in favour of signatories: Their ITA exports performed better relative to other ICT and machinery exports, unlike non-members. But "passive signatories" – which joined mainly as a by-product of a larger policy objective – reaped the most benefits. Featuring a smaller ITA sector upon accession, their final good exports increased also in absolute terms due to downstream GVC integration. However, such impacts are strongly heterogeneous with respect to countries' geographical remoteness, education levels, business environment and institutions. China stands out with especially strong post-accession export increases, also extending to intermediate goods.[1]

JEL Categories: F13, F14, L63.

Keywords: tariffs, trade policy certainty, value chains, fragmentation, WTO Information Technology Agreement, gravity equation, product-level trade, non-linearity.

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1. Introduction

Among the WTO's plurilateral agreements, the Information Technology Agreement (ITA) stands out as being the most wide–ranging, reducing to zero tariffs on a wide range of information technology products. This makes it the paramount case for study of the effects that multilateral zero-for-zero agreements, which completely eliminate tariff barriers, may have on trade flows. Moreover, production of goods covered by the agreement ("ITA goods") is characterized by high vertical integration. Their analysis can therefore help assess the validity of Yi (2003)'s theoretical model, which implies that effects of trade policy changes are especially high in vertically integrated sectors.

Policy relevance of the ITA's trade impact is heightened further for the following two reasons. First, an ITA II agreement is currently being debated. It could clarify and further amplify the product coverage of the original ITA agreement, adapt it to the current technological environment and possibly extend coverage to non-tariff measures. Second, tariff elimination agreements for other sectors are often floated as proposals, mainly by developed countries, with the aim of bringing the WTO Doha Round to conclusion.

Yet, the literature examining the trade impact of the ITA is surprisingly scarce. To our knowledge, Mann and Liu (2009), with Bora and Liu (2010) building further on their work, provide the only econometric analyses of trade impacts of the ITA. These studies do not take advantage of product-level information, relying on aggregate data instead, which can bias results if bilateral trade relationships are heterogeneous across products. Furthermore, they quantify only one aggregate impact of the ITA and on imports only. They find that ITA signatories import on average 14 percent more ITA goods after accession than non-members of the WTO. Analyzing data up to 2003, these studies mainly cover founding members of the ITA – which came into effect in 1997 – but not many important more recent signatories, including China.

Joseph and Parayil (2006) also analyse early ITA trade until 2003 and hypothesize that these more recent signatories, or passive adopters as they call them, would reap lower benefits from the agreement, given that they could not bring their own interests to bear in the negotiations.[2] But this hypothesis has not been tested. Anderson and Mohs (2010), benefiting from more extented time coverage, in contrast argue that the ITA has fostered the rapid increases in observed in developing countries' exports. While limiting themselves to a descriptive review of trends in ITA product trade, the authors shift the focus of the discussion, incorporating a supply chain perspective and consequent linkages between import and export activities: They argue that tariff reductions led to lower prices for intermediate inputs, which in turn underpinned many developing countries' competitiveness and consequently export growth. [3]

Feenstra (2008) examines, specifically for IT products, the tariff to import price pass-through, i.e. first half of this causality chain. He finds that tariff reductions on products covered by the ITA have a highly magnified effect–of up to a factor of 22 (!)–on their import prices. He argues that the very high magnitude of this effect may result because ITA members' tariffs were already in the low single digits before accession, thereby the total impact is more moderate. Our results meanwhile indicated that these high estimates are actually a result of non-linearity in the impact of tariff changes.

This paper provides the first comprehensive analysis of the ITA's impact on trade flows, taking seriously in its estimation strategy the above points, amongst others. First, against the backdrop of supply chain integration, ITA accession can lead to simultaneous impacts on both imports and exports.

[2]While Joseph and Parayil (2006) acknowledge that some developing countries have outperformed with respect to trade growth in products covered by the ITA, they argue that this outperformance has predated and is unrelated to the ITA.

[3]An expanding literature on global value chains also develop these arguments beyond the IT sector (e.g. Gawande et al. (2011), Milberg and Winkler (2010)).

Second, impacts may vary depending on how a country joined the ITA and the initial state of its ITA goods producing sector; more on this below. Third, in a vertically fragmentated sector, impacts can also be expected to differ across intermediate and final goods, which we distinguish based on the classification of Sturgeon and Memedovic (2010). Fourth, to derive unbiased estimates of these impacts, proper controls for multilateral resistance are needed, which is made possible by introduction of a non-ITA control sector. Finally, impacts may be non-linear and consist of different layers. By using product-level data, which allows us to directly integrate tariffs into the gravity model, we can distinguish three separate effects on the import side. With an additional effect on the side of exports, we identify four layers in total.

On the import side, our framework first distinguishes between tariff reduction (layer 1) and tariff elimination effects (layer 2). The latter allow for an additional impact of setting the tariff to zero, because this eliminates costly administrative burdens and time delays in crossing the border, whose detrimental impacts on imports have been found to be substantial by an emerging time in trade literature (e.g. Djankov et al. (2010), Hummels and Schaur (2013), Martincus et al. (2013)). We find tariff reduction effects, i.e. import demand elasticities with respect to tariffs, in the -0.3 to -0.4 range, suggesting that each percentage point reduction in tariffs raises ITA import value by 0.3 to 0.4 percent. Eliminating tariffs completely has a much higher impact of 10-13 percent for ITA goods, and as the value chain literature suggests, is higher for intermediate goods. Providing intuition for Feenstra (2008)'s results, we find this non-linearity particularly pronounced for ITA goods, though it also exists for our control sectors of other ICT and machinery goods. These first two layers could also be realized by a country unilaterally eliminating tariffs without joining the ITA.

The 3rd layer on the import side, meanwhile, quantifies whether the ITA has a "non-tariff" or "commitment effect" on imports – going beyond effects of tariff reduction and elimination. As the ITA also reduces participants' WTO bound tariff rate for covered products to zero, this liberalization undertaken within the ITA is harder to reverse, thereby increasing trade policy certainty. Moreover, any tariff increases would be subject to disciplinatory action enforced through the WTO dispute settlement mechanism. This could influence location decisions of multinational IT firms in favor of signatory countries and thus should increase their imports, particularly of intermediate products (Antras and Helpman (2008), Blyde and Martincus (2013), Osnago et al. (2008)). Also, exporters may be more inclined toward investments in advertising or distribution systems in signatory countries. Finally, there is the possibility that membership in an international agreement such as the ITA may over time encourage convergence in product standards, which could spur trade.[4]

We find that such an ITA commitment effect on imports exists, having increased imports by around 8-10 percent mainly among its founding members, as these countries outsourced ITA good production. Furthermore, commitment effects created just by joint WTO membership are very important, boosting ITA imports by around 40 percent in absolute terms. We, moreover, find that WTO accession has a larger impact on members' intermediate goods imports of ITA products than other ICT or machinery products.

The 4th layer is the commitment effect on exports. As the export-side analogue to layer 3, it formalizes that ITA membership may encourage relocation of multinational IT firms toward signatory countries, given that exports rely heavily on imports, particularly in downstream production stages.[5]

[4]Portugal-Perez et al. (2010) analyze the impact of the ITA on EU15 imports up to 2007 and focus on non–tariff costs. The authors find a positive trade impact when EU standards are aligned with international norms. Their results thereby indirectly suggest that the ITA may have farther–reaching impacts if it leads to harmonisation of standards.

[5]We acknowledge an extensive related literature which highlights that investment in IT goods may boost productivity more than other investments (e.g. Jorgenson (2001), Colecchia and Schreyer (2002)). If the ITA encourages such in-

This in turn should increase a country's IT exports to all other countries no matter whether they are ITA members or not.[6]

We find that this is indeed the case, but with effects varying across different types of ITA accession countries. Building on World Trade Organization (2012) – which provides a comprehensive analysis of the formation, membership and coverage overview of the ITA – we can identify a series of countries ("passive" signatories) which joined the ITA only after 1997 and mainly as a prerequisite for a larger policy objective. Such a larger objective could be threefold: accession to the WTO, the EU or to a free trade agreement with the United States. We find that passive signatories had much smaller ITA good export sectors upon accession than other signatories, and thereby perhaps featured a less powerful IT sector lobby which may explain their arguably lower motivation to join.

Our results show that passive signatories were the only ones to gain from ITA accession through higher exports in absolute terms. This post-accession increase amounted to 8 percent (and 30 percent relative to control sector exports). Together with strong increases in intermediate imports, this suggests that these countries – many of them developing or emerging – integrated in the downstream stages of production. This finding is in line with the value chain literature which highlights that downstream tasks in assembly and basic manufacturing are easiest to master and thereby provide natural entry points. China is found to differ from other passive signatories: its exports increased in both intermediate and final goods and more strongly, demonstrating achievement of a diversified export structure in the sector post ITA accession.

Finally, we also highlight large country-specific heterogeneity regarding the extent to which countries have been able to benefit from ITA membership. We find that on average those countries with low education, unfavorable business environments, weak institutions, or a remote geographical location struggled to reap export benefits from the ITA.

The remainder of the paper is structured as follows. Section 2 provides a brief overview of the ITA and preliminary graphical analyses of the ITA's impact on exports for passive and other signatories. Section 3 describes our dataset and Section 4 presents our estimation strategy. Section 5 presents results, whose robustness is examined in Section 6. Section 7 explores heterogeneity of ITA benefits depending on country determinants. Section 8 concludes.

2. The ITA and a first glance at its impact

The ITA is a plurilateral agreement under the WTO. It was negotiated among 34 countries until 1996. Nine more countries signed up by the March 1997 deadline, which at the time took the agreement's trade coverage above the "critical mass" threshold of least 90 percent of world IT trade, and the agreement came into force.[7] Membership increased to 74 countries by 2012, the end of our sample period, and 78 by 2014.

The ITA focusses exclusively on tariff elimination for certain IT-related products; it does not include provisions on non-tariff issues. It covers about 60 percent of trade in IT goods by itemizing 190 products in a rigid positive listing. These 190 products correspond to 154 HS1996 subheadings, i.e. 6-digit product codes, but many subheadings are only covered partially, making the ITA's product coverage complex (World Trade Organization, 2012). We will further elaborate in the data section on the resulting

vestment via lower tariffs and resulting productivity increases in turn increase exports, then this may constitute another channel through which ITA accession can come to affect exports (in ITA and other goods).

[6]The higher incentive to export toward ITA members, given their more liberal import regime, is already captured by the effects on the import side.

[7]The economic intuition behind such critical mass thresholds is to minimize free riding.

implications for our analysis. The ITA's positive listing has not been updated since its inception, though there are initiatives in the WTO–dubbed ITA II–to clarify, update and expand its coverage, possibly to non-tariff measures. The positive listing of the ITA implies that new ICT products generally are not covered by it, and it poses problems especially for multifunctional goods. This complex product coverage has been a key point of criticism and has caused a dispute in the WTO.[8]

The ITA requires members to apply agreed tariff concessions to all WTO members, whether ITA signatories or not, by adjusting their MFN applied and bound tariffs. Founding members were to implement zero tariffs by 2000, but some developing countries had longer implementation periods (up to 2005 at the latest). Implementation periods for countries joining later (after 1997) have been determined in negotiations and therefore varied, but in most cases did not surpass three years.

Among these late signatories, we distinguish two groups. Many late signatories can be considered to have joined the ITA mainly as a by–product of a broader policy objective.[9] We identify three reasons behind the accessions of such countries, which we refer to as "passive signatories". First, some countries that were acceding to the WTO after 1997 had the commitment to join the ITA in their accession protocol as a result of accession negotiations. Second, all recent members of the European Union (EU) had to adopt the trade policy of the EU upon accession or in the preparatory process and hence joined the ITA, unless they had already acceeded earlier. Third, the US was one of the initiators of the ITA and was actively pursuading potential FTA partners during negotiations to join the ITA. Meanwhile we will refer to all ITA members that are not passive signatories as "active signatories". These include all founding members as well as late signatories whose accession was not mainly motivated by one of these broader policy objectives.

Table 1 below presents the lists of active and passive signatories as well as accession years for all non-founding members. It illustrates that passive signatories entered the agreement in various years. The majority of passive signatories, 13 economies in total, became signatories via WTO accession. Another 15 countries were classified as passive signatories because their ITA accession was related to negotiating an FTA with the US or EU accession.

Tariffs on ITA products were generally already low before accession for member countries. This is particularly true for active signatories, whose ITA product tariffs averaged 2.5 percent in the year before accession. Later signatories had somewhat higher tariffs in the respective year before accession, averaging 3.9 percent.[10] However, they had generally been reducing their tariffs considerably on these goods already before accession (Figure 1).

Passive ITA members' importance in world ITA goods trade has grown immensely over our sample period (Figure 2). These gains have come at the expense of active signatories, which are predominantly developed countries. China, an passive ITA signatory, has become a very dominant player and this could raise concerns that a large part of our results could be driven by China. To account for that, we examine later in all our regression specifications the effects on the whole sample and on a sample excluding China's exports. However, other passive signatories have recorded remarkable increases in their world market shares as well, albeit from a low base.

Notably both for China and other passive ITA signatories the increase in market share is more impressive for exports than imports. On the flipside, the active signatories lost more of their importance in exports than imports. This illustrates that, geographically speaking, import demand for ITA goods

[8]See Dreyer and Hindley (2008) for further details.

[9]Whether this was the case was assessed by the authors based on (World Trade Organization, 2012, Table 2.1) and interviews with WTO delegations and secretariat staff.

[10]These average tariff figures include preferential tariffs. Average MFN applied tariffs are somewhat higher, 3.8 and 6.3 percent for initial and late signatories, respectively.

Table 1: ITA members categorized by motivation driving their ITA accession

"Active" ITA signatories, including all founding members[1]		
Australia	Hong Kong, China	New Zealand
Austria	Iceland	Norway
Belgium	India	Philippines
Canada	Indonesia	Poland
Chinese Taipei[2]	Ireland	Portugal
Costa Rica	Israel	Romania
Czech Republic	Italy	Singapore
Denmark	Japan	Slovak Republic
Egypt (2003)	Korea, Republic of	Spain
El Salvador	Kuwait (2010)	Sweden
Estonia[2]	Liechtenstein	Switzerland
European Union	Luxembourg	Thailand
Finland	Macao, China	Turkey
France	Malaysia	United Arab Emirates (2007)
Germany	Mauritius (1999)	United Kingdom
Greece	Netherlands	United States of America

"Passive" ITA signatories, whose ITA accession was likely significantly motivated by...		
WTO accession	EU accession	US FTA
Albania (1999)[3]	Bulgaria (2002)	Bahrain, Kingdom of (2003)
China (2003)	Cyprus (2000)	Colombia (2012)
Croatia (1999)[3]	Hungary (2004)	Dominican Republic (2006)
Georgia (1999)[3]	Malta (2004)	Guatemala (2005)
Jordan (1999)[3]	Slovenia (2000)	Honduras (2005)
Kyrgyz Republic (1999)		Morocco (2003)
Latvia (1999)		Nicaragua (2005)
Lithuania (1999)[3]		Panama (1998)
Moldova, Republic of (2001)		Peru (2008)
Oman (2000)		
Saudi Arabia, Kingdom of (2005)		
Ukraine (2008)		
Viet Nam (2006)[3]		

Sources: Authors' compilation based on WTO (2012) and information obtained through interviews of various WTO Secretariat staff.

[1] ITA founding members joined in 1997. Accession year for all non-founding members is given in parentheses.

[2] Among ITA founding members, Chinese Taipei and Estonia were the only ones which only joined the WTO subsequently (in 2002 and 1999, respectively). They had ITA membership as a requirement in their WTO accession protocols, we classify them as active signatories because they were founding members and acceeded before their WTO accession.

[3] These countries already joined the ITA during their WTO accession process in the calendar year before WTO accession (only Lithuania acceeded the WTO two calendar years later, in 2001).

