The Causal Effect of FTAs on the Trade Margins: Product-Level Evidence from Geographically Distant Partners

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Abstract

We estimate the causal effects of FTAs on the trade margins by focusing on recent agreements involving geographically distant partners. Using border-sharing countries as controls, our product-level difference-in-differences estimates reveal that FTAs had positive and significant effects, with the extensive margin accounting for around half of the export growth. In terms of timing, the intensive margin effects preceded those of the extensive margin. At the sectoral level, our results indicate that the extensive margin drove export growth in sectors with differentiated products, whereas export growth in sectors with homogeneous products was due to the intensive margin.

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1. Introduction

Free trade agreements (FTAs) are among the most actively pursued forms of trade liberalization: according to the World Trade Organization's Regional Trade Agreements Database (RTAD), as of June 2020 there were over 300 active regional agreements. Because of their prevalence, the international trade literature has devoted considerable efforts aimed at understanding the effects of such type of agreements on trade growth. The literature has also delved into the issue of which types of goods drive the observed growth in trade after it is liberalized: those that had been traded intensively in the past (usually referred to as the intensive margin of trade), or new goods (the extensive margin). Kehoe and Ruhl (2013), for example, documented that the extensive margin accounted for a substantial share in trade growth following the NAFTA, while other studies, such as Baier, Bergstrand and Feng (2014) and Baier, Yotov and Zylkin (2019), have used econometric techniques to uncover the aggregate effects of various types of economic integration agreements on the trade margins.

Much of the literature that quantifies the effects of bilateral FTAs on trade growth, however, can be enriched along two dimensions. First, as Baier and Bergstrand (2007) pointed out, most of the studies suffered from endogeneity bias problems since it could well be the case that countries that trade heavily with each other endogenously choose to engage into FTAs. Second, most of the articles investigating the subject use aggregate trade data, thus leaving many finer implications of trade liberalization absent from the analysis.

We complement the existing literature by conducting a generalized difference-in-differences (DID) analysis at the product level.[1] By employing a DID research design, we address the same concerns that Baier and Bergstrand (2007), Trefler (2004), and Anderson and Yotov (2016) highlight, in that naive regressions might yield biased estimates because of potential endogeneity issues. Our DID analysis also uses highly disaggregated product-level trade data

[1] Another approach would be to use firm-level data. Working with product-level data has some advantages over firm-level data, since most of the latter are not publicly available and their coverage is limited to a handful countries, thus making it difficult to conduct cross-country studies such as ours.

as a unit of observation, instead of the common practice of working with aggregate data. In that sense, our article aims at uncovering a causal relationship between FTAs and trade growth patterns, while at the same time offering a more granular assessment of the effects of such arrangements by exploiting the richness of detail contained in data at the product level.

To assess the effects of FTAs on the trade margins, we focus on the agreements signed by the European Union, Korea and the United States with Chile in the early 2000s, and later with Peru in the late 2000s and early 2010s. Those agreements are salient examples of the "new class" of FTAs that have entered into force since the turn of the century, which are characterized by having been signed mainly by distant partners, instead of being bound by geographical proximity as it was the norm in the past.[2] As we mentioned previously, the effects of FTAs—signed mostly among regional signatories—have been exhaustively analyzed in the literature. Here, instead, we are interested in determining whether such effects remain substantial even when the partners involved are not necessarily neighboring countries.

Relative to the existing literature, our paper produces two main contributions. First, many existing studies either conduct their analysis focusing on trade flows between FTA partners (without incorporating a control group), or simply use the rest of the world as the comparison benchmark, providing little justification as for why such a diverse set of countries is an appropriate candidate for a control group. Instead, our analysis uses neighboring countries as the control group to assess the effect of FTAs on trade. Since the bordering countries share many unobservable similarities that are known to affect trade volumes (such as common language, legal system and colonizers, among others) and are equally distant from its FTA partners, our empirical strategy can control not only for distance effects but also for unobserved and time-invariant regional features, thus alleviating the concerns for omitted variable biases. Two-way fixed effect models using the rest of the world as controls,

[2]Indeed, according to the RTAD, about 60 percent of the FTAs that have come into force since 2000 have been signed by countries with no colonial links that were neither border-sharing nor located in the same continent. Prior to 2000, only two FTAs (the Israel-US and Israel-Canada FTAs) met the same criteria.

on the other hand, are not always able to capture these unobservable similarities of the border-sharing countries.

Second, our study complements existing product-level studies that document the effects of trade integration on the trade margins, such as Baier, Bergstrand and Feng (2014) and Dutt, Mihov and Zandt (2013). However, most of this literature assesses the trade margin effects by bundling product-level information into two groups, the intensive and extensive margins, and then use this aggregate specification to conduct their analyses. Instead, we work with a product-level specification directly, which allows us to uncover aspects such as the industry- and sector-specific effects of the agreements, as well as the product-specific differences of each treaty. Moreover, our analysis using highly disaggregated data allows us to control for unobserved industry or product-level attributes that may be correlated with FTAs, which in turn can direct us towards a more unbiased estimate of the trade margin effects of FTAs.

The DID analysis yields three main results. First, we find that post-FTA export growth per product was significantly higher than in the absence of an agreement, and that this growth was substantial along both trade margins. Moreover, we find that the role of the extensive margin was crucial. Indeed, ten years after the FTAs entered into effect, exports of new goods accounted for one-third to more than half of total export growth, implying that growth along the extensive margin was as important as the intensive margin. As a result, our findings—based on causal inference—directly strengthen those in Kehoe and Ruhl (2013) and others, such as Amarsanaa and Kurokawa (2012), Dalton (2014, 2017), Cho and Díaz (2018a,b) and del Rosal (2019), who document strong correlations between the extensive margin and post-liberalization export growth, but do not establish any causal relationships.

Second, our study considers long post-FTA periods which allows us to trace the dynamic patterns of the FTA effects. We find that there are statistically significant differences in the timing of trade margins. Export growth along the intensive margin takes place earlier—within the first three to four years from the implementation of the FTAs—and those effects amplify over time. On the other hand, trade growth along the extensive margin lags the intensive margin, taking considerably longer to become significant, which occurs only in a longer horizon of more than five years post-FTA. This reflects the fact that it may take some time for some exporters to serve new markets after a newly implemented FTA because of, for example, the presence of fixed costs. This pattern is consistent with the empirical findings of Kehoe and Ruhl (2013), as well as with the predictions of theoretical models of product- and market-specific fixed costs such as Arkolakis (2010) and Mayer, Melitz and Ottaviano (2014), where new exports are more responsive to permanent shocks. In that respect, our work extends what previous studies have found at the aggregate level is also observed at the product level. When we analyze the dynamic patterns for all products, they resemble those of the extensive margin. This in turn reveals that the increases in trade volumes from these FTAs could not have been due to increases in exports of existing products exclusively, but it was also necessary that exports of new goods increase as well.

Third, when we conduct a sectoral decomposition analysis to quantify the relative contributions of the trade margins to export growth, we find that the intensive margin played a dominant role only in the high-elasticity sector, composed for the most part of homogeneous products. In sectors with lower elasticities—characterized by differentiated products—export growth was mainly driven by the extensive margin. These findings provide empirical evidence of the theoretical sectoral predictions of Chaney (2008) and offer a more detailed account of the trade margin effects than those observed at the aggregate level.

We also conduct a comprehensive battery of tests to assess the robustness of the DID results. Our main findings are robust to a falsification test, which confirms that the FTA effects we identify occur after the enactments of the agreements and not prior to them. Including country-characteristic time trends, various product- or industry-level fixed effects and other controls (such as the size of the market and income levels) does not fundamentally alter our main findings. However, some of the benchmark results are sensitive to the inclusion of country-specific linear time trends. Thus, we cannot fully rule out the possibility that the observed post-FTA growth in trade can be attributed, at least in part, to existing pre-FTA trends. We also test whether our DID regression results are sensitive to alternative functional-form transformations, including a Poisson pseudo-maximum likelihood (PPML) estimation, and find that our benchmark results remain robust. Finally, our results exhibit robustness when we assess the product-specific heterogeneity of each FTA by incorporating the fact that some products were granted tariff-removal exemptions.

The rest of the paper is organized as follows. Section 2 details the data used in the DID analysis. In Section 3 we describe the DID methodology and discuss its advantages. Section 4 presents the estimation results, followed by a series of robustness checks in Section 5. We conclude in Section 6.

2. Data

2.1. Trade data

We employ highly disaggregated product-level export data from the World Bank's World Integrated Trade Solution (WITS) database, available at annual frequency. We work with a 6-digit level of disaggregation—the finest one available from WITS—organized according to the 1996 Harmonized System (HS) product classification. Since our analysis also deals with industry-level implications, we assign each product to a 4-digit level industry according to the International Standard Industrial Classification (ISIC) Revision 3.[3] After the product-industry pairing, we are left with 5020 products.

We cover the 1996–2015 period. This gives us pre- and post-FTA spans which are long enough to examine the short- and long-term dynamics of liberalized trade. Moreover, the long post-FTA windows allow us to capture any lagged effects of the trade reforms—an issue of particular concern raised in Baier and Bergstrand (2007).

The WITS database provides data expressed in current dollars only. To generate trade

[3] In what follows, we will use the term "sectors" to denote levels of aggregation coarser than the 4-digit level ISIC.

flows in constant dollars, we deflate the nominal data using each country's goods exports deflators, taken from the OECD National Accounts database.

2.2. Treatment and control countries

Our study analyzes the behavior of EU, Korean and US exports to Chile and Peru following the signing of their respective FTAs. The EU-Chile FTA entered into effect in 2003 and the Korea-Chile and US-Chile FTAs did so in 2004. On the other hand, the agreements with Peru became effective in 2013, 2011 and 2009, respectively.[4]

As we detail in the next section, to estimate causal effects from panel data we use linear models with time and country fixed effects. We employ what is often referred to as a "staggered adoption design," initially choosing Chile as the treated country and Chile's neighbors (Argentina, Bolivia and Peru), who did *not* sign FTAs with the EU, Korea or the US when Chile did, as the control group. Since Peru eventually ended up signing its own FTAs with the EU, Korea and the US several years later, we switch Peru from the control group into the treatment group when those agreements enter into force.[5]

As mentioned earlier, the key advantage of choosing such a control group is that geographical proximity can be translated into unobserved components—trade costs, infrastructures, institutional factors such as common language, legal system and colonizers, and even non-institutional factors such as climate and culture—all of which may influence trade flows among countries. This *a priori* similarity between treated and untreated countries allows us to better discern the trade-promotion effects of FTAs once the agreements enter into force. At the same time, choosing a control group made up of comparable neighboring countries makes it more likely for the parallel trends assumption—a key foundation of the DID design—to hold than if we were to use the a control group consisting of all countries, the

[4]By EU we refer to the fifteen member countries prior to the 2004 expansion.

[5]Given that the FTAs with Peru occurred in the final years of our period of interest, we conduct a check where we control separately for any FTA with Peru, essentially locking in the treatment for Chile. The results of this exercise are presented in Table A1 in the Appendix. We thank an anonymous referee for encouraging us to conduct this check.

common practice in the literature.

