Brexit and Goods Trade: A Trending Topic*

John Lewis and Edoardo Tolva

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Abstract

Brexit is a striking example of a potentially new era of trade disintegration. We estimate its effect on UK-EU goods trade using monthly bilateral trade data for 50 countries at the HS2 product level. Under various de-trending approaches, we find that the shift from EU membership arrangements to the Trade and Cooperation Agreement (TCA) in January 2021 caused a 17–18% fall in UK-EU trade. However, the longer-run effect, comparing pre-referendum with post-TCA trade, is sensitive to how trends are included, as estimates for the interim period between the referendum and Brexit vary substantially by trend choice. By product type, TCA implementation mainly reduced trade in consumer and intermediate goods, with no significant effect on capital goods. Further, we find no clear correlation between the trade effects and the goods-level trade elasticities reported by Fontagné et al. (2022).

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*Lewis: Centre for Macroeconomics. Tolva: Department of Economics, University of Warwick, Coventry CV4 7AL, UK, email: edoardo.tolva@warwick.ac.uk. The views expressed are those of the authors and not necessarily those of any institutions to which they are affiliated. We thank Natalie Chen, Lionel Fontagné, Alejandro Graziano, Janez Kren, Dennis Novy, Kadee Russ, Thomas Sampson, Tom Zylkin and Robert Zymek for comments on earlier versions of the paper, as well as participants at 2024 European Trade Study Group, 2024 Allied Social Sciences Association 2024, 2023 Economics of Global Interactions workshop and seminar participants at Warwick University and the Dutch Central Bank for useful comments. Any remaining errors are our own.

1 Introduction

After several decades of increasingly free trade at the global level, this process appears to be in partial retreat, with trade barriers rising and steps being taken to reverse some of the integration achieved in previous years. A key example is the United Kingdom's decision to leave the European Union, withdrawing from the trading arrangements associated with EU membership. As an EU member, the UK traded on a tariff-free and quota-free basis with the rest of the EU, operated under the same single market product regulations, and participated in the EU's customs union. However, following December 2020, UK-EU trade has been governed by the Trade and Cooperation Agreement (TCA), under which tariff- and quota-free access was retained, but trade flows became subject to various non-tariff barriers due to the UK's departure from the single market and customs union. While a lot of the literature on trade has studied episodes of integration where barriers were falling, the UK's exit from the EU offers a potentially important case study for understanding the effects of increasing trade barriers, particularly in relation to non-tariff measures.

The creation of these non-tariff barriers raises several important empirical questions about their effect on aggregate trade flows, the potential substitution of EU trade with trade from the rest of the world, heterogeneous effects by direction of trade and product type, and how these effects on trade correlate with canonical estimates of trade elasticity. At the same time, the UK's exit occurred against a well-documented backdrop of the UK losing market share in a number of export markets prior to 2016 (Bank of England, 2013; Cheptea et al., 2014; Office for Budgetary Responsibility, 2021).

Our paper seeks to study how longer time trends may affect the estimate of the TCA's impact on UK-EU trade flows using product-level bilateral trade data from the UN Comtrade database. We first document the importance of, and heterogeneity in, country-pair specific trends. We then make use of COMTRADE reported export flows at the 2-digit and 6-digit product code level for 50 countries from January 2013 to December 2023, resulting in an unbalanced panel of around 23 million observations. While the empirical trade literature generally advocates incorporating trend terms, and the parallel trends assumption is fundamental to any difference-in-differences estimation strategy, much of the recent empirical research examining the effects of Brexit has not formally accounted for country-pair-specific trends.

Our first key insight is that the choice of de-trending methodology matters substantially for longer-run estimates of the effect of Brexit on UK-EU trade, because it leads to quite different estimates of what happened during the post-referendum period, after which the UK had voted to leave, but before actual trading arrangements had changed. Equally, the shorter-run effects of Brexit (i.e. comparing trade after the TCA with the period immediately before it) are less prone to being affected by the trends' specifica-

tion.

We explore this issue by estimating several different specifications with varying treatments of the trends. This reveals an important dichotomy: estimates of the short-run effect of moving from EU terms to TCA terms in December 2020 are highly robust to the specification of trends, and put the effect of Brexit on UK-EU trade flows at around 17-18% in both directions. By contrast, estimates of the longer-run effects of the Brexit process are sensitive to the treatment of trends, because this yields a different counterfactual and affects how a model interprets the relative decline in UK-EU trade during the period between the referendum and the implementation of the TCA. In terms of non-EU trade, we find no evidence of a substitution in UK exports towards non-EU markets, nor of the UK attracting a greater share of non-EU partners' exports, which suggests no substitution towards alternative partners. If anything, the effect on trade with non-EU partners was negative rather than positive during the period we study.

Our second key insight is on the heterogeneity across different product types. We explore this by splitting our sample into different buckets based on product characteristics. Examining the differences in effects between capital, intermediate, and consumer goods under Broad Economic Classification (BEC), we find that the effect is driven by consumer goods and intermediate goods, with no significant effect on capital goods. When splitting our sample into quintiles based on the canonical estimates of trade elasticity from Fontagné et al. (2022), we find no apparent correlation between trade elasticity and the estimated impacts. Indeed, we obtain the striking result that the quintile of goods with the greatest trade elasticity appears to have an insignificant effect on Brexit.

Our paper is related to several different strands of the literature on empirical trade. First, we contribute to the growing literature that seeks to analyse the impact of the EU-UK Trade and Cooperation Agreement (TCA).[1] Portes (2022) compiles many recent studies that highlight the varied impacts of Brexit. Our work focuses on trade in goods and is closely related to several studies that demonstrate how the new trading arrangements affected trade volumes between the UK and the Eurozone. Bakker et al. (2022) shows that imports from the European Union have fallen since the referendum, with an even steeper drop following the implementation of the TCA, whereas exports to the EU have maintained a stable trend. This study also highlights significant differences in responses across goods categories. Furthermore, they find that imports from the EU, relative to imports from non-EU countries, have declined for goods used as inputs to production in many UK supply chains. A negative impact is also found by Ayele et al. (2021), who similarly emphasize heterogeneity across goods in their

[1]For a review of the literature on studies that estimated the impact of Brexit before the deal, see Dhingra and Sampson (2022).

analysis. Another closely related paper is Freeman et al. (2022), who use a difference-in-differences approach comparing UK exports to the EU with those to other regions to estimate how the Brexit process affected trade over time. They find that in the period after the referendum but before the TCA came into effect there was no significant effect on UK-EU trade, but that the TCA led to a 25% decrease in UK imports from the EU. In contrast, they find that the decline in exports from the UK to the Eurozone was only transitory. In a similar vein, Kren and Lawless (2024) uses product-level data on EU imports and exports to estimate the differential effect on UK-EU trade flows over time. Again, they find no clear effect in either direction before January 2020 but document a decline of around 20% in UK-EU trade in both directions. Gasiorek and Tamberi (2023) using custom data from the United Kingdom and Eurostat data finds similar numbers for the Brexit hit highlighting while differentiating before the immediate impact and of the TCA the subsequent recovery. Freeman et al. (2025) instead study the impact of the TCA using firm-level data; they show significant heterogeneity of the responses when the firm's size is taken into account. They also find an aggregate decline of around 13% for exports and 3% for imports.

Our work adds to this literature by exploring the robustness of these findings to different trend treatments, and we show that whilst their headline finding on the immediate effects of Brexit (i.e. comparing the post TCA period with the post-referendum period) is robust, the estimate of the longer-run effects is quite sensitive to the treatment of trends, because they yield significantly different interpretations of what happened in the period between the referendum and TCA implementation.

Second, our work relates to the literature on heterogeneous effects of free trade agreements. Building on the work of Freeman and Pienknagura (2019), Orefice and Rocha (2011), and Antràs and Staiger (2012), which have found that trade liberalisation boosts intermediates more than final goods or capital goods. Our paper extends this work in an important new direction, looking at the impact of non-tariff barriers. We show that the effect appears largest for consumer and intermediate goods, but is insignificant for capital goods. We also speak to the literature initiated by Kehoe (2005) on examining the performance of empirical trade models in predicting product-level trade effects. That paper looked at NAFTA and found that existing estimates of product-level trade elasticities were a poor guide to observed trade creation effects. Our paper makes a similar but complementary point extending his result to the case of non-tariff barriers, and finding similarly that the size of the effect of Brexit does not appear to be correlated with estimated trade elasticity. This suggests that estimates of the trade elasticity derived from utilising variation in tariffs - i.e. tariff elasticities - such as Fontagné et al. (2022) may not be a good guide to the measures - i.e. such as the Brexit process - which affect non-tariff barriers.

Third, our work relates to the broader literature on gravity estimation, especially

works concerning the importance of trend variables. Bergstrand et al. (2015) argue that pairwise trends should be included as control variables in estimations of the effects of FTAs. This formalised the idea captured in two earlier papers: that failure to account for underlying trends may lead to the overestimation of the size of the effects of a given change in trade policy. Specifically, Bun and Klaassen (2007) find that the estimated trade effect of the euro is smaller once pair-specific trends are included in the model to account for longer-run factors influencing trade, as do Berger and Nitsch (2008), who find a similar result in a richer model including other measures of integration. More recently, Nagengast and Yotov (2025) show the importance of including heterogeneous effects when studying the impact of changes in trade policy. Our paper adds to this literature by applying the methodology to a new case in point - the process of Brexit - and confirms the earlier results in this new context.

