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The effects of leaving the EU on UK trade

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Abstract

This paper investigates the effect of the 2016 Brexit referendum and the Trade and Cooperation Agreement (TCA) signed by the UK and the EU in December 2020 on UK-EU trade in goods up to December 2021. The 2016 referendum introduced uncertainty, but new trade barriers between the UK and the EU were not put in place until the new agreement, the TCA, entered into force in January 2021. Using a set of different econometric techniques, and looking up to the end of the first year of the implementation of the TCA, we find no evidence that the 2016 referendum had any impact on aggregate UK-EU trade. On the other hand, our results show that the TCA reduced UK trade with the EU, but differentially for exports and imports. After a sharp drop of around 40% in January 2021, UK exports to the EU quickly recovered in the following months. This pattern of recovery was not the case for UK imports from the EU, which were negatively impacted throughout of 2021, with a cumulative loss over the first year of implementation between -24% and -27%. We find evidence that a plausible explanation for these differential effects is the relative importance of the EU market for UK firms, in comparison to the importance of the UK market for EU firms.

1 Introduction

In January 2021, after a last-minute deal on Christmas Eve 2020, the UK and the EU entered into new trade arrangements governed by the Trade and Cooperation Agreement (TCA). While the TCA maintains tariff- free trade between the two signatory parties, leaving the EU's Single Market resulted in the introduction of a range of non-tariff barriers, ranging from customs procedures to regulatory barriers. These serve to increase the costs of bilateral UK-EU trade. The fact that the agreement was signed at the very last minute also meant that there was uncertainty for firms on both sides of the channel prior to January 2021 as to the conditions under which trade with the EU would occur. The uncertainty started immediately after the referendum in June 2016 (if not before), and then fluctuated depending on the state of play of the negotiations. January 2021 saw the introduction of the new trading arrangements and asymmetric customs formalities between the UK and the EU.

In this paper we assess the impact of the 2016 Brexit referendum itself and the introduction of the TCA on trade between the UK and the 27 EU member states with monthly data up to December 2021. Estimation of the impacts of the TCA effect is made challenging by two concurring issues: the Covid-19 pandemic which disrupted economies, and the sharp rise in shipping cost – which are also in large part a consequence of Covid-19.[1] Similarly, the analysis of the effect of the referendum might be affected by other confounders. In order

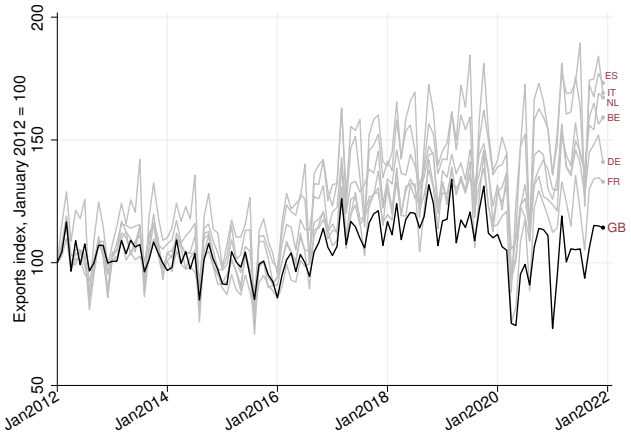
[1]There is a third issue which concerns changes in the way trade flows are recorded from January 2021. See Gasiorek and Tamberi 2021 for an extensive discussion of data concerns.

to isolate the impact of the referendum and of the TCA from other forces we apply a series of econometric techniques, which are difference-in-differences (DD), triple difference (DDD) and synthetic control.

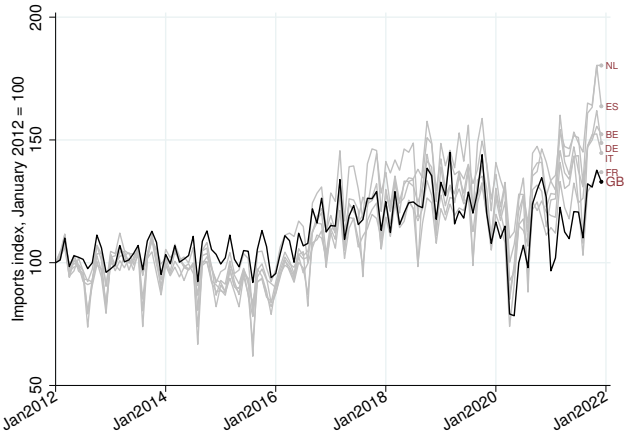
Before we turn to the formal analysis of data, Figure 1 shows the evolution of trade excluding gold of the UK and the other major EU countries with the EU, OECD and BRICS.[2] We can immediately see that, while prior to 2021 UK trade followed a very similar trajectory to those of the other major EU members, in 2021 UK trade has underperformed compared to these other countries. The same is true for UK GDP. Figure 2 plots the quarterly GDP volume index (2015=100) for all OECD countries. Among the OECD countries, the UK is the one that suffered the most when the pandemic hit in 2020q1. Moreover, by 2021q3 UK's GDP had not recovered to pre-pandemic levels and only four OECD countries performed worse than the UK at this stage. With respect to goods trade, we will see that a large part of the UK's under-performance is attributable to trade with the EU, which dropped significantly with the introduction of the TCA and accounts for a large share of total UK trade in goods, and this is particularly true for imports.

Figure 1: Trade of the UK and major EU countries, Jan2012-Dec2021

(a) Exports to EU, OECD and BRICS ex. gold



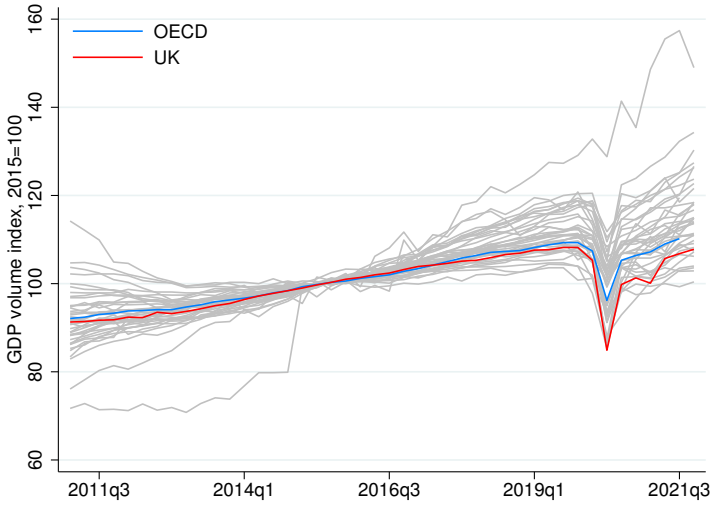
(b) Imports from EU, OECD and BRICS ex. gold



Source: authors' elaboration of HRMC and Eurostat data. UK trade data are taken from HMRC trade statistics, while trade data of EU member states come from the Eurostat Comext database.

[2]We exclude gold, as trade in gold can fluctuate substantially on a month-to-month basis and thus impact on the aggregate figures.

Figure 2: GDP volume index for OECD countries, 2015=100



Source: authors' elaboration of OECD data.

Coming to a description of the methods used in this paper, in the difference-in-differences (DD) exercise we compare UK-EU trade with UK trade with a suitable control group, which is composed of non-EU OECD countries plus BRICS.[3] In this setting, our assumption is that in absence of the referendum or the TCA, UK trade with the EU would have followed the same trajectory as UK trade with the control group. In the estimation of the TCA effect, the DD allows us to control for the evolution of Covid-19 in the UK and how it may have impacted on trade with different partners. For robustness we also control for the evolution of the pandemic in other countries including as variables the number of Covid-19 cases and deaths in each trade partner. For the triple difference estimation (DDD) we also include information about EU trade with itself and with the countries in the control group. In this way we are able to control for factors which are specific to each country and period, such as the evolution of Covid-19, implementation of lock-downs and any economic shock that affected a country in a particular period. Finally, we also recognise the possibility that not all countries in the control group may be a good comparison unit for UK-EU trade. For instance, Germany-France trade might be a better counterfactual for Germany-UK than say US-Mexico. We therefore use the Synthetic Control (SC) method, which selects as control units the subset of countries which represent the best match for UK-EU (details below).

The results appear very stable across the different methodologies. We do not find any consistent evidence that the 2016 referendum had a sizeable impact on aggregate UK-EU trade, neither for exports nor for imports. On the other hand, we find strong negative effects of the TCA on UK-EU trade, in particular for UK imports from the EU. The results show that UK exports to the EU were strongly affected in January (between -40.1% and -42.6%) but quickly recovered thereafter, suggesting that this sharp drop was mainly driven by the lack of time firms had to prepare for the eventual agreement. Over the period January-December 2021, the cumulative effect on exports was between -4.5% and -12.9%, hardly statistically significant. However, while this is true in aggregate, we also find that some sectors have been strongly affected over the entire period, in

[3]From this control group we also exclude Canada and Japan as they entered into FTA with the EU over the considered period.

particular Textile & Clothing and Footwear. On the other hand, we find that UK imports from the EU were consistently affected in all the months of 2021, with a cumulative effect of -24% to -27% over January-December 2021. Moreover, we find some evidence of anticipatory effects on UK imports from the EU, which started to decline a few months before the implementation of the TCA. The differences across sectors for imports are modest compared to those found with regard to exports. The results on imports are perhaps, *prima facie*, surprising given that the UK waived most of the border checks on imports from the EU, while EU members immediately began enforcing checks on UK goods.[4] Given that the EU is a larger market for UK exports than the UK is for EU exports, we ask whether relative market sizes might be a driver of the different results for exports and imports. We test this using a two-step approach involving the estimation TCA effects for each HS section and EU27 member. Our empirical test fails to reject the market size hypothesis, providing evidence in support of the idea that the differential results between exports and imports can be explained by relative market sizes.

1.1 Policy background

As an EU member state the UK was part of the EU's Customs Union and part of the EU Single Market. The Single Market applies to countries in the European Economic Area (EEA), which includes the EU as well as Iceland, Liechtenstein and Norway. Leaving the EU entailed a departure from each of these for the UK, but differentially for Great Britain and for Northern Ireland. Hence, Great Britain left both the Customs Union and the Single Market. In contrast Northern Ireland remains in the EU's Single Market for goods, but not for services, and while not part of the Customs Union remains part of the EU's common customs territory. The departure from the CU and the SM have impacted on the degree of market access between the UK and the EU (and the UK and third countries) in different ways. The changes in market access and the increase in firms' costs thus involves a combination of tariff barriers, administrative barriers, and regulatory barriers.

Departure from the Customs Union means that the UK is free to set its own most favoured nation (MFN) tariffs on imported goods and is able to sign free trade agreements with third countries. The UK's MFN tariff was established in May 2020, and is commonly referred to as the UK Global Tariff (UKGT). To date the UK has also managed to sign new free trade agreements with the EU (2021), Japan (2020), Australia (2022) and New Zealand (2022). The UK has also signed a series of 'continuity agreements' with those countries which have a free trade agreement with the EU and consequently as did the UK when it was a member of the EU. The aim of the continuity agreements is to replicate as closely as possible the previous arrangements.

The agreement with the EU in principle abolishes all tariffs on trade between the UK and the EU. 'In principle' is highlighted here because importantly tariff free trade only applies to goods which originate in the UK and the EU respectively, and which can be shown to originate. In order for a good to be deemed as originating there has to be sufficient economic activity undertaken in the originating country (either the UK or the EU), and there are complex 'rules of origin' for each product detailing the minimum origin requirements. In exporting to the EU, therefore, if a given UK firm wants tariff free access it is required to be able to prove that the good is eligible for duty free access. In order to reduce the barriers to market access the TCA allowed for either self-certification of origin by the exporter, or self-certification by the importer. In addition and for the first 12 months the TCA did not require firms to provide the supporting documentation at the time of import, though that documentation for each flow could be subsequently demanded. All of this serves to

[4] While the EU imposed full customs controls on UK exports to the EU, in contrast the UK decided to delay the introduction of full customs controls until later in the year. In the event, those dates also were moved and the UK introduced full customs controls from January 2022, with a further staging of controls and inspections for food and animal products till mid-2022, and later for some products.

increase market access costs for firms because of the greater need to track their supply chain in order to know whether or not they are eligible for preferential access, as well as the administrative and bureaucratic costs of providing the necessary certificates of origin, and of ensuring they have the required documentation for verification of this. The current evidence on the extent to which UK firms' are exporting using the preferential zero tariff rates, suggests that over the first year of the TCA on average the preference utilisation rate was only 76%, and in some sectors such as leather goods (HS 41-13) as low as 33%.[5]

Leaving aside the rules of origin issue, all goods traded between the UK and the EU now face customs formalities and potentially customs checks where previously this had not been the case, such as the completion of import or export declarations. For some goods the customs documentation and procedure may be relatively light, but for others and notably those subject to sanitary and phytosanitary requirements there are a range of procedures. These include, import pre-notifications, health certification (either an Export Health Certificate or Phytosanitary Certificate), documentary, identity and physical checks at the border, and entry into the partner market via a Border Control Post (BCP).

In addition to the preceding the departure of GB, if not Northern Ireland from the EU's Single Market introduces further barriers to bilateral trade.

A key principle of the Single Market is the mutual recognition of goods and services. Mutual recognition in the Single Market means that where rules are not harmonised at the EEA level, EEA Member States must recognise each other's regulations (except where there are specific derogations). Once a product is lawfully placed on the market in one Member State, it can be marketed in another Member State without barriers. A key issue here, however, is not simply with regard to whether or not the UK and the EU have the same standards and whether or not they recognise each other standards, but concerns the arrangements for proving conformity to those standards. In a trade agreement between any pair of countries this could be addressed via an agreement on the mutual recognition of conformity assessment. This would acknowledge the differences between regulatory regimes but permits one party to test and certify that a product complies with the other party's regulations. In the UK-EU TCA here is no chapter on mutual recognition of conformity assessment. There are some sectoral exceptions, and for least sensitive products 'self-certification' is possible, but for the remaining products goods made in the UK for sale in the EU must not only conform to EU standards but they must provide EU-overseen paperwork to prove this conformity. Even where 'self-certification' is allowed, the firm will have to appoint an EU-based representative who will take legal liability if necessary. For goods which require third party certification the testing has to be carried out in the EU by an EU accredited body.

Consider Figure 3 below, which is based on taking all the EU Single Market regulations and directives which impose some form of obligation on firms - be this with regard to product standards, process standards, labelling or marking requirements, or with regard to conformity assessment.[6] For each regulation the HS 6-digit products to which the regulation applies have been identified. At the 6-digit level there are close to 2,000 products for which five or more EU regulations/directives apply. The chart below, then gives the number of regulations that apply at the more aggregate HS 2-digit level. This provides some indication of the degree of regulatory intensity. This ranges from 40 regulations in HS03 (fishing), and 38 regulations in HS84 (machinery and mechanical appliances), to only 1 regulation in HS92 (musical instruments).

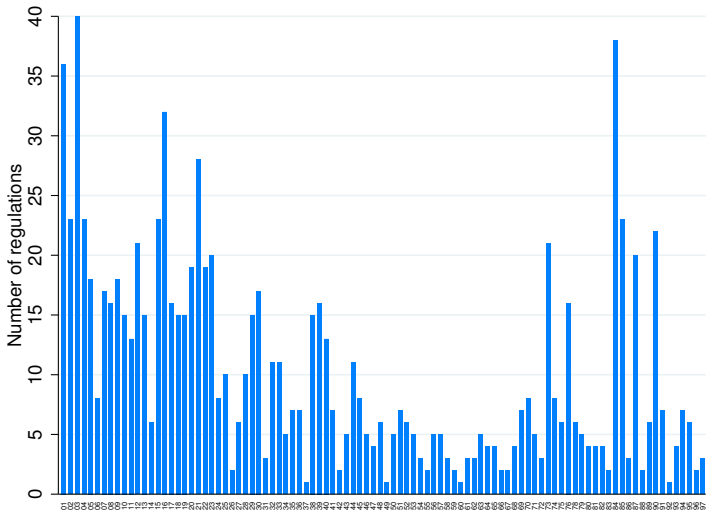
Of course, the presence of a mandatory standard (regulation or directive) does not necessarily entail a

[5] Shares based on EU27 imports from the UK in 2021 under Normal statistical regime. For an overview of preference utilisation across sectors up to July 2021 see Ayele, Larbalestier and Tamberi 2021.