A potential concern is that neighboring countries may not be an ideal control group because they may have certain idiosyncratic features that hinder a clean comparison. For example, Argentina suffered an economic crisis right before the Chilean FTAs entered into effect, and Bolivia is landlocked. However, much of the observed heterogeneity can be properly addressed by adding country-fixed or country-specific factors.[6] Another issue with our control group choice is that we may abstract from the trade diversion effect of FTAs. As Dai, Yotov and Zylkin (2014) document, FTAs may divert trade away from non-member countries, which implies that our strategy may overestimate the FTA effects. However, the graphical evidence from Figure A1 suggests that the potential trade diversion induced by the Chilean FTAs is unlikely to have been substantial, since we do not observe any noticeable drops in exports to Chile's neighboring countries (both in levels and as shares of output). To summarize, we do not argue that our choice of control group is immune to criticisms. Instead, we want to stress that, at least for the analysis of the impact of FTAs signed by geographically distant countries employing a DID model, border-sharing countries can be better candidates as controls than the rest of the world.[7]

2.3. Defining "new goods"

To construct a measure of the extensive margin of trade, we follow the methodology laid out in Kehoe and Ruhl (2013), hereinafter KR, who define the set of new goods as that including goods initially traded in small volumes, or not traded at all. More specifically, KR first average the trade value of goods over the first three years in their sample, and label

[6] Our strategy that exploits geographical variation of treatment can also be rationalized in the spirit of regression discontinuity, as shown in Black (1999) and Dell (2010). In an ideal regression discontinuity setup, the treatment effect is identified using a narrow region around the cutoff—rather than the whole area—which is line with our focus on the border-sharing countries of Chile rather than the rest of the world. Besides the FTA treatment, the key relevant factors that affect trade flows vary smoothly along the Chilean border. For instance, there are few differences in transportation costs between places located just outside the Chilean border and those located just inside the border. However, the impact of FTAs is solely determined by whether these places are under Chilean jurisdiction or not.

[7] We also use the synthetic control (SC) approach that provides an alternative, data-driven method to select a suitable control group. The results from the SC analysis can be found in the Online Appendix.

goods that collectively account for the lowest ten percent of trade volume as "least-traded" (LT) goods, or "new" goods.[8] In our analysis, LT goods will serve as our measure of the extensive margin, whereas non-LT goods will represent the intensive margin. In Table 1 below, we report the distribution of LT exports from the EU, Korea and the US to Chile and its neighbors. Note that since the KR methodology uses a cutoff value to classify a good as least-traded that is based on the overall volume of trade between two countries, the resulting composition of each LT basket is country-pair specific.

Table 1: Distribution of least-traded goods

	All LT goods		Zero-trade goods (1996)	
	Number	% of all goods	Number	% of all LT goods
EU exports to:				
Argentina	4,109.1	81.9	632	15.4
Bolivia	4,566.8	91.0	2,387	52.3
Chile	3,994.4	79.6	858	21.5
Peru	4,272.6	85.1	1,396	32.7
Korean exports to:				
Argentina	4,896.0	97.5	3,715	75.9
Bolivia	4,968.6	99.0	4,680	94.2
Chile	4,951.3	98.6	3,803	76.8
Peru	4,965.5	98.9	4,193	84.4
US exports to:				
Argentina	4,195.6	83.6	1,067	25.4
Bolivia	4,641.6	92.5	3,076	66.3
Chile	4,227.0	84.2	1,053	24.9
Peru	4,287.2	85.4	1,441	33.6
Average	4,506.3	89.8	2,358	50.3

Notes: LT goods include goods with zero trade as well as those with small trade volume, collectively making up the lowest 10% of trade between 1996 and 1998. Zero-trade goods are those with zero trade volume in 1996.

In Figure 1 we plot the evolution of total and LT exports of the EU, Korea and the US

[8]The KR methodology is not the only approach to analyze the patterns of the extensive margin. We choose to follow the KR methodology over other competing techniques because of one of its main attributes: it determines whether a good is least-traded or not by using a threshold that considers its relative, rather than absolute, importance—or lack thereof—in total trade. Since our article deals with many countries—large and small—the country-pair specific nature of the KR methodology seems to be the most appropriate one to employ. Other studies, such as Amarsanaa and Kurokawa (2012), Kehoe, Rossbach and Ruhl (2015), Dalton (2017) and Cho and Díaz (2018a) share this view and use the KR methodology as well.

to Chile and its neighbors in logarithmic scale.[9] We find that, prior to the signing of the FTAs, exports to Chile and its neighbors were relatively constant, and in some instances even on a declining trend. However, we observe significant increases in trade to Chile—and to a lesser extent, Peru—coinciding with the various FTAs entering into force. The increases were even more pronounced for the cases of LT goods. The pertinent question is then: Can these patterns—and timing—be attributed to the signing of the agreements? We tackle these issues in the following sections.

3. Methodology

In this section, we lay out our econometric strategy. A naive regression to estimate the trade volume effects of an FTA would be:

$$Y_{it} = \beta_0 + b_1 FTA_t + b'\mathbf{X} + e_{it} \tag{1}$$

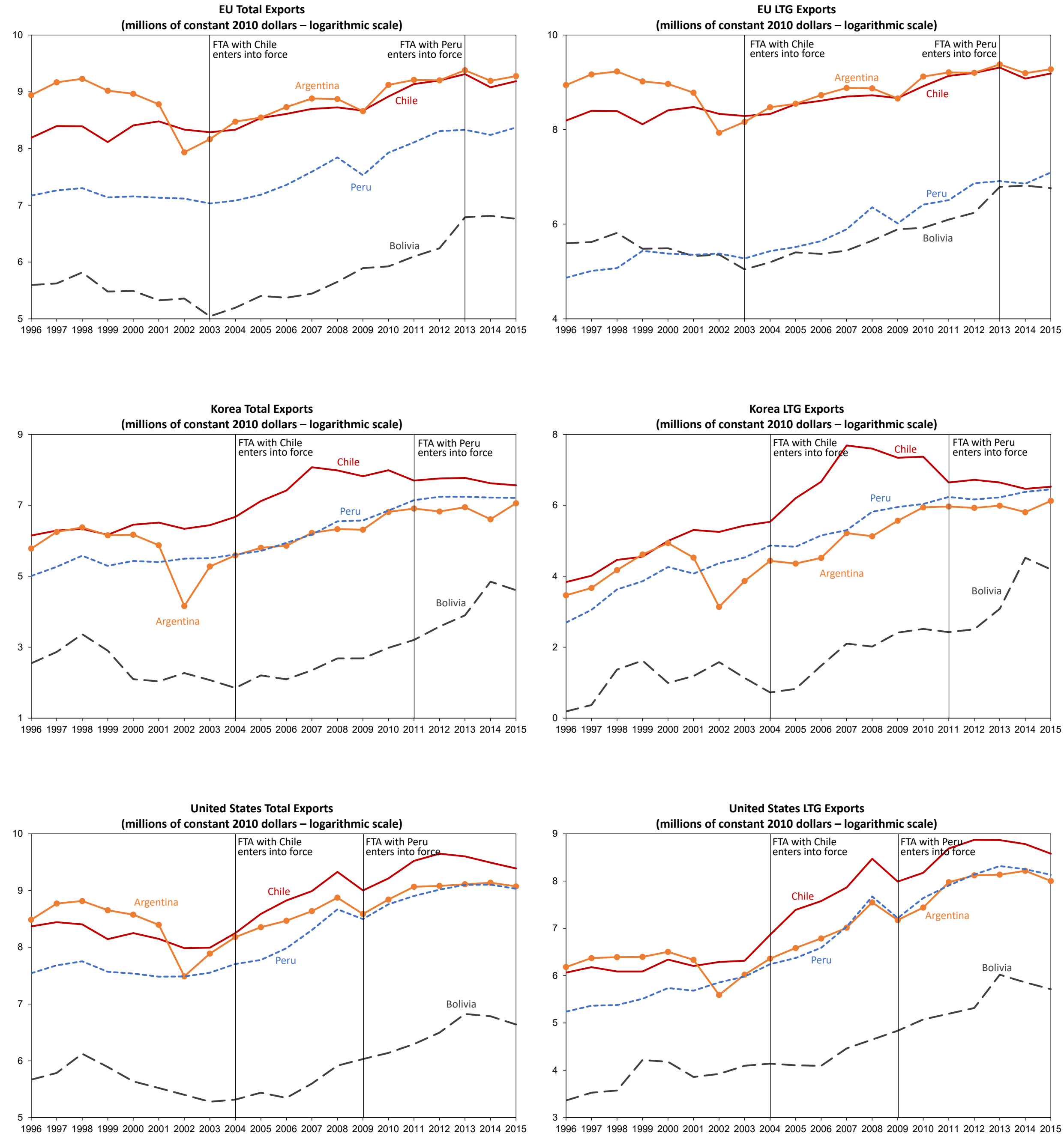
where Y_{it} denotes the exports of either the EU, Korea or the US of product i in year t to the FTA partner country; FTA_t is an indicator dummy for FTA status that takes the value of 1 if an FTA is in place in year t, and 0 otherwise; $\mathbf{X}$ captures all factors related to determinants of trade; and e_{it} is the error term.

However, attempting to empirically estimate the effects of free trade agreements on trade growth using equation (1) inevitably raises several concerns. The main one is that simple trade outcome comparisons before and after FTA in general do not identify a causal relationship between FTAs and trade growth due to endogeneity problems. Even after controlling for FTAs determinants such as distance, economic size and so on, there is still a threat to the validity of such empirical strategies, as noted in Baier and Bergstrand (2004).

The ideal approach to address those concerns would be to randomize FTAs among countries, but that strategy is clearly not feasible. Thus, we employ the difference-in-differences

[9] We also present those trends expressed both in constant dollars and as a fraction of the destination country's GDP in the Appendix.

Figure 1: Total and least-traded goods exports (1996–2015)



approach pioneered by Card and Krueger (1994), and recently used in international trade studies such as Volpe Martinicus and Blyde (2013), Munch and Schaur (2018) and Cheong, Kwak and Yuan (2017). Since, in principle, the effects of FTAs begin to take place after their implementations—but not prior to them—pre-FTA trade volumes can serve as key variables that capture the unobserved confounders whose effects are time-invariant. The DID framework helps us quantify an unbiased estimate of the effects of FTAs.

We employ the following two-way fixed effects specification:

$$Y_{ict} = \beta_0 + b_1 FTA_{ct} + \tau_t + m_c + \lambda_s + e_{ict} \tag{2}$$

We run (2) for each FTA signatory individually, that is, one regression for the FTAs signed by the EU, Korea and the US separately. Moreover, since we are interested in quantifying the FTA effects on both the intensive and extensive margin, for each FTA signatory we run three separate regressions for each type of product category: all goods, LT goods and non-LT goods. Our focus will be on the coefficient b_1, which captures the effect of the FTA on export growth.

Note that this specification is different from a two-group, two-period DID design, which does not accommodate the complexity encountered in applications that involve more than two groups or periods (see Wing, Simon and Bello-Gomez 2018). Indeed, one of the complications we face is that, as we mentioned earlier, Chile and Peru adopted the policy of interest (FTAs) at different points in time and remained exposed to this policy. Thus, the generalized DID estimation we adopt—often referred to as a "staggered adoption design"—allows us to estimate average treatment effects in multiple periods with variations in the timing of the treatment across treated countries.[10] This, in turn, enables us to tackle a variety of related research questions, such as placebo tests, time-varying treatment effects, and sectoral effects of FTAs.

