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Jun Du
Enterprise Research Centre and
Economics, Finance and Entrepreneurship Department,
Aston Business School, Aston University.
j.du@aston.ac.uk
Twitter: @jundu1mecom

Oleksandr Shepotylo
Economics, Finance and Entrepreneurship Department,
Aston Business School, Aston University.
oshepotylo@aston.ac.uk
Twitter: @shepotylo.

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ABSTRACT

The UK exit from the EU generates additional trade costs between the two parties, and the new trade costs are largely non-tariff related. We calculate ad valorem equivalents (AVE) of non-tariff measures (NTMs) and estimate their impact on the UK trade in 2021 after the end of the Brexit transition period. Using the synthetic control difference-in-difference methodology we find that the EU-UK Trade and Cooperation Agreement (TCA) had a strong, negative, and significant impact on UK bilateral trade with the EU countries, leading to 22% reduction in exports and a 26% reduction in imports. UK trade with non-EU countries has not been significantly affected. The increased trade frictions due to sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) measures as a result of entering the TCA played an important role in the decline of UK exports to the EU. On average for the first six month of 2021, a 1% increase in AVE SPS results in a 13-15% reduction in exports to the EU, and a 1% increase in TBT leads to a 2-3% reduction in exports. This amounts to a staggering reduction of UK exports by £12.4 billion (15.6% relative to the first half of 2019 or 70% of the total documented reduction in the EU exports) over this period by a simple back-of-envelope calculation. These effects are spread across a range of industrial sectors and EU countries/export destinations. The results hold to a range of robustness tests and do not appear to be “teething problems”. Further, no such effect is found for UK imports from the EU, likely due to the absence of border checks in the UK. Evidence suggests that UK products subject to a higher level of SPS being diverted towards the non-EU destinations, while the same cannot be said for products with higher TBT measures. Our findings point to specific aspects of UK-EU trade frictions that represent the steepest costs of Brexit and overall highlight the importance of domestic policy and measures in the near term.

Key words: NTM, import, export, Brexit, UK, EU

JEL codes: F13 F14

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"This agreement, this deal above all means certainty…
And there will be no non-tariff barriers to trade."

UK Prime Minister Boris Johnson's statement on EU negotiations: 24 December 2020

1. INTRODUCTION

The UK formally departed from the EU on 31 December 2020. The transition period ended on 1 January 2021 when the EU-UK Trade and Cooperation Agreement (TCA) came into effect. The TCA sets new rules for trade and cooperation between the two parties, marking significant changes in their future relationship. The aim of this study is to understand how the momentous changes triggered by the TCA impact on the UK and the EU. While the different tariff regimes associated with various Brexit scenarios and their likely and actual impacts on trade have been extensively discussed (Dhingra et al., 2017, Sampson, 2017), and several other studies have documented how Brexit uncertainty impacted on trade before the end of the transition (Bloom et al., 2019, Carballo et al., 2018, Douch et al., 2019; Graziano et al., 2020 a, b; Douch and Edwards, 2021; Fernandes and Winters, 2021), there remains an unexplored and crucial question about how the new trade regime under the TCA might affect trade post-Brexit.

The UK Office of National Statistics (ONS) reports that UK trade in 2021 had a discernible decline at the start of the year, and remained below pre-pandemic level. As we discuss in more detail below, this downturn seems to be UK-specific. Recent analyses show a sizable reduction in UK trade as a result of leaving the EU's single market and customs union. But the literature is limited, for not only are the data still emerging, there are also considerable challenges to disentangling the complexity of the trade dynamics. The situation is exacerbated by the lack of theories about economic disintegration as opposed to the extensively discussed economic integration.

Further, most studies evaluating the trade costs of Brexit focuses on quantifying the effect but yet to consider the mechanisms of the effect. This paper fills the gap by starting to unravel how the Brexit effect took hold. We focus on non-tariff measures (NTMs). Our research design takes advantage of the fact that the TCA, as agreed, does not impose any tariffs on goods traded between the UK and the EU.[1] This offers an opportunity to examine the mechanism

[1] As long as the goods qualify for tariff exemption by meeting the rules of origin.

whereby the TCA might affect trade through non-tariff-related measures rather than via tariff regime changes.