[6] This work derives from an ongoing ESRC funded, Governance After Brexit Project, entitled 'Brexit Uncertainty and the Northern Ireland Protocol: The consequences for Northern Ireland firms and their trade within the UK's Internal Market', led by Professors Gasiorek and Reilly.

barrier to market access. Indeed, being able to produce to a given standard may well facilitate market access. Nevertheless, it is the case that firms exporting to the EU have to conform to these regulations and directives, and have to be able to prove that they conform. The higher the number of regulations that need to be satisfied the more likely it is that the regulatory burden will be higher.

Figure 3: Single Market regulatory intensity: The number of regulations at the HS 2-digit level



Source: authors' calculation.

1.2 Literature review

The departure of the UK from the EU, as a process of trade policy 'disintegration' is a somewhat unprecedented policy change, which thus limits the existing relevant empirical literature. Regarding the possible impact on the UK, there is small literature on the impact of the Brexit referendum on UK-EU trade, mostly focusing on the effect of uncertainty. Crowley, Exton and Han 2018 show that firms' entry into exporting to the EU was reduced in the first six months after the referendum as a consequence of an MFN tariff threat. Graziano, Handley and Limão 2021 use odds from the betting market to track the evolution of the Brexit referendum uncertainty over time, and show that the MFN threat started to affect UK-EU trade even before the referendum of June 2016. Looking at aggregate bilateral trade between the UK and 14 EU member states, Douch and Edwards 2021 apply the synthetic control method and find that UK-EU trade started to decline after the 2015 general election won by the Conservative party.

There are also a series of ex-ante simulation studies that estimate the potential impact of UK exit from the EU under different scenarios. Here we report the results of some of the main ex-ante simulation papers without aiming to a comprehensive literature review on simulated Brexit impacts.[7] In terms of UK-EU trade effects, the static general equilibrium ex-ante modelling of Dhingra et al. 2017 gave a short-run (1 year) reduction by -14% for UK exports to the EU and -13% for UK imports from the EU under soft Brexit scenario,

[7] Many ex-ante simulation focus on GDP and welfare effects, and not all studies report effects on bilateral trade.

and -36% for exports and -34% for imports under WTO scenario (see Table 5 in Dhingra et al. 2017). Steinberg 2019 uses a dynamic general equilibrium model and simulates both the effects of referendum-induced uncertainty and actual exit from the EU on UK macroeconomic variables. The author finds little effects of uncertainty on the UK economy, with negligible effects on trade, but substantial negative effects arising with the actual exit from the EU. Under the soft (hard) Brexit scenario exports to the EU fall by -7.7% (-31.8%) and imports from the EU by -10.4% (-44.1%).[8] Felbermayr, Gröschl and Steininger 2021 use a gravity model on WIOD data to estimate the impact of EU membership and then use those estimates to simulate different Brexit scenarios. In the FTA (WTO) scenario, UK exports to the EU in Manufacturing change by +7.16% (-32.19%) while imports decrease by -4.71% (-30.63%). It is important to recognise that most ex-ante results are based on a mix of increase in tariff and non-tariff barriers. The TCA maintained tariff-free trade – conditional on meeting origin requirement – and mainly increased non-tariff barriers. Hence, the quality of ex-ante studies will depend on the accuracy with which they can measure non-tariff barriers, which are generally difficult to quantify.

Examples of trade disintegration are hard to find. Daigle, DeCarlo and LaRocca 2019 take the period 1949-2019 and identify more than 163 examples of the ending of trade arrangements between countries, most of these relate to countries (especially former Eastern European countries) leaving an agreement either to improve on an existing bilateral agreement, or to join a more liberalized and/or larger trading block. The majority of cases of countries leaving trade agreements without switching to an alternative agreement have occurred in Africa where the circumstances are not comparable to the UK. Other studies of the ending of free trade agreements include Gnutzmann, Gnutzmann-Mkrtchyan and Korn 2021 who explored the impact of Estonia leaving an FTA with Ukraine in order to join the EU using a difference-in-difference framework; Fidrmuc and Fidrmuc 2003, who used a gravity model to assess the consequences of the disintegration of the former Soviet Union, Yugoslavia, and Czechoslovakia on trade flows over the period 1990-98; and De Ménil and Maurel 1994 who also applied the gravity framework to look at the dissolution of the Austrian-Hungarian empire in the period 1924-26. None of these are particularly informative as examples for the consequences of the UK's departure from the EU.

Another instance of trade policy reversion which has been studied more extensively recently was the introduction of tariffs by the US, and particularly the Trump administration. These were either focussed on specific sectors (initially solar panels and washing machines and subsequently steel and aluminium) or on trade with China. In particular from 2018, the US administration imposed significantly higher tariffs on specific products and countries on imported goods worth more than $300 billion. In response, several countries including China, the EU, Canada, Mexico, and Turkey also imposed retaliatory tariffs on their imports from the US. Amiti, Redding and Weinstein 2019 find that the Trump tariffs increase led to substantial increase in the price of final and intermediate goods and a reduction in the number of imported varieties. The authors, in line with research of Cavallo et al. 2021 and Fajgelbaum et al. 2020, find that the increase tariffs has been entirely passed through into domestic prices.

While clearly an example of a trade policy reversal the US example is also a poor proxy for the departure of the UK from the EU. This is for at least two reasons. First, because the shares of trade involved are considerably smaller. As documented by Fajgelbaum et al. 2020 the US tariffs were imposed on 12,043 national 10-digit products covering $303 billion, amounting to 12.7% of annual U.S. imports. The retaliatory tariffs on U.S. exports by its trade partners covered 8,073 export products, worth $127 billion, which amounted to 8.2% of the annual U.S. exports. This is considerably less than the amount of trade between the UK and the

[8] Steinberg 2019 reports results for trade with the EU as a percentage of GDP in Figure 4. We derived the impacts on trade flows dividing the changes of Figure 4 by those for GDP reported in Figure 3 of Steinberg 2019.

EU. In 2020 the share of UK exports going to the EU was 47.5% and the share of imports coming from the EU was 53.2%.

Secondly, the actions of the US administration were focussed on tariffs and on trade in goods. The departure of the UK from the EU came with a tariff free and quota free trade agreement (providing rules of origin can be met), and the rise in barriers was much more to do with customs formalities and behind the border regulatory changes arising from the UK's departure not just from the EU Customs Union, but also from the Single Market. Importantly too, leaving the Single Market increased the barriers to trade in both goods and services. One aspect of that increase in market access barriers relates to the introduction of rules of origin on trade between the UK and the EU. Empirical work on the impacts of rules of origin and cumulation schemes is also relatively scarce. This arises from the complexity of the underlying rules and to the methodological difficulties of isolating the impact. Augier, Gasiorek and Lai-Tong 2004; Augier, Gasiorek and Lai Tong 2005 provide an empirical assessment using the gravity framework of rules of origin in the context of the pan-European system of diagonal cumulation introduced in 1997. They find that reducing the restrictiveness of rules of origin (via the introduction of diagonal cumulation) decreased trade both between the EU's partner countries and those partners' trade with third countries by between 7.4% to 22.1%. In the case of the UK and the EU, the situation is one of introducing rules of origin on bilateral trade, and a reduction in the extent to which both parties can apply diagonal cumulation. Carrère and De Melo 2004 use data on the preference utilization rates of Mexican exports to the USA in 2001 to estimate the costs of different rules of origin for final and intermediate goods. They find that the costs of different rules of origin vary between 2.3% and 4.6% depending on the type of rule of origin and whether or not it is applied to final or intermediate goods. Focusing on the North American Free Trade Agreement (NAFTA), Conconi et al. 2018 match input-output linkages to NAFTA's Rules of Origins and show that the agreement substantially reduced imports of intermediate products from third countries relative to NAFTA signatories. In more recent work Chung and Perroni 2021 assess the impact of rules of origin on competition and prices, based on the 1989 Canada-United States free trade agreement (CUSFTA). They find that stricter content requirements are associated with higher markups and more (inefficient) firm entry that could then hinder pro-competitive effects of trade liberalisation.

2 Econometric method

We use three different methods to measure the impact of the 2016 Brexit referendum and the TCA on UK EU trade. These are difference-in-differences (DD), triple differences (DDD) and synthetic control (SC). The rest of this section describes the methodologies in details.

2.1 Difference in differences

For the DD method we estimate the following equation with Poisson PML:[9]

$$Y_{jt} = \exp\left[\alpha_j + \alpha_t + \beta\left(EU_j \times Post_t\right)\right] + \epsilon_{jt} \tag{1}$$

where Y_{jt} is either UK exports to or imports from partner country j in period t, α_j and α_t are partner and time dummies respectively, EU_j is a dummy that takes value of one if the partner j is an EU member and $Post_t$ is

[9]We use the PPML estimator rather than the OLS on log-linear version of equation (1) because with PPML we can estimate the effect on the average of Y which can than be interpreted as the effect on total trade. On the other hand, with the log-linear OLS we would estimate an average effect across countries. More details can be found in the Appendix.

a dummy that equals one if period t is in the post-treatment period. For the referendum, the pre-treatment period is Jan2012-Jun2016, while for the TCA the pre-treatment is Jan2017-Dec2020. The parameter of interest is β which measures the effect of the referendum or TCA on UK-EU trade relative to UK trade with the control group and it is equivalent to the ratio of ratios $\beta = \frac{\bar{Y}_{EU,Post}}{\bar{Y}_{EU,Pre}} / \frac{\bar{Y}_{control,Post}}{\bar{Y}_{control,Pre}}$, where $\bar{Y}$ indicates the average.

The second DD specification that we use to estimate the TCA effect in each month of the 2021 is:

$$Y_{jt} = \exp\left[\alpha_{j,month} + \alpha_t + \sum_{month} \beta_{month}\left(EU_j \times D^{2021}_{t,month}\right)\right] + \epsilon_{jt} \tag{2}$$

where $\alpha_{j,month}$ now is a dummy for each partner-month (i.e., one for Germany-January, one for Germany-February, ...) and the variables $D^{2021}_{t,month}$ are dummies for each month of 2021. With this setting the coefficients β_{month} measure the TCA effect for each month of 2021 relative to the average of the same month over the period 2017-20 accounting for seasonality (e.g., the β_{Jan} coefficient measures the TCA effect in January 2021 relative to the average of Januaries 2017-20). For the referendum we estimate a similar equation but estimating effects for each half years.[10]

Covid-19 in DD: For the analysis of the TCA we also consider the evolution of the Covid-19 pandemic. The evolution of the pandemic has been different across countries in terms of timing and intensity. In order to control for this in the DD estimation we control for Covid-19 in equations (1) and (2) adding either the (log of) number of Covid-19 cases per capita or the (log of) number of Covid-19 deaths per capita:

$$Y_{jt} = \exp\left[\alpha_j + \alpha_t + \beta\left(EU_j \times Post_t\right) + \gamma \ln Covid19_{jt}\right] + \epsilon_{jt} \tag{3}$$

Since both the number of cases and deaths take value of zero in some periods, we approximate the log with the inverse of the hyperbolic sine transformation $\ln\left[x + \left(x^2+1\right)^{1/2}\right]$. This control becomes redundant in the triple difference as we include partner-time dummies.

2.2 Triple difference

For the triple difference estimation we expand our dataset to include information on trade of each EU member state with other EU members and also EU members trade with countries in the control group. The triple difference equation for the TCA effect is:

$$Y_{ijt} = \exp\left[\alpha_{it} + \alpha_{jt} + \alpha_{ij} + \beta\left(EU_j \times UK_i \times Post_t\right)\right] + \epsilon_{ijt} \tag{4}$$

where Y_{ijt} is trade (exports or imports) of reporter i (UK and EU27) to partner j (EU27, OECD+BRICS) in period t. The cross-section unit is now the country pair ij and α_{it}, α_{jt} and α_{ij} are reporter-time, partner-time and pair dummies, respectively. Finally, EU_j is a dummy that equals one if partner j is an EU member state and UK_i is a dummy that equals one if reporter i is the UK. Strictly speaking, this specification is not the classic triple difference and it is more similar to a gravity model – but it is not either a proper gravity model.[11] The estimation of the TCA effect β in this model is the average of two triple differences: one within reporter, and one within partner. For exports, the within reporter DDD (given by the inclusion of α_{it} dummies) is the

[10] Given that the post-referendum period is relatively long covering Jul2016-Dec2019, half-year estimates are easier to present. In unreported results we also estimated month-specific effects for the post-referendum period.

[11] We do not use a full gravity model because monthly bilateral trade data are not readily available for all countries.

comparison of UK to EU vs UK to control (first difference) before and after 2021 (second difference) with the same quantity for EU to EU vs EU to control (third difference). The second DDD is within partner: EU from UK vs EU from EU (first difference) before and after 2021 (second difference) vs the same quantity for control from UK and from EU (third difference). Moreover, because of the PPML estimator these are not really 'difference in differences' but 'ratio of ratios'. The difference with the gravity model is that gravity includes trade between units in the control group and adds further comparisons such as UK to France vs USA to Mexico.[12] To estimate the DDD model and compute month-specific effects of the TCA we estimate:

$$Y_{ijt} = \exp\left[\alpha_{it} + \alpha_{jt} + \alpha_{ij,month} + \sum_{month} \beta_{month}\left(EU_j \times UK_i \times D^{2021}_{t,month}\right)\right] + \epsilon_{ijt} \tag{5}$$

where $\alpha_{ij,month}$ are pair-month dummies (that is, UK-Germany-January, UK-Germany-February, ..., France-Germany-January etc). Similarly to the DD equation, we estimate half-year post-referendum effects using the triple-difference specification. We acknowledge that some anticipation effects might be occurring in the months preceding the implementation of the TCA. To see how important they are, we also estimate an event study specification (see section 4.4).

As widely reported in the news, the cost of shipping goods around the world increased dramatically in 2021, and these changes might affect our results. To control for the effect of shipping cost we make the assumption that these costs are proportional to the distance between two trading partners and use an interaction of the log of distance with a time-varying measure of shipping cost $Freight_t$ (details on how we measure this variable below). Our assumption here is that the increase in freight costs is proportional to distance between partners, with time variation common across all trading countries. Note that we would not want to include pair-specific trade costs that vary over time because, for UK-EU, this will be endogenous to the introduction of the TCA. A a second specification, since our cost of shipping variable is common across all partners and varies only in time, we then replace the shipping cost variable with time dummies and interact them with the log of distance.

2.3 Synthetic control

The last method that we apply is the synthetic control developed by Abadie and Gardeazabal 2003 and Abadie, Diamond and Hainmueller 2010. The exposition is done from the perspective of the TCA estimation, but we also run the SC for the referendum period. For the synthetic control our dataset is the same as the one used for the DDD estimation. In total there are 27×2=54 treated units: UK exports to each of the 27 EU members and UK imports from each EU member. We run the SC for each treated unit separately, and for each treated unit the donor pool is composed of UK's trade with the control group and the EU member's trade with the control group and other EU members. For instance, if the treated flow is UK exports to Germany the donor pool includes UK exports to control (UK to US, UK to Australia ...), Germany imports from control group (e.g., Germany from US) and Germany imports from other EU members (e.g., Germany from France). In our main specification we match over all pre-TCA values of the outcome variable (July 2016-December 2020), which as discussed in Ferman, Pinto and Possebom 2020 reduces the possibility of specification search with synthetic control. We also run as robustness a specification in which we match over the pre-treatment averages of each month (i.e., average of Januaries, of Februaries...over the period July 2016-Dember 2020).