We specify equation (2) in levels, and not in logs, because we want to keep all the zeros in the trade data.[11] Y_{ict} and FTA_{ct} are as previously defined, with c denoting the

[10] In that sense, we interpret the estimated results as the FTA effects on exports to the "treated" countries, and not only on exports to a single FTA signatory.

[11] In Section 5.5 we evaluate the robustness of the DID estimation by using alternative model specifications: one with the logarithms of the trade values (plus one) to replace the zeros, and another one using a Poisson pseudo-maximum likelihood model, as proposed by Santos Silva and Tenreyro (2006).

export destination country; τ_t is a year fixed effect term to control for any business cycle fluctuations; m_c controls for country fixed effects, such political systems and other legal or social institutions, which can potentially account for country-specific differences in the overall level of trade. Finally, λ_s is an industry fixed effect (with s denoting an industry according to the four-digit level ISIC classification) which allows us to capture level differences in trade across industries.[12]

Since panel data observations can be correlated within certain categories or groups, we report standard errors clustered at country, year and two-digit level ISIC sector jointly. This produces 1,280 clusters in total, covering four countries over twenty years for each of the sixteen two-digit level ISIC sectors.

4. Benchmark Results

We first report the estimated effects on the exports of all, LT and non-LT goods for each one of the three FTA partners we consider (EU, Korea and US) to the treated countries. We then present the time-varying effects to understand the dynamic effects of the FTAs. We wrap up by presenting the sectoral effects of FTAs.

4.1. Average treatment effects

The DID regression estimates for each FTA and product category are presented in Table 2. All estimated coefficients are positive and statistically significant at the one percent significance level, suggesting strong FTA effects on export growth not only for all goods, but also for both the least-traded and non least-traded categories. The coefficients imply that the EU, Korea and US FTAs led, on average, to additional overall exports of \$290,000, \$221,000 and \$724,000 per product, respectively, when compared to the exports to the control group.[13]

[12] We also explore alternative specifications that include industry-year and industry-country fixed effects to account for possible time-varying and country-specific differences in trade across industries. The results are presented in Table A2 in the Appendix.

[13] For comparison purposes, we present the results of the pooled OLS regression for the treatment group only in Table A3 in the Appendix. When compared to the DID estimates, the OLS coefficients overestimate the FTA effects by nearly twofold.

To assess the relative magnitudes of the increases in exports due to the FTAs, we divide the estimated coefficients by the average pre-FTA exports to the treated group and present them in last row of Table 2. Percentage increases in exports per product as a result of the FTA range from roughly 58 percent for EU exports to around 121 and 253 percent for the US and Korea, respectively.

Exports of both LT and non-LT goods were also significantly higher than in the absence of an FTA. Relative to the average exports in the base period, EU exports of LT goods to the treated group increased by around 96 percent, and the increases were even higher for US and Korean exports of LT goods (338 and 445 percent, respectively). Similarly, the increase in EU exports of non-LT goods due to the FTA was 43 percent, 68 percent for US and 169 percent for Korea. Overall, we find that among trade partners, Korean exports exhibited by far the highest growth rate upon FTA enactment. Additionally, among types of goods, LT products exports grew at a faster pace than non-LT goods.

Table 2: Average treatment effects of FTAs on exports

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
FTA	289.5***	220.9***	724.0***	89.7***	126.5***	425.3***	1103.1***	8416.8***	2226.1***
	(83.2)	(45.1)	(123.6)	(22.6)	(35.9)	(112.8)	(334.8)	(1700.1)	(343.4)
R-squared	0.049	0.018	0.026	0.025	0.007	0.023	0.092	0.145	0.098
Observations	401,600	401,600	401,600	338,820	395,580	346,980	62,780	6,020	54,620
Export growth (%)	58.0	252.7	121.0	96.1	445.2	337.7	43.2	169.1	68.2

Notes: The table reports the treatment effects for each FTA signatory and product types separately. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. The last row shows the percentage increase in exports per product, calculated by dividing the estimated coefficients by the pre-FTA average exports to the treated group.

While Table 2 shows the absolute and relative magnitudes of the export increases for the different product groups, we are also interested in determining which margin played a more dominant role in the overall export growth. To do so, we compute the relative contribution of each trade margin using a simple decomposition where we compare the average increase of LT and non-LT exports, weighted by the number of products in each category.[14] The de-

[14]For example, for the Korea FTA in Table 2, the corresponding weighted average increases in LT and

composition shares are presented in Table 3. We find that the contribution of the extensive margin to total trade growth is sizable, ranging from close to one third for the case of the EU FTA, to more than half for Korea and US FTAs. These findings are quantitatively similar to those in Kehoe and Ruhl (2013), who find that after ten years, a 10 percent increase in total trade is associated with a 43 percent increase in the value of the least-traded goods. Our results are also in line with those of Foster, Poeschl and Stehrer (2011) and Foster (2012), who find that between 59 to 83 percent (depending on their OLS specification) of increases in imports three years after the FTAs came into force were due to the extensive margin. Our DID analysis, however, captures these effects for a much longer post-FTA period.

Table 3: Contributions to post-FTA total export growth (percent)

	LT goods	Non-LT goods
EU FTA	30.5	69.5
Korea FTA	49.7	50.3
US FTA	54.8	45.2

4.2. Time-varying FTA effects

So far we have implicitly assumed that the coefficient b_1 in equation (2) is constant, implying that we estimate the average treatment effects (ATE) for the entire post-FTA period. However, the impact of FTAs on trade could be immediate or lagged over time, and may possibly vary with time across the two margins. In fact, as Baier and Bergstrand (2007) argue, the economic effects of most FTAs are typically "phased-in" over ten years from the time they came into force.

To explore the gradual effects of the FTAs, we allow for lags in the regression specification. More specifically, we add a dummy variable for each year up to the fourth year after the FTA came into effect, as well as a dummy that captures the fifth and later years since the

non-LT exports are \$124,587 (=\$126,483 $\times \frac{395{,}580}{401{,}600}$) and \$126,169 (=\$8,416,820 $\times \frac{6{,}020}{401{,}600}$), respectively. The figures in the Table 3 represent the share of each product group out of the sum of the two weighted averages.

FTA entered into force. Each dummy variable takes the value of one in its relevant year. Our modified specification with post-treatment dynamic effects is:

$$Y_{ict} = \beta_0 + \sum_{j=0}^{q} b_j FTA_{c,t-j} + \tau_t + m_c + \lambda_s + e_{ict} \tag{3}$$

Here, b_0 captures the immediate effect of FTAs, while the b_j ($\forall j > 0$) coefficients pick up any subsequent effects. If $b_j > b_0 (> 0)$, this implies that the effect of the FTA rises over time, while if the opposite is true then the initial impact of the FTA fades with time.

In Table 4, we present the regression estimates when we allow for lagged effects, sorted by product categories.We also present the corresponding percentage changes in exports implied by each coefficient by dividing it by average pre-FTA exports. The same estimates, grouped by country, are shown in Figure 2. We refer to the first two years since the signing of the FTA as the "short run" and to the following three years as the "medium run." The "long run" corresponds to the estimates for five years and beyond. For our analysis, we will only consider coefficients at either the 1 or 5 percent significance levels.

Looking at the "all goods" category, the common result we find across agreements is a long-run FTA effect, since that is the horizon when the coefficients are all positive and statistically significant. However, in shorter horizons (up to the first five years), the effects varied across FTAs. For example, in the case of the Korea FTA, we found initial short-run effects, which disappeared in the medium run, only to return in the long run. For the US, we found the initial FTA effects to be monotonically increasing over time. On the other hand, the short-and medium-run effects of the EU FTA were not significant, but the long-run effects were significantly positive.

Next, we find an LT pattern resembling that of all goods, that is, a long-run FTA effect which is common across all FTAs. For shorter horizons, the effects are also mixed across cases. For the EU FTA, we found no significant effects during the first five years of the FTA. For the Korea and US FTAs, we found a positive short-run effect, which faded in the

Table 4: Time-varying effects of FTA

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
FTA year	35.9	87.8*	300.3**	21.9	38.0	132.3	370.1	4737.0*	1315.3***
	(147.4)	(49.2)	(148.1)	(55.7)	(23.4)	(120.0)	(655.4)	(2740.3)	(442.2)
One year after	115.6	139.5**	452.7***	31.0	57.4**	246.6**	688.3	7426.8**	1590.4***
	(110.7)	(63.4)	(158.8)	(28.6)	(27.0)	(110.6)	(451.7)	(3759.9)	(573.9)
Two years after	184.4	172.9**	479.8**	61.3*	88.7*	209.1	886.5*	7765.9**	1905.1**
	(132.8)	(81.4)	(238.8)	(33.7)	(49.3)	(183.3)	(526.7)	(3931.5)	(919.1)
Three years after	292.4*	334.3*	550.9*	35.6	238.1	280.6	1449.7***	8519.5**	1905.9**
	(152.9)	(197.5)	(284.0)	(27.8)	(183.2)	(266.5)	(455.7)	(4184.1)	(743.3)
Four years after	297.7	287.2*	838.6**	45.3	214.9	537.7	1255.5**	6739.5*	2309.2***
	(193.2)	(150.7)	(426.9)	(39.8)	(135.1)	(443.4)	(535.7)	(3767.2)	(864.7)
Five and more years after	561.9***	274.1***	1169.0***	189.8***	123.5***	742.0***	1628.5***	11808.7***	3271.3***
	(136.9)	(80.4)	(254.7)	(44.3)	(41.6)	(255.2)	(474.1)	(3993.2)	(481.4)
R-squared	0.049	0.018	0.026	0.025	0.007	0.023	0.092	0.147	0.098
Observations	401,600	401,600	401,600	338,820	395,580	346,980	62,780	6,020	54,620
Export growth (%)									
FTA year	7.2	100.4	50.2	23.5	133.7	105.1	14.5	95.2	40.3
One year after	23.1	159.6	75.6	33.2	202.0	195.8	27.0	149.2	48.7
Two years after	36.9	197.8	80.2	65.7	312.2	166.0	34.7	156.1	58.4
Three years after	58.6	382.4	92.1	38.2	838.0	222.8	56.8	171.2	58.4
Four years after	59.6	328.6	140.1	48.5	756.4	427.0	49.2	135.4	70.8
Five and more years after	112.5	313.5	195.3	203.4	434.7	589.2	63.8	237.3	100.3