Figure 1: Average applied import tariffs on ITA goods by type of accession (percent)

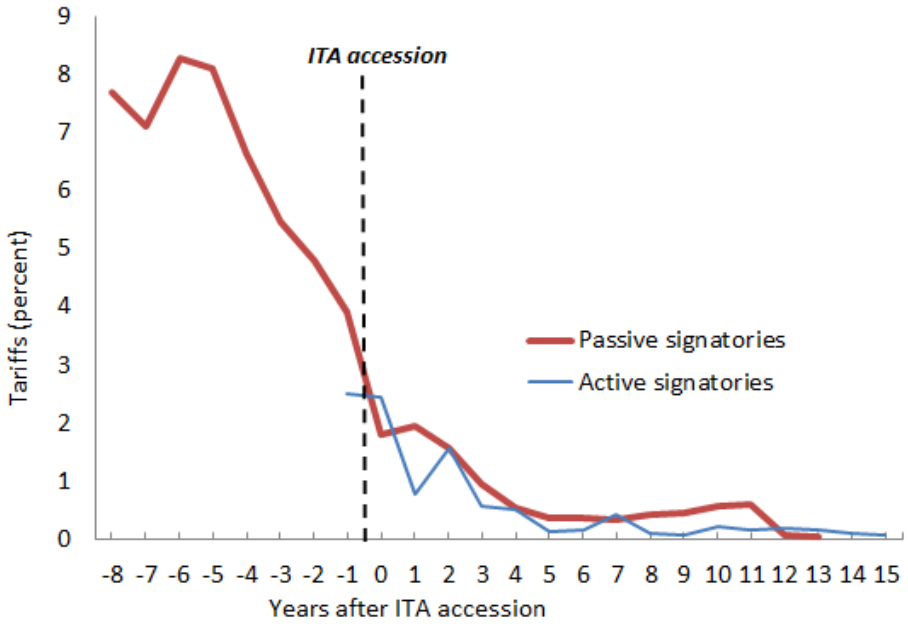


Figure 2: World market shares in ITA products by type of accession, 1996 and 2012

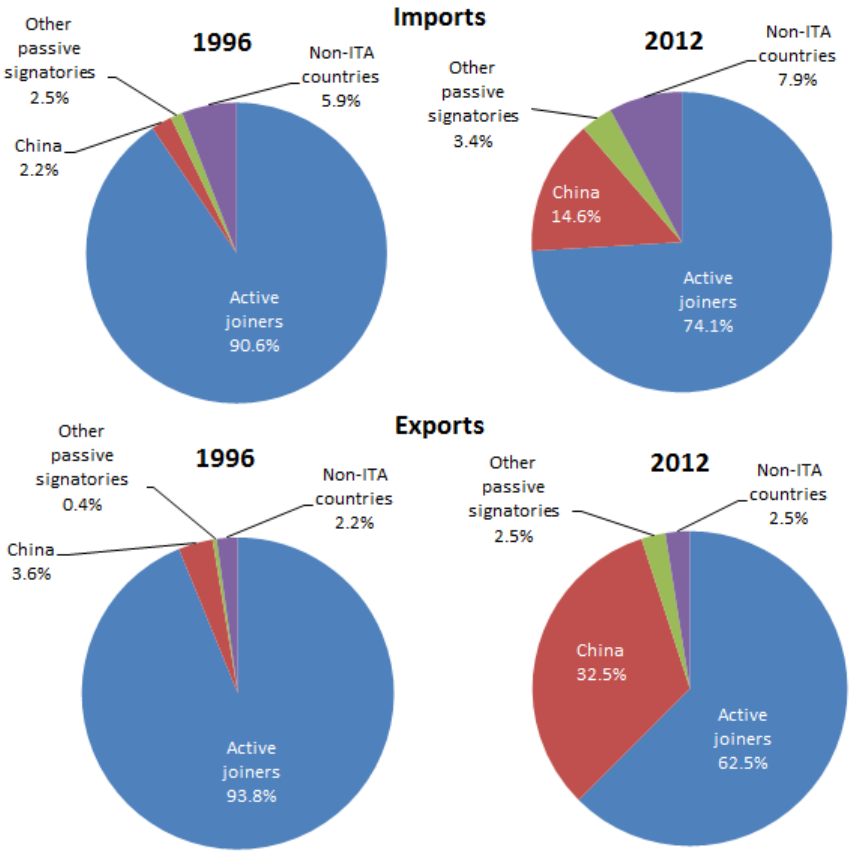
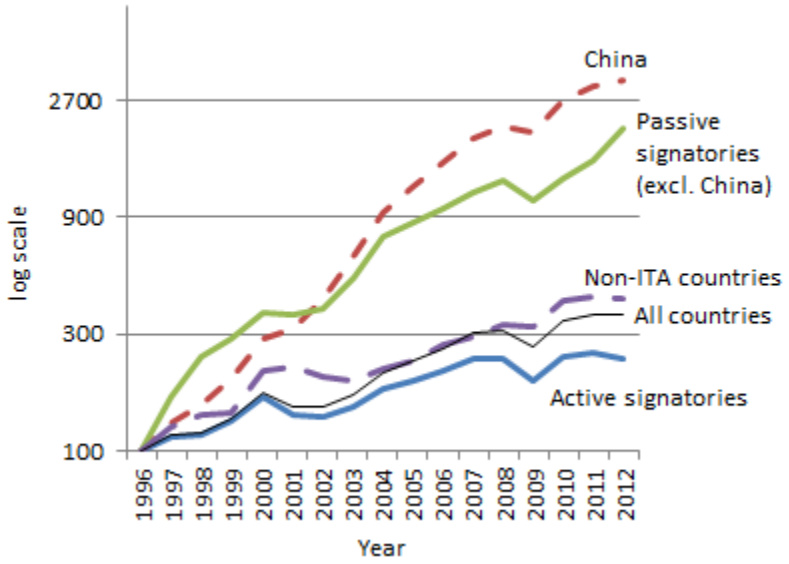


Figure 3: Export value of ITA products (index, 1996=100)



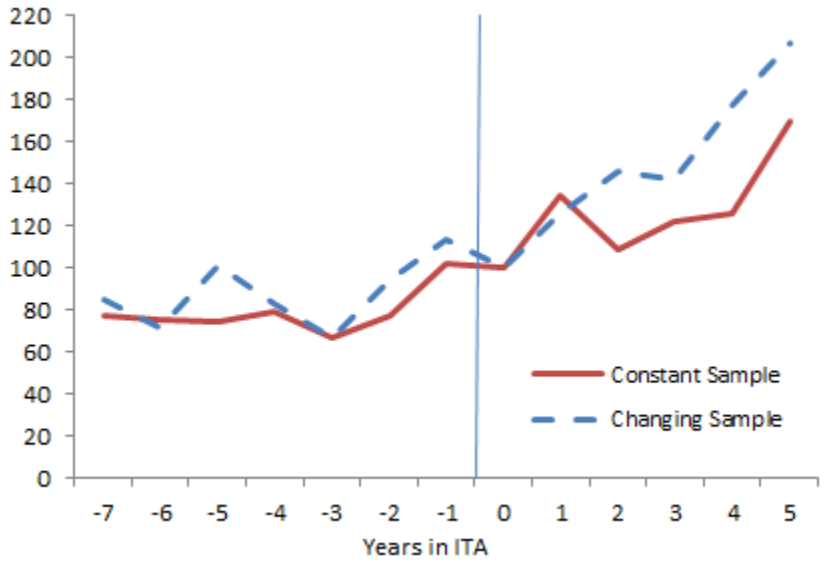
has been relatively stable over time, while origin of products changed significantly in the last decades, arguably driven by in part by location and sourcing decisions of multinational enterprises as described in the GVC literature.

This raises the interest in export trends among these groups over time. Figure 3 presents the nominal export value of ITA products by country groups with 1996 values indexed at 100. Exports of all groups have increased. Exports of active ITA members and non-ITA members exports show a similar pattern of comparatively moderate growth. Passive ITA signatories instead have a much steeper slope. When the lower initial start value is taken into account, the expansion of their exports can almost match that of China, reported separately in the figure, and actually outstripped China up to its ITA accession in 2003. However, Figure 3 does not provide a good notion of how ITA accession in particular may have impacted growth in passive signatories, because passive signatories were not in the ITA yet in the earlier years of the figure.

To obtain a notion of whether ITA accession may have boosted exports of passive signatories, we therefore look at how their exports have evolved before and after ITA accession. To eliminate influences of global fluctuations in ITA trade, we now look at market shares, which we rescale to 100 in the entry year to allow for simple averaging across countries. To retain a sufficient number of countries in the sample, we focus only on the 7 years before the ITA entry year and 5 years after. Figure 4 presents the results. Twelve passive signatories can be observed during such a 12-year time window ("Constant Country Sample"). To check the robustness of the ITA exports pattern over time across larger set of passive signatories, we look at all passive signatories ("Changing Country Sample") during this 12 year period. For both samples, the figure indeed suggests that world export market shares of passive signatories start to increase substantially around the time of ITA accession. The figure includes China, but it is insensitive to its exclusion.

Upon accession, passive signatories had a relatively small ITA export sector compared to active signatories. ITA export sectors were several times larger in active signatories in the year before ITA accesion: ITA product exports amounted to only 2.8 percent of active signatories' GDP on average (median 1.0 percent), while in passive signatories they were only 0.4 percent of GDP on average (median 0.1 percent). Figure 6 in the appendix provides the distribution of ITA export sector sizes, illustrating

Figure 4: Market share in global ITA product exports of "passive signatories" (index, accession year=100)



that the vast majority of passive signatories had very small ITA export sectors just before accession. ITA exports surpassed 1 percent of GDP in every other active signatory, while this is only the case for one in seven of the passive signatories. The same conclusions result, if we analyze ITA goods importance in countries export basket in lieu of GDP (Appendix Figure 7).

Finally, we evaluate how shares of ITA products in countries' export baskets have evolved over time (Figure 5). We note that from the mid-1990s until the dot-com bust in 2001, these shares were expanding across all groups. For active signatories, this expansion coincided with the years just after their ITA accession in 1997, but given that IT exports expanded globally, it may be hard to attribute this to the ITA. Passive signatories acceeded to the ITA in different years, but most did so in 1999 or the early 2000s (Table 1). We calculate a mean accession year for this group of late 2002. Figure 5 suggests that these passive signatories experienced growth of their ITA sector after accession. During the mid-2000s, the share of ITA products in their export baskets surged – and stabilized subsequently at a higher level – while those of other countries were stagnant. Thus the increase in global ITA export market share of Figure 4 went hand in hand with an increased importance of the sector within passive signatories' economies.

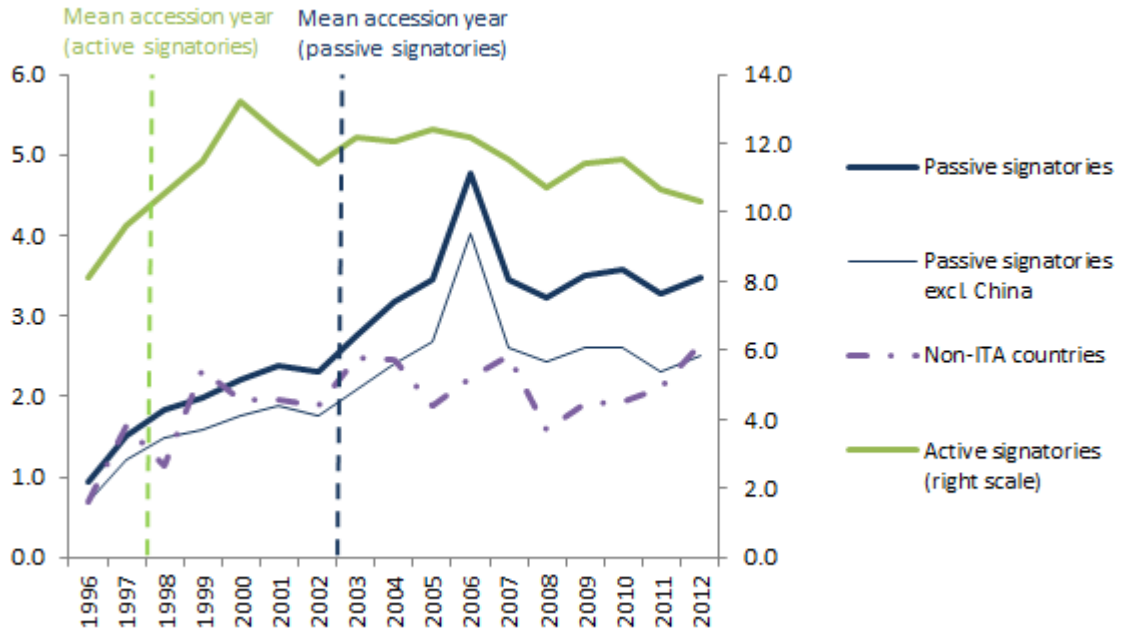
3. Data

Our dataset matches product-level trade data in ITA products to tariffs, ITA membership and common gravity variables. These are discussed in turn, but first we elaborate further on the empirical issues posed by the ITA's aforementioned complex product coverage.

The ITA contains a rigid positive listing of covered products which reaches across categories in the 6-digit HS1996 classification on which the agreement was signed: In total, it affects 154 product lines in this classification, but only 95 product lines are covered fully. The rest are covered partially, creating an issue for empirical analysis, as also highlighted by Anderson and Mohs (2010). We thus consider as ITA products in our analysis all fully covered lines plus another 11 lines, which according to World Trade Organization (2012) include a high proportion of ITA products, for a total of 106 lines.

This problem relating to the ITA's coverage becomes further amplified in later years by the updates to the HS2002 and HS2007 vintages. Consequently, its coverage has to be reassessed in each of the

Figure 5: Average ITA product share in total exports by type of ITA accession, 1996-2012 (percent)



vintages instead of being simply mapped. For instance, a given tariff line may have covered a lot of ITA products (relative to non-ITA products), when trade was reported in the HS1996 vintage, and it therefore was considered an ITA product line. However, in latter years, this line may not be considered an ITA tariff line any more due to the shift to HS2007 reporting. The reason is changing trade structure: Now relatively more non-ITA products may be traded under this line as a result of some ITA products having become technologically obsolete. Thus, the lines that we consider to be covered by the ITA vary between vintages. We therefore first obtain separate lists of the product lines covered by the ITA during 1996-2001 in HS1996, 2002-06 in HS2002 and 2007-12 in HS2007.

In a next step, we then map the HS2002 and HS2007 lines into HS1996 using conversion tables from the UN Statistics Division (UNSD) website to obtain a consistent HS1996-based dataset. The HS2002 lines map into the exact same set of lines that we also obtained for HS1996 because the updates in classification methodology were minor between these two vintages. But this is not the case for HS2007, so that our resulting dataset contains a different number of tariff lines during the time periods 1996-2006 and 2007-12: 23 (9) HS1996 lines appear only during the former (latter) period, while 74 HS1996 lines are included in all years, thereby resulting in our abovementioned total of 106 lines.

With this set of ITA-related HS1996 lines on hand, we can then obtain 6-digit HS1996 bilateral trade flow data for 1996-2012 from UN Comtrade. We use the import flow data and complement with exporter-reported mirror data. [11] This gives us 3.86 million observations of non-zero ITA trade flows covering 234 countries, though not all observations are useable in all regressions in light of missing values for tariffs.

These data on tariffs are obtained from UN Trains in HSCombined for the years 1996-2012. This

[11] We apply the mirror data whenever a certain import-reporter did not report for the particular year at all. We restrict the mirror data to such cases only, because if a country reports bilateral trade in the particular year, but doesn't specify some line or it is zero while it is present in the mirror data, then there is not actually a lack of reporting issue but a difference in methodology of classifying products between importer and exporter.

reporting in HSCombined (rather than HS1996 throughout as in Comtrade) makes necessary an additional step. HSCombined gives tariffs for 1996-2001 in HS1996, 2002-06 in HS2002 and 2007-12 in HS2007. We therefore again employ the conversion tables to generate tariffs for our set of HS1996 lines throughout all years.[12] To fill in some missing observations, we then linearly intrapolate tariffs between years for which observations exist.[13]

As further right-hand side variables, we collect any standard gravity variables which vary across time within any country or country-pair.[14] GDP and GDP per capita were taken from Penn World Table Version 8.0. RTA and currency union membership data are taken from De Sousa (2012).[15] A remoteness measure was computed analogue to those commonly used in the literature.[16] WTO membership data was collected from the WTO website.

Sturgeon and Memedovic (2010) emphasize the importance of intermediate goods to understanding global value chains. They develop a novel classification scheme, classifying product lines for different sectors into those primarily including final or intermediate goods.[17] This is helpful for us to analyze how ITA membership effects differ between countries in different positions in value chains – upstream (exporting intermediates) and downstream (importing intermediates/exporting final goods). The authors provide such a classification for electronics goods on HS2007 basis, which we use to split our sample to investigate how the ITA effects may operate through GVCs.[18] When converted to HS1996 using the UNSD conversion tables, we find this classification to cover 47 of our 106 ITA product lines.[19]

ITA products can be classified in 7 broad product categories, as outlined in World Trade Organization (2012). We resort to these to reduce the dimensionality of our dataset in our robustness check for zero trade flows which use non-linear Poisson estimation. The categories are the following (with number of 6-digit HS1996 lines included in parentheses): Computers (14), Instruments and apparatus (17), Parts and accessories (32), Semiconductor manufacturing equipment (10), Semiconductors (15), Data-storage media and software (9) and Telecommunications equipment (9). Computers, semiconductors, and parts and accessories are the most traded products, making up around 80 percent of ITA product trade flows.

In many of our regressions, we use control sectors help us assess how ITA trade has performed relative

[12]We use the conversion table for conversion of HS2007 and HS2002 to HS1996. If there are multiple HS2007 or HS2002 lines corresponding to a HS1996 line in our list, we take a simple average across thes HS2007 or HS2002 lines to obtain the tariff for the HS1996 line.

[13]Furthermore we had to take into account that the EU is presented as a single country in TRAINS. Thus we appended the dataset to include all its members in various years to achieve consistent coverage of active signatories throughout the sample period.