Inference is based on the on the permutation method. For each treated unit we run the SC for all other 27 EU members so to have 27 placebos. So for UK to Germany the placebos are France to Germany, Italy

[12] A properly specified gravity model also include intra-national trade.

to Germany etc. First, we compute the normalised root mean squared prediction error (RMSPE) for each month of the post-treatment period, where the normalisation is division by the pre-treatment fit as suggested in Abadie, Diamond and Hainmueller 2010; Abadie 2021:

$$r_{it} = \frac{\sqrt{\left(Y_{it} - SC_{it}\right)^2}}{\sqrt{\frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{it} - SC_{it}\right)^2}} \tag{6}$$

where T_0 is the number of pre-treatment periods and SC_{it} stands for the synthetic control. We also compute a normalised RMSPE for the whole post-treatment period as:

$$r_i = \frac{\sqrt{\frac{1}{T-T_0}\sum_{t=T_0+1}^{T}\left(Y_{it} - SC_{it}\right)^2}}{\sqrt{\frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{it} - SC_{it}\right)^2}} \tag{7}$$

Then the p-value from the permutations for each post-treatment month is computed:

$$p_{it} = \frac{\sum_i I_+\left(r_{it} - r_{UK,t}\right)}{N} \tag{8}$$

while for the whole post-treatment period we have:

$$p_i = \frac{\sum_i I_+\left(r_i - r_{UK}\right)}{N} \tag{9}$$

where $I_+(.)$ returns one if the argument is non-negative and zero otherwise and 28 is the number of SC computed (UK plus the 27 EU members placebos). The p-values in (8) and (9) will be zero if the UK experienced the largest gap in post-treatment relative to pre-treatment fit and value of one if UK had the smallest gap.

Given that the application of the SC to international trade is not too widespread, a few considerations are in place. The nature of international trade is such changing trade costs with one partner affects trade with other partners as well. This creates a problem for the identification of trade policy parameters as the control group is also partly affected. However, we believe that the data presented in Figure 5-6 should provide reassurance that spill-over effects are unlikely to be large in this setting. Indeed, if spill-over effects are present they are likely to be larger for UK-ROW trade than for EU27-EU27 or EU-ROW trade, because the UK accounts for a small fraction of EU27 trade – hence small effects on EU27 multilateral resistance – while the EU accounts for large share of UK trade – hence larger effect on multilateral resistance of UK. However, we do not see marked differences between the trends in UK-ROW and EU-ROW trade flows, this suggests that spill-over effects are not a major issue in this setting. In terms of the SC, we have been careful in selecting the donor pool for a pair *ij* (*i*=exporter, *j*=importer) including exports of *i* to other countries and imports of *j* from other countries. This strategy is akin to the inclusion of exporter-time and importer-time fixed effects in the triple difference (or gravity) model, which are included to control for changes in the multilateral resistance terms. Finally, regarding Covid-19, our assumption is that the pandemic represents a country-specific shock. Hence, it would affect exports of country *i* to all destinations in the same manner, or imports of country *j* from all origins in a similar way. This again motivates the selection of the SC donor pool to include only within-exporter and within-importer flows.

3 Data

Trade data for the UK are downloaded from the HMRC while data for other EU countries are downloaded from Eurostat (COMEXT). For intra-EU trade, exports are preferred to imports because of Intrastat threshold method. Therefore intra-EU imports are replaced with their mirror flows. For the UK we use HMRC reported data for both exports and imports because of smaller changes in collection method in 2021 compared to Eurostat mirror flows. Differences between HMRC and Eurostat mirror flows are analysed in Gasiorek and Tamberi 2021. The main difference concerns UK exports to the EU as reported by the HMRC and its mirror flows (EU imports reported in Eurostat). Gasiorek and Tamberi 2021 conclude that the main driver of these differences the change in Eurostat collection method for trade data with the UK which passed from the Intrastat survey (the survey used to record intra-EU trade) to customs declaration. This change implied that EU imports from the UK passed from being recorded on a country of consignment basis to a country of origin basis. On the other hand, the same methodological change was not implemented by HMRC. Hence, HMRC reported data should be utilised to analyse UK-EU trade and TCA effects. Note moreover that HMRC started to record UK imports from the EU on a country of origin basis as opposed to country of consignment in 2022. This means that UK imports from the EU data have a structural break in 2022. We therefore limit our analysis of the TCA to the first year of implementation ending in December 2021.

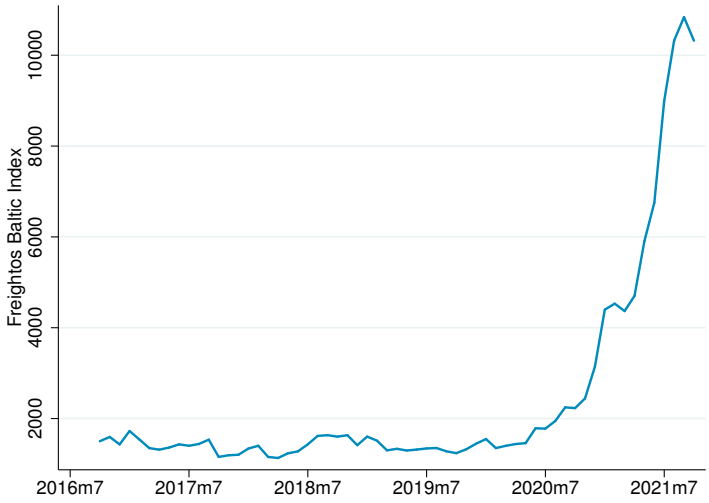
When we look at aggregate trade we exclude gold trade (HS 7108). We also look at trade disaggregated by HS sections (21 sections) to examine whether the effect has been heterogeneous across product groups. The dataset has the UK and the 27 EU members as reporters, and UK, EU27 and OECD + BRICS as partners. We exclude Japan and Canada because the EU and UK implemented FTAs with these countries in the period considered. For the analysis of the referendum, the dataset covers the period Jan2012-Dec2019, and we exclude Croatia both as exporter and importer as it joined the EU in 2013. For the analysis of the TCA, the period considered goes from July 2016 to December 2021.

In terms of other data sources, distance comes from CEPII[13]. For the cost of freight we use the Freight Baltic Index (FBX) computed by Freightos.[14]

[13] From the CEPII GeoDist database we use the variable 'distw'.

[14] See https://fbx.freightos.com/

Figure 4: Freight cost indexes, Freightos Baltic Index Global



Source: authors' elaboration of Freightos Baltic Index data.

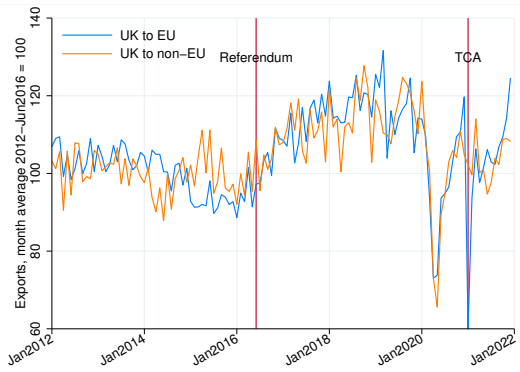
Data on Covid-19 cases and deaths are downloaded from Our World in Data (OWID). We supplement OWID data with data from the European Centre for Disease Prevention and Control for China in December 2019. The raw data are in weekly frequency and are aggregated at monthly frequency.

4 Results

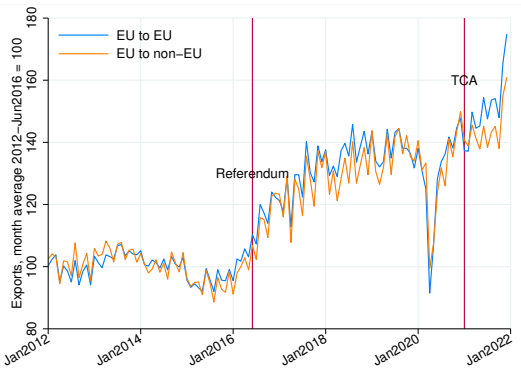
As preliminary evidence we plot the data used for the DD and DDD estimations. Figure 5 plots UK (panel a) and EU (panel b) export indices to the EU and the control group over the period January 2012-December 2021. Each point is normalised by the month average over the period January 2012-June 2016 – that is, the value for January 2018 is divided by the average of January 2012-16. These are essentially the data used in DD and DDD with normalisation accounted for by fixed effects. Figure 6 undertakes the same exercise for UK and EU imports. UK exports to the EU show a big drop in January 2021 only to realign with exports to the control group in the following months. On the other hand, EU exports to the EU (figure 5 panel b) do not show such a sharp drop in January 2021. Note moreover how exports to the EU and control group move very closely for both the UK and the EU27 also during the pandemic period. This indicates that the group of OECD + BRICS countries represents a very good control for the EU. Turning to UK imports in Figure 6 (panel a) we see that imports from the EU and control group are very close prior to 2021, but as the TCA is introduced the two flow are separated by a gap of about 20 index-points. Nothing similar happens to EU imports from the EU. Moreover, we see that UK imports from the control group behave very similarly to EU imports from the control and from the EU, and the only different flow is UK imports from the EU.

Figure 5: UK and EU exports to EU and control group

(a) UK exports to EU, OECD and BRICS ex. gold



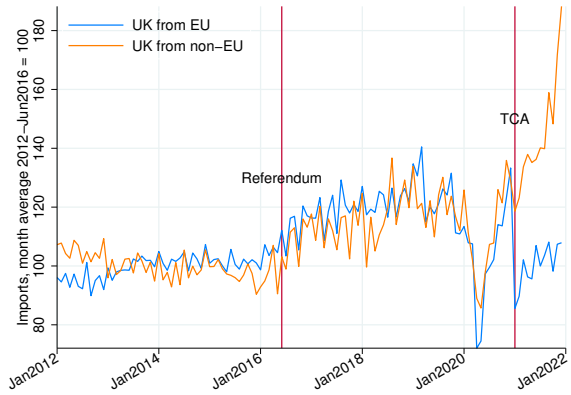
(b) EU exports to EU, OECD and BRICS ex. gold



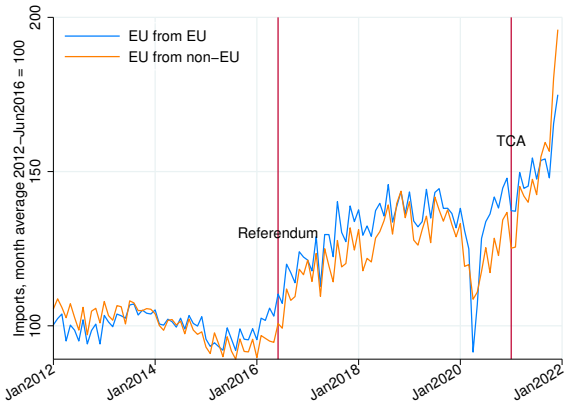
Source: authors' elaboration of HRMC and Eurostat data. UK trade data are taken from HMRC trade statistics, while trade data of EU member states come from the Eurostat Comext database. The series are normalised by the month-average for the period Jan2012-Jun2016.

Figure 6: UK and EU imports from EU and control group

(a) UK imports from EU, OECD and BRICS ex. gold



(b) EU imports from EU, OECD and BRICS ex. gold



Source: authors' elaboration of HRMC and Eurostat data. UK trade data are taken from HMRC trade statistics, while trade data of EU member states come from the Eurostat Comext database. The series are normalised by the month-average for the period Jan2012-Jun2016.

4.1 The Referendum effect

Table 1 reports the difference-in-differences and triple differences results for the 2016 referendum. The period used for the estimation is January 2012 to December 2019 with monthly data, and the post-referendum period is July 2016-December 2019. In this way we consider the referendum period excluding 2020, when Covid-19

hit. The sample excludes Croatia which joined the EU in 2013. The regressions yield small coefficients which are not statistically different from zero.

Tables 10-11 in the Appendix we also report results for each half year of the post-referendum period up to 2021, therefore including the post-TCA period. For UK exports to the EU we find no sign of a referendum or TCA impact either using DD or DDD, although the largest negative coefficient is for the first half of 2021, when the big exports drop occurred in January 2021. For UK imports from the EU we find again no sign of a referendum impact, but we find strong evidence that the TCA reduced UK imports from the EU in 2021. In unreported results we also dropped FTA partners from the control group, and again find no significant effects of the referendum on aggregate UK-EU trade.

We then run the Synthetic Control matching UK-EU trade over the period Jan2012-Jun2016. This technique shows no effect on UK exports to the EU in the post-referendum period, apart for the sharp drop which occurred in January 2021. For imports, the SC shows that UK imports from the EU started to decrease in the second half of 2019, and then felt substantially in 2021.

Table 1: Referendum results for total trade ex. gold, 2012-19

	Exports		Imports	
	(1)	(2)	(3)	(4)
	DD	DDD	DD	DDD
EU×Post-referendum	0.019		0.004	
	(0.037)		(0.040)	
UK×EU×Post-referendum		0.039		-0.001
		(0.030)		(0.034)
Pair FE	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	No
Partner-time FE	No	Yes	No	Yes
Reporter-time FE	No	Yes	No	Yes
Observations	3612	95340	3612	95340

Robust standard errors clustered at the partner level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DD and DDD estimates for the 2016 referendum effect on UK exports to and imports from the EU. The DD sample includes UK trade with the EU (ex. Croatia), OECD (ex. Canada and Japan) and BRICS countries. The DDD sample also includes EU (ex. Croatia) trade with the EU, OECD (ex. Canada and Japan) and BRICS countries.

These results are in contrast with those of Douch and Edwards 2021 which find strong negative effects of the 2016 referendum on UK trade applying the Synthetic Control, both with EU and non-EU countries. The authors also find that UK trade started to decrease in 2015. There are some differences between our and their approach. First, Douch and Edwards 2021 focus on the EU14 rather than the EU27. Second, they use data from IMF which are on Balance of Payment basis, so coverage is slightly different from ours which is on IMTS basis. Their flows are seasonally adjusted while ours are not, and their data are measured in US dollars while ours are in pound sterling. Third, they exclude any trade flow involving the UK or other EU countries from the

donor pool. Under the assumption that UK trade with rest of the world (ROW) is also affected by Brexit, Douch and Edwards 2021 estimate treatment effects for UK-ROW trade. While the baseline specification shows that UK exports to the EU are more affected than UK exports to ROW, robustness such as inclusion of EU flows in donor pool, changing the sample size or including the whole EU27 yields treatment effects larger for UK-ROW than UK-EU trade.[15]The fact that effects are not systematically larger for UK-EU flows than UK-ROW flows raises the question whether the effects picked up by Douch and Edwards 2021 are really driven by the Brexit referendum. While it is certainly possible that Brexit impacted UK trade beyond the EU, it is hard to believe that effects would be larger for non-EU trade than for EU trade.

Finally, the method used by Douch and Edwards 2021 to make inference is different from ours and to that which is standard in the SC literature (see Abadie, Diamond and Hainmueller 2010 and Abadie 2021). Rather, Douch and Edwards 2021 use the method of Saia 2017 which is based on re-sampling the donor pool to construct a standard error of the treatment effect. However, this is a different measurement of uncertainty regarding the estimate compared to the permutation method of Abadie, Diamond and Hainmueller 2010, and more similar to the leave-one-out test also proposed by Abadie, Diamond and Hainmueller 2010. Importantly, this method does not tell us whether the SC applied to other countries would yield similar treatment effects.

On the other hand, our results are in line with the conclusions of Dhingra and Sampson 2022 who notice that, while studies such as Graziano, Handley and Limão 2021 and Crowley, Exton and Han 2018 provide evidence that uncertainty had some effects on trade flows, 'the magnitude of these responses was insufficient to cause a noticeable shift in the geography of aggregate UK trade'. Moreover, in reviewing the 'Brexit literature' Dhingra and Sampson 2022 conclude in line with Ayele and Winters 2020 that there is no evidence that the exchange depreciation occurred in the aftermath of the 2016 referendum boosted British exports.