To put the EU-UK TCA into context, this was an important achievement that established a complex structure for managing trade between the two parties (Amodu et al., 2021). Ayele et al. (2021) note that customs and trade facilitation in the TCA is comprehensive and broad, providing the possibility of close cooperation in order to facilitate trade between the UK and EU. As the UK's PM Boris Johnson claimed on Christmas Eve 2020, the TCA will not impose non-tariff barriers on trade with the EU. However, what the TCA provides is nowhere near the degree of trade liberalisation the previous trade agreement UK enjoyed by being part of the EU. It has been described as a deal that is 'hard' in nature, 'thin' and incomplete (Bryan and Noé, 2021), given that its section on non-tariff measures is rudimentary. Anecdotal evidence suggests that the promise of 'no non-tariff barriers' is unlikely to be kept (Amodu et al., 2021).

Specifically, while the TCA grants the UK 'national listed status', imports must comply with the respective UK and EU laws. The compliance will be assessed by sanitary and phytosanitary (SPS) border checks; these involve the most extensive checks, with specialist paperwork and frequent physical inspections. Inevitably, traders will incur extra costs from crossing the EU-UK border. As regards technical regulation and standards, the TCA aims to streamline compliance processes and remove some of the burdens on businesses in certain sectors. But it falls short of a broad mutual recognition of conformity assessment. As a result, goods have to undergo two sets of conformity assessments both by the UK and the EU rather than one (as previously in the EU zone), adding extra costs and complexity for businesses.[2]

The upshot is that by entering into the TCA, the UK retreated from the previous advantageous trade arrangements characterised by harmonised, mutually recognised NTMs. It is anticipated that the changes to these conditions result in UK firms having poorer or more costly access to the EU markets and create disruption in the value chains across the UK-EU borders. This disruption takes the form of additional paperwork, border checks, and more complicated logistics. This is particularly true for intermediate goods, which are crucial for just-in-time supply chains management. To understand the extent to which trade frictions occur through

[2] More discussions see https://www.instituteforgovernment.org.uk/publication/future-relationship-trade-deal/goods.

NTMs, we also investigate how these effects are distributed among different types of goods and sectors, and among trade partners.

Furthermore, there are other factors that may contribute to the adverse effects suffered by UK trade post-TCA. The most likely confounder is the COVID-19 pandemic and its effects on global trade, which are hard to be isolated. To address this, we adopt an empirical strategy that constructs the first difference between the first six months of 2021 with the same period of 2020, and likewise the first difference between the first six months of 2021 and 2019. The contrast between these differences could shed light on whether it is more likely the pandemic that is driving the trade reduction.

We adopt three additional strategies to test the robustness of our results. We first repeat the analysis removing January and February data from 2021 and all comparison years to test if there is a strong adjustment effect for the first two months of the new agreement. Then we extend the examined period to the first nine months of each year to see whether the TCA's initial 'teething problems' diminish over a longer period. An undiminished negative effect implies a long-term effect that stems from the sustained higher trade costs. Third, we control for the level of tariffs, as tariffs may correlate with NTMs. Limão and Tovar (2011) show that tariff reduction increase likelihood and restrictiveness of NTMs. Niu et al. (2020) show that tariffs are negatively correlated for most goods, but not for agricultural goods. Since the correlation can be both positive (as in the food industry where products are subject to both high tariffs and high SPS protection) and negative (where low levels of tariff protection may be compensated for by high levels of non-tariff barriers), we do not find that omitting tariffs affects our main results.

The second factor that we can exploit to improve understanding about the TCA effect is the one-sided implementation of border control. As of 1 January 2021, the EU began treating the UK as a third country, implementing full customs and NTMs checks on goods passing from the UK to the EU. However, the UK delayed implementing the full border controls for imports until the end of 2023[3] to avoid delays and spikes in prices; this therefore created an asymmetry in the implementation of the new measures. Little or no effect of TCA on UK imports under the one-sided border control implementation reinforces the evidence of strong effects of TCA on exports due to the non-tariff measures induced by frictions at border.

[3] As at the date of writing (29 April 2022), the UK has four times delayed the implementation of the import controls.