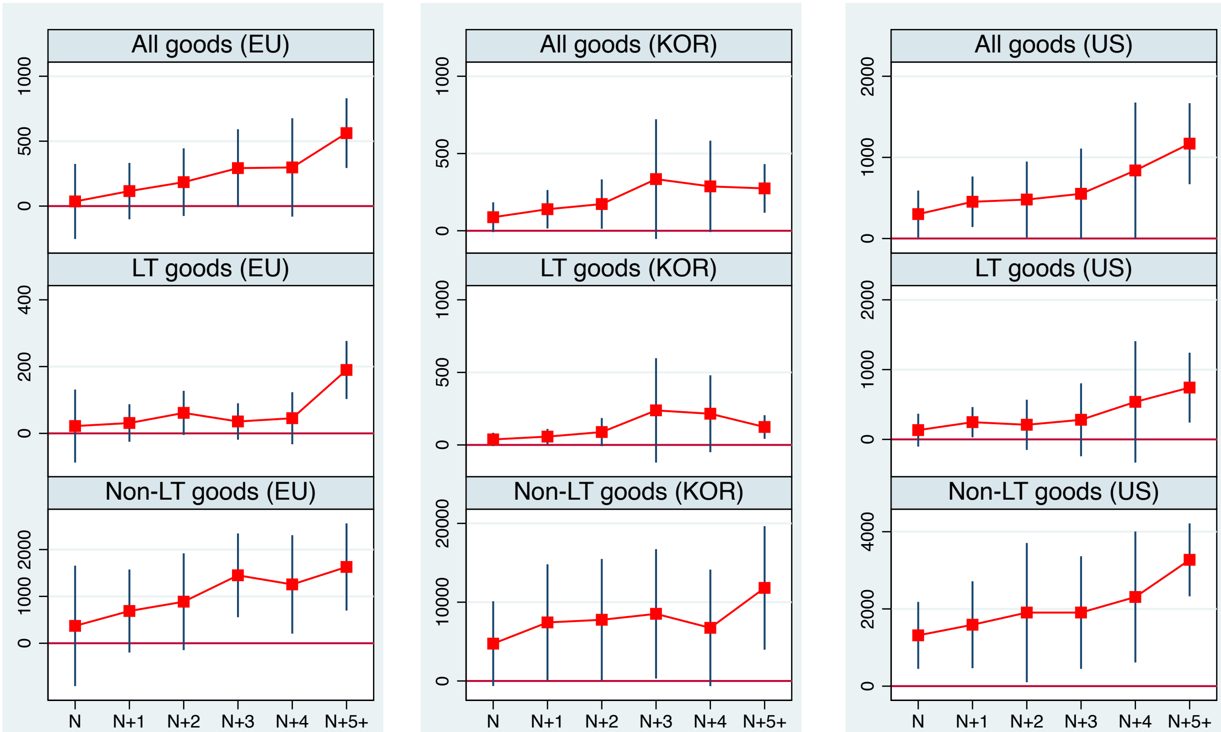
Notes: The table reports the time-varying treatment effects for each FTA signatory and product types separately. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. The last block of rows shows the percentage increase in exports per product, calculated by dividing the estimated coefficients by the pre-FTA average exports to the treated group.

medium run and turned back to significance in the long run.

Finally, for all three FTAs we consider, the effects on non-LT goods all showed up three years after the signing of the FTA and remained significant during the medium and long runs. Only for the US FTA we found significant short-run effects as well as long-run ones. In all, this reveals that the FTA effects on non-LT goods preceded those on LT goods.

Summarizing, we find that the effects of the FTAs on non-LT goods showed significance within the first three to four years and remained as such from then on. On the other hand, for LT goods the common theme across the three FTAs is that the effects are significant in the long run. However, in shorter horizons, there are variations across countries. While there are differences in the timing of post-treatment effects across different trade margins, the pattern of all goods resembles that of LT goods—strong effects in the long run but mixed in the shorter horizons. This indicates that trade growth along the intensive margin (reflected by the non-LT products) alone was not sufficient to drive the growth in overall trade. In other words, in order for an FTA to cause substantial increases in the trade volumes, it is

Figure 2: Time-varying effects of FTAs: EU(left), Korea (center) and US (right)



Notes: The horizontal axes show the years (denoted by N) since FTA. "$N + 5+$" captures 5 years or more since FTA. Each point represents the coefficient estimates of the lag terms in Table 4. The vertical lines represent the 95 percent confidence intervals of each point estimate.

not sufficient for exports of existing products to increase, but rather it is also necessary to be accompanied by increases in the exports of new products. Our findings strengthen those in Kehoe and Ruhl (2013), who document that the extensive margin growth is stronger in the medium or longer term rather than in the short run, but without establishing any causality linkages.

4.3. Sectoral FTA effects

Our previous findings show that the extensive margin played a crucial role in the growth of aggregate trade. We are also interested in determining whether this pattern is observed at the sectoral level.[15] In a theoretical setup, Chaney (2008) predicts that sectors with a larger

[15]In a separate study at the sector level, Kehoe, Rossbach and Ruhl (2015) conjecture that sectors with the highest fractions of exports accounted for by LT products will experience the largest trade increases, a claim they later validate in an ex-post analysis of NAFTA. Here, we explore sector-level effects by focusing on a different angle: rather than looking at the initial share of LT products, we are interested in the products'

product variety and lower elasticity of substitution are expected to experience a strong and positive response at the extensive margin. This is because, as trade barriers fall, some firms with lower productivity are able to export and can capture relatively larger market shares, despite having to charge higher prices than other firms. Vice versa, the intensive margin would be the dominant force in sectors with more homogeneous products, characterized by a higher elasticity of substitution.

To investigate the empirical validity of these predictions, we conduct a sectoral analysis of the FTA effects. We proceed as follows: first, we assign products into three-digit Standard International Trade Classification (SITC) Revision 3 industries. Then, we sort those industries according to their trade elasticity, as estimated by Ossa (2015).[16] Finally, we group the products contained in the sorted industries into three sectors. Products with trade elasticities belonging to the top quartile in the distribution were grouped into what we label as the "high-elasticity" sector, while those in the bottom quartile were assigned into the "low-elasticity" sector. The remaining products (those in the middle two quartiles) were assigned into the "medium-elasticity" sector.[17] The resulting classification is presented in Table 5. For the three FTA signatories, the shares of LT goods in each sector are quite similar. Note that the average elasticity of the high sector is approximately twice as large as that of the medium sector, which in turn is roughly 50 percent higher than the elasticity of the low sector.

To highlight the relationship between trade elasticities and different trade margins growth, we show the decomposition shares similar to the one in Section 4.1 for all sector-country pairs. The results are shown in Table 6.[18] We find that the contribution of the intensive margin

trade elasticity.

[16]Ossa (2015) uses data from 49 countries between 1994 and 2008 to estimate 251 industry-level trade elasticities.

[17]Changing the classification to include the top and bottom quintiles to represent the high- and low-elasticity sectors, respectively, did not change the main findings. The results for this alternative classification are available upon request.

[18]The DID regression estimates for each sector, from which the decomposition shares are calculated, are shown in Table A5 in the Appendix.

Table 5: Sectoral classification according to trade elasticities

Sectors	Fraction of all goods	LT goods' fraction (%)			Elasticity	
		EU FTA	Korea FTA	US FTA	Mean	Median
Low-elasticity	25.0	83.3	98.4	87.4	1.93	1.93
Medium-elasticity	49.8	84.4	99.1	85.8	2.72	2.63
High-elasticity	25.2	85.4	97.4	86.7	5.86	4.56

is consistently the largest in the high-elasticity sector, accounting for 74 to 90 percent of export growth in that sector. Turning to the extensive margin, we find that its contribution is always strongest in the medium-elasticity sector, followed by the low-elasticity sector, and the weakest in the high-elasticity sector. As a result, while the magnitudes of the sectoral effects vary depending on the particular FTA under consideration, the main lessons we extract are fairly consistent with the theoretical sectoral predictions of Chaney (2008) and the empirical findings of Crozet and Koenig (2010), who also found large variances in the shares of the two margins across sectors.

Table 6: Contribution to total export growth (percent)

Sectors	EU Exports		Korea Exports		US Exports	
	LT goods	Non-LT goods	LT goods	Non-LT goods	LT goods	Non-LT goods
Low-elasticity	27.8	72.2	48.9	51.1	30.0	70.0
Medium-elasticity	40.8	59.2	93.0	7.0	76.6	23.4
High-elasticity	26.2	73.8	11.3	88.7	9.7	90.3

Finally, the product-level analysis we conduct allows us to understand not only aggregate patterns, but also which sectors drove trade growth, as well as the role of the different trade margins in each sector. For instance, in Table 3 we showed that the contribution of the extensive margin in total export growth was much larger for the Korea and US FTAs (accounting for more than 50 percent) than in the case of the EU FTA. Part of this difference at the aggregate level can be better accounted for by examining changes at the sectoral level. For one, the sectoral distribution of exports before and after the FTAs (shown in Table A4 in the Appendix) reveals that Korean and US exports shifted significantly towards the medium-elasticity sector. Furthermore, for those two signatories, Table 6 shows that export growth in that sector was predominantly driven by the extensive margin, accounting for around 77 to 93 percent of export growth. On the other hand, for EU exports, we do not observe such sectoral shift in exports—in fact, the share of the medium-elasticity sector declined—nor do we find such prominent role of extensive margin in the medium-elasticity sector (which accounts for only 41 percent of export growth).

4.4. Discussion of results

We now discuss our benchmark results in relation to those of Baier, Bergstrand and Feng (2014), hereinafter BBF, which is the closest study to ours since it also empirically analyzes the effects of trade integration on the trade margins. Before proceeding, it is important to note that the two outcomes are not directly comparable since BBF use a different methodology and data sets than the ones we employ. In terms of methodology, the definitions of the trade margins in BBF differ from ours since they follow the methodology in Hummels and Klenow (2005), rather than the one in Kehoe and Ruhl (2013) as we do. Additionally, they employ a random growth first-differencing specification over five years without a control group as its benchmark specification. As for data, BBF analyze country-pair aggregate trade volume following various types of economic integration arrangements (including FTAs) signed between 1962 and 2000, without considering any sector-, industry- or product-specific features. In terms of trade margins decomposition, the level of disaggregation used in BBF is the 4-digit SITC Revision 2, which results in less than 1000 products. Keeping in mind those differences, we compare the outcomes regarding bilateral FTAs.

First, while BBF find a strongly significant intensive margin effect of FTAs, the extensive margin effect is at most marginally significant—only at the 10 percent significance level. We find that both trade margin effects are all statistically significant at 1 percent level, thus uncovering a crucial importance of trade growth along the extensive margin. Second, BBF find that over five- or ten-year horizons, the intensive margin effect is always larger than the extensive margin effect, accounting for roughly two thirds of post-FTA trade growth. On the other hand, we find that this is not always the case—both in the aggregate (as evidenced by the FTAs signed by Korea and the US) as well as at the sectoral level (as evidenced by the medium-elasticity sector). In fact, our sectoral analysis in Section 4.3 shows that the relative magnitude of trade margin effects varies across sectors differentiated by their trade elasticities, thus providing a more detailed understanding of trade margin effects.

5. Robustness Checks

In this section, we assess the robustness of the estimated FTA effects along a variety of dimensions. First, we run some diagnostics on the pre-treatment parallel-trend assumption of our DID strategy and conduct a placebo test on the years prior to the treatment. Second, we conduct a robustness check on the DID identification strategy by allowing for different time trends or characteristic-time fixed effects at the country level. Third, we further exploit the highly disaggregated data by controlling for unobserved product- and sector-level attributes. Fourth, we assess the product-specific heterogeneity of FTAs by acknowledging that some products were granted tariff removal exemptions. Finally, we further test for the robustness of our results by addressing zero-trade issues and allowing for additional country-specific controls.

5.1. Placebo (falsification) test

As Baier, Bergstrand and Feng (2014) point out, a problem when estimating the effects of trade liberalization arrangements is that of reverse causality: do FTAs cause trade or vice versa? Indeed, the key identifying assumption of DID estimation is a parallel (or common) trend assumption, meaning that—in the absence of treatment—the average change for the treated group would have been identical to the observed average change for the control group. In our setup, this implies that trade trends would have been the same in both groups in the absence of FTAs. In fact, while FTAs can be stand-alone policy reforms, they can also be part of a broader series of market reforms, or a response to negative macroeconomic shocks in the past—see Trefler (2004). In addition, as it takes a considerable amount of time (typically three to five years) to negotiate and conclude the final terms of an agreement, one might observe exports anticipating the actual implementation of the FTA, thus potentially violating the parallel trend assumption.