The paper is structured as follows. Section 2 outlines the Brexit process and associated timeline, Section 3 describes the dataset used, Section 4 describes the empirical strategy and results, and Section 5 reports the results. Section 6 concludes.

2 The Brexit process

The UK voted to leave the EU in the referendum of 23 June 2016, starting an exit process which took several years to complete. In this section we illustrate the process that led to the signing of the Trade and Cooperation Agreement (TCA) and its implementation. Table 1 summarizes the key steps.

It was not until March 2017 that official notification was given under the "Article 50" procedure, which commenced the formal 2-year notice period and started the process for negotiating exit. Subsequently, two extensions were granted to the Article 50 process: the first on 10 April 2019, which extended it until 31 October of that year, and then subsequently on 19 October 2019 until 31 January 2020, when the UK formally exited the EU. For the next 11 months after January 2020, the UK was in a transition period, under which it remained in the EU single market and the customs union, during which time further negotiations on the future relationship were held. As of 31 December 2020, the transition period ended and the UK's trade was governed by new arrangements as agreed bilaterally between the EU and UK under the "Trade and Cooperation Agreement" (TCA).[2]

This process essentially breaks down into two distinct periods. From 23 June 2016 to 31 December 2020, the UK traded on exactly the same terms as a full EU member - this includes the period between 1st February 2020 and 31st December when it was formally outside of the European Union and negotiating new trading arrangements.

[2]See House of Commons Library (2019) and House of Commons Library (2021) for more details.

Table 1: Brexit and TCA Timeline

Date	Event	Trading Arrangement
23 Jan 2013	David Cameron promises referendum if he wins next election	
7 May 2015	David Cameron wins general election	
20 Feb 2016	Referendum announced for 23 June 2016	
23 Jun 2016	UK votes to leave the EU	
29 Mar 2017	UK triggers 2-year article 50 (A50) exit procedure	
22 Mar 2019	1st extension granted (to 12 April if no deal)	EU member terms
10 Apr 2019	2nd extension granted (until 31 October)	
28 Oct 2019	1st extension granted (to 31 January 2)	
19 Oct 2019	A50 extended until 31 January 2020	
31 Jan 2020	UK leaves EU, transition period starts, TCA talks begin	
24 Dec 2020	TCA agreed in principle, effective 1st Jan	
30 Dec 2020	TCA approved by UK parliament + EU Council of Ministers	
1 Jan 2021	Transition period ends, TCA provisionally applied	
27 Apr 2021	EU parliament ratifies TCA	TCA terms
29 Apr 2021	Council of Ministers ratifies TCA	

Notes: Timeline of the Key steps of the Brexit referendum and the process that led to the signing of the Trade and Cooperation Agreement (TCA). Sources: House of Commons Library (2019) and House of Commons Library (2021)

After 31 December 2020, it traded under new arrangements of the TCA. Negotiations of the TCA continued up until 24 December; it was ratified on 30 December and then applied provisionally from 1 January (ahead of its formal entry into force on 1 May 2021). As such, there was in effect no interim "implementation period" between its agreement and operation, other than a handful of days over the festive period.

After an initial pre-referendum period, we then distinguish between phases of the Brexit process according to the arrangements in place rather than legal membership of the EU. There is the period after the referendum but before 1st Jan 2021, where formal trading arrangements were unchanged, but there was uncertainty about the form and parameters of the UK's future trading relations with the EU. Then after 1st Jan 2021, there were new trading arrangements and no uncertainty about the future.

The terms of the TCA essentially meant that the UK exited the customs union and single market but ensured tariff-free and quota-free trade. As such, any additional costs of trade between the UK and the EU raised as a result are in the form of non-tariff barriers [3], and these can take several forms:[4]

Technical Barriers to Trade Exporters must now demonstrate that their product meets the appropriate technical standards of the importing country. There is some degree of mutual recognition of practices and regulations for specific sectors, which may simplify the process for the products covered.

[3] As we note below, this is with the singular exception of rules of origin, where an exporter that cannot verify domestic content of its goods or which falls short of the local content threshold is liable for tariffs on a Most Favoured Nation basis, so technically such trade is not "tariff free".

[4] See House of Lords (2021) for more details.

Rules of Origin: Exporters must prove compliance with "rules of origin", that their products meet a minimum "local content" threshold. This constitutes both a cost for demonstrating compliance and a potential tariff payment if either an exporter cannot prove compliance or if their products fail to meet the "local content" criterion.

Sanitary and Phytosanitary Measures Animal and plant products are now subject to health inspections to ensure they meet EU standards. Part of the cost relates to paperwork, and part relates to the possibility of random physical checks (and associated costs/delays) for shipments.

Customs Both buyer and seller must fulfill customs formalities on goods and demonstrate adherence to specific rules. Costs relate both to administrative requirements and the costs associated with delays and transit times arising from delays and congestion at customs posts.

Value Added Tax Goods which flow between the EU and UK are eligible for import VAT. Although deferrals mean this doesn't have to be paid on arrival, this does create additional registration requirements for buyers and sellers, as well as broader administrative costs.

Transportation Costs Groupage, where several consignments are consolidated in the same lorry, can act to amplify the above costs because if one consignment doesn't have the required paperwork, the entire load is delayed. Similarly, leaving the EU's arrangements for cabotage (where a vehicle from a third country may transport goods from an exporter to an importer) might reduce the efficiency of transportation by increasing the number of potential empty/under-capacity shipments and raising the costs of transporting goods.

Separate arrangements govern trade between Northern Ireland and Ireland, and between Ireland and the UK, under the terms of the so-called "Northern Ireland backstop". Since our data only records trade flows between nation states (i.e. the UK as a single entity), we are not able to distinguish between (the effects on) trade flows to/from Northern Ireland as opposed to those to/from the rest of the UK.

3 Data

We collect monthly trade flow data from January 2013 to December 2023 from the UN Comtrade database. This has the advantage of higher frequency, but the back-run of

data is smaller than CEPII's annual BACI dataset, as many countries do not report monthly observations prior to 2010. The original data are reported at the 6-digit level following the Harmonized System (HS) classification. We collapse the dataset at the 2-digit level to keep the dataset computationally manageable and eliminate concordance problems over time that would be present across 6-digit product codes.[5]

Our sample consists of the top 40 importers in terms of volume in the year 2020[6] plus all other EU members not in this group. We include these additional countries since the focus of this study is the trade relationship between the United Kingdom and the EU. Regrettably, not all country-years have available monthly data, resulting in an unbalanced panel across the years. To address this issue, we supplement our dataset with additional data from Eurostat.[7] Specifically, we acquire monthly data for Austria for the years 2018-2021, and France for the years 2019-2021.[8] See Tables A.1 and A.2, in the data appendix, for a comprehensive overview of the countries included and the yearly coverage.

A limitation of the monthly trade flows reported by Comtrade is that there are no internal trade flows available. While their inclusion is beneficial for trade policy analysis (Yotov et al., 2016), we are not aware of any data source that reports this information at the monthly-product level of aggregation, and so, we do not include internal trade.[9]

For each origin-destination pair, the Comtrade database records both importer and exporter reported measures of the same flow. We conduct our baseline analysis using trade flows recorded as exports by the reporting countries. Our choice is motivated by the fact that exported values are reported as free on board (FOB) whereas imported values include cost, insurance, and freight (CIF) additional expenses, and the fact that the data coverage is slightly fuller for importer flows.

As a robustness check, we repeat our analysis using import-reported trade flows. We show that the results are qualitatively similar but quantitatively different. Since we perform our analysis on the same set of reference countries, we explain this discrepancy based on the change in how trade flows are reported between the EU and the UK after the TCA is implemented.

For our robustness check with longer run time trends, and our descriptive analysis of trends in market share, we complement our Comtrade data with trade flows between countries at the annual frequency from the BACI dataset (Gaulier and Zignago,

[5]Specifically, the classification of products is revised approximately every 5 years, meaning that some new 6-digit products are created, and other 6-digit products are split into more than one category. This is compounded by the fact that different countries may use different revisions within the same year, requiring us to identify the revision used, and then concord it to a common revision across the whole dataset.

[6]Rank based on the ITC's Trade Maps.

[7]The data-set is named "EU trade since 1988 by HS2-4-6 and CN8 (DS-645593)".

[8]We convert the value in euros to dollars using the World Bank reported monthly exchange rate.

[9]This is in line with other studies in the literature focusing on Brexit such as Freeman et al. (2022) and Kren and Lawless (2024)

2010). To break down our results by goods type, we use the Broad Economic Classification (BEC) to classify goods into capital, intermediate, and final goods (United Nations, 2022).

4 Empirical Strategy

In this section, we discuss our empirical strategy to isolate the effect of the TCA once we control for secular trends between the United Kingdom and its trading partners, highlighting similarities and differences with similar studies in the literature on the same topic.