There are empirical challenges to assessing the cost of EU exit because it requires the estimation of a counterfactual, which is how would trade have performed had the UK never left the EU. Typically, Brexit is used as a quasi-experiment, where a reduced form equation of the Brexit impact is estimated, relying on appropriate econometric techniques for identification. Du and Shepotylo (2021) summarise the most popular approaches used to connect observed data with unobserved counterfactuals in the recent literature, highlighting their pros and cons. They show that different methods may lead to varied conclusions in terms of the magnitude of impact in the case of services exports. In this study, we adopt the most appropriate method, synthetic difference-in-differences (SDID) due to Arkhangelsky et al. (2021). It has been shown to be consistent, asymptotically normal, and more efficient relative to the other methods including difference-in-difference and synthetic control.

Using the UNCTAD-WTO I-TIP database on NTMs linked to COMTRADE data on bilateral imports at the HS6 digit level in 2012-2018, we quantify sanitary and phytosanitary (SPS) measures, technical barriers to trade (TBT) and licensing requirements (LCN) by computing their ad valorem equivalents (AVE). Our methodology extends Kee et al. (2009) and Kee and Nicita (2016) to generate product- and destination-specific AVE NTMs. The SDID estimator yields estimates of the overall impact of TCA on the UK-EU exports and imports. The regression analysis further uncovers the impact of NTMs on the UK exports and imports after the end of the transition period (1 January 2021) compared with the same periods in 2019 and 2020. It examines the varied effects of NTMs through three important channels: intermediate inputs, capital goods, and consumer products. We also explore heterogeneity of the effects across EU members and types of goods.

To preview the findings, we show that TCA has a strong, negative, and significant impact on the UK's bilateral trade with the EU countries, leading to a 22% reduction in exports and a 26% reduction in imports over the first half of 2021. Trade with non-EU countries has not been significantly affected. This result is robust for an extended period of three quarters of 2021, with exclusion of January-February which saw most disruptions, controlling for tariff, when only non-EU countries are selected to build synthetic UK, as well as using 2018 as the base year for comparison.

The NTMs in terms of SPS and TBT measures have played a significant role in the adverse effect of TCA on UK exports to the EU. As a whole, we estimate a 1% increase in AVE SPS results in a 13-15% reduction in exports to the EU, while a 1% increase in TBT leads to a 2-3% reduction in exports. Together, A simple back-of-envelope calculation suggests that the increased frictions due to SPS and TBT led to a reduction of UK exports by £12.4 billion (15.6%

reduction relative to 2019) over the first six months period of 2021. Also, it explains 71% of the overall reduction in the EU exports. These effects are spread across a range of industrial sectors and in all EU countries/export destinations.

By contrast, we do not observe similar effects for UK imports from the EU, which could be due to the one-side border arrangement between the UK and the EU. Key policy implications on policy and business global strategy are drawn.

The structure of the rest of the paper is as follows. In the next section we put NTMs in context. Section 3 describes and contextualises the recent UK trade dynamics and the TCA. Data are described in Section 4. Section 5 focuses on the effect of TCA on the UK trade, while Section 6 is devoted to the estimation and to discussions about the role of NTMs in the TCA effect on UK trade. Section 7 concludes.

2. NTMS IN CONTEXT

NTMs refer to policy measures, other than tariffs, that can potentially have an economic effect on international trade in goods, changing traded quantities, prices, or both (UNCTAD, 2010). As the use of tariffs has steadily declined around the world over time, NTMs have gained importance in shaping trade flows along several important margins: the range and volume of trade, and the price and quality of traded goods and services WTO (2012). Worldwide, NTMs are estimated to be on average three times more costly than tariffs for trade (UNCTAD, 2013). In developed countries, a recent estimate suggests that more than 80% of trade is affected by NTMs (Shepherd and Peters, 2020). Furthermore, evidence shows that NTMs affect small businesses disproportionally more (Fontagné et al., 2015 and Fugazza et al., 2017).

Despite their increasing prominence, NTM effects are still not well understood. In part, this is because, unlike tariffs, NTMs influence not just the supply side (through the altered cost of production and reduced accessibility of imported intermediate inputs) but also the demand side (through the effect on the quality and safety of intermediate and final goods). As a result, the impact of NTMs on various margins of trade may be ambiguous. Moreover, NTMs are very difficult to measure and quantify – using frequency to measure NMTs does not capture how costly and binding they are. Finally, NTMs encompass health and safety measures, technical specifications, and border inspections and as such, their heterogeneity makes it difficult to find a common scale that can compare the different types of NTMs to each other. Thus, it is also challenging to assess their restrictiveness in comparison to import tariffs.