A simple way to test for the validity of the parallel trend assumption is to visually check the evolution of exports prior to the signing of the FTAs. As Figure A1 suggests, total and LT exports to all countries appear to move in parallel prior to the FTAs entering into effect. Post FTA, however, exports to the treated countries seem to increase considerably more that those to its neighbors. Also, we cannot discern any anticipatory effect (or reverse causality) where exports start growing prior to FTAs actually entering into force. While eyeballing the data provides a preliminary validation on the parallel trend assumption, a more rigorous verification is necessary, especially since our data set covers a lengthy period and the treatments start at different points in time. An alternative way to deal with this issue—referred to by Autor (2003) as a "placebo" test—is to include leads in the baseline regression:

$$Y_{ict} = \beta_0 + \sum_{j=0}^{q} b_{t+j} FTA_{c,t+j} + \tau_t + m_c + \lambda_s + e_{ict} \tag{4}$$

The basic idea behind the test is that if a variable of interest, say $FTA_{c,t}$, causes outcome variables, say Y_{ict}, future values of $FTA_{c,t}$ should not have any effect on Y_{ict}. This type of a falsification test allows us to check for any anticipatory effect in years prior to the FTA being signed. In our specification, we include leads of up to five years before the signing of the FTA because of the lengthy negotiating periods typically preceding the agreement conclusion.

Table 7 presents the results. The coefficients and confidence intervals, arranged by country, are plotted in Figure 3. For all goods and LT goods, we find no indication of any positive anticipatory effect for all five years leading up to the signing of the FTA. This suggests that

Table 7: Placebo tests

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
Five years prior	−52.9	−13.6	72.7	−6.6	−8.6	22.8	−322.6	217.0	452.5
	(140.7)	(41.2)	(193.5)	(30.5)	(23.5)	(166.2)	(606.6)	(1847.1)	(560.2)
Four years prior	−99.1	−45.5	72.5	−37.1	−52.8	10.0	−260.4	1315.5	519.8
	(140.2)	(70.3)	(179.1)	(28.4)	(63.9)	(154.5)	(574.6)	(1555.9)	(520.6)
Three years prior	−49.8	−8.6	59.2	−32.5	−24.9	4.4	18.1	2063.1	474.0
	(126.7)	(55.0)	(172.6)	(28.8)	(47.5)	(151.0)	(510.9)	(1540.6)	(512.6)
Two years prior	−6.3	6.6	133.7	−34.0	−7.5	31.8	372.3	1758.5	904.6*
	(142.4)	(39.3)	(167.7)	(32.8)	(26.6)	(143.6)	(571.5)	(1560.4)	(501.5)
One year prior	105.6	3.6	121.1	33.6	−7.1	30.2	942.8	2106.2	766.5
	(140.5)	(54.0)	(186.9)	(30.4)	(34.8)	(168.6)	(586.6)	(2384.3)	(521.5)
Post FTA	275.6***	213.8***	783.3***	79.4***	113.9***	438.0***	1210.3***	9316.6***	2649.3***
	(104.1)	(39.5)	(145.5)	(24.5)	(26.4)	(129.4)	(422.6)	(1801.6)	(409.3)
R-squared	0.049	0.018	0.026	0.025	0.007	0.023	0.092	0.146	0.098
Observations	401,600	401,600	401,600	338,820	395,580	346,980	62,780	6,020	54,620
Partial F	0.330	0.121	0.183	1.107	0.206	0.015	0.784	0.572	0.999
Prob > F	0.895	0.988	0.969	0.355	0.960	1.000	0.561	0.722	0.417

Notes: "Post FTA" refers to the ATE for the entire post-FTA period. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Partial F and Prob > F denote the F-statistics and p-values for the null hypothesis that the leading coefficients are jointly equal to zero. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

the parallel trend assumption is not violated and that the policy intervention occurs before its effect. Similarly for non-LT goods, we mostly observe no anticipatory effects prior to the FTAs, with just a couple of isolated exceptions. We also calculate the F statistic for the hypothesis that the leading coefficients are jointly equal to zero, which further shows evidence of the parallel trend assumption as we are unable to reject the null hypothesis.

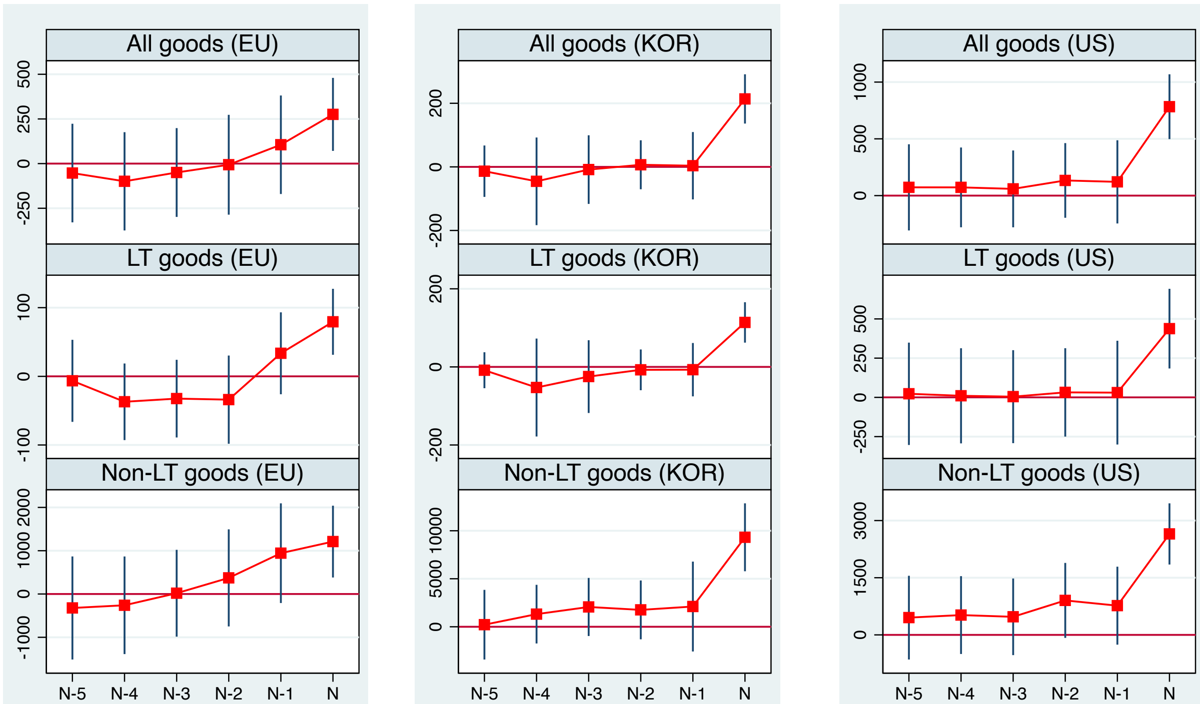
5.2. Country-specific time trends and fixed effects

Another way to check for the robustness of a DID strategy is to add a country-specific linear time trend to a regression. This relaxes the parallel trend assumption and captures unobserved factors correlated with FTAs that differ across countries over time. If each country followed a different linear trend prior to FTAs, this would be captured by $\mu_c t$ as follows:

$$Y_{ict} = \beta_0 + b_1 FTA_{ct} + \tau_t + m_c + \mu_c t + \lambda_s + e_{ict} \quad (5)$$

Consider the specification above and suppose that in year t, country c_1 signs an FTA but

Figure 3: Placebo tests: EU(left), Korea (center) and US (right)



Notes: The horizontal axes show years (denoted by N) prior to the FTA. Each point represents the coefficient estimates of the lead terms in Table 7. The vertical lines represent the 95 percent confidence intervals of each point estimate.

country c_0 does not. Allowing for different linear trends across countries implies that the expected value of the treatment effect of interest would be:

$$(E[Y_{c_1,t}|c_1,t] - E[Y_{c_1,t-1}|c_1,t-1]) - (E[Y_{c_0,t}|c_0,t] - E[Y_{c_0,t-1}|c_0,t-1]) = b_1 + (\mu_{c_1} - \mu_{c_0}) \quad (6)$$

If time trends are common across countries, (6) reduces to b_1, which corresponds to the DID estimator in the baseline regression. However, if trade was growing more rapidly in the treated country, that is $\mu_{c_1} > \mu_{c_0}$, we have $b_1 + (\mu_{c_1} - \mu_{c_0}) > b_1$.

If one were to challenge the parallel trend assumption, then equation (5) is a more appropriate representation of the underlying data-generating process. This also suggests that, in the absence of country-specific linear time trends, the estimated FTA coefficients would be biased upward.

Table 8 shows the results of four different specifications with time trends: in column (1) we assume that each country follows an idiosyncratic linear time trend; in column (2) we add a single trend variable that is common across the control group. In the last two columns, we include country-characteristic time trends to account for certain features of the control countries. As mentioned in Section 2.2, Argentina suffered a severe economic downturn between 1998 and 2002, right before the Chilean FTAs took effect. One could easily expect that exports to Argentina would have rapidly recovered in the years following the crisis. We capture this fact by including a linear time trend specific to Argentina post-2002, and show the results in column (3). Similarly, Bolivia is the only landlocked nation among the four countries under consideration and as a consequence its trade pattern may have evolved differently over time. This particular nature may affect its trade patterns which should be controlled to get unbiased estimates of the effect of FTAs. We do so in column (4).[19]

Table 8 shows mixed results regarding the robustness of our key findings. In column (1), specifying a country-specific linear time trend wipes out some of our earlier results. In particular, the positive effects of the EU and the US agreements disappear once controlling for linear time trends. In column (2), where we allow for a common time trend for the control group, the results partially re-affirm the robustness of our previous findings. On the one hand, the effects of the Korea and US FTAs remain robust (though they are quantitatively diminished), while on the other, the effects of the agreements on the trade margins becomes nullified for the case of the EU FTA. This is mainly due to the differences in the magnitude of the FTA's effect on the trade margins across countries. Throughout our analysis, the effect of the EU FTA is the weakest, whereas the effect of the Korea FTA is always the largest. In sum, these results suggest that there may had been an upward trend in trade in the treated countries prior to the enactment of the FTAs, which renders our previous results sensitive to some extent. Finally, columns (3) and (4) show that the inclusion of country-characteristic time trends does not substantially alter our main results. Overall, these results suggest that the effect of FTAs on the trade margins remains robust even when controlling for the post-crisis time trend in Argentina and the landlocked nature of Bolivia.

[19]We thank both referees for suggesting these robustness checks.