4.1 Parametrising the phases of Brexit

As discussed above, we distinguish between three mutually exclusive periods.[10] An initial pre-referendum period from January 2013 to May 2016. This is followed by a "post-referendum" from the referendum date until the implementation of new arrangements (June 2016 - December 2020). We denote the variables that refer to this period by the suffix PRF. During this time, uncertainty surrounded the UK's future trading relationship with the EU, although trade continued under existing EU membership terms[11].

In the final period, from January 2021 onwards, trade was governed by the newly agreed TCA and uncertainty had dissipated.[12] We denote the variables that refer to this period by the suffix TCA.

To identify the effect of the Brexit process on UK trade flows, we therefore create 8 dummy variables. Each one is defined by partner (EU or RW), period (PRF or TCA) and direction (Import or export from the point of view of the UK). These are shown below. For example, DXPRF is equal to one iff the origin is the UK, the destination is the EU, and the time period is June 2016 - December 2022; and zero for all other flows.

To estimate the effect of Brexit on UK exports, we estimate an equation of the following form:

$$\begin{aligned} X_{odpt} =& exp(\beta_{XPRF} DXPRF_{odt} + \beta_{XTCA} DXTCA_{odt} + \\ &+ \gamma_{XPRF} iXPRF_{odt} + \gamma_{XTCA} iXTCA_{odt} + \sigma_{pod} + \omega_{pdt} + \ldots) + \epsilon_{odkt}, \end{aligned} \tag{1}$$

where the dependent variable is the flow X of HS2 product p between an origin, o,

[10] This is in line with other studies on the TCA (Freeman et al., 2025; Kren and Lawless, 2024).

[11] See for example Graziano et al. (2021)

[12] The TCA was agreed on December 30, 2020, provisionally applied from January 1, 2021, and formally enacted on May 1, 2021. We do not differentiate between provisional and formal application periods, and we disregard the single day (December 31, 2020) when the UK traded under previous arrangements with certainty about future relations.

Table 2: Dummy variable definitions

	Trade flow				
Dummy	UK to EU	UK to RoW	EU to UK	RoW to UK	All others
DXPRF	2016m6 - 2020m12	0	0	0	0
DXTCA	2021m1-2022m12	0	0	0	0
iXPRF	0	2016m6 - 2020m12	0	0	0
iXTCA	0	2021m1-2022m12	0	0	0
DMPRF	0	0	2016m6 - 2020m12	0	0
DMTCA	0	0	2021m1-2022m12	0	0
iMPRF	0	0	0	2016m6 - 2020m12	0
iMTCA	0	0	0	2021m12-2022m12	0

Notes: Each cell records the observations for which a given dummy equals 1. "0" denotes 0 for all observations in that directional pair. Span of dates denotes it equals one within that period for all observations in that directional pair, and zero otherwise.

and a destination, d, in month t. We include a series of fixed effects to capture the potentially confounding influence of other factors on trade such as origin-destination-product (σ_{pod}) and destination-product-time (ω_{pdt}) as common in the gravity literature in international trade.[13]

We exclude origin-destination-time fixed effects as they would be collinear with our variables of interest i.e. $DXPRF$, $DMPRF$, $DXTCA$ and $DMTCA$. In line with the rest of the literature, we use the Poisson Pseudo Maximum Likelihood Estimator of Santos Silva and Tenreyro (2006). In all our baseline specifications, we use robust standard errors with two-way clustering by origin-destination and product.[14] This yields a diff-in-diff estimation, where the treatment group is UK trade with the EU during the Brexit process, which allows us to compare the relative performance of the UK with other advanced economy exporters over the time period.

To gauge the effect on imports into the UK, we estimate the corresponding specification:

$$\begin{aligned} X_{odpt} = & exp(\beta_{MPRF} DMPRF_{odt} + \beta_{MTCA} DMTCA_{odt} + \\ & + \gamma_{MPRF} iMPRF_{odt} + \gamma_{MTCA} iMTCA_{odt} + \sigma_{pod} + \mu_{pot}) + \epsilon_{odkt} \end{aligned} \tag{2}$$

With this specification we estimate the absolute effect of Brexit on trade flows by giving us two sets of coefficients (γ and β) which correspond to the UK-EU and UK-RoW effects respectively. This allows us to see whether and to what extent any fall in UK-EU trade was offset by a corresponding rise in UK-RoW trade. In particular, we want to explore the extent to which the changed UK-EU trading arrangements reduced trade or merely diverted it. Furthermore, this offers restrictions on the sign and size of the

[13]The product-destination-time fixed effect should take care of potential issues around differences in destinations in recording of trade flows on a "Free-on-board" vs "Cost insurance and Freight" perspective and other measurement issues.

[14]In the appendix we show that our results are robust to the use of standard errors clustered at the origin-destination level.

coefficients. The β_{DMTCA} and β_{DXTCA} should be negative, implying that a rise in trade costs reduces trade. By the same token, the range of the γ_{iMTCA} and γ_{iXTCA} coefficients should be bounded by zero (the case where there is pure trade destruction and no diversion). However, it could also be the case that a worsening of the economic activities could lead to a general reduction in trade flow with all the partners.[15] Under this scenario we would have a negative coefficient. As an upper bound instead we should have β_{DMTCA} and β_{DXTCA} respectively, which is the case where there is full trade diversion from EU to RoW, and no aggregate loss of trade.

A natural question that may arise is what is the appropriate reference group to study to compare the change in import and export between European Union members and the United Kingdom. In our main export specifications, we choose to focus on trade flows from countries defined as advanced economies, and in our main import specification on exports to advanced economies.[16] Therefore, in equation (1), we exclude from the sample all the non-EU origins that are classified as Emerging and Developing Economies by the IMF.[17] We do this because advanced economy exporters are the most natural comparison group against which to compare the UK's export performance. Similarly, imports of advanced economies are the most natural comparison group for imports into the UK when looking at the relative shift in trade flows towards/away from the UK. Therefore, in equation (2), we drop non-EU non-advanced economies from our destination countries. As a robustness check, we estimate the impact using the full sample and we show that the results are not driven by the choice of the sample.

4.2 Time trends

A common approach in the trade literature is to study policy changes while accounting for all possible confounding effects using fixed effects. But several papers have emphasised the potential importance of time trends. Bergstrand et al. (2015) argue that the effects of regional trade agreements may be biased upwards by failure to account for time-varying country-pair specific changes in bilateral trade costs, especially in cases where regional integration agreements are endogenous and provide both theoretical and empirical evidence in support of this proposition. In the context of the Euro, Bun and Klaassen (2007) find substantial sensitivity to the inclusion of trends; because trade between euro member countries has been trending upwards prior to the euro,

[15] Alabrese et al. (2024) provide evidence of a widespread reduction in economic activities in the United Kingdom due to Brexit in 2022.

[16] To classify countries we follow the Classification of Economies in the World Economic Outlook (WEO) compiled by the International Monetary Fund (IMF, 2024).

[17] In our sample this implies that we are excluding Brazil, Chile, China, China (Hong Kong SAR), India, Indonesia, Malaysia, Mexico, Philippines, Russia, Saudi Arabia, Thailand, Turkey, United Arab Emirates, Vietnam.

they find evidence that including pair-specific trends can reduce the estimated impact of the euro by a factor of between 3 and 20, depending on the time period chosen.

We document below two key stylised facts which underscore the potential importance of pair-specific time trends.

First, the implementation of the TCA occurred during a period when both the United Kingdom's "market shares" with EU and non-EU partners were deteriorating. To see this, we compute each of the three exporter blocks' (UK, EU, RoW) share of advanced economy exports to the EU (panel a) and Rest of the World (panel b) respectively, which we then re-base to its 2016 level.[18] Our units here are percentages, not percentage points, so for example, a fall in market share from 8% to 4% since 2016 would be a fall of 50%, which would appear on the chart (in log terms) as -0.693.

To construct this figure, we use BACI data,[19] as it covers a longer time span than our dataset and, being based on annual data, includes a larger sample of countries.

The upper panels of figure 1 suggest that the UK's market share in the EU relative to advanced economy peers declined slightly prior to the referendum, and that the drop observed between 2016 and 2019 (indicated by vertical dashed lines) appears to roughly align with the pre-referendum trend. Between 2007 and 2016, the UK's share of the EU import market decreased by just over 2% per year. The corresponding plot of RoW market share also shows a decline from 2014 onwards, albeit with more apparent volatility around the trend.

On the import side, we compute the corresponding measure - i.e. the share of each EU/RoW exports (left hand panel) to advanced economies which goes to UK, EU and Rest of the World respectively, again rebased to the 2016 level.[20] Panel c shows that prior to the referendum, EU exports were gradually tilting more towards the Rest of the World, tilting marginally towards the UK, but moving away from other EU countries. After 2016, there is a sharp decline in the share going to the UK, and a modest rise to other destinations. For imports from the Rest of the World, there is less of a clear pattern.

Second, there is clear evidence of rich heterogeneity in pair-specific trends over the period. Figure 2 shows the changes in shares of trade from the beginning (2013) to the end (2023) of our sample period.