[14]Non-time variant variables such as distance are controlled for by country-pair(-product) fixed effects in all our specifications.

[15]De Sousa (2012) data only cover currency union relationships up to 2009. To extend the data, we added Estonia joining the Euro in 2011. As we are not aware of any other countries joining or exiting a currency union after 2009 and before 2013, we assume that no further changes in currency union membership occurred after this time. Like the Glick and Rose (2002) currency union definition, ours is also transitive, i.e. if country-pairs x–y, and x–z are in currency unions, then y–z is a currency union. Therefore with both El Salvador and Ecuador having adopted the U.S. Dollar, they would both be considered to be in a currency union with the United States as well as each other.

[16]Our remoteness measure is computed for importers and exporters using the standard formula, weighting bilateral distances by trading partner shares in world GDP (see e.g. UNCTAD and WTO (2012)). To obtain a single remoteness measures for any bilateral pair in the interest of parsimony, importer and exporter remoteness are then multiplied before taking the natural logarithm.

[17]Their classification could become part of a revised BEC classification, which will distinguish between customized intermediate goods (typically relating to trade within global value chains) and other intermediate goods.

[18]These data on HS2007 basis were kindly provided to us by the authors. Sturgeon and Memedovic (2010) include analogs on SITC and ISIC basis.

[19]When the ICT (machinery) control sector is added 102 of 202 (165 of 995) lines are covered by the classification.

to that of comparable goods post ITA accession. We use two of such control sectors: other information and communications technology (ICT) goods, not covered by the ITA, and machinery goods.

For ICT goods, the OECD provides a definition which covers a total of 193 product lines in the 6-digit HS1996 classification.[20] Of these 193 lines, 77 are also covered by the ITA under our definition of 106 lines. Thus non-ITA ICT goods – the control sector – comprise 116 lines and add another 3.70 million observations to the dataset.[21] Meanwhile, 29 lines are covered by the ITA that are not considered ICT goods by the OECD.[22]

Finally, we also construct a broad machinery control sector. We select HS sections 84, 85, 87, and 90. These comprise electrical and non-electrical machinery, road vehicles and optical/photographic/precision instruments and were chosen because these sectors also tend to be quite integrated in GVCs. This broad machinery sector comprises all ITA and ICT tariff lines.[23]. Its inclusion brings our dataset to a total of 28.36 million observations.

4. Empirical Strategy

The paper's estimation strategy uses the basic structural gravity model developed by Anderson and Van Wincoop (2003), adapted for a panel approach and varying trade costs across goods. Already Anderson and van Wincoop (2004) discuss the advantages of using disaggregate, product-level, data to account for varying trade costs and elasticities.[24] In addition, pair-specific obserable or unobservable trade determinants may vary across different products. Using product-level data, as this study does, therefore has the advantage of minimizing aggregation bias.[25]

Our product-level panel version of Anderson and Van Wincoop's (2003) structural gravity equation is

$$x_{ijkt} = \frac{y_{ikt}x_{jkt}}{y_{kt}}\left(\frac{T_{ijkt}}{\Pi_{ikt}P_{jkt}}\right)^{1-\sigma_k} \tag{1}$$

where the t subscript denotes years. The variable x_{ijkt} denotes imports of country j from country i of good k; y_{ikt} is the total production of good k by country i; x_{jkt} is total expenditure for good k in country j; y_{kt} is global production of good k; and T_{ijkt} stands for bilateral trade costs. Multilateral resistance, or general equilibrium effects, are represented by Π_{ikt}, the outward trade barriers faced by country i, and P_{jkt}, the inward trade barriers of country j. If such overall trade costs faced by a country are high, it will be expected to trade more with any bilateral partner at a given bilateral trade cost (than a country facing low overall trade costs). Notably, multilateral resistance varies over time.

[20]This coverage results when we combine the Organization for Economic Cooperation and Development (2003) and the updated Organization for Economic Cooperation and Development (2011) definitions to achieve a broad definition of ICT goods across time.

[21]In addition, product lines that are covered by the ITA for instance only in 2007-12 are considered control sector lines during 1996-2006, if covered by the OECD ICT definition.

[22]These 29 lines cover manifold products, mainly printing machinery, electric typewriters and optical photo-copiers; laser discs and magnetic tapes; electric and power capacitators; equipment for measuring liquid or gas; and parts of accessories of aforementioned products.

[23]To be exact, two ITA tariff lines (HS 381800: Chemical element/compound wafers doped for electronics; HS 950410: Video games used with the TV receiver) are not covered by the four HS sections, but remain in the dataset throughout.

[24]Other studies highlighting this include Clausing (2001), Anderson and Yotov (2010b), Anderson and Yotov (2010a).

[25]We find that such aggregation bias can be considerable when replicating our analysis on aggregate ITA trade flows (Appendix A).

The gravity relation is conveniently linear in logarithmic form, which allows estimation by OLS. The relationship is presented then as:

$$lnx_{ijkt} = lny_{ikt} + lnx_{jkt} - lny_{kt} + (1-\sigma_k)lnT_{ijkt} - (1-\sigma_k)ln\Pi_{ikt} - (1-\sigma_k)lnP_{jkt}. \quad (2)$$

This transformation does not allow to incorporate zero trade flows. The exclusions of the zero trade flows can lead to bias whenever the non-positive trade flows are not random (Helpman et al., 2008). To avoid the bias, we will also estimate the multiplicative version of equation (1) in the robustness section.

As data on total production and expenditure on specific products are not available and multilateral resistance terms are hard to measure, our model relies on fixed effects analog to Olivero and Yotov (2012):

$$lnx_{ijkt} = \alpha_{ikt} + \alpha_{jkt} + \alpha_{kt} + (1-\sigma_k)lnT_{ijkt} \quad (3)$$

where $\alpha_{ikt} = lny_{ikt} - (1-\sigma_k)ln\Pi_{ikt}$, $\alpha_{jkt} = lnx_{jkt} - (1-\sigma_k)lnP_{jkt}$ and $\alpha_{kt} = lny_{kt}$.

Next we set out the trade cost equation. Bilateral trade costs, T_{ijkt}, are a composite affected by various policy and non-policy variables, all of which need to be accounted for in order to obtain accurate estimates of our ITA impacts of interest. We posit that there may be various channels through which the ITA affects bilateral trade costs T_{ijkt} and thereby ultimately trade flows. We refer to these various channels as layers. Two of these layers relate directly to tariffs. As tariffs can hardly be quantified in aggregate data, this provides another important motivation for using product-level data. Furthermore, we posit that the ITA may have non-tariff related impacts on both the import and export side. This results in the following trade cost equation:

$$T_{ijkt} = (1+t_{ikt})exp(\gamma_1 t0_{ikt} + \gamma_2 imita_{ijt} + \gamma_3 exita_{jt} + \gamma_4 I_{ijt} + \alpha_{ijk}) \quad (4)$$

The tariff costs are broken down into the applied bilateral tariff (t_{ijkt}) and a binary cost for having a positive tariff ($t0_{ijkt}$). First, the ITA may boost imports by reducing the applied bilateral tariff, our first layer. Introducing tariffs directly as an explanatory variable in the estimation identifies this impact.

The second layer quantifies that reducing tariffs to zero may have an additional impact on imports beyond tariff reduction. Eliminating the tariff completely might imply a decrease in transaction and administrative costs related to clearing customs as no tariff is to be paid. The intuition here is that reducing tariffs from 2 to 0 percent could have a bigger impact than reducing them from 4 to 2 percent. A growing "time in trade" literature highlights that reducing bureaucratic hurdles in customs, therefore curbing associated clearing times, is expected to have a substantial impact on trade.[26] The relationship could also go the other way. First, even with zero tariff, the customs procedures might not be much reduced as the VAT has to be paid[27]. Second, there could be extra administrative burden from the need to prove to the customs officials that the good should be classified under the line that is covered by the agreement (Hunt and Hunt (2014)). Our empirical findings suggest that trade barrier reducing effects dominate.

The non-tariff costs are also dissected into two different channels: the non-tariff impact of the ITA on imports and on exports.

[26] Freund and Pierola (2012) show that customs clearings times have a big impact on trade.

[27] e.g. see Office of the Revenue Commissioners (2013) for EU customs procedures.

The import side non-tariff impact, $imita_{ijt}$, is thus the third layer. This ITA importer dummy only takes a value of one only when the exporter is a WTO member; this is because the concessions of ITA are only guaranteed to WTO members. The intuition for this channel is that the ITA may have a further positive trade impact apart from tariff reductions. This is suggested by the literature highlighting that trade policy certainty has an impact on investment and entry decisions of firms, including through firm location (Handley and Limão, 2012, 2013). Therefore, we also refer to these types of effects as ITA commitment effects.

The fourth and final layer is the export-side analogue, $exita_{jt}$, to the third layer. The notion here is that location and sourcing decisions of firms increasingly depend on import availability in light of global production sharing. Thus, a liberal and certain trade policy may foster exports, particularly in the IT sector, which has been documented to be one of the sectors most strongly characterized by global production sharing (see Milberg and Winkler (2013) chapter 2 for analysis of US economy). Anecdotal evidence suggests for instance that, in short-listing potential production locations, multinational enterprises may only consider such locations that are part of certain international agreements or have certain institutional features that suggest that risks of business operations, including importing and exporting, being disrupted are low. The exporter ITA membership dummy $exita_{jt}$ equals one simply when the exporter is an ITA member vis-à-vis any trading partner as higher exports, materializing e.g. due to more technology transfer, should not necessarily only go to WTO (or other ITA) members.

The I_{ijt} matrix first contains two variables capturing the impact of the ITA and WTO on non-members.[28] The first captures the ITA's impact on other WTO importers that did not join. This dummy takes the value of one for non-ITA WTO importers, when the exporter is also a WTO member. When its coefficient is negative it indicates less ITA products being traded with non-ITA WTO importers. If positive, it implies that higher ITA goods imports were common also among WTO members in general. In that case, the additional impact that joining the ITA would have for a WTO member is lower. The second dummy variable is similar. It takes the value of one if only one partner is a WTO member and is often referred to as WTO trade diversion. If its coefficient takes a negative value, it implies that countries, after acceding to the WTO, reduce their trade with countries that are not members.

The other variables in the I_{ijt} matrix are commonly used gravity regressors that vary simultaneously across the importer, exporter and time dimensions.They include dummies for joint currency union membership and for a common preferential or regional trade agreement (RTA). Relating to preferential trade agreements, we introduce another two variables. We note that many countries that joined the ITA "passively" were EU accession countries. With ITA and EU accession often happening around the same time, it is possible that the ITA passive exporter effect could capture some EU trade creation, in case it exceeds that of other RTAs. To forestall this possibility we include an EU internal trade dummy for exports of countries that joined the EU after 1997.[29] Likewise we add a dummy for exports to the US of countries that joined an FTA with the US after 1997.

Finally, equation (4) includes a fixed effect term α_{ijk} which accounts for all country-pair-product specific trade determinants – whether observable or unobservable. Given large heterogeneity in bilateral trade relationships, such a fixed effect term has been strongly advocated by various authors (e.g. Baldwin

[28]This type of effect is often called within-WTO trade diversion of the ITA by Bora and Liu (2010) but – as opposed to in the case of preferential trade agreements – we find that the term might be misleading in case of the ITA as its preferences are extended on an non-discriminatory basis to all other WTO members *de jure* and *de facto* oftentimes to all other countries.

[29]While some of the EU impact should be picked up by the RTA dummy, some authors have pointed out, that trade creation may vary substantially across specific agreements and may be particularly strong for the EU (Eicher, Henn, and Papageorgiou, 2012).

and Taglioni (2007)).

Plugging in the trade cost equation (4) into the gravity equation (3) yields our estimation equation:

$$\begin{aligned} lnx_{ijkt} &= \alpha_{it} + \alpha_{jt} + \alpha_{kt} + \alpha_{ijk} + (1-\sigma_k)ln(1+t_{ijkt}) \\ &+ \beta_1 t0_{ikt} + \beta_2 imita_{ijt} + \beta_3 exita_{jt} + \beta_4 I_{ijt} + \epsilon_{ijkt} \end{aligned} \quad (5)$$

where $\beta_l = \gamma_l(1-\sigma_k)$ for $l = 1, ..., 4$.

We drop the product dimension of the multilateral resistance proxies α_{it} and α_{jt} in equation (5). This implies that we do not control for asymmetric changes of multilateral resistance across products. We deem the risk of such changes to be low, given the relative homogeneity of the products we consider (including in the control sectors). Moreover, the remaining set of fixed effects remains rather rich to capture the important of the unobservable economic impacts by accounting for importer-exporter-product and product-time effects in addition to the these multilateral resistance terms. Dropping the product dimension from the multilateral resistance terms is needed to allow us to identify our ITA commitment effects of interest, whose identification relies on variation between ITA and non-ITA products. It is important to highlight that equation (5) can therefore only be estimated on a dataset including a control sector in addition to ITA products. We present two of these control sectors: other, i.e. non-ITA, ICT products and machinery. The ITA commitment effect estimates resulting from this equation illustrate how ITA trade flows performed *relative* to those of the control sector after ITA accession.

We also employ the following simplified equation in some estimations:

$$lnx_{ijkt} = \alpha_{kt} + \alpha_{ijk} + (1-\sigma_k)ln(1+t_{ijkt}) + \beta_1 t0_{ikt} + \beta_2 imita_{ijt} + \beta_3 exita_{jt} + \beta_4 \tilde{I}_{ijt} + \epsilon_{ijkt} \quad (6)$$

It has the advantage that it can allows us to focus on the variation within a country-pair over time. This can address the question – often posed by policy makers – how joining ITA has affected a country's trade compared to that before accession and gives a notion of the absolute gains in imports or exports. The α_{it} and α_{jt} terms have been dropped and only the country-pair-product and product-time fixed effects are retained. This is methodogically risky, because we thereby lose our controls for the variation of multilateral resistance over time. However, *average* multilateral resistance during 1996-2012 remains contolled for via the country-pair-product fixed effects and we expand I_{ijt} to include four additional variables in this simplified specification. These additional variables are (logs of) importer and exporter GDP, a distance-based remoteness dummy – often used as a proxy for multilateral resistance in early literature – and a dummy taking the value of one for all countries that have joined the WTO after 1997.[30] This last variable is included to disentangle ITA impacts from those caused by general trade enhancing-reforms in the wake of WTO accession. There is evidence that recent WTO accessions have been characterized by more onerous reform requirements (Tang and Wei, 2009), which could also affect the ITA sector. Nonetheless, we are fortunate that omission of the multilateral resistance terms does have large impacts on estimates.[31] This strengthens our confidence in the validity of such a simplified regression that only exploits ITA product data and relies on variation across time for identification.

Equation (5) and its more simpified version are estimated first for all goods and then separately for intermediate goods and final goods to obtain additional insights on value chain structures. Computationally, estimation of equation (5) has been challenging until recently because it includes four

[30] Including GDPs as explanatory variables will partly capture some of the variation attributable to multilateral resistance given that the latter is correlated with country size (Anderson and Yotov, 2010a).

[31] Appendix Table A5 presents estimates for equation (5), using ITA and control sector data, but dropping the multilateral resistance terms. Estimates remain very similar to our Table 2 baseline, suggesting that multilateral resistance did not vary hugely during our sample period. Appendix Table A5 is further discussed in the robustness section.

sets of high-dimensional fixed effects. Because of our panel being unbalanced, traditional estimation would require that three sets of fixed effect dummies be held in memory. As each dummy would contain than 5 million observations, computer memory constraints bind. Traditionally these constraints implied that only one high-dimensional fixed effect could be considered by transforming the estimation equation (Greene, 2003).[32]. Labor economists have devised solutions to the challenges of multiple high-dimensional fixed effects, starting with approximations in Abowd et al. (1999). Guimaraes and Portugal (2010) provide an iterative technique to obtain exact estimates of equations with two high-dimensional fixed effects in a computationally manageable way, which has recently been generalized to an unlimited number of fixed effects.[33]

Finally, it is important to consider endogeneity in our estimation equations. There is ample empirical evidence that sectors characterized by higher levels of import penetration receive greater protection (e.g. Trefler (1993), Lee and Swagel (1997)), which is in line with the predictions of political economy models of trade protection. [34] To the extent that high import flows (our dependent variable) coincide with high import penetration, we thus need to suspect that they cause higher tariff levels, reduce the likelihood of zero tariffs as well as that of joining the ITA. In absence of appropriate instrumental variables, the standard in the literature which we also follow here has become to rely on country-pair(-product) fixed effects (Baier and Bergstrand, 2007). This mitigates the issue as long as import penetration does not dramatically change over the sample period. If import penetration does change, but relatively homogeneously across sectors within a country (say due to changes in macroeconomic conditions such as exchange rates), then our importer-time fixed effects constitute a second line of defense. Any remaining endogeneity would bias our estimates toward zero. Thus, to the extent that some endogeneity remains despite the extensive fixed effect controls, our estimates would need to be interpreted as lower bounds.