4.2 The TCA effect

The previous section showed that the 2016 referendum had little to no impact on aggregate UK-EU trade in the years following the referendum. While we do not exclude the possibility that adjustments to uncertainty about future trade costs were taking place in the post-referendum period, using a range of econometric techniques we could not find evidence of a negative impact of the referendum on aggregate UK-EU trade. Hence, we now focus on the post-referendum period to estimate more precisely the impact of the TCA on UK-EU trade. Because we do not exclude the possibility of structural adjustments taking place after the referendum, and because as observed in Figures 5-6 both UK and EU trade started to grow substantially in 2016, we restrict our analysis to the post-referendum period 2017-2021.

4.3 DD total trade

Results for the DD estimation are reported in Table 2. When we control only for time and partner FE in Table 2, we get a small negative effect on exports (-2.8% over the whole 2021) which is not significant at conventional levels of significance. Results by month tell us that there was a substantial drop in January 2021 (-41%) followed by a quick recovery. On the other hand, UK imports have been consistently affected in all the

[15]The authors estimate treatment effects for three periods: Jun2015-Jun2016, Jul2016-Feb2017 and Mar2017-Mar2018. The baseline results for UK exports to the EU14 in the three periods are -20.8%, -25% and -20.3%, while for UK exports to ROW are -3.6%, -13.4%, -15.2%. Including EU flows, the results for UK exports to the EU are -5.4%, -9.8% and -10.9%. See also tables B9-B13 in the appendix of Douch and Edwards 2021.

months of 2021 and over the whole year they were down by 31.5%. Coefficient estimates are translated into percentage effects by computing exp(b)-1.

We find no difference in results when we control for Covid-19 in Table 12, either when we control for Covid-19 cases or deaths. On the other hand, results become very different when we control for the cost of freight costs in Tables 13-14. In Table 13 we control for the log of freight cost interacted with distance. In Table 13 we also add the log of Covid-19 deaths as a control. Finally, in Table 14 we use the interaction of distance with time-dummies to account for changes in freight costs and we also add Covid-19 deaths as control in the last two columns. For UK exports to the EU, we now get larger negative and significant effects, with a cumulative decline over 2021 of 22-23%. For imports, the results remain negative and significant in almost all months of 2021 although reduced in magnitude. However, these strong negative and significant results for UK exports to the EU are not present when we use DDD or SC.

Table 2: DD results total trade ex. gold

	Exports	Exports	Imports	Imports
EU×2021	-0.029		-0.379***	
	(0.052)		(0.081)	
EU×Jan×2021		-0.531***		-0.305**
		(0.081)		(0.111)
EU×Feb×2021		-0.076		-0.389**
		(0.067)		(0.150)
EU×Mar×2021		-0.098		-0.333
		(0.057)		(0.175)
EU×Apr×2021		-0.021		-0.360**
		(0.039)		(0.113)
EU×May×2021		-0.011		-0.356***
		(0.045)		(0.061)
EU×Jun×2021		0.074		-0.308***
		(0.056)		(0.066)
EU×Jul×2021		0.028		-0.319***
		(0.053)		(0.080)
EU×Aug×2021		0.014		-0.285**
		(0.073)		(0.092)
EU×Sep×2021		0.046		-0.387***
		(0.085)		(0.087)
EU×Oct×2021		-0.004		-0.449**
		(0.101)		(0.145)
EU×Nov×2021		0.066		-0.424**
		(0.088)		(0.135)
EU×Dec×2021		0.045		-0.577***
		(0.068)		(0.137)
Partner FE	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes
Partner-month FE	No	Yes	No	Yes
Observations	2640	2640	2640	2640

Robust standard errors clustered at the partner level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DD estimates for UK exports to and imports from the EU.

4.4 DDD total trade

The DDD estimation show a non-significant -0.046 effect on UK exports to the EU over the period January-December 2021, with a sharp drop in January 2021 (-40%, strong significance). The result for the specification of Table 3 is robust to controlling for shipping costs, either interacting distance with freight cost indices or with time dummies (Table 15). As in the DD estimation, imports appear to have been affected in all the months of 2021 and the results are robust to controlling for freight costs. These results, differently from the

DD specification, are robust to any shock affecting a given country in a particular time period. We therefore consider these more reliable that those of the DD specification. In Table 16 in the Appendix we also report a robustness test where we exclude the FTA partners from the control group, and we find very similar results.

Table 3: DDD results total trade ex. gold

	Exports	Exports	Imports	Imports
UK×EU×2021	-0.046		-0.319***	
	(0.044)		(0.041)	
UK×EU×Jan×2021		-0.513***		-0.378***
		(0.066)		(0.060)
UK×EU×Feb×2021		-0.027		-0.409***
		(0.063)		(0.079)
UK×EU×Mar×2021		-0.119**		-0.312***
		(0.044)		(0.094)
UK×EU×Apr×2021		-0.006		-0.369***
		(0.045)		(0.067)
UK×EU×May×2021		-0.020		-0.356***
		(0.042)		(0.048)
UK×EU×Jun×2021		0.047		-0.283***
		(0.048)		(0.052)
UK×EU×Jul×2021		0.012		-0.314***
		(0.050)		(0.060)
UK×EU×Aug×2021		0.009		-0.199***
		(0.067)		(0.059)
UK×EU×Sep×2021		0.006		-0.278***
		(0.073)		(0.047)
UK×EU×Oct×2021		-0.047		-0.325***
		(0.091)		(0.081)
UK×EU×Nov×2021		0.031		-0.261***
		(0.079)		(0.054)
UK×EU×Dec×2021		-0.023		-0.361***
		(0.060)		(0.090)
Partner-time FE	Yes	Yes	Yes	Yes
Reporter-time FE	Yes	Yes	Yes	Yes
Pair FE	Yes	No	Yes	No
Pair-month FE	No	Yes	No	Yes
Observations	72300	72300	72300	72300

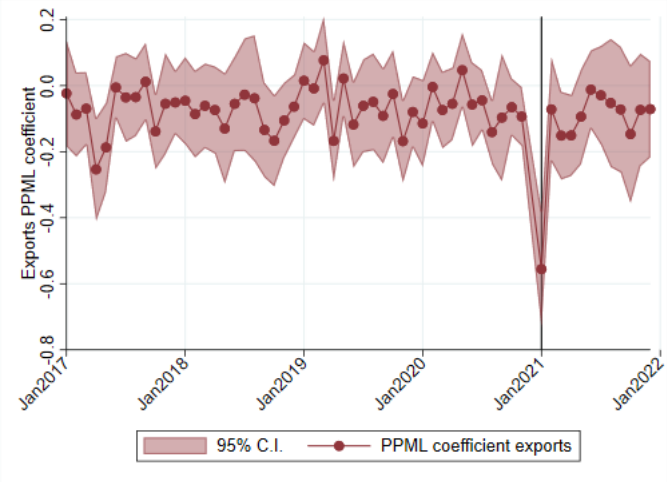
Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DDD estimates for UK exports to and imports from the EU.

In our estimation we do not deal explicitly with the possibility of anticipation effects affecting trade flows

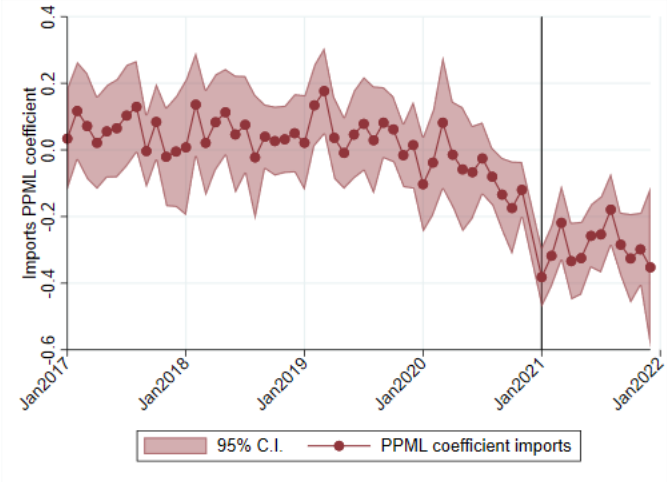
before 2021. However, the estimates of Table 1 show no sign of a referendum effect on UK-EU trade up to 2019. These results are in line with the simulations of Steinberg 2019 which finds that referendum-induced uncertainty has little impact on UK macroeconomic variables. At the same time, we do not exclude the possibility of anticipation effects occurring in the months leading to the TCA. To see whether the data show any sign of an anticipation effect, we estimate the triple-difference equations using an event study approach. This is done by interacting the EU dummy with dummies for each month, using as the reference period December 2020 – the last pre-treatment period. For this event study approach we use all the months over the period January 2017 to December 2021. The results are reported in Figure 7 where we plot the estimated coefficients together with the 95% confidence interval based on robust s.e. clustered at the pair level. The figure for exports (panel a) does not show any sign of anticipation and we can see the sharp drop in January 2021. The decline in imports on the other hand seems to have started around July-August 2020, only to drop even further in January 2021. Note however that these regressions do not account for seasonality and are therefore less accurate than the results reported in Table 3.

Figure 7: DDD event study coefficients

(a) DDD event study UK exports to the EU



(b) DDD event study UK imports from the EU



Confidence interval based on robust standard errors clustered at the exporter-importer level in parenthesis. The figures report the DDD event-study estimates for UK exports to and imports from the EU. The reference period is December 2021.

4.5 DDD HS sections

In this section we report on the results of the triple difference estimation by HS section (21 sections). We estimated equation (4) and (5) for each section separately. The results for exports (Table 4) are more heterogeneous than those for imports (Table 5). For exports, the products which have been negatively affected over the period January-December 2021 are Vegetables (-35%), Fats & oils (-57%), Food, beverages & tobacco (-15%), Textile (-59%), Footwear (-72%) and Miscellaneous manufacturing (-20%). Most sectors experienced a sharp drop in January 2021, but not in the other months of 2021. On the other hand, we see that for imports the effect over the months of January-December 2021 are not significant for only five of the HS sections.

Table 4: DDD results exports by HS sections

HS section	Jan-Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Animals & animal products	-0.031	-0.331	-0.149	0.154	0.279	0.123	0.017	-0.197	-0.096	-0.008	0.036	-0.121	-0.171
Vegetable products	-0.432***	-1.006***	-0.504*	-0.389	-0.610*	-0.353*	-0.620***	-0.676***	-0.340*	-0.202	-0.703***	-0.087	0.043
Animal and veg. fats & oils	-0.844***	-0.28	-1.192*	-0.197	-1.484**	-1.163**	-1.433*	-0.337	-0.682	-0.843**	0.091	0.389	-0.752
Foodstuffs, bev. & tobacco	-0.168*	-1.031***	-0.374***	-0.196	-0.116	-0.036	-0.174	-0.039	-0.031	-0.135	-0.190*	-0.084	0.01
Mineral products	0.069	-0.08	0.326	0.086	0.238	0.354	0.861	-0.726*	0.1	0.417	0.151	0.501	-0.708*
Chemicals	-0.023	-0.587***	0.091	-0.122	-0.037	-0.109	0.17	0.023	0.156	-0.121	-0.146	0.097	0.183
Plastics & rubber	-0.122	-0.590***	-0.103	-0.089	-0.096	-0.052	0.028	-0.1	-0.116	-0.062	-0.171*	-0.153	-0.068
Leather	-0.268	-0.663	-0.262	-0.092	-0.07	-0.417	-0.232	-0.283	-0.069	-0.221	-0.198	-0.305	-0.474***
Wood	0.062	-0.722*	0.26	0.149	0.620***	0.451	0.218	0.157	-1.049*	0.309	0.166	0.473	0.317
Paper	-0.076	-0.549**	0.034	0.043	-0.096	-0.077	-0.018	-0.197	-0.05	-0.08	-0.008	0.033	-0.043
Textile & clothing	-0.889***	-1.469***	-1.036***	-0.665***	-0.927***	-0.973***	-0.943***	-0.848***	-0.756***	-0.684***	-0.765***	-0.740***	-1.090***
Footwear & headgear	-1.278***	-2.275***	-1.698***	-1.336***	-1.332***	-1.447***	-1.278***	-1.425***	-0.676*	-0.762***	-0.876**	-1.164**	-1.686***
Ceramic & glass	-0.153*	-0.636***	-0.375*	-0.152	-0.074	-0.12	-0.126	0.034	-0.015	-0.111	-0.182*	-0.139	-0.046
Gold & pearls	-0.485	-0.319	-1.495***	-1.544***	-0.054	1.049**	0.521*	0.610*	0.800**	-1.139**	-1.390***	-0.722*	-0.56
Metals	-0.075	-0.613***	-0.011	-0.241***	0.064	-0.13	-0.098	-0.106	-0.049	0.043	0.047	-0.022	0.067
Machinery & electrical eq.	0.052	-0.518***	0.018	0.008	0.143	0.077	0.168*	0.151	0.11	0.168*	-0.048	0.054	0.144
Transport eq.	-0.055	-0.460***	0.109	-0.247	-0.023	-0.237*	-0.092	0.23	0.007	-0.033	-0.01	0.153*	-0.069
Precision tools	0.126*	-0.317***	0.152	0.231**	0.226*	0.179	0.086	0.169*	0.088	0.126	0.013	0.214**	0.198***
Arms & ammunitions	-0.125	-0.402	-1.196*	0.19	0.232	0.4	-0.356	0.714**	0.325	0.219	-0.636*	-0.641*	-0.598**
Miscellaneous manuf.	-0.226*	-0.805***	-0.089	-0.195	-0.075	0.101	-0.077	-0.323*	-0.243	-0.414***	-0.208	-0.273*	-0.301**
Art & antiques	2.213***	1.089	2.725***	1.664***	2.499***	3.326***	1.852***	2.204***	2.370***	2.189***	1.920***	2.483***	1.907***

The table reports the DDD coefficients for each HS section including exporter-time, partner-time and exporter-importer fixed effects. For the month-specific effects, the regressions include importer-exporter-month fixed effects. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5: DDD results imports by HS sections