[18] Formally speaking for exports from origin block j to destination block K we have:

$$share_{jkt} = \frac{F_{jkt}}{\sum F_{kt}} / \frac{F_{jk2016}}{\sum F_{k2016}} * 100$$

[19] for more details on this dataset see Gaulier and Zignago (2010).

[20] Formally speaking for flows from origin block j to destination bloc k we have:

$$share_{jkt} = \frac{F_{jkt}}{\sum F_{jt}} / \frac{F_{jk2016}}{\sum F_{j2016}} * 100$$

Figure 1: UK market share dynamics: 2007-2023

(a) Exports to EU

(b) Exports to RW

(c) Imports from EU

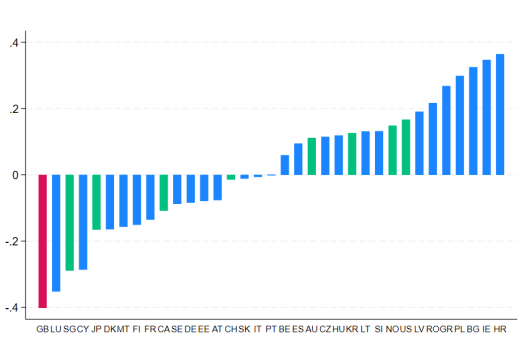
(d) Imports from RW

Notes: Panel (a) and (c) show the dynamics of export and import shares to the European Union for the United Kingdom, the Rest of the World, and European members. Panel (b) and (d) instead report the changes in export and imports shares to the Rest of the World. The reference year is 2016. The data are collected from the BACI dataset made available by CEPII (Gaulier and Zignago, 2010).

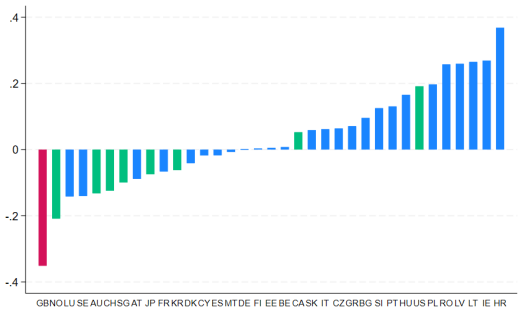
The upper panel shows the change in each exporting country's market share in the EU export market, (calculated over the same country coverage as our export equation, i.e. advanced economy/EU exporters only). The UK's relative market share declines by about 30% over the period, the largest decline of any country apart from Cyprus. But this chart also highlights the spread of outcomes - at the top end for example, Norway's share of the EU market has grown by around the same magnitude. Even within EU exporters (blue bars), there is substantial variation, as there is for non-EU exporters (green bars).

The lower panel shows the equivalent on the import side- i.e. the change in the log share of EU exports going to each advanced economy/EU destination country over the period 2013-2022. The UK has suffered the sharpest decline, of around 35%, around double that of the destination with the next largest fall, Norway, and well over twice the fall of the next largest EU destination. There is substantial heterogeneity across different destinations- with Croatia seeing the largest rise of almost 40%.

Figure 2: Change in share of EU countries' exported



(a) Change in trade shares 2013-2022



(b) Change in share of EU exports to each importer

Notes: Panel (a) reports the difference in market share of Non-EU countries between the start and the end of our sample. Panel (b) compares instead the share of export towards non-EU countries. Data are downloaded from the UN Comtrade database. Country abbreviations: AT=Austria; AU=Australia ; BE=Belgium ; BG=Bulgaria ; CA=Canada ; CH=Switzerland; CY=Cyprus ; CZ=Czechia ; DE=Germany : DK= Denmark ; EE=Estonia; ES=Spain; FI=Fingland ; FR=France : GB=United Kingdom ; HR=Croatia ; HU=Hungary ; IE=Ireland ; IT=Italy ; JP=Japan; KR= South Korea; LT=Lithuania ; LV=Latvia ; MT=Malta ; NO=Norway ; PL=Poland; PT=Portugal; SE=Sweden ; SG=Singapore ; SI=Slovenia; SK=Slovakia; US=United States

Any estimation relying on difference-in-differences is only valid if the parallel trends assumption holds, i.e. that in the absence of the treatment, both treated and untreated groups would have followed the same trend. If this assumption doesn't hold, then any difference-in-differences estimation would wrongly attribute the trend differential to the treatment dummy. Alternatively, this problem can be mitigated by the inclusion of differential trends, which purge the control and treatment groups of any differences in trends.

Given this, and motivated by these empirical patterns, which emphasize the importance of allowing for (heterogeneity in) time trends, we augment the baseline equations with several alternative terms aimed at capturing trends over time.

We begin with the simplest parametric approach, that is, the inclusion of a linear trend in UK-EU trade flows to complement the two existing step dummies in equations (1)-(2). In the exports equation, this variable *Xtrend* equals the number of months since the start of the sample if the origin is the UK and the destination is the EU; and equals zero otherwise. We define the equivalent UK-RoW trend, *iXtrend* in the same way—i.e., if the origin is the UK and the destination is the RoW, this equals the number of months since the start of the sample and zero for all other pairs. Correspondingly, the import counterparts *Mtrend* and *iMtrend* are defined in the same way for EU origins and UK destinations, and non-EU origins UK destinations respectively.[21]

Next, we include the full set of origin-EU and origin-RoW specific trends in our

[21] *Mtrend* is equal to the number of months since the start of the sample if the origin is in the EU and the destination is the UK, and zero otherwise. Similarly, *Mtrend* is equal to the number of months since the start of the sample if the origin is non=EU and the destination is the UK, and zero otherwise.

export equation - i.e. for every origin country, not just the UK; and the equivalent set of EU-destination and RoW-destination specific trends in the imports equation. Lastly, in our richest specification, we include a full set of country pair-specific trends in both equations. This is the approach advocated by Bergstrand et al. (2015), as a way of accounting for differential trends in bilateral trade costs between country pairs and by Bun and Klaassen (2007) to account for trends in any other country-pair specific variables.

4.2.1 Alternative Specifications for the Time Trends

We explore other ways of capturing the time effects, other than simply estimating a within-period trend as part of our estimation. First, motivated by the literature on trade policy uncertainty,[22] we include a trend counterpart to the PRF dummies. This term is included alongside the set of pair-specific time trends described above. This captures the idea that during the post-referendum period uncertainty costs may have slowly built over the post-referendum periods. In the exports equation, this variable $XPRFtrend$ is set equal to the number of months since June 2016 for any pair where the origin is the UK and the destination is in the EU and the month is between July 2016 and December 2020 inclusive; and zero otherwise. $iXPRFtrend$ is defined in the same way - for pairs where the origin is a non-EU country and the destination is the UK, this is equal to the number of months since June 2016; and zero otherwise. Similarly, $MPRFtrend$ and $iMPRFtrend$ are correspondingly defined to capture post-referendum trends in flows in the opposite direction.[23]

Second, we de-trended the data based on longer run trends before our sample begins. To do this, we estimated a model using BACI data (the same dataset used to construct figure 1) over the five calendar years prior to our sample (2008-2012), regressing trade flows on the same set of fixed effects, and a set of county pair-specific time trends. We then saved these time trends, and used these to de-trend the monthly Comtrade data in our estimation sample.[24] This approach is used instead of the pair-specific time trends. This captures the idea that there might have been longer run secular trends driving trade flows, and seeks to strip these out by using a longer back-run of data than our detailed higher frequency and product specific dataset allows.[25] By avoiding any in-sample data for the estimation of trends, this also ensures they are

[22] which finds that heightened uncertainty about future policy can depress trade flows (Handley, 2014; Feng et al., 2017).

[23] $MPRFtrend$ is equal to the number of months since June 2016 if the origin is in the EU, the destination is the UK and month is between June 2016 and December 2020 inclusive, and zero otherwise. $iMPRFtrend$ is equal to the number of months since June 2016 if the origin is in non-EU, the destination is the UK and month is between June 2016 and December 2020 inclusive, and zero otherwise.

[24] Formally speaking we divide the pair-specific trend coefficients by 12, then include these in the regression with the coefficient fixed to one using Stata's "offset" command.

[25] We are grateful to Janez Kren for this suggestion.

not influenced by post-referendum dynamics in any way.[26]

5 Results

Table 3 reports the results of the estimation of equation (1) where we look at the impact of Brexit and the TCA on UK exports. In column (1) we can see that the estimates for $DXTCA$ and $iXTCA$ are close in magnitude, suggesting a similarly sized fall in UK exports to the EU and the rest of the world. The lack of a positive effect on rest of the world exports suggests the fall in exports to the EU was trade destruction rather than trade substitution. In column (2), we introduce in our analysis two linear trends that capture the evolution of the UK-EU ($Xtrend$) and UK-RoW ($iXtrend$) relationships. Both trends are negative and significant and, more crucially, their inclusion takes away the significance from all the variables but the dummy between the UK and the EU. Once controlling for the trend in the UK economy, the coefficients imply that the impact of the TCA has been a drop in UK exports towards the EU of -18.3%.[27] Note here that because the post-referendum dummies are insignificant, this implies that the "long-run" effect (i.e. comparing the TCA with the pre-referendum period) of Brexit is the same as the "short-run" effect (i.e. comparing the TCA with the post-referendum period). This distinction, however, becomes more important later on, and we return to this point in the next section.