5. Results

Our results highlight that the ITA's impact on trade consists of four layers. Moreover, many of these impacts vary depending on whether a country acceded "passively". Previous literature only allowed for a single import-side impact of the ITA and used aggregate ITA trade. The discussion here focusses exclusively on regressions which account for all these layered and heterogeneous impacts in product-level data. To allow comparability to previous literature, we add these layers gradually in the appendix, moving from aggregate to product-level data in the process. Coefficients on the standard gravity variables are also discussed there.[35] Finally, the discussion highlights th+at using product-level data is crucial to allow for product-specific unobservable determinants in country pairs. [36]

[32] In a balanced panel, two sets of fixed effects could be stripped algebraically.

[33] Stata command reghdfe by Sergio Correia of Duke University implements this generalization. It relies on the notion that the matrices for the computation of the coefficient estimates are sparse and only identifies non-zero entries. This reduces memory constraints at the cost of higher computation time. For regressions with more than two fixed effects, no exact standard errors can be derived by the routine, because the exact number of absorbed fixed effects is hard to calculate to obtain an exact number of degrees of freedom. So we rely on the routine's conservative bound standard errors, which we cluster by country-pair-pruduct combinations.

[34] While the seminal model of Grossman and Helpman (1994) predicts that higher import penetration would actually lead to lower levels of protection, Maggi and Rodrıguez-Clare (2000) show that this prediction is reversed when the assumptions are relaxed that (i) trade taxes are the government's only policy instrument and that (ii) government has access to non-distortionary taxation.

[35] We suppress these for reasons of space from Table 2, which contains our main results. For Table 2 regressions, these coefficients remain similar to those of regression 24 in Appendix Table A2.

[36] Most notably effects on exports may be overstated in aggregate data, as comparison of regressions 25 and 23 in Appendix Table A2 and Appendix Table A1 shows.

Table 2 presents our results. Going across, it is divided into three sets of columns analysing ITA impacts on all, intermediate and final goods. As not all product lines can be classified into intermediate and final goods, sample selection effects imply that the all goods estimates do not necessarily lie between the former two. Going down, it is divided by horizontal dashed lines into sections separating the four different layers of ITA trade effects, WTO trade diversion and other selected control variables. [37]

Table 2 also incorporates directly two types of robustness checks. First, in addition to the simplified specification only based on the ITA product data (regressions 1, 4, 7), we allow for our different control sectors ICT (regressions 2, 5, 8) and Machinery (regressions 3, 6, 9). The second robustness check relates to China. One of the main novelties of our dataset is that it covers a substantial period of time after China's ITA accession. This allows us to analyse to which extent China's performance has differed from that of other ITA members. As section 2 already highlighted, China's importance in trade of ITA products has increased immensely on the export side, and, to a lesser extent, on the import side. Interestingly, however, all coefficients of interest remain broadly unchanged when China's exports are excluded.[38] The only exception is the passive ITA exporter effect and we therefore include in Table 2 (in grey shading) its coefficient from the analogue regression excluding Chinese exports.[39] This highlights that, while China is not very distinct in its import pattern from other countries, it has become an exceptional case of export success in ITA products since its accession to the agreement.

[37] All Table 2 regressions include at a minimum country-pair-product as well as product-time fixed effects. Product-time fixed effects ensure that estimates are not affected by global supply or demand shocks in specific products. F-Tests reject time fixed effects in their favour throughout our regressions, although coefficients hardly change between the two types of specifications.

[38] We also explored whether results change further when excluding Chinese imports. This is not the case.

[39] These coefficients are taken from Appendix Table A3, which represents the complete analogue table to Table 2 but excluding Chinese exports.

Table 2: The layers of ITA trade effects

	Type of goods	All			Intermediate			Final		
	Fixed effects[4]	ijk & kt	ijk, kt, it & jt		ijk & kt	ijk, kt, it & jt		ijk & kt	ijk, kt, it & jt	
	Sample[5,6]	ITA	ITA & ICT	Machinery	ITA	ITA & ICT	Machinery	ITA	ITA & ICT	Machinery
	Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Layer 1: Tariff	ln(1+tariff) for ITA goods	-0.347***	-0.389***	-0.293***	-0.117	-0.592**	-0.327*	-0.677***	-0.194	-0.118
		(-4.26)	(-4.54)	(-3.89)	(-0.72)	(-3.01)	(-2.00)	(-4.56)	(-1.24)	(-0.78)
reduction effect	ln(1+tariff) for other goods		-0.677***	-0.614***		-0.928***	-0.562***		-0.577***	-0.528***
			(-9.52)	(-22.10)		(-4.13)	(-6.24)		(-4.93)	(-6.10)
Layer 2: Tariff	Zero tariff for ITA goods	0.101***	0.123***	0.099***	0.130***	0.190***	0.139***	0.071***	0.090***	0.092***
		(20.45)	(21.33)	(20.11)	(13.99)	(15.72)	(13.92)	(8.53)	(9.34)	(9.89)
elimination effect	Zero tariff for other goods		0.030***	0.008**		0.051**	0.014		0.021*	0.034***
			(4.81)	(3.23)		(3.05)	(1.66)		(2.07)	(3.89)
Layer 3: Non-Tariff effect for Imports	Active ITA Importer[1]	0.336***	0.155***	0.159***	0.405***	0.284***	0.192***	0.339***	0.078**	0.097***
		(11.63)	(9.18)	(11.47)	(7.34)	(7.02)	(6.54)	(6.69)	(2.77)	(3.64)
	Passive ITA Importer[1]	0.349***	0.113***	0.122***	0.478***	0.368***	0.218***	0.347***	0.023	0.061*
		(14.32)	(6.49)	(8.70)	(10.40)	(8.74)	(7.27)	(8.23)	(0.82)	(2.28)
	Non-ITA WTO Importer[1]	0.325***	0.102***	0.094***	0.446***	0.361***	0.194***	0.265***	-0.020	0.013
		(12.70)	(6.57)	(7.48)	(9.14)	(9.64)	(7.27)	(5.93)	(-0.78)	(0.52)
	Total impact of joining ITA (Lin. combinations of within-WTO ITA trade creation and diversion)[7]:									
	Indiv. ITA Im.	0.010	0.053***	0.065***	-0.041	-0.077*	-0.002	0.074**	0.097***	0.084***
	- non-ITA WTO Im.	(0.63)	(3.50)	(5.12)	(-1.36)	(-2.22)	(-0.08)	(2.57)	(4.06)	(3.66)
	Exog. ITA Im.	0.023	0.011	0.029*	0.032	0.007	0.024	0.082**	0.043	0.048*
	- non-ITA WTO Im.	(1.49)	(0.68)	(2.28)	(1.08)	(0.18)	(0.90)	(3.08)	(1.70)	(2.02)
Layer 4: Non-tariff effect for Exports	Active ITA Exporter	-0.074***	0.167***	0.086***	-0.025	0.091	-0.014	-0.109**	0.028	0.018
		(-3.57)	(8.18)	(5.11)	(-0.64)	(1.61)	(-0.35)	(-3.21)	(0.90)	(0.61)
	Passive ITA Exporter	0.429***	0.177***	0.143***	0.393***	0.195***	0.051	0.507***	0.381***	0.419***
		(25.74)	(9.09)	(9.55)	(13.20)	(3.87)	(1.58)	(17.52)	(11.48)	(13.45)
	Exog. ITA Exporters other than China[8]	0.018	0.125***	0.111***	0.060	0.085	0.071	0.081*	0.309***	0.253***
		(0.83)	(4.63)	(5.58)	(1.61)	(1.13)	(1.64)	(2.20)	(6.95)	(6.20)
	One in WTO	0.070**	-0.009**	-0.049***	0.066	-0.105***	-0.080***	0.181***	0.036	0.053*
		(3.12)	(-0.62)	(-6.06)	(1.61)	(-3.48)	(-3.86)	(4.45)	(1.40)	(2.43)
	Exporter late WTO signatory[2]	-0.036			-0.047			-0.027		
		(-1.45)			(-1.02)			(-0.63)		
	Exporter late EU signatory[3]	0.480***	0.083***	0.063***	0.376***	-0.006	0.190***	0.823***	0.188***	0.249***
		(18.36)	(3.34)	(5.65)	(7.93)	(-0.10)	(5.73)	(18.01)	(4.46)	(6.36)
	Exporter late US-FTA signatory[3]	-0.116	0.080	0.127***	-0.069	0.140	0.135	0.018	0.123	0.107
		(-1.73)	(1.62)	(5.06)	(-0.58)	(1.47)	(1.93)	(0.16)	(1.50)	(1.45)
	Observations	2477294	5632921	21813553	680728	1165824	2530265	825203	1970737	2397118
	R^2	0.8050	0.7978	0.7984	0.8238	0.8161	0.8268	0.7839	0.7936	0.8003
	Adjusted R^2	0.8049	0.7974	0.7982	0.8237	0.8150	0.8262	0.7838	0.7928	0.7997

Notes: Based on robust standard errors clustered by country-pair-product combinations. All regressions include all (non-collinear) standard gravity variables as in Appendix Tables A1 and A2 (coefficients not reported). The number of observations is higher in it/jt specifications, because these fixed effects lead to GDPs and remoteness – which contain some missing values – to be dropped.

[1] ITA importer variables only take the value of one if exporter is a WTO member and if the product in question is an ITA product.

[2] Takes the value of one for all exporters that acceeded to WTO after 1997.

[3] Takes the value for exports of "1" for intra-EU trade (after accession) of all countries that joined the EU after 1997. Analogously for US FTA.

[4] Sets of fixed effects: kt = product-time; ijk = country-pair-product; it = importer-time; jt = exporter-time.

[5] ICT good definition based on union of OECD (2003) and OECD (2011) definitions.

[6] Broad sector including electrical and non-electrical machinery and equipment (HS sections 84-85), vehicles (HS section 87), and optical/cinematographic/precision instruments (HS section 90). These also comprise all but two 6-digit ITA product lines.

[7] The difference of these two variables – ITA trade creation and ITA trade diversion within the WTO – expresses how much more ITA importers import compared to non-ITA WTO members. In other words, this would be the amount that a country, which is already a WTO member, could expect to import more from other WTO members by joining the ITA.

[8] This coefficient is obtained from an exact analog regression that excludes China's exports from the sample. The Passive ITA exporter coefficient is the only one to substantially vary as a result of such a sample modification. The full regression results from this restricted sample are reported in Appendix Table A3.

5.1. Layer 1: Tariff reduction effect

The first of three layers of impact that the ITA may have on imports is related to tariff reductions. The effect measures impacts of tariff reductions whether or not they were related to ITA accession.[40] The results suggest that a one per cent reduction of tariffs on ITA products would cause a 0.3 to 0.4 per cent increase in imports. In the control sector regressions, we allow these import demand elasticies to differ for other ICT and machinery products and obtain higher elasticites for these in absolute terms (-0.6 to -0.7).

As expected, these tariff elasticities are lower than most import demand elasticities reported in the literature and derived based on total trade, which also includes many homogenous products. For instance, Kee et al. (2008) and Tokarick (2014) estimate such elasticities for many different countries and come up with averages in the range of -1.1 to -1.2, although an earlier study by Senhadji (1998) is relatively close to our value, at -0.32. However, that our values are lower is mainly due to us allowing for non-linear impacts of tariff liberalization by including the separate tariff elimination dummy in the second layer. When this second layer is dropped and thereby comparability to these studies is achieved, our ITA import demand elasticity increases to the -0.7 to -0.8 range (see regression 22 in Appendix Table A2), which seems intuitive given that ITA products are fairly differentiated.[41]

Our results from the control sector regressions suggest that tariff reduction effects on intermediate goods are higher than for final goods, both for ITA and control sector goods. For ITA goods, however, this cannot be confirmed in the more basic specification without multilateral resistance controls (regressions 4 and 7). This may be a result of the much smaller samples for which the intermediate/final good distinction is available, which becomes accentuated in the smaller ITA only sample used in these regressions.

5.2. Layer 2: Tariff elimination effect

Reducing tariffs to zero has a large impact on imports of ITA products, above and beyond those of tariff reductions. That there is an additional impact of eliminating tariffs seems intuitive, because zero tariffs reduce border formalities considerably. Our estimates suggest that tariff elimination – whether done because of ITA accession or in another context – will boost ITA imports by about 10-13 per cent across all goods.[42] Thus, making the last effort to reduce small tariffs, say from 1 to 0 percent, will achieve a much higher impact than reducing a high tariff by several percentage points without reaching zero.

Tariff elimination is especially important for ITA goods imports, more so than for other ICT goods or the broader machinery sector for which we obtain tariff elimination impacts of 3 and 1 percent trade increases, respectively. These differences likely come against the background of the ITA sector's especially high integration into value chains, so that burdensome border formalities imply high costs which gets reflected in lower trade values. The estimates for intermediate and final goods support this conclusion. For intermediate goods the impact of tariff elimination is higher – in the 14-20 percent range – likely because these goods are particularly important in value chains. Tariff elimination for final ITA goods is expected to increase such imports by 7-10 percent.

[40] In light of our control variables for other layers, there is no reason to believe that their impacts should vary depending on whether tariff reductions were related to ITA accession or not.

[41] Moreover, adding lagged tariffs in our robustness analysis (Table 3) increases the tariff reduction effect considerably.

[42] Regression coefficients on dummy variables, such as our ITA membership variables of interest, express impacts in log units, which are very similar to percentage changes for values close to zero. The exact percentage change implied by any coefficient b can be calculated as $\exp(b)$-1. The 10-13 percent range mentioned here is obtained from the highest and lowest coefficients on "Zero tariff for ITA goods" in regressions 1-3: exp(0.099)-1=10.4%; exp(0.123)-1=13.1%.

To our knowledge, zero tariff dummies to capture tariff elimination effects have thus far not been commonly included in the gravity literature. In fact, much of the literature does not even include tariffs as an explanatory variable, partly for data availability reasons. However, we do not find our strong tariff elimination effects surprising in light of the findings of two related literatures. First, the time in trade literature finds that border formalities which slow down merchandise trade have substantial effects on trade flows (e.g. (Djankov et al., 2010)). Second, the extensive empirical literature on the trade impacts of preferential trade agreements (PTAs) on trade generally finds these to be large. This suggests that there are strong impacts of reducing tariffs to zero, as many of these agreements do. However, this PTA literature mostly does not include separately tariffs and tariff elimination dummies in their analyses, so that all these effects are typically compounded into a PTA dummy. Although PTA impacts are not the focus here, our estimates provide some additional information on PTA impacts in the ITA sector, because we explicitly consider tariffs and a zero tariff dummy in the same regression. In our estimation, the PTA coefficient will only quantify PTA benefits going beyond tariff reduction and elimination, i.e. those related to harmonization and reduction of non-tariff barriers. We find that for ITA goods, these on average lead to a 5 per cent trade increase (see regression 28 in Appendix Table A2).

Our confirmation of the existence of tariff elimination impacts – not only in the ITA sector but also in the broader ICT and machinery sectors – holds strong policy implications. It implies that, from a trade perspective, it would be beneficial to reduce tariffs to zero wherever possible, but particularly on those lines where tariffs are already low, so that losing related tariff revenues would not have large fiscal implications. To the extent that sectoral tariff elimination agreements at the WTO provide a credibility mechanism that allows governments to achieve such tariff elimination, they may be worthwhile pursuing. Our estimates here suggest that tariff elimination of an ITA II agreement (to the extent that is eliminates tariffs on other ICT products) could benefit trade considerably, though potentially to a lesser extent than the original ITA. Finally, tariff elimination in other sectors, such as machinery or chemicals – also often tentatively explored at the WTO – may also have benefits beyond those of tariff reduction. Further research would be needed to quantify possible tariff elimination impacts in these sectors.

5.3. Layer 3: Commitment effect for imports

This layer quantifies whether the ITA had a further impact on imports beyond those of tariff reduction and elimination. This additional impact would result from the binding commitments that the agreement establishes, making the resulting tariff elimination much more costly to reverse than if it were achieved through unilateral actions. This may spur additional integration, for instance because higher trade policy certainty makes investments by exporters into distribution networks in ITA members less risky than those in non-ITA member countries. As a result, exporters may prefer ITA members as destination markets.

We start our results interpretation with regression 1. Coefficients are broadly constant across the Active and Passive ITA Importer and the non-ITA WTO Importer variables. We recall that these three variables are nothing more than a decomposition of a "Both in WTO" dummy variable commonly used in studies on the trade impact of joint WTO membership(Rose (2004) and subsequent literature). Thus, when the two ITA Importer variables and the non-ITA WTO Importer variable take the same coefficient values, as in regression 1, they refer to WTO trade creation. Estimates thus imply that joining the WTO leads to a 40 per cent trade increase in ITA products, with impacts higher in intermediate goods given deepening GVC integration. In contrast, ITA membership does not have an additional impact.[43] For information, we include also in Table 2 (in the grey shaded lines) the differences between

[43]Country pairs including just one WTO member register a much lower increase of only 7 per cent compared to country

the active/passive ITA Importer and non-ITA WTO Importer effects.[44] They quantify the additional impact that acceding to the ITA has for countries that are already WTO members. These linear combinations of estimates are hardly different from zero across all goods (regression 1), although there is a small positive impact of 8 per cent for final goods imports (regression 7).