Table 8: Country-specific time trends and fixed effects

	All goods				LT goods				Non-LT goods			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
EU FTA	−84.5	12.5	247.3***	181.3*	−17.8	5.4	99.7***	43.5	−75.6	283.8	617.7*	919.6**
	(102.9)	(92.3)	(81.9)	(106.6)	(34.2)	(30.1)	(22.2)	(28.2)	(375.7)	(357.0)	(319.1)	(395.3)
R-squared	0.049	0.049	0.049	0.049	0.025	0.025	0.025	0.025	0.092	0.092	0.092	0.092
Korea FTA	166.0**	175.5***	222.7***	196.0***	129.8**	111.5***	130.3***	122.0***	3650.8	6417.7***	8017.4***	7838.4***
	(72.8)	(52.7)	(46.0)	(51.9)	(56.8)	(37.7)	(36.6)	(43.1)	(2729.3)	(2357.3)	(1787.3)	(1663.1)
R-squared	0.018	0.018	0.018	0.018	0.007	0.007	0.007	0.007	0.147	0.146	0.145	0.146
US FTA	92.4	457.3***	729.3***	461.4***	18.2	205.1	466.6***	217.2*	443.7	1784.9***	1828.6***	1906.2***
	(188.7)	(140.3)	(125.0)	(136.5)	(181.1)	(133.2)	(112.8)	(121.1)	(489.8)	(368.5)	(338.6)	(384.2)
R-squared	0.026	0.026	0.026	0.026	0.023	0.023	0.023	0.023	0.098	0.098	0.098	0.098
Country-specific trends	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
Common trend for controls	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No
Argentina-specific trend	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Bolivia-year FE	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Column (1) includes a country-specific linear time trend; column (2) includes a common linear time trend for the control group only; column (3) includes Argentina-specific time fixed effects to account for the recovery after its 1998–2002 economic crisis; column (4) includes Bolivia-specific time fixed effects to account for its landlocked nature. All models include country, year and industry fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

5.3. Product-level fixed effects and sector-specific trends

Since the unit of analysis of our study is at the country-product level, alternative robustness checks could feature the inclusion of various types of product-level fixed effects or different trends across disaggregated sectors. This could allow us to better account for differences in pre-FTA trade costs for each product and capture different dynamics in trade across sectors. For example, individual products can rise and fall over time in global importance, which in turn could be driving the observed changes in the trade margins after the FTAs took effect. Allowing for product-year fixed effects is a more rigorous approach to addressing this concern. Similarly, certain sectors might reap productivity-enhancing innovations that led to rising export across countries over time. Including sector-specific time trends also helps us get unbiased estimates of the effect of FTAs on trade growth by controlling for possible driving forces of changes in the trade margins at a disaggregated level.

Columns (1) to (3) in Table 9 present the results of alternative specifications where the industry fixed effects of the benchmark regressions have been replaced with product, product-year and product-country fixed effects, respectively. Column (4) reports the results of the different linear time trends across sectors.[20] We find that the magnitude of the estimates obtained originally, and their significance, are not affected by these robustness exercises.

5.4. Excluding FTA-exempt products

In the benchmark specification, the dummy variable FTA_{ct} was country- and time-specific, but not product-specific. This is because FTAs not only mandate the elimination of tariffs, but the removal of non-tariff barriers, as well as wider implications for investment, government procurement and dispute settlement, to mention a few. In addition to these aggregate implications, FTAs might impact products in a differentiated manner. For ex-

[20]Because some of the standard ISIC sectors contain very few products (for example, Sector 23: Coke, petrol and fuel contains only twenty products) we construct four broader sectors that include a larger number of goods: "primary," which includes ISIC sectors A-B and C, "light manufactures," which contains sectors 15 through 22, "heavy manufactures," which includes sectors 23 through 28, and "equipment and others," which contains sectors 29 through 37.

Table 9: Product-level fixed effects and sector-specific trends

	All goods				LT goods				Non-LT goods			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
EU FTA	289.5***	289.5***	289.5***	289.5***	89.7***	87.9***	89.7***	90.2***	1103.1***	1468.2***	1103.1***	1156.1***
	(83.7)	(93.9)	(68.3)	(83.3)	(22.5)	(24.5)	(23.2)	(21.7)	(347.1)	(457.5)	(286.5)	(333.9)
R-squared	0.259	0.389	0.592	0.049	0.071	0.278	0.235	0.025	0.342	0.525	0.620	0.092
Korea FTA	220.9***	220.9***	220.9***	220.9***	126.5***	120.5***	126.5***	126.6***	8416.8***	11055.3***	8416.8***	8352.5***
	(45.4)	(44.2)	(41.3)	(44.9)	(35.6)	(30.5)	(32.4)	(35.7)	(1679.6)	(2534.4)	(1691.5)	(1652.9)
R-squared	0.151	0.349	0.383	0.018	0.114	0.354	0.301	0.007	0.331	0.568	0.555	0.153
US FTA	724.0***	724.0***	724.0***	724.0***	425.3***	426.6***	425.3***	424.3***	2226.1***	2808.5***	2226.1***	2262.7***
	(124.4)	(116.8)	(120.0)	(126.5)	(113.2)	(96.5)	(122.4)	(118.5)	(342.1)	(464.2)	(268.7)	(341.7)
R-squared	0.281	0.629	0.452	0.026	0.274	0.640	0.438	0.024	0.379	0.544	0.594	0.098
Product FE	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Product-year FE	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No
Product-country FE	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Industry FE	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Sector-specific trends	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Column (1), (2) and (3) replace industry fixed effects with product, product-year, and product-country fixed effects, respectively; column (4) includes a sector-specific linear time trend, where the sectors were constructed by aggregating the 4-digit ISIC level industries into four sectors: primary, light manufacturing, heavy manufacturing, and equipment and others. All models include country and year fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

ample, pre-FTA tariff rates may vary across products, or some products may already enjoy duty-free status.[21] Moreover, depending on the specific agreement, some products are waived from tariff removal either temporarily—though gradual removal and/or allowing for grace periods—or permanently, as in the case of Korean washing machines and refrigerators to Chile. Given that we have product-level data and finer details on the actual FTAs signed, we can explore the details of each treaty and incorporate certain product-specific differences. Specifically, we review the tariff elimination schedule of each FTA and identify the products that were given tariff-removal exemptions, either permanent or with the longest temporary exemption. For such products, we set $FTA_{ict} = 0$ if product i was excluded from the tariff removal schedule in the FTA with country c (either temporarily or permanently).[22] All in all, the number of products waived from tariff elimination represented one to two percent of all goods, most of which were least-traded.[23]

Table 10 presents the average treatment effects results when we allow for product-specific effects. We find that the DID estimates are still significant across different product categories and countries, with little changes in their values when compared to the benchmark estimates. In addition, the contribution of the extensive margin ranges from 30.9 percent for EU exports, followed by 48 and 58 percent for Korean and the US exports, respectively. These outcomes are quite similar to those presented in Table 3.

5.5. Robustness to alternative specifications

Our benchmark model is estimated using a linear specification with trade values in levels. This allows us to keep the zero-trade flows, since our goal is to quantify the FTA effects on the different trade margins. On the other hand, the usual practice in the empirical gravity literature is to use trade data in logarithms. We reconcile this discrepancy by adding a value

[21] For Chile, however, pre-FTA tariff rates were uniform at 6 percent for the products we consider.

[22] Alternatively, one could employ a triple differences approach and compare products that did not receive tariff cuts with those eligible for full tariff removal. This type of approach was adopted in Besedeš, Kohl and Lake (2020).

[23] The specific distribution of products waived from tariff elimination in each FTA is omitted here because of space constraints, but is available in the Online Appendix.

Table 10: Average treatment effects excluding FTA-exempt products

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
FTA	302.9***	213.6***	709.0***	91.8***	123.6***	435.3***	1106.3***	8812.3***	2000.1***
	(81.9)	(45.4)	(123.8)	(22.4)	(36.0)	(113.2)	(333.1)	(1738.7)	(347.4)
R-squared	0.049	0.018	0.026	0.025	0.007	0.023	0.092	0.146	0.097

Notes: The table reports the treatment effects for each FTA signatory and type of product separately, excluding the products that received tariff-removal exemptions. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

of one US dollar to all observations and take logs, a common transformation used in the literature. We then estimate the model in logs and show the results in columns (1) to (3) of Table 11.

However, one remaining downside of this log-linear estimator is the presence of a heteroskedasticity bias, as pointed out by Santos Silva and Tenreyro (2006). As a result, a more comprehensive solution to tackle the presence of zero trade flows is to estimate the model in multiplicative form by employing the PPML estimator. Thus, we estimate the following regression:

$$Y_{ict} = \exp[\beta_0 + b_1 FTA_{ct} + \tau_t + m_c + \lambda_s] + e_{ict} \tag{7}$$

Table 11 presents the the log estimates in columns (1) to (3) and the PPML estimates in columns (4) to (6). Our main findings are, for the most part, robust to both log and PPML specifications. Under log specifications, we find significant post-FTA increases in trade for all types of products, with exception of non-LT goods for Korean exports, which remain insignificant. On the other hand, the PPML estimation results show estimated coefficients that are all statistically different from zero at the one percent level for all types of goods and FTAs. Comparing across FTAs and product types, Korean exports exhibit the largest treatment effects, while the estimated coefficients for LT goods are generally higher than those corresponding to non-LT goods.[24]

[24]Alternatively, we used total exports in logs as the dependent variable for each category and found the

Table 11: Average treatment effects of FTAs: logged values and PPML estimation

	Values in logs			PPML estimation		
	All goods	LT goods	Non-LT goods	All goods	LT goods	Non-LT goods
EU FTA	0.305***	0.340***	0.237***	0.379***	0.425***	0.366***
	(0.097)	(0.104)	(0.082)	(0.056)	(0.080)	(0.059)
Korea FTA	0.332***	0.323***	0.369	0.722***	0.884***	0.582***
	(0.071)	(0.069)	(0.250)	(0.152)	(0.239)	(0.115)
US FTA	0.393***	0.403***	0.493***	0.500***	0.429***	0.440***
	(0.104)	(0.102)	(0.099)	(0.090)	(0.124)	(0.067)

Notes: The dependent variable in columns (1) to (3) is the natural logarithm of the trade value in thousands of 2010 US dollars plus one. Columns (4) to (6) quantify the treatment effect using the PPML estimation. All specifications include country, year and industry fixed effects. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Clustered standard errors in parentheses.

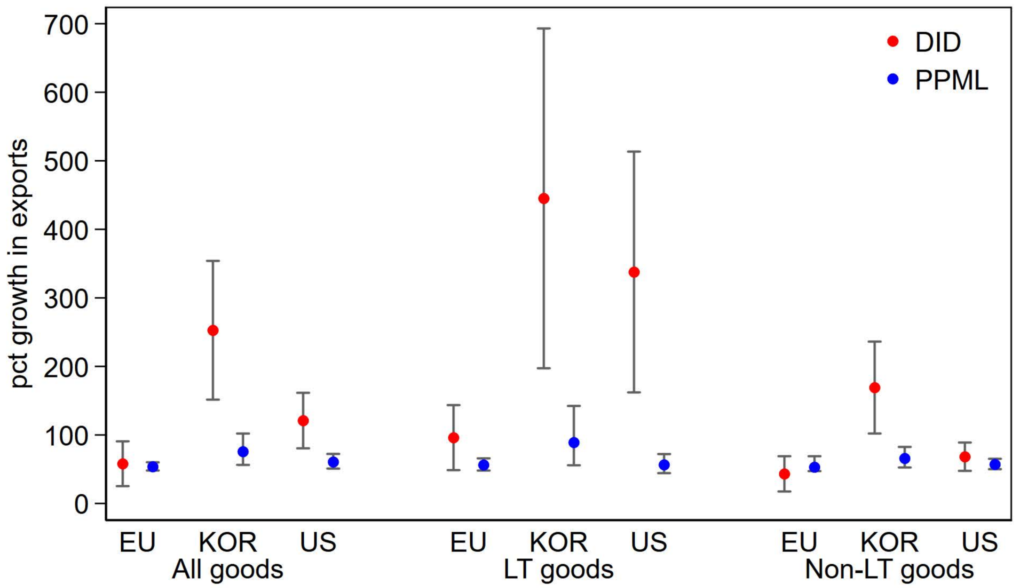
In Figure 4 we plot the results of the benchmark DID and PPML specifications. Note that the ranking of the trade-promotion effects is preserved under both specifications across the three FTA signatories for all product categories, that is, the Korea FTA exhibits the largest effects, followed by the US and EU agreements. Similarly, both specifications estimate larger FTA effects for LT goods than for non-LT products for the Korea and EU FTAs, whereas for the US FTA case the PPML estimation produces effects that are essentially identical for the two categories. On the other hand, the log-linear specification does not preserve the same qualitative findings shared between the DID and PPML specifications.