In columns (3) and (4) we then introduce richer specifications for the trends to corroborate our results. In Column (3) we have origin-EU and origin-RoW linear trends for all countries (as opposed to only including 2 UK-specific trends in column(2)), while in column (4) we use the full set of bilateral origin-destination trends. Across all 3 trends specifications (columns 2 to 4) the results are very similar and the introduction of trends makes the impact of the post-referendum dummies ($DXPRF - iXPRF$) insignificant, as well as the impact of the TCA on UK exports to the rest of the world ($iXTCA$). And the different types of trends in columns (2) to (4) yield very similar estimates of $DXTCA$. In line with the recommendation of Bergstrand et al. (2015), our preferred specification, and the baseline going forward in the paper, is column (4) which has the richest treatment of trends.

Table 4 reports our estimates of regression (2) for the import equation. As with the previous results, including trends in the estimation removes the statistical significance of the post-referendum dummies. However, in this case, Column (4) shows that following the introduction of the TCA, there was a significant decline in UK imports not

[26] In addition, by estimating the trends from a sample period before the referendum promise was announced, this insulates the estimates of trend from any anticipation effects following the pledge by David Cameron in January 2013 to hold a referendum on EU membership if he won the next general election.

[27] We apply the transformation $100 * (\exp(\beta) - 1)$

Table 3: Estimate Brexit Impact on UK Exports

	(1) No Trend	(2) UK Trend	(3) All Bloc Trend	(4) All Pair trends
DXTCA	-0.357***	-0.203***	-0.202***	-0.202***
	(0.053)	(0.059)	(0.059)	(0.059)
iXTCA	-0.299***	-0.092	-0.094	-0.100*
	(0.056)	(0.065)	(0.065)	(0.060)
DXPRF	-0.096***	-0.016	-0.017	-0.017
	(0.031)	(0.026)	(0.026)	(0.025)
iXPRF	-0.148***	-0.040	-0.041	-0.041
	(0.050)	(0.041)	(0.041)	(0.041)
Xtrend		-0.002***		
		(0.001)		
iXtrend		-0.002**		
		(0.001)		
Observations	19807341	19807341	19807341	19807341
Pseudo R^2	0.978	0.978	0.979	0.979
Origin-destination-product FE	Y	Y	Y	Y
Destination-roduct-time FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-dest

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

only from European Union member states but also from non-member countries. In terms of magnitude, the coefficients in Column (4) suggest that the TCA reduced UK imports from the EU by approximately 22.6%, a figure that is quantitatively similar to our estimates of its impact on exports.

We perform a series of robustness checks to ensure that our results are not driven by any particular choice of the sample. In particular, we first re-estimate our baseline results using all the countries in our sample and not just the ones classified as developed by the IMF. Second, we exclude 2022 from our sample to check that our results are not affected by the COVID-19 outbreak. The results of these alternative specifications are reported in Tables B.3 and B.4 in the appendix, where we can see that the estimated effect is in the same range as our baseline specification.

We also re-estimate our main specification using alternative data to build our starting sample. In particular, we use import-reported flows rather than export-reported flows. We do this to ensure that our results are not driven by some differences in how the flows are reported by countries. The results of this alternative sample are illustrated in Tables B.5 and B.6 in the appendix. We can see that the impact seems to be qualitatively similar; however, it seems slightly bigger in magnitude, though we note the potential methodological issues associated with using EU data for imports from the UK discussed above.

Table 4: Estimate Brexit Impact on UK Imports

	(1) No Trend	(2) UK Trend	(3) All Bloc Trend	(4) All Pair trends
DMTCA	-0.386***	-0.257***	-0.257***	-0.256***
	(0.032)	(0.058)	(0.058)	(0.059)
iMTCA	-0.202***	-0.163***	-0.166***	-0.149**
	(0.049)	(0.060)	(0.060)	(0.059)
DMPRF	-0.130***	-0.063**	-0.064**	-0.064**
	(0.020)	(0.027)	(0.027)	(0.027)
iMPRF	-0.103***	-0.082*	-0.089*	-0.058
	(0.035)	(0.047)	(0.047)	(0.041)
Mtrend		-0.001**		
		(0.001)		
iMtrend		-0.000		
		(0.001)		
Observations	18331298	18331298	18331298	18331298
Pseudo R^2	0.981	0.981	0.982	0.982
Origin-destination-product FE	Y	Y	Y	Y
Origin-product-time FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-Dest

Notes: This table reports the estimates of equation (2). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

5.1 Alternative De-trending

Given the importance of trends in understanding the impact of the TCA on the UK-EU trade relationship, in this section we explore alternative approaches to control for the differences between long- and short-run effects of the new agreement.

To do this, we consider two alternative parameterisations of the Brexit effect. First, we include a separate UK-EU trend term, defined over the transition period itself. In the export equation (1), these are equal to the number of months since June 2016 times the value of DXPRF, and the number of months since June 2016 times iXPERF.[28] Similarly, for the import equation (2), equal to the number of months since June 2016 times the value of DMPRF and iMPRF respectively. This captures the idea that the effect during the post-referendum period may have built gradually, rather than (or in addition) to the effect captured by the simple step dummy.

Second, instead of including pair-specific trends estimated within the sample period, we instead estimate pair-specific trends using pre-sample data. Specifically, we estimate a simple gravity equation using the annual BACI data over the period 2008-2012 with the same set of fixed effects and trends as our baseline. We then save the

[28]This means the variable will be zero, for any month outside of the post-referendum period, and for any country pair where the origin is not the UK or the destination is not in the EU

Table 5: Alternative Trends: Estimate Brexit Impact on UK Exports

	(1) Baseline	(2) Transition Trend	(3) Pre-sample detrend
DXTCA	-0.202***	-0.375***	-0.361***
	(0.059)	(0.105)	(0.066)
iXTCA	-0.100*	-0.047	-0.261***
	(0.060)	(0.162)	(0.069)
DXPRF	-0.017	-0.012	-0.109***
	(0.025)	(0.024)	(0.035)
iXPRF	-0.041	-0.043	-0.141**
	(0.041)	(0.040)	(0.056)
DXPRFtrend		-0.003**	
		(0.001)	
iXPRFtrend		0.001	
		(0.002)	
Observations	19807341	19807341	18354438
Pseudo R^2	0.979	0.979	0.976
Origin-destination-product FE	Y	Y	Y
Destination-Product-time FE	Y	Y	Y
Additional trends	Orig-dest	Orig-dest	Pre-sample Orig-dest

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. In column (3), pre-sample trends are construct using Baci data. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

resultant pair-specific trends, and use them to de-trend the monthly data.[29] This allows for underlying pair-specific trends, but does so in a way which doesn't rely on any "in sample" data for the de-trending. This has the potential advantage of mitigating the potential that Brexit has causal effects prior to implementation - i.e. trends are estimated before the referendum is even announced, so are not contaminated by any anticipation effects arising from agents after the referendum as agents foresee a rise in trade costs, which then affects trade flows ahead of the actual change in trade arrangements.

The results of these estimations are shown alongside our baseline results and are reported in Table 6.

What the coefficients imply for the effect of the TCA is a little more complicated. For (1) and (3) the effect of shifting from the post referendum period to the TCA is given by the difference between DXTCA and iXTCA: $e^{(\beta_{DXTCA}-\beta_{DXTCA})}$. But for column (2), that same effect is given by the difference between DXTCA and the combined effect of DXPRF and the Xtrantrend, allowing for the fact that at the point of the TCA coming

[29] Formally, take the estimated pair specific trend, divide it by 12, to reflect the fact we are going from annual to monthly data, and then include this as regressor with the coefficient constrained to one, using STATA's offset command; and this takes the place of the within-sample pair specific trends

Table 6: Alternative Trends: Estimate Brexit Impact on UK Imports

	(1) Baseline	(2) Transition Trend	(3) Pre-sample detrend
DMTCA	-0.256***	-0.598***	-0.391***
	(0.059)	(0.076)	(0.044)
iMTCA	-0.149**	-0.226**	0.059
	(0.059)	(0.105)	(0.068)
DMPRF	-0.064**	-0.054**	-0.179***
	(0.027)	(0.021)	(0.028)
iMPRF	-0.058	-0.055	0.046
	(0.041)	(0.041)	(0.040)
DMPRFtrend		-0.007***	
		(0.001)	
iMPRFtrend		-0.001	
		(0.001)	
Observations	18331298	18331128	16908756
Pseudo R^2	0.982	0.982	0.978
Origin-destination-product FE	Y	Y	Y
Origin-product-time FE	Y	Y	Y
Additional trends	-	Orig-EU Orig-RoW	Pre-sample Orig-dest