Regressions 2 and 3 introduce our two control sectors.

It is important to note that layer 3 (and 4) coefficients have a different interpretation in control sector regressions. Adding the control sector and importer-time and exporter-time effects implies that we now rely on between-product variation within each importer and exporter for identification. This implies that the ITA importer and exporter dummies come to express how commitment effects of the ITA have influenced imports of ITA products *relative* to ICT or machinery products. Thus, coefficients here express how much the performance in ITA product trade differed – after ITA accession – from that in the control sector.

The regressions confirm the previous result that WTO membership is very important for facilitating countries' integration in ITA goods trade having about a 10 percent stronger effect than in the broader ICT or machinery sectors.[45] WTO membership is particular important to profit from intermediate goods trade in the ITA sector, while it does not boost final goods imports beyond those of control sectors.

Beyond that, the control sector regressions confirm additional ITA commitment effects on imports: Countries that joined the ITA increased after acession further their ITA imports relative to those of other ICT and machinery products. These impacts apply mainly to active signatories, indicating an relative increase of around 6 percent across all goods. Despite the strong declines that active signatories faced in their ITA import market shares (highlighted in Figure 2), ITA accession actually helps them to perform stronger than in other ICT and machinery products. The effect is driven by increases in final goods imports of around 9-10 percent, while intermediate imports have actually decreased for active signatories. This suggests that production of active signatories, which include many developed countries, was oriented away from downstream stages (which rely on intermediate imports), outsourcing these production steps to other countries. As a result of this process, active signatories' final goods imports then increased. Meanwhile, in passive signatories intermediate ITA imports kept up with ICT imports, suggesting their stronger role in downstream production of ITA products. Analysis of export impacts further strengthens this interpretation.

5.4. Layer 4: Commitment effects for exports

On the export side, active ITA signatories are estimated to have experienced a decline of about 7 percent after accession on account of declines in final goods exports. However, again, this decline seems small in light of their large loss in market shares in global ITA exports over the period, depicted in Figure 2 earlier. They were able to retain their intermediate good exports constant after accession, only losing some ground in final goods. This is in line with the value chain literature, which suggests that skills needed for producing intermediate products tend to be higher on average than for downstream activities; and thereby many developed countries have increasingly concentrated on export of high-value intermediates.

Viewed relative to the control sectors, moreover, active signatories' ITA exports have done well after ITA accession. ITA exports outperformed ICT and machinery exports, by 18 and 9 percent, respectively, across all products (regressions 2 and 3). In other words, active signatories' ITA exports would likely have performed worse if they had not joined the ITA. Arguably, they could have been more in line with

pairs in which none of the partners is a WTO member (see the "One in WTO" coefficient).

[44] These linear combinations of coefficients are obtained post estimation.

[45] This is suggested by the coefficient on Non-ITA WTO importers in regressions 2 and 3.

their performances in ICT and machinery exports where active signatories (many of them developed countries) experienced larger losses in export market shares to developing countries.[46]

Passive signatories' exports have responded to ITA accession differently to those of active signatories. As a group, their exports increased by over 50 per cent, but this impact is largely driven by the outperformance of China. China has become more than a mere downstream assembly hub for ITA products since its ITA accession. Our estimates suggest that it has, in addition to final goods, also taken to exporting substantially more ITA intermediate products, including relative to ICT intermediates.

Nonetheless, passive signatories other than China have profited from ITA accession. This is shown by our more disaggregate estimates. They register absolute gains in final goods exports of 8 1/2 per cent as a result of ITA accession. When evaluated relative to control sectors, final goods exports in these countries even rose about 30 per cent in response to accession. Meanwhile, they did not record significant export gains in intermediate goods. This suggests that ITA membership facilitated adoption of downstream positions in ITA value chains for these passive signatories, focussed on producing final goods, including through the assembly of intermediate goods. The literature on value chains indeed suggests that for initial entrants, it is most common to join in downstream activities, because capabilities needed to perform those tasks can be acquired most easily (see World Trade Organization (2014) for an overview).

5.5. WTO Trade Diversion and other selected controls

There is no evidence for WTO trade diversion in absolute terms, as illustrated by the positive coefficients in regressions 1, 4, and 7. If anything it seems that trade between members and non-WTO members has increased compared to that between two non-WTO members. However, it rose by much less than that among two members. Relative to the control sectors, imports of intermediate ITA products have declined for pairs with one WTO member, like they have for non-ITA WTO importers. This provides further evidence that intermediate imports more strongly shifted toward passive ITA members (rather than other countries) and that they achieved downstream GVC integration.

The final coefficients reported in Table 2 are those for exporters that joined the WTO, EU, or a US FTA after the start of our sample. As accession to such agreement typically involves broad policy reforms that may affect inter alia ITA exports, these dummies are needed. They forestall that impacts of such accessions are confounded as ITA effects, in case they caused larger trade impacts than those captured already by e.g. the PTA dummy. We find that indeed ITA exports to other EU countries increased considerably more than implied by the PTA dummy estimate for those countries that joined the EU recently.[47]

6. Robustness

In this section we present four further robustness checks. As noted previously, Table 2 already incorporated two aspects that could be considered robustness checks – exclusion of China's exports from the sample and two different control sectors – because they are essential for interpreting the results. Appendix Table A3 presents the complete results obtained from the sample excluding China's exports. The four additional robustness checks presented here, meanwhile, only confirm that results do not change further.

[46] Unfortunately, we cannot confirm how these results are driven by intermediate and final goods as statistical significance is diminished in the smaller subsamples, likely in light of sample selection.

[47] Eicher et al. (2012) disaggregate the PTA dummy and find that EU trade creation is higher than that of many of other PTA agreements. In this sense, the late EU signatory dummy also insulates our estimates to some extent from such heterogeneous PTA trade creation.

Table 3: Robustness I: Lagged Tariff Reduction Effects

Sample[5,6]	ITA			ITA & ICT		
Fixed Effects[4]	ijk & kt			ijk, kt, it & jt		
Regression No.	1	10	11	2	12	13
ln(1+tariff), ITA goods	-0.347***	-0.374***	-0.578***	-0.389***	-0.038	-0.037
	(-4.26)	(-3.52)	(-4.80)	(-4.54)	(-0.34)	(-0.29)
ln(1+tariff), ITA goods, t-1		-0.367***	-0.613***		-0.675***	-0.842***
		(-4.10)	(-6.01)		(-7.20)	(-7.68)
ln(1+tariff), ITA goods, t-2			0.303**			-0.047
			(3.17)			(-0.47)
ln(1+tariff), ITA,	-0.347***	-0.741***	-0.888***	-0.389***	-0.713***	-0.926***
Sum of t to t-2	(-4.26)	(-7.14)	(-7.03)	(-4.54)	(-6.36)	(-6.75)
ln(1+tariff), other				-0.677***	-0.242**	-0.261*
				(-9.52)	(-2.66)	(-2.53)
ln(1+tariff), ICT goods, t-1					-0.597***	-0.249**
					(-7.67)	(-2.83)
ln(1+tariff), ICT goods, t-2						-0.582***
						(-6.93)
ln(1+tariff), ICT,				-0.677***	-0.839***	-1.091***
Sum of t to t-2				(-9.52)	(-8.99)	(-9.56)
Zero tariff, ITA goods	0.101***	0.071***	0.052***	0.123***	0.100***	0.082***
	(20.45)	(12.73)	(8.76)	(21.33)	(14.99)	(11.35)
Zero tariff, other				0.030***	0.027***	0.020**
				(4.81)	(3.91)	(2.71)
Active ITA Importer[1]	0.336***	0.383***	0.425***	0.155***	0.174***	0.184***
	(11.63)	(12.33)	(12.70)	(9.18)	(9.04)	(8.76)
Passive ITA Importer[1]	0.349***	0.396***	0.447***	0.113***	0.124***	0.141***
	(14.32)	(14.84)	(14.95)	(6.49)	(6.21)	(6.22)
Non-ITA WTO Importer[1]	0.325***	0.359***	0.415***	0.102***	0.137***	0.169***
	(12.70)	(12.88)	(13.64)	(6.57)	(7.71)	(8.70)
Impact of joining ITA (Lin.combin. of within-WTO ITA trade creation and diversion effects):[7]						
Indiv. ITA Im.	0.010	0.024	0.010	0.053***	0.037*	0.015
- non-ITA WTO Im.	(0.63)	(1.52)	(0.61)	(3.50)	(2.21)	(0.83)
Exog. ITA Im.	0.023	0.036*	0.032	0.011	-0.012	-0.028
- non-ITA WTO Im.	(1.49)	(2.18)	(1.72)	(0.68)	(-0.69)	(-1.40)
Active ITA Exporter	-0.074***	-0.104***	-0.147***	0.167***	0.152***	0.150***
	(-3.57)	(-4.67)	(-6.43)	(8.18)	(6.42)	(5.95)
Passive ITA Exporter	0.429***	0.463***	0.501***	0.177***	0.208***	0.250***
	(25.74)	(22.96)	(21.65)	(9.09)	(8.74)	(9.14)
Exog. ITA Exporters	0.018	0.033	0.064	0.125***	0.172***	0.226***
other than China[8]	(0.75)	(1.19)	(1.95)	(4.63)	(4.70)	(5.13)
Observations	2477294	1894584	1600294	5632921	4181602	3514499
R^2	0.8050	0.8100	0.8162	0.7978	0.8017	0.8077
Adjusted R^2	0.8049	0.8099	0.8160	0.7974	0.8013	0.8072

Notes: All regressions are on the all goods sample. Explanatory variables are all as in Table 2 analogs (Regressions 1 and 2, respectively), although more of them are suppressed here for reasons of space. Notes of Table 2 apply, including for [1] through [8].

The first of these additional robustness checks constrains in the control sector regressions the tariff reduction and elimination effects. Effects are not allowed to be sector-specific any more, but there is a single effect for ITA and control sector products. Appendix Table A4 illustrates that this, as expected, leads to aggregate tariff reduction and elimination effects in the center of the previous ITA and control sector estimated. Other coefficients do not change. In particular, the commitment effects on the export side are completely insulated from this modification, also as expected.

The second additional robustness check re-estimates the control sector regressions on a reduced set of fixed effects, featuring country-pair-product and product-time only (as in Table 2's regressions 1, 4, 7). Appendix Table A5 shows that results are very similar to those of Table 2, which also include time-varying importer/exporter effects in addition. This highlights that in the control sector regressions, it is indeed the added variation between ITA products, on the one hand, and ICT/machinery products, on the other hand, that drives the results. Limiting the identifying variation between these types of products to within one importer or exporter in a given time-period (as in Table 2) via the multilateral resistance controls, in contrast, does not have much impact. As mentioned above, this in turn gives us confidence in our regressions on ITA products only (Table 2, regressions 1, 4 and 7), on which we rely for quantifying absolute trade impacts of the ITA. Omission of multilateral resistance controls – the time-varying importer/exporter effects – does not affect results much. This is a useful property in our application because in the regressions on ITA products, we cannot avoid such omission in order to retain our commitment effect dummies for imports and exports.

The third additional robustness check relates to dynamic impacts of tariff reductions. As Figure 1 illustrated, ITA signatories already reduced their tariffs rapidly in the run up to accession. If these tariff reductions only had an impact on trade some time later, it could thus be the case that their impact is falsely attributed e.g. to the tariff elimination effect. In Table 3, we therefore add lagged tariff levels. We add lags gradually. For the first lag, we find that it is very significant and of the same order as the contemporaneous tariff in the ITA only sample (regression 10). The total tariff reduction elasticity therefore rises to the order of -0.7 to -0.9, when we approximate it by simply summing tariff reduction coefficients across lags. This larger impact is confirmed also if two lags are added (regression 11) or if we include the ICT control sector and, alongside, importer-time and exporter-time fixed effects (regressions 12-13).[48] With regards to the tariff elimination effect, we do find that it is somewhat reduced as a result of this modification, but remains highly significant and its magnitude exceeding that of a 6 percent tariff reduction in all specifications. Results on ITA commitment effects remain basically unchanged.

The fourth additional robustness check explores zero trade flows. All estimations up to this point contained only the positive trade flows, ignoring the product lines with no trade. Eliminating zero trade flows by taking logs of the gravity equation had crucial advantages in deriving our main results discussed above. Foremost, it allowed us to introduce up to four high-dimensional fixed effect controls in estimations containing more than 20 million observations. These fixed effects ensured that omitted variable bias is kept to a minimum in our product-level data which can be subject to many unobserved determinants with respect to importers, exporters, products, and time. Many authors have underscored the importance of inserting comprehensive fixed effect controls in gravity estimation (e.g. Baldwin and Taglioni (2007)).

While zeros are hard to incorporate in our setup because of computational constraints posed by the various high-dimensional fixed effects, we recognize that their exclusion can induce selection bias (Helpman et al., 2008). The most straightforward way to introduce zeros, and we will pursue it in

[48] We added up to three lags in unreported results without further changes. Coefficients from the second lag onwards become statistically insignificant or positive.

Table 4: Robustness II: Addressing zero trade flows with Poisson estimation

Estimation technique	Least Squares				Poisson	
Data disaggregation	6-digit products		Prod. Categories[9]		Prod. Categories[9]	
Zero trade flows	No	No	Yes	Yes	Yes	Yes
Includes China's Exports	Yes	No	Yes	No	Yes	No
Regression No.	14	15	16	17	18	19
ln(1+tariff)	-0.416***	-0.356***	-1.576***	-1.545***	-3.855***	-3.492***
	(-4.47)	(-3.77)	(-4.78)	(-4.56)	(-4.26)	(-3.71)
Zero tariff	0.067***	0.067***	-0.176***	-0.172***	-0.215**	-0.238***
	(12.02)	(11.82)	(-6.41)	(-6.12)	(-3.21)	(-3.31)
Active ITA Importer[1]	0.333***	0.377***	0.390***	0.401***	0.012	-0.035
	(10.16)	(11.52)	(4.00)	(3.99)	(0.08)	(-0.21)
Passive ITA Importer[1]	0.350***	0.379***	0.489***	0.437***	0.794***	0.827***
	(12.73)	(13.70)	(6.30)	(5.47)	(5.24)	(5.31)
Non-ITA WTO Importer[1]	0.318***	0.331***	0.459***	0.414***	0.396***	0.394***
	(11.01)	(11.40)	(5.29)	(4.69)	(3.54)	(3.46)
Total impact of joining ITA (Lin. combinations of within-WTO ITA trade creation and diversion)[7]:						
Active ITA Importer minus	0.015	0.046**	-0.069	-0.014	-0.385***	-0.426***
non-ITA WTO Importer	(0.86)	(2.69)	(-1.39)	(-0.26)	(-4.18)	(-3.88)
Passive ITA Importer minus	0.031	0.048**	0.030	0.022	0.398***	0.432***
non-ITA WTO Importer	(1.93)	(2.90)	(0.50)	(0.36)	(4.13)	(4.41)
Active ITA Exporter	-0.134***	-0.082***	-0.036	-0.016	-0.629***	-0.901***
	(-5.83)	(-3.36)	(-0.62)	(-0.26)	(-5.30)	(-5.57)
Passive ITA Exporter	0.413***	0.058*	0.315***	0.162*	0.783***	0.245
	(21.79)	(2.41)	(5.38)	(2.22)	(8.35)	(1.58)
One in WTO	0.067**	0.093***	0.106	0.035	0.057	0.075
	(2.91)	(4.02)	(1.52)	(0.49)	(0.52)	(0.66)
Exporter late WTO joiner[2]	-0.079**	-0.277***	-0.100	-0.189	0.194	0.174
	(-2.81)	(-9.10)	(-1.13)	(-1.95)	(1.15)	(0.88)
Exporter late EU joiner[3]	0.518***	0.682***	1.307***	1.372***	0.955***	1.187***
	(17.61)	(23.16)	(16.64)	(17.39)	(5.74)	(8.70)
Exporter late US-FTA joiner[3]	-0.110	0.068	-0.028	0.016	-0.556	-0.478
	(-1.43)	(0.90)	(-0.12)	(0.07)	(-1.95)	(-1.67)
Observations	2477294	2386043	230386	224840	262011	256240
R^2	0.7964	0.7939	0.8579	0.8546	...	...
Adjusted R^2	0.7539	0.7503	0.8430	0.8392	...	...

Notes: Notes of Table 2 apply, including for [1] through [4] and [7]. Regressions are based on all goods in the ITA product sample and all include country-pair-product category and time fixed effects. While the time fixed effects would be statistically rejected in favor of product-time fixed effects at the 0.1 percent level or higher by F-Statistics, Poisson estimation does not achieve convergence in the presence of the high dimensional product-time fixed effects.