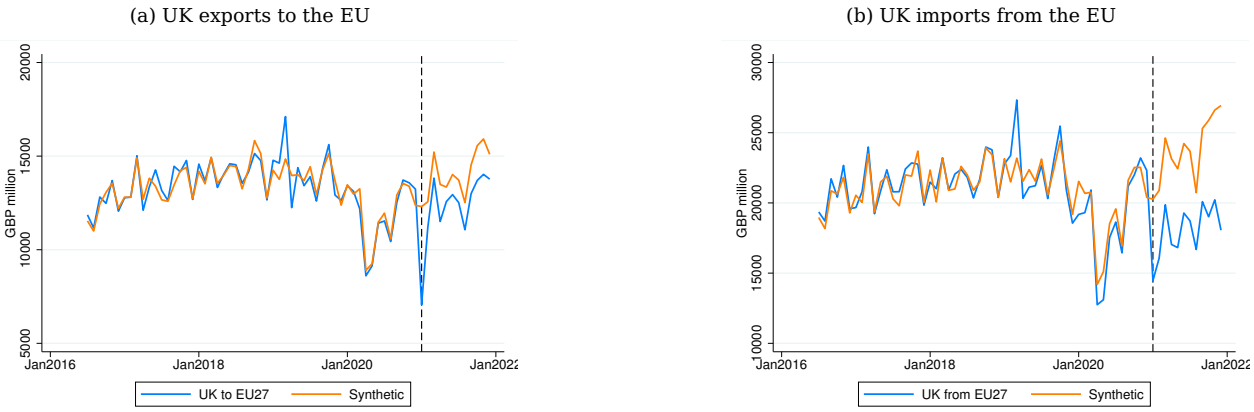
HS section	Jan-Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Animals & animal products	-0.491*	-0.453**	-0.607*	-0.514**	-0.481*	-0.497**	-0.432	-0.552*	-0.536*	-0.393	-0.584**	-0.419	-0.468
Vegetable products	-0.255**	-0.191	-0.329	-0.261*	-0.465***	-0.283**	-0.190*	-0.211	-0.068	-0.17	-0.312**	-0.163	-0.478***
Animal and veg. fats & oils	-0.49	-0.031	-1.344*	-0.231	-0.808*	-0.792*	-0.614	-0.468	-0.22	-0.106	-0.549	-0.28	-0.345
Foodstuffs, bev. & tobacco	-0.191**	-0.118	-0.216	-0.203*	-0.207*	-0.158	-0.142	-0.211	-0.206*	-0.179	-0.229	-0.171*	-0.269*
Mineral products	-0.254*	-0.238	-0.142	-0.299	-0.308	-0.426	-0.179	-0.084	0.04	-0.105	-0.261	-0.203	-0.53
Chemicals	-0.566***	-0.622	-1.034***	-0.793**	-0.560**	-0.776***	-0.494*	-0.522**	-0.453*	-0.372**	-0.566**	-0.401*	-0.231
Plastics & rubber	-0.155**	-0.271***	-0.331***	-0.338***	-0.292***	-0.201***	-0.052	-0.144	-0.04	-0.005	-0.114	-0.061	-0.095
Leather	-0.410*	-0.733***	-0.634***	-0.531**	-0.537*	-0.407	-0.409*	-0.502**	-0.450**	-0.25	-0.352**	-0.265	-0.1
Wood	-0.003	-0.186	-0.042	0.039	0.205	0.062	0.022	-0.152	0.109	0.07	-0.112	0.01	-0.123
Paper	-0.063	-0.162	-0.023	-0.184*	-0.144	-0.142	0.09	-0.091	0.036	0.017	-0.068	-0.015	-0.138
Textile & clothing	-0.139*	-0.304***	-0.323***	-0.198**	-0.238**	-0.15	-0.137	-0.272***	-0.074	0.114	0.054	-0.122	-0.229**
Footwear & headgear	-0.571***	-0.411***	-0.766***	-0.555***	-0.379*	-0.564***	-0.624***	-0.746***	-0.443*	-0.560*	-0.474*	-0.652***	-0.695***
Ceramic & glass	-0.267***	-0.330***	-0.511***	-0.353***	-0.262**	-0.196**	-0.214*	-0.496***	-0.187***	-0.158*	-0.146	-0.150*	-0.217***
Gold & pearls	-0.309	-0.584*	-0.056	-0.620*	-0.552	-0.663	-1.698***	0.214	0.089	0.408	0.14	-0.538	-0.41
Metals	-0.341***	-0.271***	-0.238***	-0.302***	-0.266***	-0.284**	-0.464***	-0.384***	-0.349***	-0.449***	-0.321***	-0.410***	-0.333***
Machinery & electrical eq.	-0.188*	-0.360***	-0.292*	-0.205	-0.282*	-0.182	-0.115	-0.155	-0.165*	-0.092	-0.188*	-0.115	-0.158
Transport eq.	-0.352*	-0.245	-0.184	0.057	-0.275	-0.462*	-0.037	-0.557*	-0.045	-0.700***	-0.583**	-0.668***	-0.453***
Precision tools	-0.202*	-0.173	-0.233**	-0.106	-0.209	-0.276*	-0.281*	-0.183	-0.206*	-0.169	-0.243*	-0.121	-0.253*
Arms & ammunitions	-0.525**	-2.084***	-0.247	-0.005	0.047	-0.011	0.229	0.029	-1.159***	-1.207***	-0.881***	-0.626	0.237
Miscellaneous manuf.	-0.241***	-0.296***	-0.414***	-0.386***	-0.240***	-0.245***	-0.318***	-0.344***	-0.249***	-0.061	-0.167**	-0.024	-0.273***
Art & antiques	-0.215	-0.065	0.813	-0.585	1.173*	0.718	-3.203***	0.317	-2.093***	-2.044***	0.074	0.262	-2.259***

The table reports the DDD coefficients for each HS section including exporter-time, partner-time and exporter-importer fixed effects. For the month-specific effects, the regressions include importer-exporter-month fixed effects. * p < 0.05, ** p < 0.01, *** p < 0.001.

4.6 Synthetic control

Figure 8 plots the outcome of the SC analysis for both exports (panel a) and imports (panel b). Calculation of p-values with the permutation method shows that for exports the UK was an extreme only in January and April 2021. Consistently with other methodologies applied, for imports we find that the UK performed particularly poorly and permutation tests show significant effects in each month of 2021, apart perhaps August and September. For exports, over the period January-December 2021 we find a TCA effect of -12.9% which is largely attributable to a -42.6% decline in January. For imports, the cumulative effect is -23.9% and similar across the months. Table 6 reports the summary results for UK exports to and imports from the EU. Detailed results of the SC by partner and months are reported in separate tables in Tables 17-20 in the Appendix.

Figure 8: UK-EU trade SCM result



Synthetic control results for UK exports to and imports from the EU. The SC is estimated over the period Jul2016-Dec2020 for each EU member state and then aggregated to the EU27 total. For UK exports to (imports from) a given EU member state, the donor pool is composed by UK exports to (imports from) OECD and BRICS countries excluding Canada and Japan, as well the EU member state imports from (exports to) other EU members, OECD and BRICS countries excluding Canada and Japan.

Table 6: Synthetic control results

Period	Exports		Imports	
	% difference	p-value	% difference	p-value
Jan-Dec 2021	-12.86	0.04	-23.96	0.00
Jan 2021	-42.58	0.00	-28.59	0.00
Feb 2021	-10.90	0.04	-23.12	0.00
Mar 2021	-9.17	0.04	-19.31	0.00
Apr 2021	-14.66	0.00	-26.39	0.00
May 2021	-5.81	0.57	-25.03	0.00
Jun 2021	-7.65	0.21	-20.42	0.00
Jul 2021	-8.78	0.36	-20.97	0.00
Aug 2021	-11.60	0.29	-19.54	0.04
Sep 2021	-10.58	0.32	-20.62	0.04
Oct 2021	-11.94	0.25	-26.50	0.00
Nov 2021	-11.89	0.25	-24.03	0.00
Dec 2021	-8.78	0.39	-32.95	0.00

Note: p-values based on the normalised RMSPE.

In Figure 12 in the Appendix we report the results where instead of matching over all pre-treatment periods of the outcome variable, we match over the average of each months. That is, our predictors are the average of the outcome variable over January 2017-20, the average over February 2017-20 and so on which means that we have 12 predictors. Results are consistent with the ones presented above showing an overall decline

in exports of -15% and in imports of -23.6%, with similar patterns across months to the main specification.

Table 7 reports the top 20 donors for the baseline SC matched on all pre-treatment periods. As we estimated SC for UK trade with each EU27 member separately, the EU member weights have been aggregated to UK-EU27 level weighting each EU member by its share in UK trade over the period Jul2016-Dec2020. The pairs should be read as exporter-importer. For UK exports to the EU, the largest contributors are UK exports to Russia (7.8%), France exports to Germany (7.7%) and Norway to the Netherlands (6.7%). Together, the top 20 donors account for 75% of the weights for UK exports to the EU. For UK imports from the EU the most important flow is UK imports from Switzerland (19%), followed by Germany exports to France (12%) and US exports to the UK (10%). The donor weights for imports are more concentrated than for exports, and together the top 20 donors account for 83% of total weights.

Note that while we report only the top 10 countries, in the estimation of the SC for each EU member state we find that weights are sparse, and that a large portion of donors attract zero weights. Considering that for trade of the UK with each EU member state the donor pool is composed of 60 control flows (17 flows for UK to ROW, 43 flows of EU member states trade with EU27 and ROW), for the EU27 total we have a donor pool of $27 \times 60 = 1,620$ units. Across all SC estimation, the number of units which attract non-zero weights are 179 for exports and 154 for imports. However, many of these donors attract small weights, making the SC results sparse. As explained in Abadie 2021, this sparsity makes the SC results transparent and interpretable.

Table 7: Top 20 donors for Synthetic Control

Exports to EU					Imports from EU			
Pair	weight	Pair	weight		Pair	weight	Pair	weight
GB-RU	0.078	RU-DE	0.029		CH-GB	0.19	BE-FR	0.02
FR-DE	0.077	NO-BE	0.024		DE-FR	0.12	IT-ES	0.02
NO-NL	0.067	DE-IE	0.023		US-GB	0.10	IN-GB	0.02
RU-FR	0.067	DE-FR	0.021		NO-GB	0.06	FR-CN	0.02
GB-US	0.065	DE-NL	0.019		DE-US	0.05	NL-DE	0.02
GB-ZA	0.053	GB-CH	0.017		NL-FR	0.04	CN-GB	0.01
NL-IE	0.042	IE-ES	0.017		FR-PT	0.03	IT-IN	0.01
GB-KR	0.036	KR-NL	0.017		KR-GB	0.03	CO-GB	0.01
GB-CN	0.034	RU-NL	0.015		ES-IT	0.03	ZA-GB	0.01
CH-DE	0.032	IT-NL	0.013		FR-DE	0.02	PL-IT	0.01

Another paper that applied the Synthetic Control to estimate the impact of the TCA on UK trade is Springford 2022. However, rather than looking at UK-EU trade, Springford 2022 estimates the SC on total UK trade with the world and separating exports and imports. The author estimates that the TCA decreased total UK exports by 15.7% in the first year of the TCA. Two things are worth mentioning: as for the discussion of the referendum results of Douch and Edwards 2021, we believe that geography matters and that a credible estimate of TCA effects should show different impacts between UK-EU trade and UK-ROW trade. While it is possible that UK trade with ROW is also affected, the effect must be higher with the EU to be attributable to the TCA. Second, and perhaps most importantly, the SC method does not yield a confidence interval and inference should be performed with permutation methods, which are absent in Springford 2022. Indeed, the results for the treatment effects obtained by Springford 2022 are similar to ours, but after we draw inference based on permutation tests we find that the case of UK exports is not always extreme – apart for January 2021.

4.7 Difference between exports and imports results: a possible explanation

Our empirical results consistently show that that the TCA had a strong negative effect on UK imports from the EU, but there is little or no evidence of an aggregate negative effect on UK exports to the EU. A possible explanation for the asymmetry between exports and imports is the relative importance of the EU market for UK firms, in comparison to the importance of the UK market for EU firms. Over the period 2017-19, the UK exported 47.4% of its goods exports to the EU27. On the other hand, only 5.9% of total EU27 goods exports went to the UK over the same period. Hence, for UK firms dismantling trade relations with the EU may be very costly, while ceasing to serve the UK market is likely to be relatively less important for EU exporters. While we acknowledge that there could be other (not necessarily alternative) explanations to the difference between exports and imports results, we believe that measuring precisely other potential drivers can be hard and goes beyond the scope of this paper. In this section we test whether data rejects the market size hypothesis as an explanation to the differences between exports and imports results.

To test this hypothesis we work with the data at the level of 21 HS sections and ask whether, for each HS section, the decline in trade is larger in markets that account for a smaller share of total exporters' exports. The test is done in two stages. First, we run a triple difference for each HS section and flow (exports, imports) separately estimating a TCA effect for each EU27 member state:

$$Y_{ijthf} = \exp\left[\alpha_{ithf} + \alpha_{jthf} + \alpha_{ijhf} + \sum_{j=1}^{27} \beta_{jhf}\left(EU_j \times UK_i \times Post_t \times a_j\right)\right] + \epsilon_{ijthf} \tag{10}$$

where a_j is a dummy for each partner, h stands for the HS section and f for flow (exports, imports). Estimating equation (10) by PPML for each HS section and flow separately we obtain a TCA effect $\tilde{\beta}_{jhf}$ for each HS section h, each EU27 member j and each flow f. In total there are 21 HS section, 27 EU members and 2 flows, so we should obtain 1,134 coefficients. However, for some EU27 member-HS section combination where trade is very sparse we cannot estimate a coefficient due to insufficient data or no trade (e.g., UK imports of Arms and ammunitions from Bulgaria). In total we are able to estimate 1,112 partner-section coefficients, hence losing 22 coefficients.[16]

The second stage involves the regression of the $\tilde{\beta}_{jhf}$ coefficients on the exports share w_{jhf} and HS section by flow dummies. The exports share $w_{jh,exports} = \frac{X_{jh}}{X_h}$ are defined as the ratio of UK exports of HS section h to EU27 member j over total UK exports of HS section h to the world. Similarly, for imports $w_{jh,imports}$ are defined as j's exports of HS section h to the UK over total j's exports of HS section h to the world. The shares are computed with data for total exports over the years 2017-19. The regression that we estimate is:

$$\tilde{\beta}_{jhf} = a + a_{hf} + \delta w_{jhf} + \epsilon_{jhf} \tag{11}$$

If our hypothesis is correct, then we should expect $\delta > 0$. It is important to notice that our test is done within HS section using variation in shares across partners. This means that differences in trade policies that could influence the shares are controlled for, given that the trade policy is the same for all EU27 member states.

The summary statistics for the first stage results $\tilde{\beta}_{jhf}$ and the exports shares w_{jhf} to be used in the second stage are reported in Table 8. For UK imports from the EU, the average TCA effects across HS sections and partners is -0.521, while for UK exports to the EU the average effect is -0.239. The average exports share for

[16]The PPML estimator failed to converge for the estimation of the imports equation of Arts and antiques. We therefore estimated this equation by OLS using the log of imports as dependent variable.

EU exports to the UK is 0.05 while for UK exports to the EU is 0.02. These are simple averages across HS sections and partners hence they do not take into account the size of each sector/market.[17]

Table 8: TCA effects and exports shares by HS section and partners

	Mean	sd	Median	Min	Max	N
$\tilde{b}$ imports	-0.521	1.120	-0.312	-9.455	5.226	545
$\tilde{b}$ exports	-0.239	1.078	-0.236	-3.666	8.413	567
Share UK imports	0.051	0.061	0.037	0.000	0.451	545
Share UK exports	0.020	0.042	0.004	0.000	0.477	567

The second stage results are reported in Table . In the first column we report the results for the estimation of model (11) by OLS. To account for the uncertainty in the estimation of $\tilde{\beta}_{jhs}$ given by the first stage, in column two we estimate model (11) by weighted least squares with weights given by the t-stats of the first stage coefficients. In both cases we find a positive and statistically significant coefficient on the export share, suggesting that the importance of the destination market in total exports is a driver of the TCA effects.

Table 9: Regression of TCA effects on partner-section exports shares

	(1) OLS	(2) WLS
Exports share	1.305**	3.912**
	(0.450)	(1.339)
Constant	-0.424***	-0.825***
	(0.037)	(0.096)
Flow-section FE	Yes	Yes
Observations	1112	1112

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robust standard errors in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the results of the regressions of the partner-section TCA effects estimated with PPML on the exports share. The regression pool together TCA effects on exports and imports and include section-flow fixed effects. Exports shares for the TCA effects on exports are defined as UK exports of HS section to a EU27 member of total UK exports of HS section over 2017-19. Exports shares for the TCA effects on imports are defined as EU27 member exports of of HS section to the UK over total EU27 member exports of HS section to the world over 2017-19.

How do these results relate to the differences in total exports and imports TCA effects of section 4.2? Using the OLS estimate of column one we have the following equation for the TCA effect:

[17] Some of the EU markets such as Malta or Cyprus are small, while the UK can be a large destination for exports of these small EU countries. This explains the fact that the average exports share is slightly larger for EU27 exports to the UK than the reverse. On the other hand, when we consider the share of total exports the EU27 is a very large market for the UK, while the UK is relatively small for the EU27.

$$\text{TCA effect} = -0.424 + 1.305 \times \text{Exports share} \tag{12}$$

The exports share of the EU27 to the UK over 2017-19 is 0.059. Using this value, the equation predicts a TCA effect of -0.347 with 95% CI of [-0.395, -0.299] and the triple difference estimation of Table (3) gives a coefficient of -0.319 for UK imports from the EU. This is remarkably close. For UK exports to the EU the exports share over 2017-19 is 0.474, hence the model predicts a TCA effect of 0.194. This is larger than the DDD estimate of -0.046 but still within the 95% confidence interval of the predictions of model (12) which is [-0.173, 0.561].