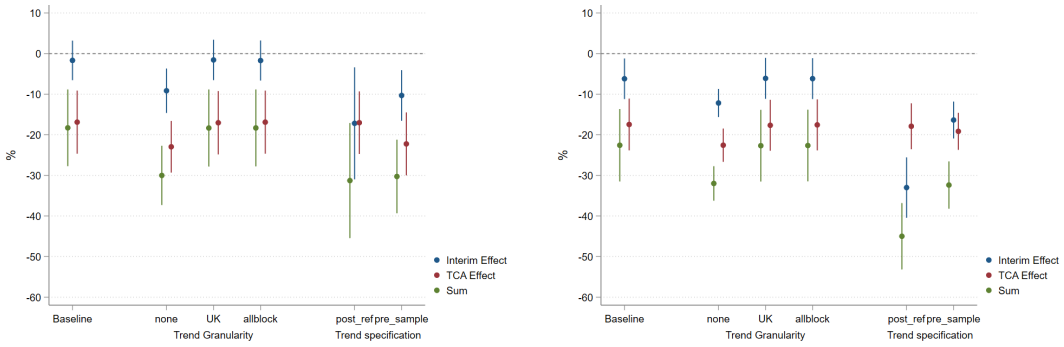
Notes: This table reports the estimates of equation (2). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export.In column (3) pre-sample trends are construct using Baci data. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

in, there had been 54 months' worth of the trend term. Thus the effect is given by: $e^{(\beta_{DXTCA} - \beta_{DXTCA} + 48 * \beta DXPRFtrend)} - 1$.

Chart 3 below plots point estimates and 95% confidence intervals for the TCA effects described above (red), the "long-run" effects (green), given by the TCA term, and the effect of the interim period, post-referendum but before the TCA (blue), which is the difference between the red and the green dots.

In our baseline case, the coefficients imply that the effect of moving to the TCA from the post-referendum period lowered UK exports to the EU by -16.6%. The effect during the post-reflection period was about -3% (albeit statistically insignificant). Looking across the other specifications, the blue dots appear to have roughly similar values - i.e., the effect is fairly robust to the granularity and parametrisation of time trends in all cases. By contrast, the estimates of the long-run effect (the red dots) vary more substantially. This variation is driven by quite wide variation in estimates of "interim effect" - i.e. what happened during the post-referendum period (the blue dots). In our baseline case, this effect is around 3%. In the post-referendum trend case , this effect is over 20%. This makes the point that estimates of the long-run effect (i.e. comparing trade after the TCA with its pre-referendum level) are sensitive to the assumptions about trends used. In particular, when a post-referendum trend is included, the

Figure 3: Estimation of the impact of the TCA using Different Trends



(a) UK Exports to EU members (b) UK imports from non-EU members

Notes: Point estimates and 95% confidence intervals for the "Interim" effects described above (blue), the TCA effects (red), and the effect of the post-referendum period (green) which is the difference between the two.

trending down of UK exports in this period is partly attributed to the post-referendum trend and is hence "booked" to Brexit. By contrast, in our baseline, the trend operates throughout the whole sample period, and hence any trend decline is attributed to the secular trend, and hence doesn't show up as an effect of Brexit. In terms of exports to non-EU countries, once a trend of some form is included, the short- and long-run effects mostly appear to be insignificant.

On the import side, we report the equivalent regression result and plot the equivalent charts. Again, a similar story to the export side holds for imports. The short-run effects are relatively robust to the different specifications of trends. Our baseline estimate puts the short-run effect at -18.2%, with a statistically insignificant effect from the post-referendum period. All other specifications with a trend yield very similar estimates. Again, there is much greater variation in estimates of the longer-run effect, which are again driven by large dispersion in estimates of the post-referendum period.

Our estimates for the TCA impact are broadly similar to those of Kren and Lawless (2024) which find comparable estimates of the impact of the TCA around 20% in both directions. Their preferred specification compares UK exports into (imports from) the EU with those from the rest of the world and is equivalent to equation (1) in tables 3 /4, without the of our $iXTCA$ or $iMTCA$ terms which they are not able to estimate because they lack data for non-UK exports to non-EU destinations. Our results suggest that their difference in results across specifications is driven in significant part by the choice of counterfactual.

Their equivalent estimate of the long run effect is similar to ours in (1) but we find the inclusion of trend in our preferred specification lowers the size of the long-run effect. More generally, we establish the robustness of the short run effect to a variety of different de-trending approaches, and highlight the estimates of longer run effects are quite sensitive to the trend treatment chosen.

Freeman et al. (2022), again without allowing for time trends, also finds similar numbers when looking at the change in UK imports from the EU but no effect on UK exports. Our results suggest an explanation - namely that in the absence of time trends, the coefficients on EU vs non-EU countries are very similar in size for exports, and so the identification based on the relative size of the two will lead to estimates close to zero. Another paper Freeman et al. (2025), using firm-level data, finds that the TCA caused a drop in exports towards the EU of around 13% while imports declined by only 3%. Our export numbers are slightly larger, but the import numbers are more different, though we note here that this paper uses a different methodology so is less easily comparable.

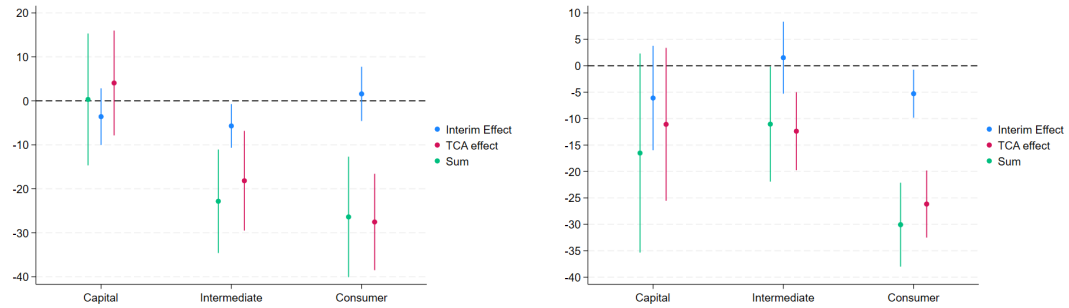
If we look at the literature that tried to estimate the impact of the TCA before the TCA entered in place, our estimates are generally lower than those earlier studies which sought to estimate the effect by looking at the effects of EU membership on trade. For example Dhingra and Sampson (2022) estimated a TCA type agreement would lead to "roughly one-third decline" in trade, which is approaching double the effect we find. Similarly, the size of our estimated effects on UK-EU trade is smaller than those of Ebell et al. (2016). More broadly, our results are in line with the finding of Novy et al. (2024) that using post-Brexit data tends to find lower estimates than studies conducted pre-referendum. A possible explanation for this may be the time-varying trade elasticity. Several empirical papers have found that the reaction of trade flows to a change in trading arrangements increases over time as the effect builds (Boehm et al., 2023; Anderson and Yotov, 2023; Chen et al., 2024). Viewed in this light, our results can be thought of as an estimate of the short-run effect, as there are only a few years of data post TCA. By contrast, the pre-referendum papers, utilising many more years of data after the change in trading arrangements (e.g. EU accession) used to estimate the effect, are capturing a longer-run effect.

5.2 Results by product type

We now take our baseline specification and explore potential heterogeneity at the product level.

A common way to categorize products is the Broad Economic Classification (BEC), which splits goods based on their main final use. It is composed of three categories: capital, consumption, and intermediates. We assign each HS-6 digit product code into one of these three groups. For each group, we retain only the flows which are in that group and sum at the HS2 level. This yields three separate datasets at the HS2 level: one for capital goods, one for intermediate goods, and one for consumer goods. Note that within a given HS2 category, it's possible for some HS6 products to be capital, some to be intermediate, and some to be consumer goods. Therefore, that HS2 cate-

Figure 4: Estimation of the impact of the TCA by BEC



(a) UK Exports to EU members

(b) UK imports from EU

Notes: Effect of the TCA by Broad Economic Classification. The plot reports point estimates and 95% confidence intervals for the "Interim" effects described above (blue), the TCA effects (red), and the effect of the post-referendum period (green) which is the difference between the two.

gory is not assigned to just one of the groups; rather, that HS2 category would then appear in all three regressions. For example, within HS-2 digit code 73 "Articles of Iron and Steel", there is 730890, "Structures and parts of structures" classified as capital; 731815 "Screws and bolts", classified as intermediate; and 732310 "Iron or steel wool, pot scourers and scouring or polishing pads, gloves and like" classified as consumer.[30]

We then run the same regressions as before, for each of the three sub-samples. We use our preferred specification from the previous section (i.e., the one from the final column of the lowermost panel with no dummy for the post-referendum period), and we include the estimation results across all goods for reference.

The results for the key parameters of interest for UK-EU trade flows in both directions are shown below in graphical form.[31]

Across both directions, the results tell a fairly similar and symmetric story. There is no statistically significant effect on capital goods flows in either direction from the introduction of the TCA. But there is an effect on intermediate goods, similar to the baseline estimate for all goods (around 12% for exports, and 18% for imports), and the largest fall of all (around 25%) is for consumer goods. We note that a similar story also holds for longer-term effects (red dots).