[9] For these regressions the dataset is collapsed to the 7 broad ITA product categories described in Section II. In addition, all countries are dropped which do not make up at least 0.25 per cent of either world imports or exports within at least one of these categories; this reduces the number of countries to 112 (from 235), while retaining more than 97 percent of global trade. This reduction in the dimensionality of the dataset is necessary in order to include zero trade flows, while still allowing the Poisson estimation to converge. In these regressions the Zero tariff variable, instead of being a 0-1 dummy, describes the fraction of product tariff lines within the category in which the tariff is zero. Thus, it takes values between 0 and 1.

this robustness check, is to avoid taking logs altogether, thereby preserving the zero trade flows. The gravity equation is then estimated in multiplicative form, as in equation (1), using Poisson estimation as proposed by Silva and Tenreyro (2006). The Poisson estimation only allows one set of fixed effects to be absorbed, requiring dummy variables for other sets of fixed effects to be created and held in memory. This implies that we cannot replicate any of baseline regressions of Table 2 directly in a Poisson setup. However, we are able replicate a close analogue to regression 1 by reducing its product-time fixed effect to a time fixed effect.[49] Regressions 14 and 15 in Table 4 first provide the least squares results from such a setup. They are very similar to those of regression 1.[50] This provides evidence that *time-specific* shocks to ITA goods are relatively homogenous, so that the product-time fixed effects do generally not impact coefficients much as compared to the simpler time fixed effects.[51] We thus feel comfortable in simplifying the fixed effects structure in this way to enable us to incorporate zero trade flows.

To ensure convergence of the Poisson estimation, we in addition need to (i) reduce our country coverage to 112 countries and (ii) reduce our product dimension by aggregating to the 7 broad categories of ITA products in section 2.[52] As already in Appendix Table A1 and Appendix Table A2, we again find that using detailed product-level data is important, because heterogeneity between products is high, although it does not vary much over time. It is therefore important that country-pair specific influences are allowed to vary at the most detailed product level possible. In other words, collapsing into the 7 broad categories impacts the coefficients in least squares estimation, in particular by enlarging tariff reduction elasticities to the -1.5 range at the expense of counterintuitive signs of tariff elimination (regressions 16 and 17 in Table 4). We are, however, not overly concerned because the sole objective of these regressions is to provide a benchmark for the analogue Poisson estimates (regressions 18 and 19). We indeed find that the general pattern of results remains similar in the Poisson regressions. Albeit tariff reduction elasticities increase somewhat, leading to changes in commitment effect coefficients for active signatories, we remain on the whole confident in our baseline results.

Finally, we extend our robustness check for zero trade flows one step further, because we note that in Table 4 the number of observations increases by less than 15 per cent as a result of including zero trade flows. The reason is that tariff data are unavailable for many country pairs in the years with zero trade flows. In Appendix Table A6, we therefore drop the tariff reduction and elimination effects, only retaining the ITA importer and exporter dummies. Again, when moving to the Poisson regression, active ITA signatory effects change somewhat, but otherwise the general pattern of results remains the same.

7. Heterogeneity of ITA trade impacts depending on other country-specific determinants

This brief section illustrates that trade impact reapt from ITA membership can vary substantially depending on country circumstances. To quantify these country circumstances we focus on four determinants that are often mentioned in the global value chain literature as important for achieving GVC participation. They are geographical remoteness, education levels, the general business environment and institutions. For remoteness, we devise a custom ITA-specific measure quantifying the distance

[49] Time fixed effects' dimensionality is sufficiently low for them to be created in memory. The country-pair-product fixed effects, which are high dimensional, are absorbed in the regression.

[50] For the machinery control sector, there is a larger effect on coefficients, but mostly their magnitudes, with general patterns remaining largely the same.

[51] In contrast, we find that country-pair fixed effect values vary considerably across products.

[52] In reducing our country coverage to 112 (from 234 in the baseline dataset), we exclude all countries that do not account for at least 0.25 per cent of world trade in at least one of the 7 categories in 2011. The resulting smaller dataset still covers more than 97 per cent of world trade in 2011.

from ITA-good import hubs; this measure attributes greater weight to distances to those importers that import large quantities of ITA goods. For landlocked countries, we refine this measure further by including a multiplicative penalty obtained by dividing the countries' export costs per container by that of the most proximate coastal country. Education is proxied by secondary school completion rates (Prati et al., 2013). We use control of corruption (from the World Bank's World Governance Indicators) as a proxy for the overall business environment, which Breen and Gillanders (2012) have shown to be highly correlated. Finally, institutions are proxied by the rule of law, taken from the same source.[53]

For illustration purposes, we focus here exclusively on how layer 4 impacts–the commitment effect on exports–vary. We do so by interacting the country-specific determinants with the active and passive ITA exporter dummies and adding them to a version of our baseline regression 2 (of Table 2) that excludes China's exports. Resulting regression coefficients are reported in Appendix Table A7. This table also shows the 2010 values of determinants by percentiles for passive signatories. Using these two inputs, we compute Table 5 presented here. It illustrates for passive signatories that deviations from the baseline commitment effect on exports of 0.165 are large, underscoring that country circumstances play an important role in how much countries benefit from ITA membership. The results suggest that the most remote 25 percent of passive signatories did not benefit from a positive commitment effect on exports, unless they managed to outweigh their remoteness by particularly favorable education levels, business environments or institutions. Likewise, we find that those countries with low education, unfavorable business environments or weak institutions struggled to reap export benefits from the ITA. These results are in line with the consensus of the GVC literature, which suggests that a broad reforms are needed to create a favorable environment in which GVC participation can be achieved and deepened.

Table 5: Export commitment effect for passive ITA signatories in 2010, by percentile of interaction variable

Interaction Variable[1]	Remoteness[2]	Education	Business environment	Rule of law
10th percentile	0.169***	0.005	-0.039	-0.088
25th percentile	0.159***	0.008	-0.010	-0.034
Median	0.126***	0.094**	0.044	0.018
75th percentile	-0.033	0.177***	0.163***	0.172***
90th percentile	-0.052	0.216***	0.284***	0.267***

Notes: *, **, *** denote 5, 1, 0.1 per cent significance levels obtained by the delta method based on robust standard errors clustered by country-pair-product combinations. The figures in the tables are computed from percentile-specific interaction variable values and coefficients for passive signatories, both displayed in Appendix Table A7. For example, the 0.128 value for the 50th percentile in the "IT-based remoteness" column is obtained by -0.0088+(-0.0472)*(-2.864).
[1] Footnotes of Appendix Table A7 detail how these interaction variables are obtained/constructed.
[2] To world ITA goods import markets.

We subjected these results to a variety of (unreported) sensitivity checks, all of which confirmed their robustness. First, we included different interaction variables such as standard GDP-based remoteness, ITA-specific remoteness without penalty for landlocked countries, and ITA-specific remoteness from export hubs (in light of importance of import availability in GVCs). For institutions, we included alternative proxies from the World Governance Indicator database such as regulatory quality, government effectiveness, political stability and absence of violence, and accountability and voice. Second, we included China's exports again in the regression sample. Finally, we also added analog interactions on the first 3 layers. Apart from confirming above results, this last check also showed that the other 3 layers' impacts are also heterogeneous depending on determinants. Countries with a more centric geographical location, better education, and superior business environments and institutions benefit more from tariff

[53]See notes of Appendix Table A7 for further data description.

reductions. Meanwhile tariff elimination and ITA commitment effects on imports tend to be higher for those countries with less favorable environments in light of our four determinants.

8. Conclusion

The Information Technology Agreement (ITA) is likely the most significant plurilateral tariff reduction agreement to date. Under the aegis of the WTO, 78 countries eliminated all import tariffs on a wide range of IT-related goods. Its broad coverage within the sector, as well as comprehensive implementation of the agreement, makes the ITA a key case to understand the impacts of tariff elimination agreements within the WTO.

This paper presents a comprehensive study of the ITA's trade impacts by integrating into the analysis recent insights from both the global value chain (GVC) and time in trade literatures (e.g. Djankov et al. (2010), Hummels and Schaur (2013)). Using a large panel data set of product-level data, we can integrate tariffs directly into the analysis and are able to dissect three layers through which the ITA affects imports: tariff reduction, tariff elimination, and non-tariff effects related to higher trade policy certainty implied by binding commitments at the WTO. Moreover, we find that these commitment effects also affect exports, an angle which literature has thus far neglected. This effect proxies for export increases caused by relocation of production toward signatories, including as a result of location and sourcing decisions of multinationals that are key in value chains. This layering of effects has been neglected in most gravity literature, which often only considers one composite dummy for joint membership in trade agreements.

We only summarize our results again very briefly: The ITA has strong impacts on trade, through all four layers that we identify. Effects vary across intermediate and final goods, as suggested by the value chain literature, and are heterogeneous across country groups.

Our paper has implications, on the one hand, for gravity methodology with regards to the analysis of trade agreements' impacts and, and on the other hand, for policy.

With regards to gravity methodology, tariff data should be integrated directly into the analysis wherever possible. Doing so produces a wealth of new policy-relevant information. Tariff elimination effects can be very high in certain sectors, such as ITA and ICT goods, which feature high value chain integration, as suggested by the time in trade literature. Neglecting tariff elimination effects can thereby lead to overestimation of tariff reduction effects. For ITA goods, this seems to explain the high tariff-to-import price pass-through obtained by Feenstra (2008). Finally, through this breakdown we can distinguish how large the impacts are through other channels that go beyond tariff reduction and elimination. Implementing such a layered approach benefits considerably from product-level data, albeit country-average tariffs could be explored in gravity analysis of aggregate trade flows. Our analysis, however, sounds a caution, revealing considerable heterogeneity across products within country pairs in ITA trade (though time-specific shocks tend to be quite homogenous across products). Since such heterogeneity cannot be controlled for in aggregate trade flow data, estimates obtained from it can suffer from bias. For the ITA case, we find that aggregation tends to overstate the agreement's impacts (Appendix A).

With regards to trade policy, resulting implications are threefold, making the case for countries to (i) expand the ITA's product coverage through an ITA II agreement, (ii) to pursue further zero-for-zero sectoral agreements and/or (iii) unilateral, non-discriminatory, tariff reductions to zero. In light of sizable tariff elimination effects, there could an especially strong case for reducing those tariffs to zero that are already small. Large trade benefits could thereby be achieved with only small undesired side effects, for instance on fiscal revenues. However, we find that there are strong synergies between education, institutions, overall business environment and the gains from ITA membership. In the absence of the

latter, countries and particularly remote ones may see benefits from ITA membership substantially reduced.

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10. Appendix A: Establishing comparability to previous literature via gradual addition of layers

Bora and Liu (2010) (BL) have undertaken the, to our knowledge, most comprehensive investigation of ITA trade impacts to date. The discussion here therefore starts from their preferred specification and aims at demonstrating how each single one of our innovations affects results.

BL conduct their estimation on aggregate data, i.e. their panel dataset includes one observation per country-pair in each year with the total trade value in ITA products. We repeat BL's results for comparison purposes at the beginning of Appendix Table A1.[54] BL find that countries experience trade creation from joining the ITA, as signaled by the ITA importer dummy. After accession, they import 7.25 per cent ($= exp(0.07) - 1$) more from other WTO members. BL's estimates further suggest that the ITA reduced trade with non-ITA WTO members, which now import 6 per cent less. Taking these two estimates together, BL conclude that a WTO member should see its imports increase by 14 percent ($=exp[0.07 - (-0.06)] - 1$) upon joining the ITA. In addition, BL find that the WTO also diverts trade away from non-members, as highlighted by the "One in WTO" coefficient, and that RTAs boost bilateral trade substantially. However, they fail to identify a significant positive impact of currency unions, that is commonly found in gravity regressions covering all goods.

We first update the sample and introduce effects for exporters on aggregate ITA trade data. Second, we move to product-level data, which then allows us to split the import-side impact into its three layers.

10.1. Updating the sample and introducing exporter effects

To ensure comparability to BL, we also report our initial regressions on aggregate data. Regression 20 is our closest analogue. It differs mainly in terms of our updated sample, covering 1996-2012 (versus BL's of 1988-2012). [55] Our sample therefore covers many more years of trade within the ITA after its establishment in 1997, including the rise of China as an IT production hub.

The updated sample gives a markedly different view of the ITA's impact. Contrary to BL, our results do not show a negative impact on non-ITA WTO members. WTO members as a group import 26 per cent more IT products, as highlighted by the non-ITA importer coefficient. ITA membership boosts imports by a further 21 per cent. Also, we do not find any trade diversion of the WTO. With regards to currency union membership, we now find it to be statistically significant, in line with the literature on currency unions (Rose, 2000, and following literature), boosting trade by 30-35 per cent and similar in magnitude as RTA membership.[56]

[54] See Bora and Liu (2010), Table 2.3, column 2.

[55] Apart from the different sample coverage, the second main difference is that BL maintain GDP per capita regressors. Arguably, BL include them, because they start their analysis from specifications which do not include country-pair fixed effects. In regressions without country-pair fixed effects, which also rely on cross-sectional variation, such regressors can serve a purpose. There they capture that richer countries trade more, for instance due to better transport connections and domestic infrastructure in addition to higher preference for variety. Once, however, country-pair fixed effects are included, GDP per capita coefficients (which take very high coefficients in BL's preferred regression) seem to capture effects typically captured by GDPs, whose coefficients are diminished, even becoming negative for importers. We therefore do not include GDP per capita in our regressions, as we maintain country-pair (or more detailed) fixed effects throughout to forestall otherwise possible omitted variable bias (Baldwin and Taglioni, 2007). Dropping GDP per capita variables does not affect our results much. Furthermore there are a couple of further minor differences of our regression 20 vis-a-vis BL. BL also include a couple of other variables which are not commonly included in gravity equations and that we therefore drop. These variables are dummies for political alliances and for presence of a Generalized System of Preferences scheme. Any bias that could be introduced by exclusion of the latter by direct inclusion of tariffs in our analysis.

[56] It is furthermore noteworthy that (given that per capita GDPs are not included) both our GDP coefficients take values close to unity as suggested by many theoretical models (e.g. Anderson and Van Wincoop (2003)).

Table A1: Benchmark using aggregate data

Time coverage of sample	1988-2003	1996-2012			
Includes China's Exports	Yes	Yes	No	Yes	No
Regression No.	BL (2010)[10]	20	21	22	23
ITA Importer[1]	0.07*	0.422***	0.156*	0.267***	0.048
	(2.29)	(5.15)	(1.98)	(3.32)	(0.61)
Non-ITA WTO Imp.[1]	-0.06*	0.235**	-0.105	0.065	-0.224**
	(-2.07)	(2.73)	(-1.27)	(0.76)	(-2.72)
Total impact of joining ITA (Combination of within-WTO ITA trade creation and diversion)[7]:					
ITA Importer minus	0.13*	0.187***	0.260***	0.202***	0.262***
Non-ITA WTO Importer	...	(4.96)	(6.97)	(5.35)	(6.97)
ITA Exporter			0.404***	0.312***	
			(10.77)	(7.99)	
One in WTO	-0.16***	-0.009	-0.184*	-0.060	-0.216**
	(-5.11)	(-0.13)	(-2.57)	(-0.81)	(-3.06)
RTA	0.42***	0.270***	0.271***	0.240***	0.248***
	(10.88)	(6.94)	(6.88)	(6.14)	(6.29)
Currency Union	0.48	0.293***	0.264**	0.266**	0.245**
	(0.59)	(3.60)	(3.23)	(3.25)	(2.99)
ln(Remoteness)	0.65	-1.176***	-1.177***	-1.216***	-1.218***
	(1.21)	(-5.14)	(-5.12)	(-5.34)	(-5.32)
ln(Importer GDP)	-0.86***	1.307***	1.271***	1.303***	1.269***
	(-6.79)	(18.79)	(18.40)	(18.84)	(18.41)
ln(Exporter GDP)	0.20	1.200***	0.787***	1.142***	0.769***
	(1.51)	(14.63)	(9.78)	(14.20)	(9.62)
Observations	133,352	173124	170657	173124	170657
R^2	82.0	0.8648	0.8626	0.8651	0.8627
Adjusted R^2	...	0.8474	0.8447	0.8476	0.8449

Notes: All regressions include country-pair and time fixed effects. *, **, *** denote 5, 1, 0.1 per cent significance levels. T-statistics in parentheses, based on robust standard errors clustered by country-pair-product combinations. See Table 2 for notes [1] and [7]. Dashed horizontal lines visually delineate different layers of ITA trade impacts and other types of controls analog to Table 2.

[10] Bora and Liu's (2010) preferred specification (their Table 2.3, column 2). In contrast to us, Bora and Liu also include (logs of) importer and exporter GDP per capitas, a dummy variable for a formal alliance between countries and dummies for existence of a GSP preference scheme. These coefficients are omitted from this table.

[11] Statistical significance for the linear combination of coefficients of Bora and Liu (2010) cannot be computed without access to their dataset. However, it would seem likely that it might be significant at the 5% level (which we assume here), given that the two individual coefficients are significant at this level.

We follow BL by including remoteness to proxy for changes in multilateral resistance in all our regressions that do not include time-varying importer and exporter controls. In Regression 1, remoteness takes a statistically significant negative sign. In presence of the country-pair fixed effects, this implies that during our sample period, when countries have *become* more remote, they have traded less on average.[57] Coefficients on remoteness generally remain negative and statistically significant in our regressions, but excluding remoteness does not affect other coefficients.