While the DID treatment effects are, in general, greater than the PPML ones, we find that both specifications yield closer estimates the smaller the prevalence of zero-trade products—and thus the lower the variability in the distribution of trade volumes across products—in the bilateral trade relation and product category. For example, zero-trade goods are less prominent in EU exports (see Table 1) and for all and non-LT goods the FTA effects for both specifications are quite comparable. Likewise, the effects on US exports of non-LT

results, presented in Table A6 in the Appendix, to be mostly comparable to our product-level specifications, with some weakened significance for EU exports.

goods are of similar magnitudes. On the other hand, the discrepancy in estimates is most evident in the case of the Korean exports, where pervasive zero-traded goods—even in the non-LT goods category, due to significant changes in the Korean export structure during the period we consider—leads to over-dispersion in the trade flows.

Figure 4: Comparison of treatment effects: DID and PPML



Notes: For the benchmark DID treatment effects, we report the export growth rates shown in the last row of Table 2. The corresponding growth rates for the PPML estimations were calculated using the following conversion: $\exp(\hat{b}_1 - 1) \times 100$. The vertical lines represent the 95 percent confidence intervals.

5.6. Additional controls

In this section, we further test for the robustness of our results by including additional controls of country-specific nature. We include several proxies for the size of a market (such as the level of GDP, both in real and PPP terms, and the population size, all in natural logs), living standards (GDP per capita in logs) and the nominal exchange rate (in US dollars) into the baseline regression in equation (2), both individually and also jointly. These data, for Chile and its neighbors, were extracted from the World Development Indicators database.

As Table 12 shows, the main findings on the average treatment effects remain robust to the inclusion of the country-specific controls.[25] All estimated coefficients are still statistically different from zero for all types of goods at the one percent level for the Korea FTA. For the EU and US FTAs, LT goods estimates are also positive and statistically significant at the five percent level, although there is some evidence that the effects for non-LT goods are nullified when including GDP variables such as GDP per capita and GDP in PPP terms.

Table 12: Average treatment effects incorporating additional controls

	(1) Baseline	(2) GDP (per cap)	(3) GDP (PPP)	(4) GDP (real)	(5) Population	(6) Exchange rate	(7) All
				All goods			
EU FTA	289.5***	128.1	50.7	217.9***	187.5**	280.1***	124.2
	(83.2)	(84.4)	(85.1)	(82.0)	(94.6)	(84.9)	(84.7)
Korea FTA	220.9***	220.7***	196.2***	233.1***	198.1***	220.5***	213.8***
	(45.1)	(55.7)	(53.4)	(52.4)	(46.5)	(45.0)	(54.4)
US FTA	724.0***	589.7***	424.3***	741.1***	561.4***	722.0***	510.0***
	(123.6)	(147.2)	(149.7)	(145.9)	(124.9)	(123.5)	(147.6)
				LT goods			
EU FTA	89.7***	73.6***	60.9**	96.9***	46.4*	88.6***	78.7***
	(22.6)	(24.0)	(23.7)	(23.2)	(24.6)	(23.3)	(23.5)
Korea FTA	126.5***	140.1***	132.7***	141.6***	116.7***	126.2***	139.3***
	(35.9)	(46.0)	(42.8)	(42.3)	(37.6)	(35.8)	(44.4)
US FTA	425.3***	452.2***	349.4***	541.6***	275.1**	424.3***	431.4***
	(112.8)	(135.0)	(134.8)	(136.3)	(111.7)	(112.5)	(132.7)
				Non-LT goods			
EU FTA	1103.1***	173.2	−165.0	482.9	936.9**	1015.2***	96.0
	(334.8)	(332.6)	(334.9)	(322.4)	(366.4)	(338.0)	(325.8)
Korea FTA	8416.8***	7296.2***	5984.2***	7818.4***	8167.9***	8395.1***	6450.4***
	(1700.1)	(1897.5)	(1891.1)	(1902.1)	(1658.2)	(1692.1)	(1896.7)
US FTA	2226.1***	1248.0***	638.7	1573.8***	2136.9***	2220.3***	692.6*
	(343.4)	(393.9)	(408.1)	(377.5)	(354.4)	(345.0)	(418.2)

Notes: The table reports the treatment effects for each FTA signatory and product types separately incorporating one control at a time (coefficients for the controls are not reported). Column (1) replicates baseline results from Table 2. Column (7) includes GDP per capita, population and nominal exchange rate as control variables. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Clustered standard errors in parentheses. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

[25] Because of space constraints, the full list of coefficients for all the controls in each specification are not reported, but are available upon request.

6. Conclusion

This article quantifies the FTA effects on export growth along the extensive and intensive margins. Understanding such effects is important, for example, because as the literature has recently shown, exports of new goods have further implications on welfare and productivity. Employing a DID approach at the product level, we focus on recent FTA episodes signed between geographically distant partners, using border-sharing neighbors who did not sign the FTAs as a control group. This allows us to overcome potential endogeneity issues and calculate unbiased estimates of the causal effects of trade liberalization in the form of FTAs. Our DID estimates show that FTAs had a positive and significant effects on trade growth and that the extensive margin accounted for one-third to more than half of exports growth.[26] Since we consider long post-FTA windows, we can also distinguish between the short- and long-term effects of the agreements. In that respect, we find that the effects of the FTAs on extensive margin increase over time and become significant five (or more) years after the agreements were signed, lagging the effects observed on the intensive margin. This supports the findings of Kehoe and Ruhl (2013), who document that extensive margin growth is stronger in the medium and long runs, but not in the short term. Our main findings are robust to inclusions of several controls and alternative specifications.

Additionally, we exploit the richness of detailed product-level data to explore the sectoral variations in the FTA effects. We find that in sectors with homogeneous goods—characterized by high elasticities of substitution—trade growth was driven by the intensive margin. On the other hand, in sectors with low elasticities of substitution, we found significant responses on the extensive margin of trade. In sum, we show that FTAs raise the overall volume of trade by affecting the trade margins differently, both in terms of timing and sectors. Given that FTAs similar to the ones we focus on have come into force in the recent years, our analysis can be applied to study them, in turn enhancing our understanding of

[26]The significance of the role of extensive margin in post-FTA export growth is further validated by the synthetic control approach in the accompanying Online Appendix.

the effects of trade liberalization among remote partners—an issue which should also be of interest to policymakers working on the design of trade reforms. Similarly, our findings on which specific sectors are more likely to experience increases in the trade of new goods can certainly complement the vast literature on the productivity gains derived by export growth along the extensive margin following trade liberalizations originating from Melitz (2003).

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Appendix

Figure A1: Total and least-traded goods exports (1996–2015)

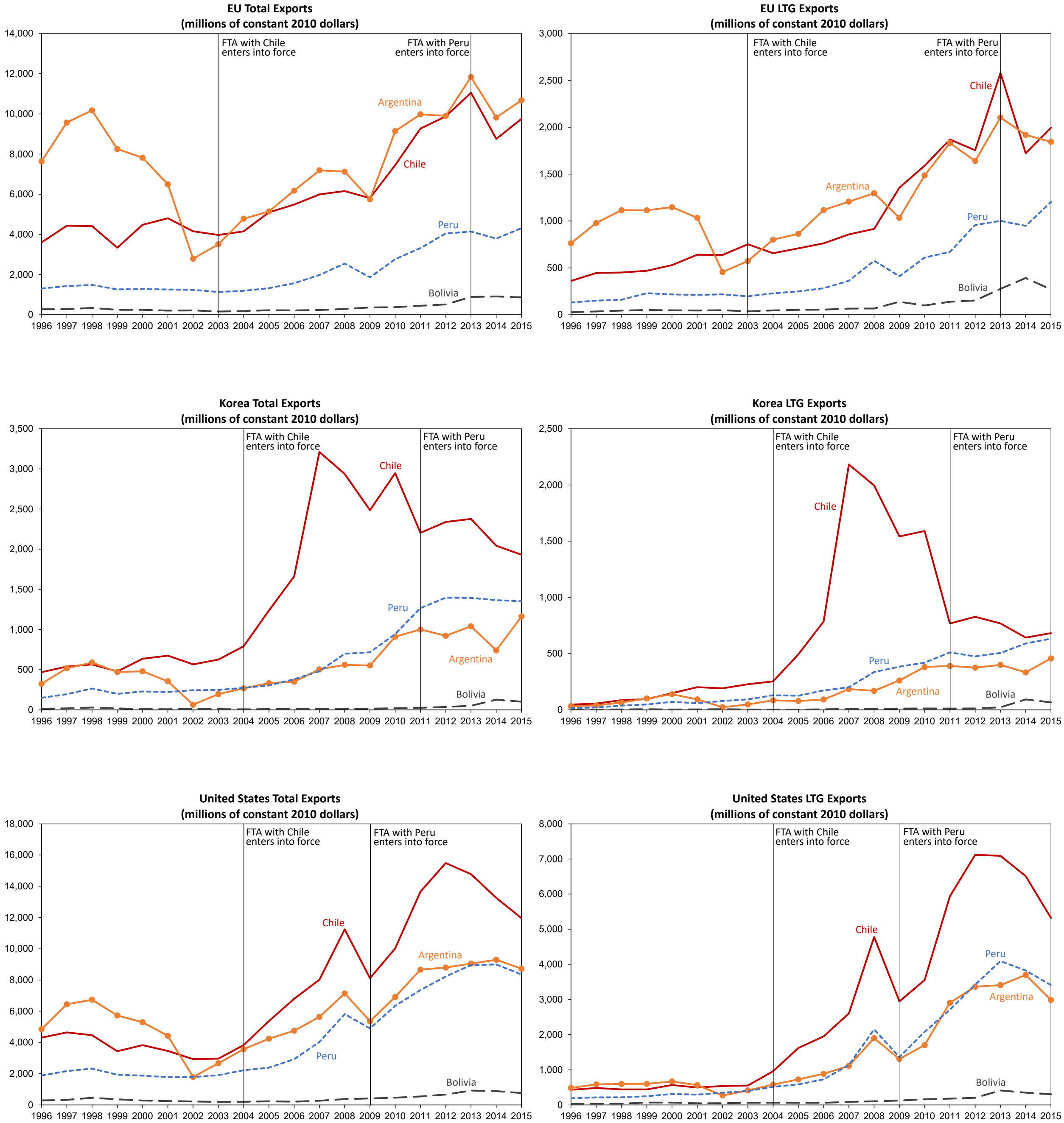

Figure A2: Total and least-traded goods exports (1996–2015)