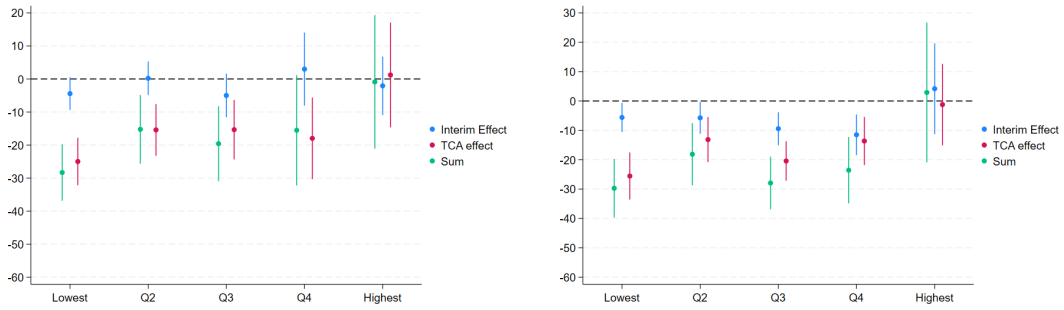
This could reflect the effects of Brexit on supply chains, reducing UK exports to non-EU countries as imported inputs from the EU become subject to higher trade barriers. Higher non-tariff barriers, such as additional certificates, may discourage trade in consumption goods such as fresh products, which explains why we find the largest drop in that category.

This finding differs from earlier work on the impact of free trade agreements, which

[30]This means that the sum of observations across the three need not add up to the number of observations in the "all" regression.

[31]See Tables B.7 and B.8 for the full set of results.

Figure 5: Estimation of the impact of the TCA by Elasticity



(a) UK Exports to EU members

(b) UK imports from EU

Notes: Effect of the log-elasticity bins based on the estimates by Fontagné et al. (2022). The plot reports point estimates and 95% confidence intervals for the "Interim" effects described above (blue), the TCA effects (red), and the effect of the post-referendum period (green) which is the difference between the two.

has typically found the biggest effect on intermediate (Miroudot et al., 2009). Economic integration has boosted trade in intermediate goods the most (Baldwin, 2006), and these effects are larger for proximate trade partners (Freeman and Pienknagura, 2019).

5.3 Results by trade elasticity

We then explore how the effects might vary with the trade elasticity. Taking the canonical estimates of HS6 product-level trade elasticities from Fontagné et al. (2022), we again split our sample into 5 groups based on the trade elasticity's value of each product. To do this, we rank the HS6 sectors by elasticity, then divide them into 5 equal-sized buckets, which we denote "Lowest", "Q2", "Q3','Q4", and "Highest". As before, for each bucket in turn, we retain only the HS6 codes in that bucket, aggregate at the HS2 level, to yield an HS2-level dataset consisting of trade flows only of goods in that given bucket.

Beginning with exports, Figure 5 Panel (a) shows the coefficient on $DXTCA$ across bins. There seems to be no particular relation between the elasticity bin and the associated hit, with the product category that suffered the most being goods with the lowest trade elasticity (column 1). Strikingly, the goods with the lowest elasticity have had the largest response, and vice versa.[32]

Similarly, for imports, Figure 5 Panel (b) shows that low elasticity goods have the largest coefficient, while for high elasticity goods the effect is insignificant - also the "wrong" way round.

This suggests that the estimated trade elasticities - based on variation in tariff barriers - are not a good predictor for the size of the effect that Brexit had on a given goods type. Because the effect of Brexit on raising EU-UK trade barriers worked entirely on

[32]See Tables B.9 and B.10 for the full set of results.

the non-tariff side, this suggests that estimates of the trade elasticity which use tariff variation are not necessarily a good guide to the effect of non-tariff barriers. This result is consistent with Kehoe (2005), which found that estimated trade elasticities at the goods level were poor predictors of the effects of NAFTA at the goods level.

6 Conclusions

In this study we look at the impact of the Trade and Cooperation Agreement on trade flows between the United Kingdom and the European Union. Our main contribution is to show the importance of taking into account long-term trends and to provide evidence on the heterogeneous impact by product characteristics.

Allowing for trends, as suggested by Bergstrand et al. (2015), is consistent with the heterogeneity in pair-specific trade flows over time and fits the stylized fact of the decline in UK export share over time. Following this recommendation we find that the treatment of trends does have important consequences for estimation results, and shows that the point made by Berger and Nitsch (2008) and Bun and Klaassen (2007) about the importance of allowing for time trends when considering the effects of economic integration agreements also appears to apply in cases where trade barriers increase.

Estimating the Brexit effect associated with leaving EU membership arrangements in 2020 and moving to TCA terms, we find that the effect on trade was broadly symmetric: at around 17% on UK exports to the EU and 18% for imports from the EU to the UK. This holds across a variety of ways of allowing for trends in cross-country trade patterns.

But there is considerable heterogeneity across those in terms of how they understand the fall in UK-EU trade during the post-referendum period, when the UK was still trading under the same arrangements as an EU member. This in turn implies a similar heterogeneity in the "longer term" Brexit effects - i.e. those which compare the pre-referendum period with the post TCA period. This suggests caution should be applied to estimates of longer run effects, because of the sensitivity to the treatment of trends in estimates of what happened during interim period.

Our estimates of the TCA effect on impact are somewhat lower than those typically found in pre-referendum work. Given that our estimates only refer to the short-run effects, we see them as a lower bound. To the extent that one finds a decline in UK-EU trade during the post-referendum period which can be attributed to Brexit, these would increase the figure.

We also document two important heterogeneities across product types. Splitting the sample by BEC, we find clear evidence of heterogeneity by product type. For capital goods, there is no significant effect on trade; for intermediate goods, there is an

effect in both directions, similar to the overall effect; and the largest effect is on consumer goods, just over double the effect across all goods. Taken together, these results show clear differences across product types, but the relative size of the effect on UK-EU exports across the three is different from the findings elsewhere in the literature, which suggests that elasticities are higher for intermediate goods.

Splitting our sample by trade elasticity, we find that canonical estimates of the trade elasticity based on tariffs do not appear to correlate with variation in the effects of Brexit at the goods level. If anything, products with the lowest tariff-elasticity appear to have been the most affected by Brexit, similar to the finding on product-level effects of NAFTA by Kehoe (2005). This suggests that caution in applying tariff elasticities to assess the effect of changes in non-tariff measures.

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A Data Appendix

Table A.1: List of Countries Used

Country name	Country name
Australia	Luxembourg
Austria	Malaysia
Belgium	Malta
Brazil	Mexico
Bulgaria	Netherlands
Canada	Norway
Chile	Philippines
China	Poland
Croatia	Portugal
Cyprus	Romania
Czech	Russia
Denmark	Saudi Arabia
Estonia	South Korea
Finland	Singapore
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
India	Switzerland
Indonesia	Thailand
Ireland	Turkiye
Italy	United Arab Emirates
Japan	United Kingdom
Latvia	United States of America
Lithuania	Viet Nam

Table A.2: Country coverage by year

Year	Reporter	Partner	Country Missing
2013	47	50	China, UAE, Viet Nam
2014	46	50	China, UAE, Russia, Viet Nam
2015	49	50	China
2016	50	50	–
2017	50	50	–
2018	50	50	–
2019	50	50	–
2020	49	50	UAE
2021	49	50	UAE
2022	48	50	UAE, Russia
2023	47	50	UAE, Russia, Viet Nam

Notes: Data taken from the UN Comtrade database, downloaded in March 2025.

B Additional Results

Table B.3: Impact on Exports: Alternative Samples

	(1) Baseline	(2) All countries	(3) End sample in 2021
DXTCA	-0.202***	-0.224***	-0.201***
	(0.059)	(0.066)	(0.058)
iXTCA	-0.100*	-0.116*	-0.090
	(0.060)	(0.066)	(0.058)
DXPRF	-0.017	-0.031	-0.034
	(0.025)	(0.028)	(0.022)
iXPRF	-0.041	-0.046	-0.020
	(0.041)	(0.043)	(0.038)
Observations	19807341	26241232	16033647
Pseudo R^2	0.979	0.978	0.981
Origin-destination-product FE	Y	Y	Y
Destination-product-time FE	Y	Y	Y
Additional trends	Orig-dest trend	Orig-dest trend	Orig-dest trend

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Column (1) reports our baseline estimates. Column (2) reports the results including emerging economies. In Table (3) the sample ends in 2021. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.4: Impact on Imports: Alternative Samples

	(1) Baseline	(2) All countries	(3) End sample in 2021
DMTCA	-0.256***	-0.261***	-0.277***
	(0.059)	(0.061)	(0.056)
iMTCA	-0.149**	-0.153***	-0.150**
	(0.059)	(0.058)	(0.060)
DMPRF	-0.064**	-0.071**	-0.007
	(0.027)	(0.029)	(0.024)
iMPRF	-0.058	-0.067	-0.071
	(0.041)	(0.041)	(0.045)
Observations	18331298	26198571	14882801
Pseudo R^2	0.982	0.980	0.983
Origin-destination-product FE	Y	Y	Y
Origin-Product-time FE	Y	Y	Y
Additional trends	Orig-dest trend	Orig-dest trend	Orig-dest trend