We agree with Anderson and Van Wincoop (2003) that a remoteness index is not theoretically adequate to control for multilateral resistance, as it is only based on distance, and overall trade costs are determined by various factors.[58] Nonetheless we appreciate it as limited distance-based proxy. It can be valuable in applications such as ours, where – in absence of a control sector – inclusion of complete multilateral resistance controls does not allow us to identify coefficients based on time variation.

Regression 2 excludes China's exports. Given that here we do not yet allow for all of the differential effects as in Table 2 in the main text, we find that many coefficients vary compared to the full sample of Regression 1. Coefficients of regression 2 are somewhat artificial from the viewpoint of importers, because they are based on an incomplete import sample, which excludes imports than China. However, from the viewpoint of non-Chinese exporters they provide a notion of how much more sales can be expected to these importer groups. The ITA importer coefficient is now much lower, signalling that much of ITA members' increased imports originated from China. There is also some weak evidence that exporters are diverting shipments away from non-ITA WTO importers. Meanwhile, China defies this trend, exporting strongly to non-ITA WTO members.[59] The same is true for non-WTO members, from which WTO members deviate trade away, while China aggressively orients its exports also toward these countries.[60] On the whole, the regression 2 results are much closer to the BL specification, which seems intuitive, because BL's sample excludes much of China's rise to being a powerful exporter of ITA products. On the flipside, this suggests that when imports from China are disregarded, import patterns have not changed as dramatically since BL's sample end in 2003. Even though, we still estimate that a country joining the ITA would increase imports from countries other than China by 30 per cent – more than double BL's estimate.

Regressions 22 and 23 add an ITA exporter dummy, which can already be included in aggregate data. These regressions suggest that the ITA's impact on exports could indeed by positive and strong – a 50 per cent boost in exports for all ITA members and a 37 per cent boost for ITA exporters other than China – with estimates highly statistically significant. In addition, imports by ITA members also remain higher, but mainly on account of exports from China, as the comparison between the two regressions highlights.[61]

[57] The remoteness index varies over time as the geographical composition of world GDP shifts. Thereby countries close to East Asia, for instance, have become less remote over time. Note also that to obtain a single remoteness measures for any bilateral pair in the interest of parsimony, importer and exporter remoteness were multiplied before taking the natural logarithm.

[58] For instance, a country that is proximate to many other countries that represent a significant share of the world economy could nonetheless face high overall trade costs, if it is politically and economically isolated vis-à-vis those neighbouring countries.

[59] This interpretation results from the decrease in the "Non-ITA WTO importer" coefficient from Regression 20 to Regression 21.

[60] This interpretation results from the decrease in the "One in WTO" coefficient from Regression 20 to Regression 21.

[61] Evidence in Regression 23 also suggests that exporters other than China are diverting away shipments from non-ITA importers, but this result does not hold up in later specifications.

10.2. Introducing product-level data and unravelling the ITA's impact on imports

Results experience some important changes when we use product-level data to subsequently allow for the different layers of impacts. Appendix Table A2 presents the results. In moving to product-level data, fixed effect controls generalize to country-pair-product to also account for any product-specific characteristics in bilateral relationships. Likewise, the time fixed effects generalize to product-time to account for any global shocks to trade in different products.

Table A2: Product-level data: Stepwise introduction of the layers of ITA trade impacts

Includes China's Exports	Yes	No	Yes	No	Yes	No
Regression No.	24	25	26	27	28	29
ln(1+tariff)			-0.741***	-0.683***	-0.249**	-0.198*
			(-9.63)	(-8.74)	(-3.05)	(-2.39)
Zero tariff					0.108***	0.105***
					(21.75)	(20.91)
ITA Importer[1]	0.317***	0.169***	0.347***	0.246***	0.343***	0.243***
	(17.47)	(9.13)	(15.72)	(10.93)	(15.55)	(10.80)
Non-ITA WTO Importer[1]	0.227***	0.052**	0.318***	0.179***	0.337***	0.198***
	(12.01)	(2.72)	(13.84)	(7.67)	(14.65)	(8.48)
Total impact of joining ITA (Combination of within-WTO ITA trade creation and diversion)[7]:						
ITA Importer minus	0.090***	0.116***	0.029*	0.067***	0.007	0.044***
Non-ITA WTO Importer	(9.28)	(11.75)	(2.41)	(5.34)	(0.55)	(3.57)
ITA Exporter	0.349***	0.077***	0.358***	0.085***	0.362***	0.089***
	(29.21)	(5.31)	(26.04)	(5.01)	(26.33)	(5.25)
One in WTO	0.007	-0.023	0.064**	0.071***	0.073***	0.079***
	(0.42)	(-1.37)	(3.11)	(3.44)	(3.50)	(3.79)
RTA	0.064***	0.085***	0.055***	0.082***	0.047***	0.074***
	(7.02)	(9.16)	(4.99)	(7.29)	(4.28)	(6.58)
Currency Union	0.178***	0.168***	0.125***	0.116***	0.137***	0.128***
	(10.35)	(9.76)	(7.27)	(6.74)	(7.94)	(7.39)
ln(Remoteness)	-0.313***	-0.585***	-0.204**	-0.462***	-0.192**	-0.447***
	(-5.28)	(-9.79)	(-2.84)	(-6.36)	(-2.67)	(-6.17)
ln(Importer GDP)	0.955***	0.897***	1.116***	1.042***	1.104***	1.031***
	(50.31)	(46.77)	(43.62)	(40.22)	(43.18)	(39.79)
ln(Exporter GDP)	1.439***	0.517***	1.417***	0.533***	1.417***	0.537***
	(61.59)	(19.66)	(51.66)	(17.07)	(51.67)	(17.21)
Observations	3216747	3100247	2477294	2386043	2477294	2386043
R^2	0.7903	0.7879	0.8047	0.8020	0.8048	0.8021
Adjusted R^2	0.7902	0.7878	0.8046	0.8019	0.8047	0.8020

Notes: All regressions include country-pair and product-time fixed effects. *, **, *** denote 5, 1, 0.1 per cent significance levels. T-statistics in parentheses, based on robust standard errors clustered by country-pair-product combinations. See Table 2 for notes [1] and [7]. Dashed horizontal lines visually delineate different layers of ITA trade impacts and other types of controls analog to Table 2.

The first important change is that purely moving to product-level data reduces ITA exporter trade impacts for countries other than China. Joining the ITA increases these countries' exports by about 8-9 per cent across all importers (Regressions 25, 27, 29). Yet, some additional impact for these exporters is now contained in the ITA importer and non-ITA WTO importer coefficients, which rise across

specifications. These export boosts are accessible to all WTO members, however, regardless of ITA membership. To see this, recall that these two importer dummies are a decomposition of a"Both in WTO" dummy. When the non-ITA WTO importer coefficient becomes positive as in Appendix Table A2, it is appropriately interpreted as WTO trade creation. The additional impact of ITA accession on imports – expressed by the difference between the ITA importer and non-ITA WTO importer coefficients – is meanwhile much diminished (grey shaded line in Table 2).

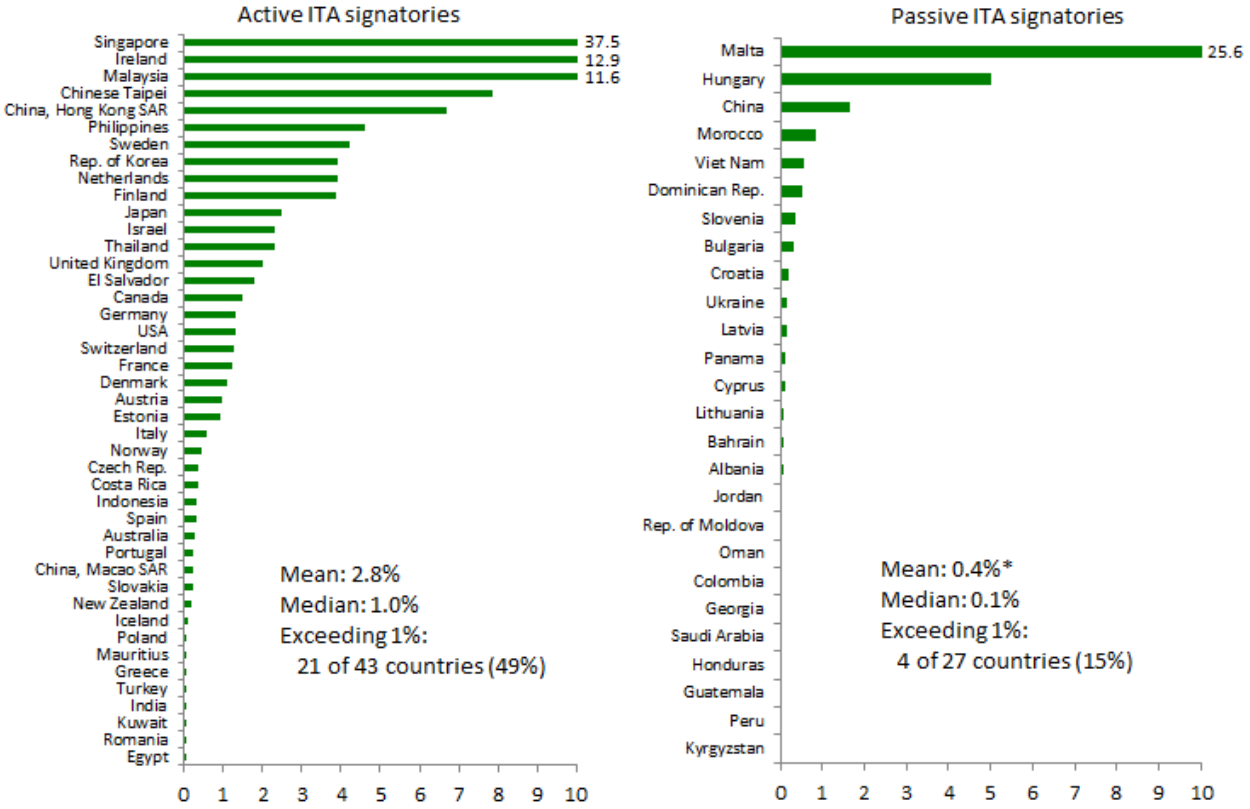
The second important change is that, when tariffs and the zero tariff dummy are subsequently introduced into estimation, the ITA importer effect in fact disappears completely (Regression 28). Again, after these additional variables are included, the interpretation of the ITA importer effect changes: It now quantifies only the third layer of ITA trade creation, i.e. benefits over and above those of tariff reductions and setting the tariff to zero, for instance those related to trade policy certainty. Analog to regression 1 in the main text, there are no importer commitments of ITA accession found (in this all goods sample without control sector) with all commitment gains rather attributable to WTO membership. Not surprisingly, exporter impacts stay the same in response to introducing tariffs and zero tariffs, because these really only decompose effects related to the importer side.

Moreover, comparison of regressions 26 and 28 yields an interesting observation. Regression 26 drops the tariff elimination effect to obtain a more traditional estimate of the import demand elasticity with regard to tariffs. Our tariff coefficient this signals a higher import demand elasticity of -0.74. This estimate lies in the middle of ranges of estimates derived in studies based on aggregate trade (rather than ITA products). For instance, Kee et al. (2008) and Tokarick (2014) estimate such elasticities for many different countries and come up with averages in the range of -1.1 to -1.2, while an earlier study by Senhadji (1998) reports -0.32. Yet our -0.74 estimate compounds a non-linear effect of tariff reductions, as regression 28 illustrates. The impact of tariff reductions that do not eliminate the tariff completely is much lower, on the order of -0.25. Setting the tariff to zero has a much larger effect beyond this on the order of an 11 percent trade increase.

In concluding our discussion of Appendix Table A2, we note a few other interesting changes in these product-level results. Any evidence of WTO trade diversion disappears. If anything, trade between WTO and non-WTO members is higher than that between two non-WTO members – by about 7 1/2 per cent. The magnitudes of RTAs' and currency unions' effects on trade are diminished to 5 and 15 per cent, respectively. They seem in line with some more recent literature on these issues which tends to find smaller, albeit statistically significant effects. These results are retained in our regressions of Table 2.

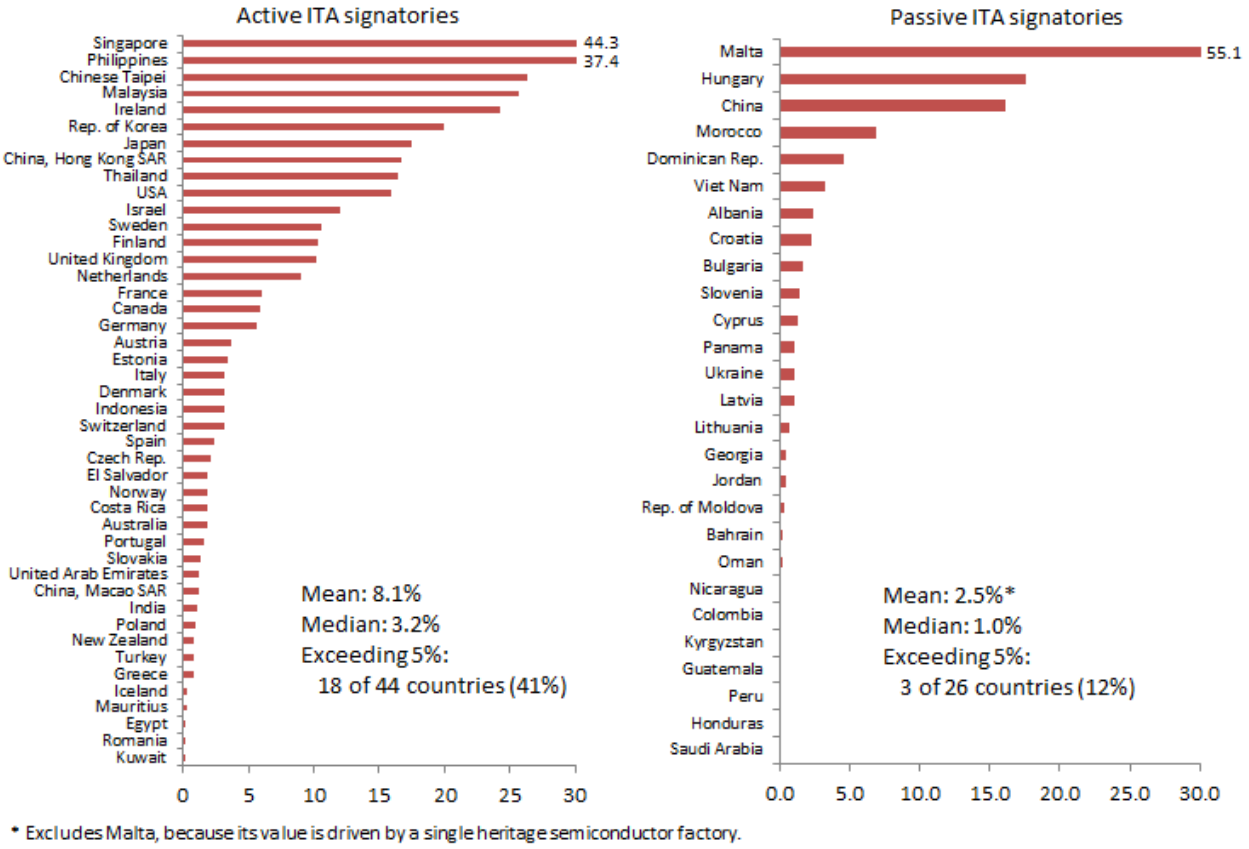
11. Appendix B: Additional figures and tables

Figure 6: ITA product exports in the year previous to accession (percent of GDP)



* Excludes Malta, because its value is driven by a single heritage semiconductor factory.

Figure 7: ITA product share in a country's total exports in the year previous to accession (percent)



* Excludes Malta, because its value is driven by a single heritage semiconductor factory.