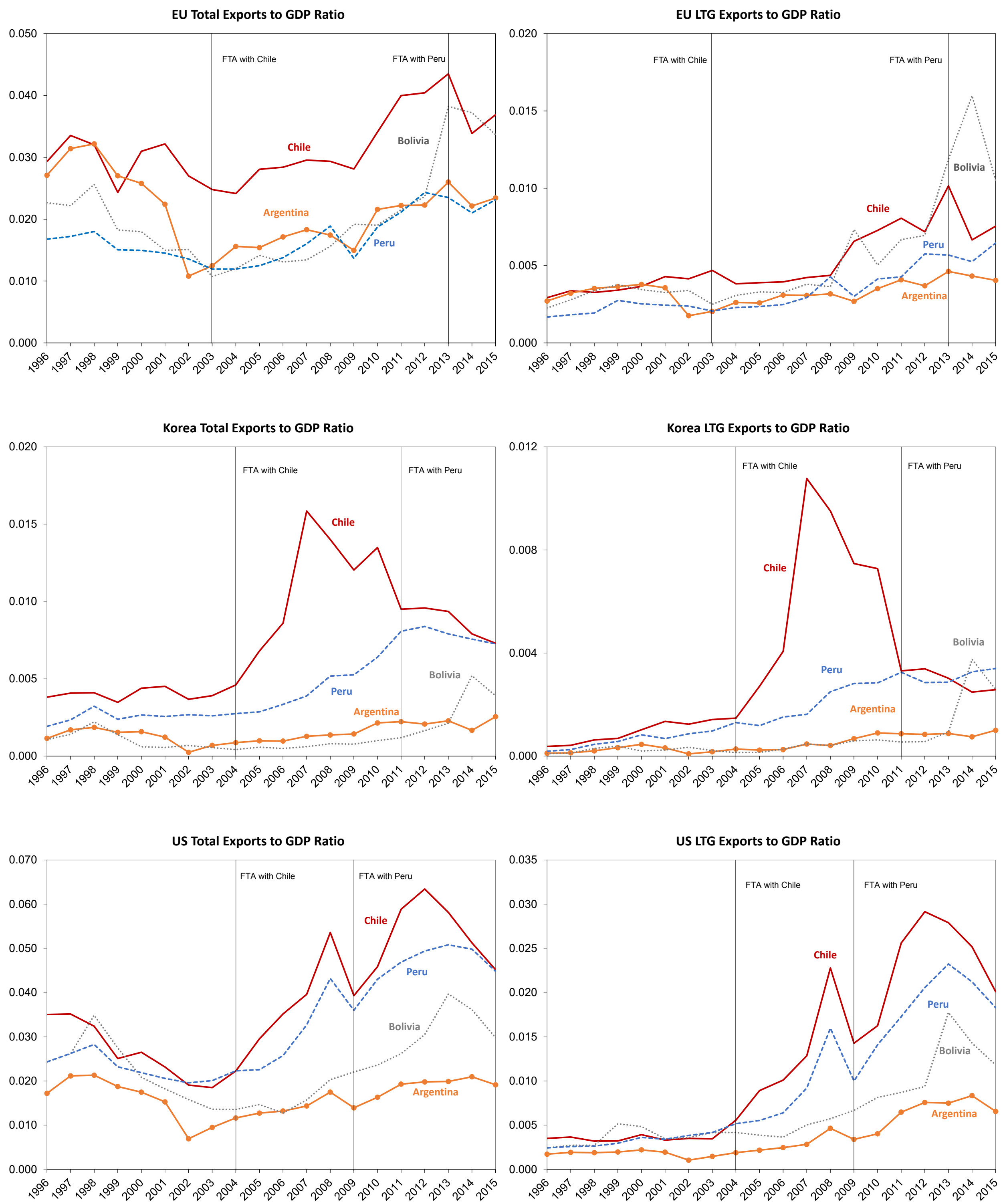

Table A1: Benchmark results versus results excluding Peru

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
(1) Benchmark results									
FTA	289.5***	220.9***	724.0***	89.7***	126.5***	425.3***	1103.1***	8416.8***	2226.1***
	(83.2)	(45.1)	(123.6)	(22.6)	(35.9)	(112.8)	(334.8)	(1700.1)	(343.4)
R-squared	0.049	0.018	0.026	0.025	0.007	0.023	0.092	0.145	0.098
Observations	401,600	401,600	401,600	338,820	395,580	346,980	62,780	6,020	54,620
(2) Controling for Peru's FTAs									
FTA	472.4***	274.9***	963.7***	140.1***	159.5***	643.8***	1670.8***	8877.8***	2502.6***
	(97.8)	(63.5)	(202.0)	(28.8)	(46.9)	(200.0)	(354.5)	(2517.9)	(430.5)
R-squared	0.048	0.016	0.023	0.026	0.007	0.020	0.093	0.140	0.097
Observations	386,540	376,500	366,460	326,004	370,755	316,971	60,536	5,745	49,489
Export growth (%)									
(1) Benchmark results	58.0	252.7	121.0	96.1	445.2	337.7	43.2	169.1	68.2
(2) Accounting for Peru	56.8	242.7	128.8	110.9	601.0	551.4	46.7	140.1	60.9

Notes: The top panel shows the benchmark regressions; the bottom panel accounts for the FTAs signed with Peru by dropping its post-FTA periods from the sample. The last block of rows shows the percentage increase in exports per product, calculated by dividing the estimated coefficients by the pre-FTA exports to the FTA partner(s).

Table A2: Alternative industry-level fixed effects

	All goods			LT goods			Non-LT goods		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
EU FTA	289.5***	289.5***	289.5***	89.7***	90.4***	89.7***	1103.1***	1176.8***	1103.1***
	(83.2)	(81.6)	(66.6)	(22.6)	(20.7)	(22.6)	(334.8)	(349.2)	(280.1)
R-squared	0.049	0.066	0.094	0.025	0.090	0.052	0.092	0.128	0.225
Korea FTA	220.9***	220.9***	220.9***	126.5***	126.1***	126.5***	8416.8***	8120.2***	8416.8***
	(45.1)	(38.4)	(40.3)	(35.9)	(29.1)	(31.6)	(1700.1)	(1695.4)	(1664.7)
R-squared	0.018	0.034	0.040	0.007	0.021	0.023	0.145	0.207	0.218
US FTA	724.0***	724.0***	724.0***	425.3***	415.4***	425.3***	2226.1***	2419.0***	2226.1***
	(123.6)	(101.5)	(117.0)	(112.8)	(87.2)	(119.4)	(343.4)	(317.9)	(262.9)
R-squared	0.026	0.055	0.041	0.023	0.054	0.040	0.098	0.125	0.137
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	No	Yes	No	No	Yes	No	No	Yes	No
Industry-country FE	No	No	Yes	No	No	Yes	No	No	Yes

Notes: Column (1) replicates our benchmark results. Columns (2) and (3) replace industry fixed effects with industry-year and industry-country fixed effects, respectively. All models include country and year fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

Table A3: Pooled OLS results

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
FTA	808.5***	298.5***	1243.0***	226.0***	152.5***	757.2***	2862.5***	11061.9***	3856.0***
	(111.4)	(54.1)	(175.9)	(27.0)	(33.7)	(162.1)	(334.2)	(2629.1)	(361.6)
R-squared	0.003	0.000	0.000	0.001	0.000	0.000	0.010	0.026	0.011
Observations	200,800	200,800	200,800	165,320	198,320	170,260	35,480	2,480	30,540
Export growth (%)	161.9	341.5	207.7	242.2	536.7	601.3	112.1	222.3	118.2

Notes: The table reports the FTA effects for each FTA signatory and product types separately. Units are in thousands of 2010 US dollars. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.The last row shows the percentage increase in exports per product, calculated by dividing the estimated coefficients by the pre-FTA exports to the FTA partners.

Table A4: Sectoral share of exports to FTA countries (percent)

Sectors	EU Exports Pre-FTA	EU Exports Post-FTA	Korea Exports Pre-FTA	Korea Exports Post-FTA	US Exports Pre-FTA	US Exports Post-FTA
Low-elasticity	24.4	23.1	21.1	13.2	22.4	17.5
Medium-elasticity	44.6	41.3	36.1	40.0	42.8	56.0
High-elasticity	31.1	35.6	42.8	46.8	34.8	26.5

Table A5: Sectoral effects

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
Low elasticity	247.0**	69.6***	416.3***	64.6***	35.9***	121.2***	834.4	2378.0***	1959.4***
	(117.0)	(15.3)	(68.4)	(15.4)	(6.7)	(28.4)	(526.4)	(700.2)	(341.0)
R-squared	0.068	0.053	0.086	0.048	0.017	0.030	0.095	0.249	0.146
Observations	100,400	100,400	100,400	83,620	98,840	87,740	16,780	1,560	12,660
Medium-elasticity	169.8**	206.0***	876.6***	68.9***	204.5***	756.8***	540.7	1680.2*	1396.4***
	(71.4)	(71.5)	(204.5)	(17.5)	(70.7)	(227.8)	(355.6)	(899.2)	(264.5)
R-squared	0.047	0.010	0.031	0.039	0.009	0.031	0.099	0.117	0.114
Observations	200,160	200,160	200,160	168,940	198,340	171,660	31,220	1,820	28,500
High-elasticity	568.9***	400.9***	727.6***	154.8**	60.3***	70.2***	2543.1***	17620.2***	4246.6***
	(207.4)	(100.1)	(176.0)	(73.6)	(18.6)	(17.2)	(911.0)	(3696.3)	(914.2)
R-squared	0.052	0.043	0.058	0.031	0.014	0.039	0.102	0.179	0.089
Observations	101,040	101,040	101,040	86,260	98,400	87,580	14,780	2,640	13,460
Export growth (%)									
Low-elasticity	51.4	94.5	77.7	62.1	167.8	116.2	36.5	62.9	63.7
Medium-elasticity	39.6	331.8	171.6	74.4	572.1	480.6	25.1	41.5	55.7
High-elasticity	85.2	259.4	86.6	183.0	301.1	95.9	69.1	275.7	85.5

Notes: The table reports the treatment effects for each FTA signatory, product type and sector separately. Units are in thousands of 2010 US dollars. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Units are in thousands of 2010 US dollars. All models include country, year and industry fixed effects. Clustered standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. The last block of rows shows the percentage increase in exports per product, calculated by dividing the estimated coefficients by the pre-FTA average sectoral exports to the treated group.

Table A6: Aggregate trade in logs

	All goods			LT goods			Non-LT goods		
	EU	Korea	US	EU	Korea	US	EU	Korea	US
FTA	0.163*	0.492***	0.429***	0.176	0.482**	0.584***	0.178*	0.478***	0.346***
	(0.096)	(0.168)	(0.070)	(0.119)	(0.206)	(0.090)	(0.091)	(0.151)	(0.068)
R-squared	0.981	0.959	0.985	0.967	0.949	0.983	0.985	0.962	0.984
Observations	80	80	80	80	80	80	80	80	80

Notes: The table reports the aggregate treatment effects for each FTA signatory and product types separately. Units are in log of thousands of 2010 US dollars. We include country and year fixed effects. Robust standard errors in parenthesis. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.