Notes: This table reports the estimates of equation (2). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Column (1) reports our baseline estimates. Column (2) reports the results including emerging economies. In Table (3) the sample ends in 2021. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.5: Impact on Exports: Import-reported data

	(1) No Trend	(2) UK Trend	(3) All Bloc Trend	(4) All Pair trends
DXTCA	-0.369***	-0.267***	-0.266***	-0.265***
	(0.032)	(0.060)	(0.060)	(0.061)
iXTCA	-0.207***	-0.157***	-0.160***	-0.146**
	(0.049)	(0.060)	(0.059)	(0.059)
DMPRF	-0.123***	-0.070**	-0.072**	-0.072**
	(0.020)	(0.029)	(0.029)	(0.028)
iMPRF	-0.102***	-0.075	-0.084*	-0.060
	(0.035)	(0.046)	(0.046)	(0.041)
Xtrend		-0.001*		
		(0.001)		
iXtrend		-0.001		
		(0.001)		
Observations	19393215	19393215	19393215	19393215
Pseudo R^2	0.980	0.980	0.981	0.982
Origin-destination-product FE	Y	Y	Y	Y
Origin-product-date FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-Dest

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.6: Impact on Imports: Import-reported data

	(1) No Trend	(2) UK Trend	(3) All Bloc Trend	(4) All Pair trends
DMTCA	-0.357***	-0.203***	-0.202***	-0.202***
	(0.053)	(0.059)	(0.059)	(0.059)
iMTCA	-0.299***	-0.092	-0.094	-0.100*
	(0.056)	(0.065)	(0.065)	(0.060)
DMPRF	-0.096***	-0.016	-0.017	-0.017
	(0.031)	(0.026)	(0.026)	(0.025)
iMPRF	-0.148***	-0.040	-0.041	-0.041
	(0.050)	(0.041)	(0.041)	(0.041)
Mtrend		-0.002***		
		(0.001)		
iMtrend		-0.002**		
		(0.001)		
Observations	19807341	19807341	19807341	19807341
Pseudo R^2	0.978	0.978	0.979	0.979
Origin-destination-product FE	Y	Y	Y	Y
Origin-product-date FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-Dest

Notes: This table reports the estimates of equation (2). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.7: Impact by BEC: Export

	(1) Capital	(2) Intermediate	(3) Consumption
DXTCA	-0.004	-0.289***	-0.258***
	(0.079)	(0.105)	(0.080)
iXTCA	-0.191***	-0.358***	-0.157**
	(0.070)	(0.091)	(0.062)
DXPRF	-0.033	0.052	-0.063**
	(0.036)	(0.038)	(0.030)
iXPRF	-0.134***	-0.204**	-0.040
	(0.045)	(0.084)	(0.044)
Observations	3,216,874	13281908	16116717
Pseudo R^2	0.966	0.975	0.979
Origin-destination-product FE	Y	Y	Y
Origin-product-date FE	Y	Y	Y
Additional trends	Orig-dest	Orig-dest	Orig-dest

Notes: This table reports the estimates of equation (1) by Broad Economic Categories. The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.8: Impact by BEC: Imports

	(1) Capital	(2) Intermediate	(3) Consumption
DMTCA	-0.206*	-0.371***	-0.144**
	(0.121)	(0.061)	(0.065)
iMTCA	-0.150**	-0.166**	-0.084
	(0.075)	(0.065)	(0.094)
DMPRF	-0.097*	-0.074***	-0.020
	(0.055)	(0.027)	(0.035)
iMPRF	-0.024	-0.072***	-0.049
	(0.058)	(0.027)	(0.072)
Observations	2,927,376	12282971	14839087
Pseudo R^2	0.975	0.983	0.979
Origin-destination-product FE	Y	Y	Y
Origin-product-date FE	Y	Y	Y
Additional trends	Orig-dest	Orig-dest	Orig-dest

Notes: This table reports the estimates of equation (2) by Broad Economic Categories. The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.9: Impact by Elasticity: Export

	(1) Low	(2) Medium-low	(3) Medium	(4) Medium-high	(5) High
DXTCA	-0.333***	-0.165***	-0.218***	-0.169*	-0.009
	(0.061)	(0.063)	(0.072)	(0.101)	(0.104)
iXTCA	-0.159**	-0.139***	-0.106	-0.304***	-0.197*
	(0.066)	(0.045)	(0.077)	(0.102)	(0.103)
DXPRF	-0.045*	0.002	-0.051	0.029	-0.021
	(0.026)	(0.026)	(0.035)	(0.055)	(0.046)
iXPRF	-0.093**	-0.097***	-0.032	-0.057	-0.135**
	(0.037)	(0.031)	(0.088)	(0.068)	(0.069)
Observations	13856685	14920069	13390922	12846777	8,455,349
Pseudo R^2	0.977	0.974	0.981	0.960	0.971
Origin-destination-product FE	Y	Y	Y	Y	Y
Origin-product-date FE	Y	Y	Y	Y	Y
Additional trends	Orig-dest	Orig-dest	Orig-dest	Orig-dest	Orig-dest

Notes: This table reports the estimates of equation (1) by elasticity quantiles based on Fontagné et al. (2022). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table B.10: Impact by Elasticity: Imports

	(1) Low	(2) Medium-low	(3) Medium	(4) Medium-high	(5) High
DMTCA	-0.353***	-0.200***	-0.328***	-0.269***	0.029
	(0.072)	(0.066)	(0.063)	(0.075)	(0.118)
iMTCA	-0.214***	-0.163*	-0.236***	-0.096	0.052
	(0.068)	(0.097)	(0.063)	(0.161)	(0.132)
DMPRF	-0.058**	-0.059**	-0.099***	-0.122***	0.041
	(0.027)	(0.029)	(0.032)	(0.040)	(0.076)
iMPRF	-0.087***	-0.066	-0.108**	-0.025	-0.041
	(0.033)	(0.063)	(0.044)	(0.124)	(0.102)
Observations	12743950	13646796	12295217	11671289	7,657,771
Pseudo R^2	0.983	0.977	0.985	0.966	0.968
Origin-destination-product FE	Y	Y	Y	Y	Y
Origin-product-date FE	Y	Y	Y	Y	Y
Additional trends	Orig-dest	Orig-dest	Orig-dest	Orig-dest	Orig-dest

Notes: This table reports the estimates of equation (2) by elasticity quantiles based on Fontagné et al. (2022). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as import. Standard errors in parentheses clustered at the pair, product and time level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

C Alternative Calculation of Standard Errors

Table C.11: Estimate Brexit Impact on UK Exports

	(1)	(2)	(3)	(4)
	No Trend	UK Trend	All Bloc Trend	All Pair trends
DXTCA	-0.044	-0.203***	-0.202***	-0.202***
	(0.045)	(0.043)	(0.043)	(0.043)
iXTCA	-0.172**	-0.092	-0.094	-0.100*
	(0.069)	(0.058)	(0.058)	(0.054)
DXPRF	-0.039*	-0.016	-0.017	-0.017
	(0.023)	(0.021)	(0.020)	(0.020)
iXPRF	-0.128**	-0.040	-0.041	-0.041
	(0.062)	(0.038)	(0.039)	(0.039)
Xtrend		-0.002***		
		(0.000)		
iXtrend		-0.002**		
		(0.001)		
Observations	19816120	19807341	19807341	19807341
Pseudo R^2	0.965	0.978	0.979	0.979
Origin-destination-product FE	Y	Y	Y	Y
Destination-roduct-time FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-dest

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Standard errors in parentheses clustered at the pair and product level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table C.12: Estimate Brexit Impact on UK Exports

	(1)	(2)	(3)	(4)
	No Trend	UK Trend	All Bloc Trend	All Pair trends
dM_DTCA	-0.386***	-0.257***	-0.257***	-0.256***
	(0.030)	(0.038)	(0.038)	(0.038)
iM_DTCA	-0.202***	-0.163***	-0.166***	-0.149***
	(0.049)	(0.054)	(0.054)	(0.053)
dM_DTRN	-0.130***	-0.063***	-0.064***	-0.064***
	(0.017)	(0.018)	(0.018)	(0.017)
iM_DTRN	-0.103***	-0.082*	-0.089**	-0.058
	(0.034)	(0.044)	(0.044)	(0.039)
Mtrend		-0.001***		
		(0.000)		
iMtrend		-0.000		
		(0.001)		
Observations	18331298	18331298	18331298	18331298
Pseudo R^2	0.981	0.981	0.982	0.982
Origin-destination-product FE	Y	Y	Y	Y
Origin-product-time FE	Y	Y	Y	Y
Additional trends	-	-	Orig-EU Orig-RoW	Orig-Dest

Notes: This table reports the estimates of equation (1). The dependent variable is the trade flow between an origin o a destination d in sector h in month t. Sectors are defined a 2-digit (HS2) product codes. Source UN Comtrade trade flows 2013-2023 reported as export. Standard errors in parentheses clustered at the pair and product level. All columns are estimated via PPML. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.