Overall, these results provide support for the hypothesis that the asymmetries in the TCA impacts for UK exports to and imports from the EU can be explained by the relative importance of the destination market for each exporters. However, it is important to note, that this does not constitute a detailed explanation of all the factors driving the TCA effects, which is beyond the scope of this paper. This is because the export shares are determined by a range of factors determining market access barriers ranging from policy to market structure, as well as geographical factors such as distance, and technological factors impacting on the organization of production and supply chains.

5 Conclusions

Our analysis of monthly goods trade data shows no evidence of a negative impact on UK trade with the EU in the period following the referendum of 2016. In contrast we find that the introduction of the Trade and Cooperation Agreement in January 2021 had a strong effect on UK-EU trade in 2021. We find significant differences between UK exports to and imports from the EU. UK exports, in aggregate, were strongly affected in January 2021 only to recover to normal levels in the following months. The substantial decline in January 2021 is almost certainly attributable to the last-minute nature of the deal, and the lack of time firms had to prepare for the agreement that was put in place. An interesting feature of the results is the subsequent recovery in exports, which was probably not anticipated by most commentators and no doubt more work will need to be undertaken indue course to understand this better. In contrast, UK imports have been consistently affected in all the months of 2021 and have not shown signs of recovery. This too will require more research in due course. Our results are in line with the dynamic general equilibrium simulation of Steinberg 2019, which show negligible impacts of referendum-induced uncertainty on UK-EU trade but substantial TCA effects, with UK imports more affected than UK exports. A plausible explanation for these differential effects of the impacts of exports and imports is the relative importance of the EU market for UK firms, in comparison to the importance of the UK market for EU firms. This meant that it was more important for UK firms to maintain access to the EU, than it was for EU firms to maintain access to the UK. Using exports share, we provide some evidence in support of this hypothesis. While UK exports seems to have responded to new trade barriers and are heterogeneous across products, the effects on imports are very similar across products.

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Appendix

Difference between PPML and log-linear OLS

In the text we argued in favour of the PPML estimator rather than the log-linear OLS estimator on the ground that the PPML estimator allows us to estimate the effect on total exports to the EU, while the log-linear OLS would give us an average effect across EU countries. While both estimators provide an estimate of the proportional treatment effect, the interpretation of coefficients is different. The difference is due to the first order conditions of the two estimators. For the PPML, the FOC is in levels, hence the effect is estimated on the average of the dependent variable. The FOC of the log-linear OLS is on the log of the dependent variable, hence the effect is measured on the geometric average. For the difference-in-differences estimation of UK exports to the EU, the PPML coefficient equals the following quantity:

$$\tilde{b}_{PPML} = \ln\left[\frac{\bar{Y}_{EU,Post}/\bar{Y}_{EU,Pre}}{\bar{Y}_{Control,Post}/\bar{Y}_{Control,Pre}}\right]$$

where $\bar{Y}_{EU,Post} = (N_{EU}T_{Post})^{-1}\sum_{i\in EU}\sum_{t\in Post}Y_{it}$ is average UK exports to the EU in 2021 (across 27 member states) and $\bar{Y}_{EU,Pre} = (N_{EU}T_{Pre})^{-1}\sum_{i\in EU}\sum_{t\in Pre}Y_{it}$ is average UK exports to the EU in the pre-TCA period, with $N_{EU} = 27$ being the number of countries in the EU and T_{Post} (T_{Pre}) the number of periods in the post (pre) TCA period. At the denominator we have the same quantities for exports to the control group. Since we have a balanced panel data, the number of countries within EU and control group are the same both pre and post TCA, and the number of periods are the same pre/post TCA for the EU and control groups, these quantities cancel out so the PPML coefficient effectively measures the proportional change in total trade:

$$\tilde{b}_{PPML} = \ln\left[\frac{Y_{EU,Post}/Y_{EU,Pre}}{Y_{Control,Post}/Y_{Control,Pre}}\right]$$

Hence, the difference-in-differences estimated with the PPML estimator allows us to retrieve the TCA effect on total trade with the EU.

On the other hand, the OLS difference-in-differences coefficient is:

$$\tilde{b}_{OLS} = \left(\overline{\ln Y_{EU,Post}} - \overline{\ln Y_{EU,Pre}}\right) - \left(\overline{\ln Y_{Control,Post}} - \overline{\ln Y_{Control,Pre}}\right)$$

where $\overline{\ln Y_{EU,Post}}$ is the geometric average of UK exports to the EU in the post-TCA period:

$$\overline{\ln Y_{EU,Post}} = \frac{1}{N_{EU}T_{Post}} \sum_{i \in EU} \sum_{t \in Post} \ln Y_{it} = \ln \left[\left(\prod_{i \in EU} \prod_{t \in Post} Y_{it} \right)^{1/N_{EU}T_{Post}} \right] = \ln \left(\overline{Y^G}_{EU,Post} \right)$$

where $\overline{Y^G}_{EU,Post}$ is the geometric average. Hence the log-linear OLS difference-in-differeces coefficient is:

$$\tilde{b}_{OLS} = \ln \left[\frac{\overline{Y^G}_{EU,Post} / \overline{Y^G}_{EU,Pre}}{\overline{Y^G}_{Control,Post} / \overline{Y^G}_{Control,Pre}} \right]$$

Given the multiplicative nature of the geometric average, a proportional change in one of the elements of the average of the average will have the same weight. This means that a change in UK exports to Malta or to Germany have the same importance. Differently, the PPML estimator gives more importance to larger flows.

Additional results for 2016 referendum

Table 10: Results DD referendum by half years, 2012-21

	Exports		Imports	
	(1)	(2)	(3)	(4)
	exports	exports	imports	imports
EU×Post	0.007		-0.059	
	(0.047)		(0.072)	
EU×Post×2016h2		0.003		0.041
		(0.054)		(0.063)
EU×Post×2017h1		-0.020		0.034
		(0.056)		(0.037)
EU×Post×2017h2		0.051		0.060
		(0.044)		(0.046)
EU×Post×2018h1		0.041		0.084**
		(0.038)		(0.030)
EU×Post×2018h2		0.014		-0.012
		(0.061)		(0.058)
EU×Post×2019h1		0.051		0.051
		(0.057)		(0.071)
EU×Post×2019h2		-0.028		0.002
		(0.079)		(0.081)
EU×Post×2020h1		0.002		-0.069
		(0.061)		(0.119)
EU×Post×2020h2		0.017		-0.060
		(0.073)		(0.172)
EU×Post×2021h1		-0.071		-0.312*
		(0.060)		(0.136)
EU×Post×2021h2		0.047		-0.415***
		(0.073)		(0.097)
Pair FE	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes
Pair-month FE	No	Yes	No	Yes
Observations	5160	5160	5160	5160

Robust standard errors clustered at the partner level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DD estimates for the 2016 referendum and TCA effect on UK exports to and imports from the EU. The DD sample includes UK trade with the EU (ex. Croatia), OECD (ex. Canada and Japan) and BRICS countries.

Table 11: Results DDD referendum by half years, 2012-21

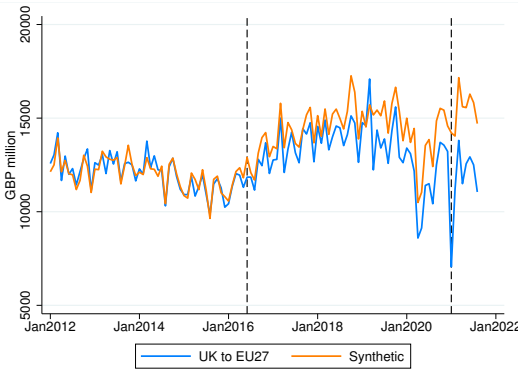
	Exports		Imports	
	(1)	(2)	(3)	(4)
	exports	exports	imports	imports
UK×EU×Post	0.026		-0.068	
	(0.032)		(0.038)	
UK×EU×Post×2016h2		0.011		0.005
		(0.035)		(0.030)
UK×EU×Post×2017h1		0.000		0.029
		(0.046)		(0.032)
UK×EU×Post×2017h2		0.051		0.014
		(0.039)		(0.035)
UK×EU×Post×2018h1		0.030		0.033
		(0.036)		(0.035)
UK×EU×Post×2018h2		0.012		-0.004
		(0.044)		(0.047)
UK×EU×Post×2019h1		0.080*		0.037
		(0.039)		(0.046)
UK×EU×Post×2019h2		0.027		0.012
		(0.049)		(0.051)
UK×EU×Post×2020h1		0.058		-0.065
		(0.042)		(0.062)
UK×EU×Post×2020h2		0.030		-0.122
		(0.047)		(0.082)
UK×EU×Post×2021h1		-0.051		-0.337***
		(0.046)		(0.062)
UK×EU×Post×2021h2		0.029		-0.320***
		(0.060)		(0.053)
Pair FE	Yes	No	Yes	No
Partner-time FE	Yes	Yes	Yes	Yes
Reporter-time FE	Yes	Yes	Yes	Yes
Pair-month FE	No	Yes	No	Yes
Observations	136200	136200	136200	136200

Robust standard errors clustered at the partner level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DDD estimates for the 2016 referendum and TCA effect on UK exports to and imports from the EU. The DD sample includes UK and EU trade with the EU (ex. Croatia), OECD (ex. Canada and Japan) and BRICS countries.

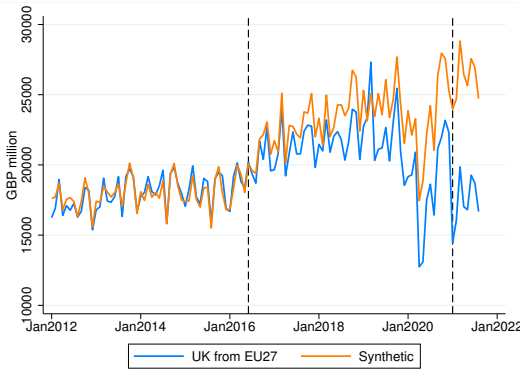
Synthetic control matched over the period Jan2012-Jun2016. Excludes Croatia as it joined the EU in 2013.

Figure 9: UK-EU trade SCM result

(a) UK exports to the EU



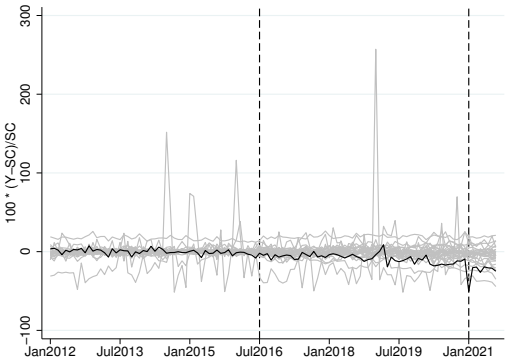
(b) UK imports from the EU



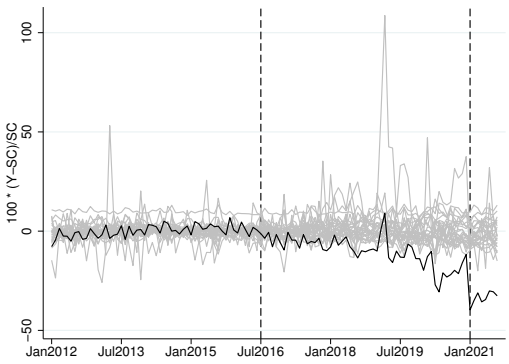
The figure reports the SC estimates for UK exports to and imports from the EU27. The pre-treatment period is Jan2012-Jun2016, matching is performed over all pre-treatment values of the outcome variable.

Figure 10: UK-EU trade SCM result

(a) Exports to the EU



(b) Imports from the EU



The figure reports placebo of the SC estimates for UK trade with the EU27. The pre-treatment period is Jan2012-Jun2016, matching is performed over all pre-treatment values of the outcome variable. The vertical axis measures percentage deviations of the SC from the outcome variable Y. The black solid line represents UK-EU27 trade while the grey lines are trade of each EU27 member with the remaining EU countries.

Robustness to DD and DDD specification for TCA effects

Table 12: DD results total trade ex. gold controlling for Covid-19

	Exports	Exports	Imports	Imports	Exports	Exports	Imports	Imports
EU×2021	-0.031		-0.359***		-0.030		-0.363***	
	(0.048)		(0.069)		(0.050)		(0.069)	
Log Covid-19 deaths	-0.015**	-0.013*	-0.022	-0.025*				
	(0.005)	(0.005)	(0.011)	(0.011)				
EU×Jan×2021		-0.527***		-0.246***		-0.530***		-0.250***
		(0.065)		(0.056)		(0.069)		(0.054)
EU×Feb×2021		-0.069		-0.328***		-0.073		-0.333***
		(0.061)		(0.086)		(0.063)		(0.079)
EU×Mar×2021		-0.094*		-0.291*		-0.095		-0.294*
		(0.045)		(0.126)		(0.048)		(0.128)
EU×Apr×2021		-0.017		-0.322***		-0.017		-0.319***
		(0.045)		(0.093)		(0.042)		(0.088)
EU×May×2021		-0.011		-0.314***		-0.008		-0.322***
		(0.047)		(0.062)		(0.046)		(0.052)
EU×Jun×2021		0.070		-0.286***		0.070		-0.299***
		(0.059)		(0.042)		(0.058)		(0.041)
EU×Jul×2021		0.019		-0.297***		0.025		-0.302***
		(0.059)		(0.082)		(0.059)		(0.077)
EU×Aug×2021		0.004		-0.258***		0.006		-0.274***
		(0.069)		(0.067)		(0.070)		(0.064)
EU×Sep×2021		0.032		-0.370***		0.033		-0.383***
		(0.084)		(0.084)		(0.084)		(0.078)
EU×Oct×2021		-0.004		-0.466***		-0.005		-0.464***
		(0.103)		(0.139)		(0.102)		(0.141)
EU×Nov×2021		0.062		-0.448**		0.065		-0.441**
		(0.089)		(0.141)		(0.089)		(0.142)
EU×Dec×2021		0.045		-0.588***		0.048		-0.578***
		(0.071)		(0.138)		(0.070)		(0.142)
Log Covid-19 cases					-0.012*	-0.011*	-0.024*	-0.029**
					(0.005)	(0.006)	(0.011)	(0.011)
Partner FE	Yes	No	Yes	No	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Partner-month FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2640	2640	2640	2640	2640	2640	2640	2640

Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 13: DD results total trade ex. gold controlling for freight cost

	Exports	Exports	Imports	Imports	Exports	Exports	Imports	Imports
EU×Year=2021	-0.217**		-0.302**		-0.206**		-0.275**	
	(0.066)		(0.094)		(0.066)		(0.093)	
ln(dist)×ln(FBX)	-0.056**	-0.055**	0.015	0.001	-0.052**	-0.052**	0.014	-0.003
	(0.019)	(0.020)	(0.040)	(0.044)	(0.018)	(0.019)	(0.028)	(0.027)
EU×Year=2021×Jan		-0.650***		-0.303***		-0.640***		-0.249***
		(0.074)		(0.060)		(0.066)		(0.045)
EU×Year=2021×Feb		-0.204**		-0.387***		-0.190**		-0.331***
		(0.075)		(0.080)		(0.071)		(0.055)
EU×Year=2021×Mar		-0.234**		-0.330**		-0.224**		-0.296**
		(0.073)		(0.102)		(0.072)		(0.090)
EU×Year=2021×Apr		-0.168**		-0.357***		-0.157*		-0.327***
		(0.062)		(0.090)		(0.064)		(0.090)
EU×Year=2021×May		-0.181*		-0.352***		-0.172*		-0.321**
		(0.078)		(0.103)		(0.080)		(0.103)
EU×Year=2021×Jun		-0.099		-0.304***		-0.094		-0.293***
		(0.078)		(0.086)		(0.079)		(0.070)
EU×Year=2021×Jul		-0.180*		-0.315		-0.177*		-0.306*
		(0.085)		(0.166)		(0.082)		(0.144)
EU×Year=2021×Aug		-0.204*		-0.280*		-0.202*		-0.267*
		(0.092)		(0.136)		(0.091)		(0.122)
EU×Year=2021×Sep		-0.166		-0.382*		-0.168		-0.380*
		(0.113)		(0.186)		(0.113)		(0.160)
EU×Year=2021×Oct		-0.224		-0.444		-0.212		-0.478*
		(0.115)		(0.264)		(0.119)		(0.202)
Log Covid-19 deaths					-0.015**	-0.013**	-0.025*	-0.027**
					(0.005)	(0.005)	(0.010)	(0.010)
Partner FE	Yes	No	Yes	No	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Partner-month FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2552	2552	2552	2552	2552	2552	2552	2552

Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 14: DD results total trade ex. gold controlling for Covid-19 and distance-by-time

	Exports	Exports	Imports	Imports	Exports	Exports	Imports	Imports
EU×Year=2021	-0.253**		-0.501***		-0.249*		-0.480***	
	(0.096)		(0.097)		(0.098)		(0.095)	
EU×Year=2021×Jan		-0.734***		-0.168**		-0.731***		-0.109
		(0.093)		(0.059)		(0.096)		(0.060)
EU×Year=2021×Feb		-0.299		-0.135		-0.289		-0.074
		(0.154)		(0.087)		(0.153)		(0.094)
EU×Year=2021×Mar		-0.197		-0.087		-0.188		-0.034
		(0.115)		(0.151)		(0.118)		(0.158)
EU×Year=2021×Apr		-0.190		-0.203*		-0.179		-0.160
		(0.136)		(0.096)		(0.137)		(0.099)
EU×Year=2021×May		-0.182		-0.367***		-0.169		-0.316**
		(0.108)		(0.086)		(0.115)		(0.099)
EU×Year=2021×Jun		-0.161		-0.310***		-0.153		-0.277***
		(0.136)		(0.053)		(0.139)		(0.063)
EU×Year=2021×Jul		-0.202**		-0.568***		-0.200**		-0.543***
		(0.072)		(0.076)		(0.077)		(0.063)
EU×Year=2021×Aug		-0.249*		-0.321**		-0.253*		-0.309**
		(0.100)		(0.112)		(0.104)		(0.098)
EU×Year=2021×Sep		-0.049		-0.631***		-0.052		-0.619***
		(0.156)		(0.181)		(0.161)		(0.166)
EU×Year=2021×Oct		-0.354*		-0.949***		-0.357**		-0.966***
		(0.138)		(0.219)		(0.138)		(0.226)
EU×Year=2021×Nov		-0.276**		-0.787***		-0.279**		-0.803***
		(0.098)		(0.224)		(0.098)		(0.229)
EU×Year=2021×Dec		-0.216		-1.045***		-0.219		-1.063***
		(0.152)		(0.192)		(0.153)		(0.198)
Log Covid-19 deaths					-0.015**	-0.014**	-0.023	-0.027**
					(0.005)	(0.005)	(0.012)	(0.009)
Partner FE	Yes	No	Yes	No	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Partner-month FE	No	Yes	No	Yes	No	Yes	No	Yes
ln(dist) × time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2640	2640	2640	2640	2640	2640	2640	2640

Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 15: DDD results total trade ex. gold controlling for freight cost

	Exports	Exports	Imports	Imports	Exports	Exports	Imports	Imports
UK×EU×2021	-0.055		-0.311***		-0.046		-0.319***	
	(0.044)		(0.042)		(0.044)		(0.041)	
ln(dist)×ln(FBX)	-0.002	0.001	0.000	0.004				
	(0.007)	(0.007)	(0.006)	(0.006)				
UK×EU×Jan×2021		-0.513***		-0.378***		-0.512***		-0.379***
		(0.066)		(0.060)		(0.066)		(0.061)
UK×EU×Feb×2021		-0.027		-0.409***		-0.027		-0.410***
		(0.063)		(0.079)		(0.064)		(0.079)
UK×EU×Mar×2021		-0.119**		-0.312***		-0.119**		-0.313***
		(0.044)		(0.094)		(0.045)		(0.093)
UK×EU×Apr×2021		-0.006		-0.369***		-0.006		-0.370***
		(0.045)		(0.067)		(0.046)		(0.066)
UK×EU×May×2021		-0.020		-0.357***		-0.020		-0.357***
		(0.042)		(0.048)		(0.042)		(0.047)
UK×EU×Jun×2021		0.047		-0.283***		0.047		-0.283***
		(0.048)		(0.052)		(0.048)		(0.052)
UK×EU×Jul×2021		0.012		-0.314***		0.012		-0.314***
		(0.050)		(0.060)		(0.049)		(0.060)
UK×EU×Aug×2021		0.009		-0.199***		0.009		-0.198***
		(0.067)		(0.058)		(0.067)		(0.059)
UK×EU×Sep×2021		0.006		-0.278***		0.006		-0.278***
		(0.073)		(0.047)		(0.073)		(0.047)
UK×EU×Oct×2021		-0.047		-0.325***		-0.048		-0.324***
		(0.091)		(0.081)		(0.092)		(0.082)
UK×EU×Nov×2021						0.030		-0.260***
						(0.080)		(0.055)
UK×EU×Dec×2021						-0.024		-0.360***
						(0.060)		(0.091)
Partner-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reporter-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair FE	Yes	No	Yes	No	Yes	No	Yes	No
Pair-month FE	No	Yes	No	Yes	No	Yes	No	Yes
$\ln(dist)\times$ time-FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	69890	69890	69890	69890	72300	72300	72300	72300

Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001.

To see whether the inclusion of FTA partners in the control group is driving results, both for the referendum and the TCA effects, we exclude the FTA partners from the control group (these are: Canada, Switzerland, Chile, Colombia, Israel, Iceland, Japan, South Korea, Mexico, Norway, Turkey and South Africa). We then estimate the following DD regression:

$$Y_{jt} = \exp\left[\alpha_j + \alpha_t + \beta_{Ref}\left(EU_j \times Post_t^{Ref}\right) + \beta_{TCA}\left(EU_j \times Post_t^{Ref} \times D_t^{2021}\right)\right] + \epsilon_{jt}$$

and the DDD regression:

$$Y_{ijt} = \exp\left[\alpha_{ij} + \alpha_{it} + \alpha_{jt} + \beta_{Ref}\left(EU_j \times UK_i \times Post_t^{Ref}\right) + \beta_{TCA}\left(EU_j \times UK_i \times Post_t^{Ref} \times D_t^{2021}\right)\right] + \epsilon_{ijt}$$

where $Post_t^{Ref}$ is a dummy that takes value of one for the post-referendum period (July 2016-December 2021) and D_t^{2021} is a dummy that takes value of one for the post-TCA period (January 2021-December 2021). The coefficient β_{Ref} measures the impact of the referendum on the period July 2016-December 2020 relative to the pre-referendum period January 2012-June 2016. The coefficient β_{TCA} measures the impact of the TCA in 2021 relative to the post-referendum period. Results are reported in Table 16. Coefficient estimates and significance level is very similar to the results reported in the text.

Table 16: DD and DDD results excluding FTA partner

	Exports		Imports	
	(1)	(2)	(3)	(4)
	exports	exports	imports	imports
EU×Post-referendum	-0.011		-0.062	
	(0.052)		(0.054)	
EU×2021	-0.030		-0.318**	
	(0.056)		(0.105)	
UK×EU×Post-referendum		0.036		-0.045
		(0.033)		(0.027)
UK×EU×2021		-0.049		-0.273***
		(0.048)		(0.045)
Pair FE	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	No
Partner-time FE	No	Yes	No	Yes
Reporter-time FE	No	Yes	No	Yes
Observations	3960	103800	3960	103800

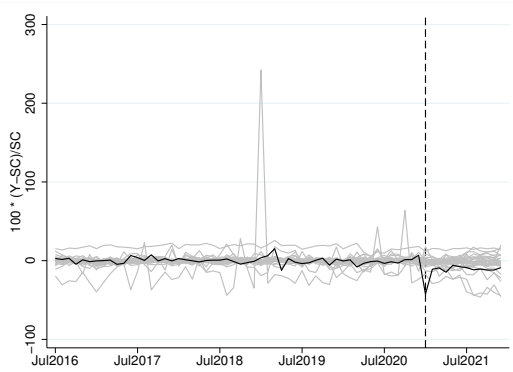
Robust standard errors clustered at the exporter-importer level in parenthesis. * p < 0.05, ** p < 0.01, *** p < 0.001. The table reports the DD (columns 1 and 3) and DDD (columns 2 and 4) estimates for UK exports to and imports from the EU excluding FTA partners from the control group.

Synthetic control placebos

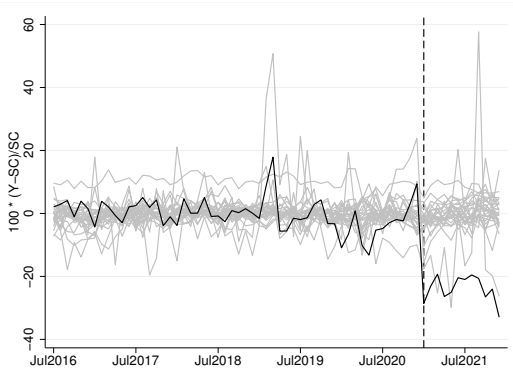
Figure 11 reports the placebos for the percentage difference of the actual flow relative to the SC estimate for the UK (black line) and the placebos (in light grey).

Figure 11: UK-EU trade SCM placebo

(a) Exports to the EU



(b) Imports from the EU



The figure reports placebo of the SC estimates for UK trade with the EU27. The pre-treatment period is Jul2016-Dec2020, matching is performed over all pre-treatment values of the outcome variable. The vertical axis measures percentage deviations of the SC from the outcome variable Y. The black solid line represents UK-EU27 trade while the grey lines are trade of each EU27 member with the remaining EU countries.

Disaggregated SC results by partner and months of 2021

Table 17: Disaggregated SC results for UK exports

Importer	Jan_Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AT	-21.96	-43.90	-21.48	-4.70	-9.84	-14.17	0.84	-26.60	-28.06	-34.18	-36.32	-6.12	-38.98
	(0.11)	(0.00)	(0.15)	(0.81)	(0.44)	(0.41)	(0.89)	(0.04)	(0.07)	(0.07)	(0.04)	(0.56)	(0.07)
BE	2.19	-36.29	21.53	22.88	1.59	11.54	-0.33	18.46	3.24	-2.67	-1.00	-5.75	-6.98
	(0.59)	(0.00)	(0.15)	(0.15)	(0.96)	(0.52)	(0.96)	(0.30)	(0.85)	(0.81)	(0.89)	(0.78)	(0.78)
BG	-33.70	-54.59	-45.24	-14.50	-36.87	-44.58	-48.94	-36.05	-28.86	-9.51	-52.56	-14.90	-17.77
	(0.44)	(0.11)	(0.04)	(0.56)	(0.22)	(0.26)	(0.15)	(0.37)	(0.56)	(0.89)	(0.07)	(0.63)	(0.74)
CY	-36.98	-49.53	-40.19	-24.77	-39.81	-25.28	-36.26	-34.64	-39.37	-51.22	-49.34	-34.80	-18.52
	(0.22)	(0.15)	(0.26)	(0.22)	(0.15)	(0.22)	(0.22)	(0.04)	(0.15)	(0.07)	(0.11)	(0.22)	(0.37)
CZ	-24.08	-56.51	-23.68	-11.62	-23.73	-12.83	-15.99	-21.51	-18.85	-32.07	-27.46	-23.23	-21.52
	(0.00)	(0.00)	(0.04)	(0.11)	(0.04)	(0.33)	(0.30)	(0.15)	(0.11)	(0.07)	(0.07)	(0.00)	(0.07)
DE	-19.26	-43.14	-17.99	-10.20	-13.42	-5.82	-19.25	-15.95	-22.79	-24.41	-23.22	-18.38	-16.60
	(0.00)	(0.00)	(0.00)	(0.11)	(0.11)	(0.67)	(0.07)	(0.19)	(0.07)	(0.04)	(0.04)	(0.19)	(0.26)
DK	-12.16	-38.87	-20.02	-10.71	3.58	1.66	-10.85	-0.76	1.02	-21.34	-20.20	-4.36	-25.02
	(0.15)	(0.00)	(0.11)	(0.37)	(0.81)	(0.78)	(0.22)	(0.78)	(0.96)	(0.19)	(0.15)	(0.70)	(0.19)
EE	-7.69	-39.87	-2.86	-16.84	14.57	-19.08	-24.57	-4.09	23.41	-11.37	-17.45	0.90	4.95
	(0.48)	(0.04)	(0.78)	(0.15)	(0.41)	(0.22)	(0.07)	(0.74)	(0.11)	(0.33)	(0.15)	(0.96)	(0.81)
ES	-25.30	-39.94	-30.04	-28.47	-27.93	-24.26	-25.33	-16.35	-16.63	-4.97	-35.81	-34.93	-18.94
	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.11)	(0.07)	(0.37)	(0.37)	(0.67)	(0.00)	(0.00)	(0.37)
FI	-31.69	-42.16	-25.20	-37.08	-27.45	-31.97	-33.47	-31.21	-32.71	-35.51	-25.12	-38.68	-19.75
	(0.04)	(0.00)	(0.11)	(0.00)	(0.00)	(0.04)	(0.00)	(0.04)	(0.04)	(0.07)	(0.19)	(0.00)	(0.44)
FR	-16.25	-50.26	-16.89	-10.65	-21.41	-6.84	-8.94	-7.82	-13.66	-15.11	-15.14	-13.62	-14.61
	(0.15)	(0.00)	(0.04)	(0.26)	(0.07)	(0.52)	(0.52)	(0.56)	(0.33)	(0.19)	(0.26)	(0.22)	(0.41)
GR	-33.52	-50.96	-40.96	-32.41	-34.55	-33.19	-21.94	-43.26	-30.85	-20.93	-28.08	-32.16	-32.95
	(0.33)	(0.11)	(0.07)	(0.26)	(0.07)	(0.22)	(0.44)	(0.15)	(0.30)	(0.37)	(0.37)	(0.41)	(0.37)

The table reports the SC treatment effects and p-values (in parenthesis) of UK exports for each EU country and month of 2021.