Table A3: The layers of ITA trade effects: Regressions excluding China's exports

	Type of goods	All			Intermediate			Final		
	Fixed effects[4]	ijk & pt	ijk, kt, it & jt		ijk & kt	ijk, kt, it & jt		ijp & kt	ijk, kt, it & jt	
	Sample[5,6]	ITA	ITA & ICT	Machinery	ITA	ITA & ICT	Machinery	ITA	ITA & ICT	Machinery
	Regression No.	1a	2a	3a	4a	5a	6a	7a	8a	9a
Layer 1: Tariff	ln(1+tariff), ITA goods	-0.296***	-0.358***	-0.268***	-0.142	-0.603**	-0.381*	-0.560***	-0.097	-0.002
		(-3.58)	(-4.10)	(-3.50)	(-0.86)	(-3.01)	(-2.29)	(-3.73)	(-0.61)	(-0.01)
reduction effect	ln(1+tariff), other		-0.673***	-0.603***		-0.839***	-0.478***		-0.591***	-0.545***
			(-9.17)	(-21.12)		(-3.57)	(-5.19)		(-4.91)	(-6.17)
Layer 2: Tariff	Zero tariff, ITA goods	0.101***	0.128***	0.104***	0.131***	0.194***	0.142***	0.068***	0.096***	0.097***
		(19.91)	(21.60)	(20.47)	(13.86)	(15.72)	(13.85)	(8.06)	(9.73)	(10.22)
elimination effect	Zero tariff, other		0.033***	0.010***		0.053**	0.015		0.024*	0.040***
			(5.07)	(3.78)		(3.04)	(1.76)		(2.30)	(4.34)
Layer 3: Non-Tariff effect for Imports	Active ITA Importer[1]	0.393***	0.152***	0.151***	0.448***	0.302***	0.218***	0.437***	0.050	0.051
		(13.59)	(8.19)	(9.92)	(7.99)	(6.64)	(6.72)	(8.72)	(1.65)	(1.78)
	Passive ITA Importer[1]	0.381***	0.099***	0.108***	0.497***	0.360***	0.210***	0.380***	-0.010	0.015
		(15.54)	(5.44)	(7.38)	(10.68)	(8.18)	(6.72)	(9.00)	(-0.35)	(0.52)
	Non-ITA WTO Importer[1]	0.340***	0.081***	0.070***	0.453***	0.371***	0.200***	0.281***	-0.076**	-0.059*
		(13.23)	(4.84)	(5.23)	(9.20)	(9.07)	(6.95)	(6.29)	(-2.80)	(-2.29)
	Total impact of joining ITA (Lin. combinations of within-WTO ITA trade creation and diversion)[7]:									
	Indiv. ITA Im.	0.053***	0.071***	0.80***	-0.005	-0.069	-0.018	0.156***	0.125***	0.110***
	- non-ITA WTO Im.	(3.21)	(4.40)	(5.99)	(-0.16)	(-1.82)	(0.64)	(5.49)	(5.06)	(4.63)
	Exog. ITA Im.	0.041*	0.017	0.038**	0.044	-0.010	0.010	0.099***	0.066*	0.074**
	- non-ITA WTO Im.	(2.56)	(1.09)	(2.92)	(1.44)	(-0.27)	(0.36)	(3.67)	(2.53)	(2.97)
Layer 4: Non-tariff effect for Exports	Active ITA Exporter	-0.001	0.165***	0.089***	0.060	0.125*	0.008	-0.080*	-0.008	-0.028
		(-0.06)	(7.64)	(5.03)	(1.43)	(2.05)	(0.20)	(-2.22)	(-0.23)	(-0.91)
	Passive ITA Exporter	0.018	0.125***	0.111***	0.060	0.085	0.071	0.081*	0.309***	0.253***
		(0.83)	(4.63)	(5.58)	(1.61)	(1.13)	(1.64)	(2.20)	(6.95)	(6.20)
	One in WTO	0.101***	-0.005	-0.034***	0.091*	0.014	-0.021	0.207***	0.005	-0.010
		(4.95)	(-0.31)	(-5.23)	(2.39)	(0.43)	(-1.07)	(5.64)	(0.20)	(-0.43)
	Exporter late WTO signatory[2]	-0.256***			-0.249***			-0.294***		
		(-9.74)			(-5.10)			(-6.60)		
	Exporter late EU signatory[3]	0.665***	0.069**	0.051***	0.534***	-0.019	0.177***	1.013***	0.170***	0.229***
		(25.45)	(2.77)	(4.54)	(11.27)	(-0.35)	(5.32)	(22.21)	(4.03)	(5.82)
	Exporter late US-FTA signatory[3]	0.086	0.056	0.110***	0.133	0.128	0.115	0.229*	0.095	0.085
		(1.30)	(1.13)	(4.37)	(1.14)	(1.35)	(1.64)	(2.12)	(1.16)	(1.14)
	Observations	2386043	5403726	20865965	658002	1120624	2439325	793820	1891031	2297614
	R^2	0.8024	0.7936	0.7968	0.8210	0.8128	0.8252	0.7800	0.7886	0.7974
	Adjusted R^2	0.8023	0.7932	0.7966	0.8209	0.8116	0.8247	0.7799	0.7878	0.7967

Notes of Table 2 apply, including for [1] through [7].

Table A4: The layers of ITA trade effects: Regressions excluding sector-specific tariff reduction and elimination effects

Goods type	All goods		Intermediate		Final	
Sample[5, 6]	ITA & ICT	Machinery	ITA & ICT	Machinery	ITA & ICT	Machinery
Regression No.	2b	3b	5b	6b	8b	9b
ln(1+tariff)	-0.511***	-0.564***	-0.652***	-0.449***	-0.392***	-0.412***
	(-8.29)	(-20.75)	(-3.88)	(-5.33)	(-3.72)	(-5.09)
Zero tariff	0.081***	0.023***	0.146***	0.062***	0.057***	0.059***
	(16.90)	(10.06)	(13.21)	(8.88)	(7.20)	(8.22)
Individual ITA Importer[1]	0.165***	0.170***	0.289***	0.197***	0.083**	0.100***
	(9.77)	(12.26)	(7.14)	(6.72)	(2.97)	(3.78)
Exogenous ITA Importer[1]	0.126***	0.140***	0.386***	0.246***	0.028	0.063*
	(7.25)	(10.01)	(9.16)	(8.19)	(1.01)	(2.36)
Non-ITA WTO Importer[1]	0.097***	0.088***	0.357***	0.187***	-0.025	0.008
	(6.23)	(7.06)	(9.52)	(7.01)	(-0.98)	(0.34)
Total impact of joining ITA (Lin. combinations of within-WTO ITA trade creation and diversion)[7]:						
Individual ITA Importer minus non-ITA WTO Importer	0.068***	0.816***	-0.067	0.010	0.108***	0.092***
	(4.51)	(6.40)	(-1.95)	(0.38)	(4.51)	(4.01)
Exogenous ITA Importer minus non-ITA WTO Importer	0.029	0.052***	0.029	0.059*	0.053*	0.055*
	(1.87)	(4.17)	(0.78)	(2.18)	(2.12)	(2.30)
Individual ITA Exporter	0.165***	0.082***	0.098	-0.015	0.025	0.016
	(8.12)	(4.90)	(1.73)	(-0.39)	(0.83)	(0.54)
Exogenous ITA Exporter	0.177***	0.142***	0.198***	0.052	0.382***	0.420***
	(9.10)	(9.49)	(3.93)	(1.64)	(11.51)	(13.49)
Exogenous ITA Exporters other than China[8]	0.130***	0.112***	0.097	0.076	0.314***	0.258***
	(4.81)	(5.62)	(1.28)	(1.75)	(7.05)	(6.31)
One in WTO	0.046***	-0.006	0.065*	0.010	0.068**	0.055**
	(3.34)	(-0.93)	(2.16)	(0.57)	(2.97)	(2.66)
Exporter late EU signatory[1]	0.073**	0.057***	-0.017	0.174***	0.181***	0.244***
	(2.94)	(5.09)	(-0.32)	(5.26)	(4.29)	(6.21)
Exporter late US-FTA signatory[1]	0.072	0.124***	0.128	0.126	0.117	0.103
	(1.47)	(4.94)	(1.35)	(1.79)	(1.43)	(1.39)
Observations	5632921	21813553	1165824	2530265	1970737	2397118
R^2	0.7977	0.7984	0.8161	0.8267	0.7936	0.8003
Adjusted R^2	0.7974	0.7982	0.8150	0.8262	0.7928	0.7997

Notes: All regressions include country-pair-product, product-time, exporter-time and importer-time fixed effects. Notes of Table 2 apply, including for [1] through [8].

Table A5: Control sector regressions with reduced set of fixed effects

Type of goods	All goods		Intermediate		Final	
Sample[5,6]	ITA & ICT	Machinery	ITA & ICT	Machinery	ITA & ICT	Machinery
Regression No.	2c	3c	5c	6c	8c	9c
ln(1+tariff), ITA goods	-0.367***	-0.246**	-0.549**	-0.254	-0.165	-0.100
	(-4.10)	(-3.14)	(-2.72)	(-1.52)	(-1.02)	(-0.64)
ln(1+tariff), other	-0.561***	-0.525***	-0.701**	-0.484***	-0.500***	-0.510***
	(-7.48)	(-17.86)	(-2.97)	(-5.15)	(-4.05)	(-5.58)
Zero tariff, ITA goods	0.133***	0.108***	0.206***	0.151***	0.096***	0.098***
	(22.36)	(21.18)	(16.68)	(14.73)	(9.64)	(10.25)
Zero tariff, other	0.036***	0.014***	0.060***	0.022**	0.025*	0.038***
	(5.72)	(5.42)	(3.52)	(2.58)	(2.48)	(4.18)
Active ITA Importer[1]	0.144***	0.149***	0.292***	0.172***	0.081**	0.101***
	(8.11)	(10.23)	(6.77)	(5.56)	(2.73)	(3.59)
Passive ITA Importer[1]	0.119***	0.138***	0.373***	0.242***	0.048	0.086**
	(6.49)	(9.38)	(8.38)	(7.69)	(1.61)	(3.03)
Non-ITA WTO Importer[1]	0.109***	0.109***	0.373***	0.215***	-0.015	0.022
	(6.42)	(7.98)	(9.13)	(7.40)	(-0.55)	(0.82)
Total impact of joining ITA (Lin. combinations of within-WTO ITA trade creation and diversion)[7]:						
Active ITA Importer minus non-ITA WTO Importer	0.036*	0.040**	-0.080*	-0.043	0.096***	0.079***
	(2.26)	(3.00)	(-2.20)	(-1.51)	(3.81)	(3.27)
Passive ITA Importer minus non-ITA WTO Importer	0.010	0.029*	-0.0001	0.027	0.063*	0.064*
	(0.61)	(2.21)	(-0.00)	(0.95)	(2.34)	(2.50)
Active ITA Exporter	0.203***	0.112***	0.134*	0.027	0.016	0.014
	(8.64)	(5.85)	(2.01)	(0.61)	(0.46)	(0.42)
Passive ITA Exporter	0.180***	0.145***	0.166**	0.053	0.377***	0.419***
	(8.97)	(9.43)	(3.20)	(1.62)	(10.97)	(13.00)
Passive ITA Exporter other than China[8]	0.136***	0.117***	0.069	0.075	0.289***	0.238***
	(4.85)	(5.66)	(0.88)	(1.70)	(6.20)	(5.56)
One in WTO	0.049**	-0.003	0.064	0.022	0.080**	0.065**
	(3.20)	(-0.50)	(1.95)	(1.08)	(3.21)	(2.87)
Exporter late WTO signatory[2]	0.820	0.111	-0.405	0.417	-0.697	-1.151
	(0.19)	(0.06)	(-0.13)	(0.11)	(-0.26)	(-0.46)
Exporter late EU signatory[3]	0.062*	0.038***	-0.020	0.161***	0.171***	0.236***
	(2.48)	(3.40)	(-0.38)	(4.83)	(4.02)	(5.96)
Exporter late US-FTA signatory[3]	0.066	0.105***	0.164	0.132	0.088	0.077
	(1.29)	(3.99)	(1.69)	(1.82)	(1.02)	(0.98)
Observations	5013163	19482905	1044408	2250239	1737530	2112701
R^2	0.8001	0.8003	0.8189	0.8292	0.7959	0.8025
Adjusted R^2	0.7998	0.8001	0.8180	0.8287	0.7952	0.8019

Notes: All regressions include time-varying product and country-pair-product fixed effects. *, **, *** denote 5, 1, 0.1 per cent significance levels. T-statistics in parentheses, based on robust standard errors clustered by country-pair-product combinations. See Table 2 for notes [1] through [7]. Dashed horizontal lines visually delineate different layers of ITA trade impacts and other types of controls analog to Table 2.

[8] This coefficient is obtained from an exact analog regression that excludes China's exports from the sample. The Passive ITA exporter coefficient is the only one to substantially vary as a result of such a sample modification.

Table A6: Maximizing the number of zero observations in the Poisson estimation

Estimation Technique	Least Squares		Poisson	
Includes China's Exports	Yes	No	Yes	No
Regression No.	16a	17a	18a	19a
Active ITA Importer[1]	0.491***	0.512***	0.075	0.047
	(5.34)	(5.48)	(0.51)	(0.31)
Passive ITA Importer[1]	0.564***	0.488***	0.963***	0.970***
	(7.36)	(6.22)	(6.64)	(6.55)
Non-ITA WTO Importer[1]	0.473***	0.418***	0.502***	0.511***
	(5.47)	(4.77)	(4.27)	(4.31)
Total impact of joining ITA (Combination of within-WTO ITA trade creation and diversion)[7]:				
Active ITA Importer minus	0.018	0.093*	-0.426***	-0.463***
Non-ITA WTO Importer	(0.48)	(2.44)	(-5.96)	(-5.71)
Passive ITA Importer minus	0.091	0.070	0.461***	0.459***
Non-ITA WTO Importer	(1.58)	(1.20)	(5.39)	(5.28)
Active ITA Exporter	-0.129*	-0.068	-0.350**	-0.882***
	(-2.56)	(-1.23)	(-2.97)	(-5.86)
Passive ITA Exporter	0.319***	0.159*	0.761***	0.345*
	(5.58)	(2.25)	(8.19)	(2.28)
One in WTO	0.200**	0.099	0.101	0.120
	(2.92)	(1.40)	(0.95)	(1.09)
Exporter late WTO signatory[2]	-0.074	-0.212*	0.182	0.180
	(-0.90)	(-2.36)	(1.22)	(1.02)
Exporter late EU signatory[3]	1.348***	1.418***	0.987***	1.179***
	(17.51)	(18.35)	(6.20)	(8.72)
Exporter late US-FTA signatory[3]	-0.071	-0.028	-0.564	-0.486
	(-0.30)	(-0.12)	(-1.90)	(-1.64)
Observations	268438	261936	392416	384816
R^2	0.8510	0.8477	...	...
Adjusted R^2	0.8360	0.8323	...	...

Notes: All regressions include zero trade flows. Notes of Table 4, including its note [9], apply. See Table 2 for notes [1] through [3].

Table A7: Heterogeneity of commitment effects on exports

Interaction Variable[1]	None[2]	Remoteness[2]	Education[2]	Business environment[2]	Rule of law[2]
Explanatory Variables	2a	30	31	32	33
Active ITA Exporter	0.165***	0.029	0.169***	0.150***	0.153***
	(7.64)	(1.10)	(5.41)	(5.92)	(5.73)
Active ITA Exporter		-0.048***	-0.007	0.017	0.017
* Interaction Variable		(-9.97)	(-1.04)	(1.69)	(1.17)
Passive ITA Exporter	0.125***	-0.009	-0.108	0.114***	0.080**
	(4.63)	(-0.22)	(-1.65)	(4.26)	(2.97)
Passive ITA Exporter		-0.047***	0.070***	0.198***	0.190***
* Interaction Variable		(-4.42)	(3.95)	(5.18)	(5.38)
Observations	5403726	5355574	4462009	5376594	5377659
R^2	0.7936	0.7932	0.7969	0.7932	0.7932
Adjusted R^2	0.7932	0.7928	0.7966	0.7928	0.7929
Memorandum item:					
Interaction variable values in 2010 by percentile for passive ITA[3]					
10th		-3.766	1.607	-0.773	-0.885
25th		-3.560	1.652	-0.628	-0.600
50th		-2.864	2.870	-0.352	-0.329
75th		0.520	4.048	0.249	0.480
90th		0.910	4.604	0.854	0.982

Notes: *, **, *** denote 5, 1, 0.1 per cent significance levels. T-statistics in parentheses, based on robust standard errors clustered by country-pair-product combinations. All regressions include all control variables analog to those of Table 2, Regression 2, which are omitted here as they take very similar values. All regressions use the ITA & ICT sample from which China's exports are excluded. The four sets of fixed effects (it, jt, kt, ijk) are included in all regressions.

[1]. Analog regression without any interaction variables. Repeated from Appendix Table A3, Regression 2a.

[2]. Remoteness is measured as the sum over importers in any given year of Distance ijt * (ITA Imports it / ITA World Imports t). For landlocked countries only, this is then multiplied by a year-specific multiplier of (cost of exporting a container in j)/(cost of exporting a container in nearest coastal country). The data on the cost of exporting a container are from the World Bank's Doing Business Indicators database. Distance is measured in thousands of kilometers and centered around its mean. Therefore the coefficient on the interaction displays how much the benefit of joining the ITA changes for a country that is 1000 km further removed from import hubs than the average country.
Education is proxied by the secondary school completion rate (Prati et al, 2013). This completion rate is divided by 10, so that the interaction coefficient depicts the effect of increasing completion rates by 10 percentage points.
Business environment is proxied by the control of corruption variable of the World Bank's World Governance Indicators. Breen and Gillanders (2010) demonstrate that control of corruption is a good approximation for the quality of the overall business environment.
Rule of law variable is taken from the World Bank's World Governance Indicators.

[3]. These percentile values for 2010 are used in the computations in Table 5 and were calculated based on the sample of passive signatories only.