Table 18: Disaggregated SC results for UK imports (continued)

Importer	Jan_Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HR	-57.24	-65.34	-53.44	-52.03	-56.13	-49.26	-51.02	-44.01	-45.67	-59.32	-56.24	-73.12	-81.36
	(0.04)	(0.07)	(0.15)	(0.00)	(0.15)	(0.15)	(0.00)	(0.19)	(0.07)	(0.15)	(0.11)	(0.04)	(0.00)
HU	-7.80	-46.70	-7.29	2.42	-34.05	-16.94	-26.06	8.95	13.17	52.04	-30.27	-13.93	5.11
	(0.30)	(0.00)	(0.41)	(0.81)	(0.07)	(0.22)	(0.19)	(0.67)	(0.48)	(0.00)	(0.15)	(0.63)	(0.74)
IE	7.53	-40.90	-12.50	-4.62	-1.23	-3.08	29.48	2.39	7.66	19.65	20.77	21.17	51.59
	(0.48)	(0.07)	(0.52)	(0.78)	(0.93)	(0.85)	(0.26)	(0.96)	(0.56)	(0.56)	(0.22)	(0.52)	(0.19)
IT	-15.82	-57.17	-7.50	-11.53	-14.61	-1.14	-1.30	-15.59	-17.43	1.82	-20.65	-15.76	-28.95
	(0.07)	(0.00)	(0.37)	(0.19)	(0.15)	(0.85)	(0.85)	(0.22)	(0.19)	(0.81)	(0.11)	(0.22)	(0.11)
LT	0.23	-45.39	0.34	7.53	16.56	-6.02	12.79	29.93	29.91	-17.61	-16.00	8.26	-17.57
	(0.85)	(0.30)	(0.93)	(0.78)	(0.59)	(0.85)	(0.78)	(0.37)	(0.41)	(0.70)	(0.48)	(0.85)	(0.63)
LU	98.97	74.68	-11.86	84.00	16.91	58.11	258.06	53.03	64.18	144.73	47.92	120.42	277.43
	(0.07)	(0.11)	(0.63)	(0.04)	(0.56)	(0.22)	(0.00)	(0.19)	(0.15)	(0.07)	(0.15)	(0.04)	(0.04)
LV	-10.61	-62.29	-22.39	-7.28	-10.52	0.31	-23.30	-9.41	-3.82	7.15	-8.18	37.69	-25.32
	(0.30)	(0.00)	(0.15)	(0.78)	(0.67)	(0.96)	(0.37)	(0.63)	(0.74)	(0.74)	(0.63)	(0.07)	(0.26)
MT	-46.73	-20.80	-35.13	-39.07	-32.83	-37.02	-56.46	-42.16	-58.18	-62.12	-59.50	-57.43	-60.04
	(0.93)	(0.78)	(0.70)	(0.59)	(0.70)	(0.70)	(0.67)	(0.56)	(0.52)	(0.59)	(0.44)	(0.63)	(0.56)
NL	-7.48	-27.68	6.04	-11.95	-14.42	2.79	-4.14	-4.60	-6.80	-5.59	1.42	-9.50	-15.32
	(0.59)	(0.04)	(0.52)	(0.22)	(0.19)	(0.78)	(0.74)	(0.78)	(0.52)	(0.67)	(0.85)	(0.52)	(0.41)
PL	-33.87	-67.53	-27.96	-23.47	-35.09	-24.56	-30.96	-28.90	-27.25	-35.99	-32.55	-37.55	-34.61
	(0.00)	(0.00)	(0.04)	(0.07)	(0.00)	(0.07)	(0.04)	(0.07)	(0.00)	(0.11)	(0.07)	(0.04)	(0.04)
PT	-35.28	-51.87	-5.68	-33.73	-45.23	-48.68	-45.56	-14.85	-38.06	-27.31	-36.45	-49.12	-26.77
	(0.04)	(0.00)	(0.67)	(0.04)	(0.00)	(0.00)	(0.07)	(0.11)	(0.00)	(0.04)	(0.04)	(0.07)	(0.19)
RO	-24.35	-50.30	-28.27	-3.65	-25.18	-20.93	-20.57	-38.60	-18.66	-20.50	-22.78	-23.51	-19.21
	(0.00)	(0.00)	(0.00)	(0.56)	(0.11)	(0.07)	(0.07)	(0.04)	(0.15)	(0.15)	(0.15)	(0.07)	(0.11)
SE	-14.23	-39.79	-9.66	-10.67	-20.76	-7.79	-27.02	-22.87	-18.90	-26.50	-3.69	5.40	11.53
	(0.33)	(0.11)	(0.41)	(0.30)	(0.15)	(0.41)	(0.15)	(0.26)	(0.15)	(0.07)	(0.81)	(0.63)	(0.48)
SI	-26.92	-58.19	-31.13	-20.66	-37.89	-32.72	70.20	-27.05	-20.29	-32.27	-32.13	-44.78	-56.12
	(0.41)	(0.22)	(0.30)	(0.44)	(0.15)	(0.41)	(0.15)	(0.37)	(0.52)	(0.37)	(0.30)	(0.11)	(0.15)
SK	3.52	-42.74	-19.53	6.30	-4.57	2.30	61.92	27.98	10.09	0.17	-8.13	1.23	7.25
	(0.56)	(0.26)	(0.37)	(0.78)	(0.63)	(0.89)	(0.00)	(0.30)	(0.85)	(0.96)	(0.78)	(0.93)	(0.81)
Total	-12.86	-42.58	-10.90	-9.17	-14.66	-5.81	-7.65	-8.78	-11.60	-10.58	-11.94	-11.89	-8.78
	(0.04)	(0.00)	(0.04)	(0.04)	(0.00)	(0.57)	(0.21)	(0.36)	(0.29)	(0.32)	(0.25)	(0.25)	(0.39)

The table reports the SC treatment effects and p-values (in parenthesis) of UK exports for each EU country and month of 2021.

Table 19: Disaggregated SC results for UK imports

Exporter	Jan-Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AT	-23.08	-27.89	-10.01	-11.25	-23.72	-33.62	-21.67	-22.96	-17.48	-26.20	-33.76	-21.86	-26.55
	(0.07)	(0.00)	(0.30)	(0.26)	(0.04)	(0.00)	(0.04)	(0.04)	(0.11)	(0.07)	(0.00)	(0.04)	(0.07)
BE	-22.81	-31.86	-23.19	-21.72	-19.58	-24.70	-17.53	-16.93	-14.08	-19.96	-24.71	-22.78	-36.70
	(0.07)	(0.04)	(0.07)	(0.07)	(0.11)	(0.11)	(0.22)	(0.19)	(0.44)	(0.26)	(0.11)	(0.19)	(0.04)
BG	-19.48	-8.83	-0.07	15.16	-19.72	-20.59	-25.69	-42.98	-36.90	-28.77	-28.04	-14.20	-23.10
	(0.56)	(0.67)	(0.96)	(0.56)	(0.44)	(0.44)	(0.37)	(0.15)	(0.15)	(0.30)	(0.41)	(0.81)	(0.70)
CY	-34.70	-32.16	-34.79	-35.83	-36.91	-9.02	-28.21	-37.71	-24.46	-35.01	-29.58	-56.49	-56.21
	(0.19)	(0.15)	(0.15)	(0.07)	(0.07)	(0.52)	(0.26)	(0.07)	(0.15)	(0.07)	(0.22)	(0.22)	(0.00)
CZ	-31.07	-30.64	-27.79	-28.71	-41.15	-30.79	-29.94	-35.00	-25.24	-5.24	-36.04	-32.42	-49.88
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)	(0.63)	(0.00)	(0.00)	(0.00)
DE	-20.19	-33.16	-19.96	-10.87	-19.81	-18.20	-16.68	-17.48	-15.40	-18.82	-20.60	-23.17	-28.16
	(0.04)	(0.00)	(0.04)	(0.07)	(0.04)	(0.07)	(0.07)	(0.07)	(0.19)	(0.04)	(0.07)	(0.04)	(0.07)
DK	-28.26	-31.59	-12.28	-40.96	-26.32	-31.85	-3.19	3.50	-46.36	-25.47	-34.11	-38.51	-52.04
	(0.63)	(0.44)	(0.78)	(0.26)	(0.33)	(0.37)	(0.96)	(0.93)	(0.19)	(0.41)	(0.26)	(0.56)	(0.30)
EE	18.79	-7.81	-4.13	0.44	97.10	28.37	36.33	-3.61	10.43	17.02	68.34	-15.91	-1.12
	(0.44)	(0.70)	(0.81)	(0.96)	(0.04)	(0.48)	(0.30)	(0.93)	(0.74)	(0.67)	(0.11)	(0.67)	(0.96)
ES	-22.94	-10.64	-13.71	-18.97	-23.87	-24.60	-30.27	-30.94	-16.61	-20.92	-31.09	-20.71	-33.00
	(0.15)	(0.37)	(0.22)	(0.15)	(0.11)	(0.07)	(0.07)	(0.07)	(0.26)	(0.33)	(0.07)	(0.22)	(0.11)
FI	-32.58	2.04	-22.69	-39.39	-45.24	-48.36	-35.05	-33.92	-38.13	-35.92	-28.99	-22.05	-43.30
	(0.15)	(0.78)	(0.15)	(0.07)	(0.00)	(0.00)	(0.11)	(0.07)	(0.00)	(0.07)	(0.04)	(0.22)	(0.19)
FR	-21.76	-32.10	-22.80	-20.56	-26.31	-24.88	-22.03	-18.01	-11.66	-14.05	-16.54	-22.72	-29.52
	(0.15)	(0.04)	(0.07)	(0.11)	(0.07)	(0.11)	(0.19)	(0.22)	(0.41)	(0.19)	(0.30)	(0.19)	(0.11)
GR	-25.33	-11.96	-31.95	-21.91	-37.12	-34.88	-33.37	-18.91	-10.17	-29.39	-31.63	-21.09	-21.58
	(0.00)	(0.19)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.07)	(0.30)	(0.07)	(0.00)	(0.04)	(0.11)

The table reports the SC treatment effects and p-values (in parenthesis) of UK imports for each EU country and month of 2021.

Table 20: Disaggregated SC results for UK imports (continued)

Exporter	Jan-Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HR	-57.65	-73.88	-51.03	-64.43	-39.38	-71.37	-52.23	-34.41	-63.46	-56.10	-58.67	-70.07	-56.77
	(0.15)	(0.00)	(0.04)	(0.07)	(0.11)	(0.04)	(0.11)	(0.15)	(0.07)	(0.15)	(0.15)	(0.11)	(0.22)
HU	-36.83	-40.97	-26.13	-33.75	-49.17	-40.84	-33.31	-37.13	-36.74	-36.22	-40.27	-32.46	-34.99
	(0.07)	(0.07)	(0.07)	(0.00)	(0.00)	(0.00)	(0.07)	(0.04)	(0.04)	(0.07)	(0.04)	(0.11)	(0.07)
IE	-19.62	-11.37	-36.38	-18.96	-23.67	-21.05	-5.43	-5.86	-27.94	-20.68	-34.22	-6.28	-23.58
	(0.19)	(0.30)	(0.00)	(0.22)	(0.11)	(0.04)	(0.59)	(0.48)	(0.04)	(0.26)	(0.00)	(0.67)	(0.04)
IT	-16.72	-31.82	-17.64	-9.70	-14.34	-13.89	-14.56	-16.61	-3.90	-18.99	-16.17	-19.44	-23.54
	(0.04)	(0.00)	(0.07)	(0.15)	(0.07)	(0.07)	(0.04)	(0.04)	(0.59)	(0.00)	(0.00)	(0.04)	(0.00)
LT	-9.85	10.33	-15.11	-21.96	-1.60	-17.99	-11.04	-2.33	-0.32	-11.45	-16.08	-15.52	-15.17
	(0.85)	(0.52)	(0.44)	(0.19)	(0.85)	(0.41)	(0.41)	(0.81)	(0.96)	(0.74)	(0.56)	(0.44)	(0.56)
LU	-37.06	-45.84	-39.63	-40.26	-53.96	-36.26	-34.84	-34.28	-22.36	-25.25	-28.94	-29.53	-53.53
	(0.30)	(0.15)	(0.04)	(0.11)	(0.04)	(0.26)	(0.41)	(0.26)	(0.44)	(0.41)	(0.41)	(0.37)	(0.26)
LV	28.00	1.60	2.50	47.38	5.67	9.15	31.65	54.56	77.88	64.47	29.12	13.56	-1.54
	(0.19)	(0.93)	(0.85)	(0.04)	(0.81)	(0.74)	(0.11)	(0.11)	(0.04)	(0.07)	(0.22)	(0.70)	(0.96)
MT	-38.28	-25.27	-26.70	-20.88	-44.74	-33.12	-5.02	-27.75	-42.53	-50.31	-72.80	-33.06	-77.23
	(0.81)	(0.59)	(0.48)	(0.67)	(0.44)	(0.52)	(0.93)	(0.70)	(0.59)	(0.37)	(0.26)	(0.63)	(0.30)
NL	-33.11	-31.88	-31.06	-30.65	-41.21	-37.07	-31.22	-31.93	-31.15	-29.08	-35.17	-28.52	-38.44
	(0.04)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)	(0.07)	(0.04)	(0.00)	(0.04)	(0.07)	(0.07)	(0.07)
PL	-25.68	-26.85	-26.08	-22.38	-26.13	-24.14	-25.37	-26.12	-23.94	-21.69	-26.17	-28.76	-30.48
	(0.00)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.07)	(0.04)	(0.00)	(0.00)	(0.00)	(0.04)	(0.04)
PT	-25.32	-16.29	-21.58	-18.06	-36.44	-32.30	-24.72	-40.67	-16.71	0.87	-34.37	-18.67	-44.85
	(0.00)	(0.15)	(0.04)	(0.07)	(0.04)	(0.07)	(0.07)	(0.00)	(0.19)	(0.93)	(0.00)	(0.11)	(0.00)
RO	-22.49	-34.80	-27.04	-9.43	-19.79	-13.79	-8.00	-10.59	6.95	-26.47	-37.20	-41.00	-48.78
	(0.07)	(0.00)	(0.04)	(0.59)	(0.15)	(0.48)	(0.56)	(0.63)	(0.78)	(0.11)	(0.00)	(0.11)	(0.04)
SE	-24.24	-16.76	-19.88	-18.17	-33.75	-27.92	-14.32	-18.42	-15.84	-14.85	-33.30	-37.81	-39.88
	(0.07)	(0.19)	(0.07)	(0.07)	(0.11)	(0.00)	(0.19)	(0.19)	(0.22)	(0.30)	(0.07)	(0.00)	(0.04)
SI	-11.69	-10.32	-4.52	1.33	-27.49	-10.71	-1.98	-18.44	-10.39	-17.60	-14.09	-7.07	-18.95
	(0.63)	(0.67)	(0.85)	(0.89)	(0.15)	(0.48)	(0.89)	(0.41)	(0.37)	(0.44)	(0.37)	(0.70)	(0.48)
SK	-33.08	-53.79	-32.86	-10.03	-41.87	-27.80	-14.33	-29.76	-46.68	-28.03	-42.42	-37.82	-31.62
	(0.15)	(0.04)	(0.07)	(0.26)	(0.04)	(0.15)	(0.52)	(0.26)	(0.00)	(0.15)	(0.07)	(0.07)	(0.30)
Total	-23.96	-28.59	-23.12	-19.31	-26.39	-25.03	-20.42	-20.97	-19.54	-20.62	-26.50	-24.03	-32.95
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)

The table reports the SC treatment effects and p-values (in parenthesis) of UK imports for each EU country and month of 2021.

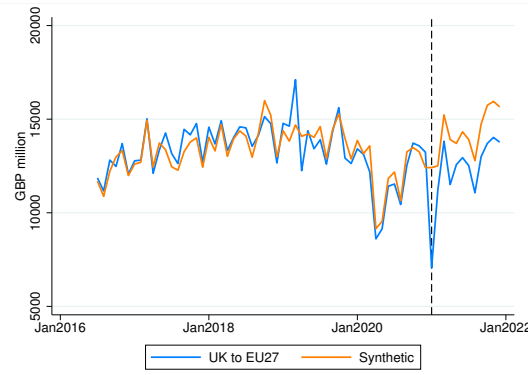
Alternative predictors for SC

As a robustness to our SC estimation, we changed the set of predictors. Rather than matching over the entire pre-treatment period (Jul2016-Dec2020) we use as predictors the average of the outcome variable over each month. This gives us 12 predictors that will be the average over January 2017-20, the average over February 2017-20, March, ... The resulting series are plotted in figure 12 for both exports and imports. This robustness gives a cumulative effect over January-December 2021 of -14.2% (p-value from permutation 0.04) for exports

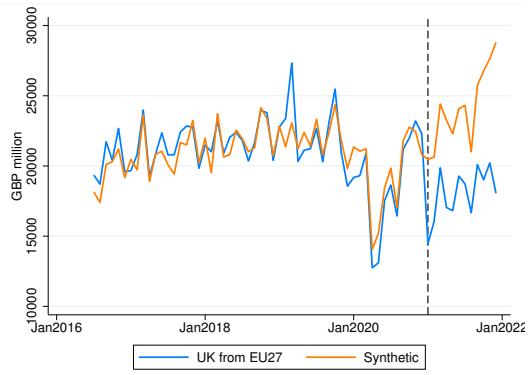
and -25% for imports (p-value=0.00), slightly larger than our baseline estimates. The permutation tests also show similar significance levels.

Figure 12: UK-EU trade SCM result

(a) UK exports to the EU



(b) UK imports from the EU



The figure reports the SC estimates for UK exports to and imports from the EU27. The pre-treatment period is Jul2016-Dec2020, matching is performed over month averages of the pre-treatment values of the outcome variable.