Non-tariff measures evoke policy measures without imposing tariffs. In principle, such policy measures are introduced for safety and welfare-enhancing gains and do not explicitly have a protectionist aim. Nonetheless, they could be used as protectionist measures and may in fact be perceived as such. Any policy that impacts trade can be considered an NTM even if it regulates government procurement or the labour markets. NTMs prevent entry because of compliance costs. They are usually part of preferential trade agreements (Hoffman at al. 2017) and are regulated by specific committees at the WTO.

An NTM typology developed by the UNCTAD Multi-Agency Support Team (MAST) (UNCTAD, 2013) lists three broad types in sixteen chapters from A through P, according to the taxonomy[4]:

- Technical measures, A~C, are designed to regulate health and safety, technical standards, and pre-shipment inspections.
- Non-technical measures, D~O, are often trade-related, and include quotas and subsidies. It is worth noting that NTMs cover a wide range of topics, from finance to competition and from intellectual property to government procurement.
- Export measures, in chapter P, include export-related measures.

NTMs may serve dual purposes. They aim to regulate market access and/or ensure that imported products conform to public policy objectives (de Melo and Nicita, 2018). As economies develop and modernise, consumers and firms demand better quality, safer, and more reliable final goods and intermediate inputs. NTMs can also be protectionist tools that are available to policymakers whose objectives include lobbying for domestic industries (Grossman and Helpman, 1994). There is literature that links the current surge in NTMs with the reduction in tariff protection (Maggi et al., 2019). While a government may commit to a certain tariff schedule, it can still use NTMs that are not explicitly regulated by its WTO commitments to ring-fence domestic industries from foreign competition.

Following the recent trend for increasingly deep bilateral trade agreements (Limão, 2016), trade talks are mostly focused on cost-raising NTMs, encompassing ever widening policy questions concerning intellectual property, health and safety, technical standards, capital flows, and procurement. While there is evidence that such deep and comprehensive trade

[4] A detailed list is provided in Appendix Table A1.

agreements are trade-creating, they have been criticised for a lack of transparency and for promoting the interests of multinational corporations (Rodrik, 2018).

Given their heterogeneous and ubiquitous nature, NTMs are key factors that govern international trade flows. Although NTMs are non-discriminatory in nature and should apply equally to domestic and foreign products, we know little about how they are practically applied and whether they embody discrimination against foreign goods. Even if the rules and regulations are identical for domestic and foreign goods, there is a problem with monitoring and enforcement, as time and resources are spent on ensuring that sanitary and technical standards for imported goods satisfy the regulatory standards. Locally produced goods may enjoy the advantage of automatic recognition and low 'red tape', whereas foreign producers may need to prove the quality and safety of their products at the border every time they pass through customs. Therefore, more research on the non-discriminatory nature of NTMs is required. It may also be the case that products from a common economic area, such as the European Union single market, are treated as being a par with domestic goods and are mutually recognised, while products from outside of the common market are subject to burdensome checks and controls. This study examines these questions in detail.

Finally, it must be asked how NTMs relate to preferential trade agreements. The proliferation of preferential trade agreements (PTAs) in the last 25 years have generated a global trade system where the trading partners participate, with different levels of integration, in various multilateral and bilateral groups. The situation is further complicated by the increasing complexity of PTAs. While earlier types of preferential trade arrangements, such as the General Scheme of Preferences (GSP) and the Latin American free trade area, were focused on tariff reduction, modern PTAs cover a much broader set of policies, including intellectual property protection, investment treaties, and non-tariff measures that regulate health and safety and technical standards (Limão, 2016, Rodrik, 2018).

Research on the impact of PTAs on the level of non-tariff protection is scarce. It is unknown how the stringency of an NTM might depend on the fact that the bilateral trading partners have a PTA. Furthermore, do specific types of PTAs have similar effects on NTMs? These are open questions that we intend to answer in this paper. We address these issues by allowing NTMs to interact with a PTA to have a differential impact on trade.

3. UK TRADE THROUGH THE EU EXIT TRANSITION PERIOD

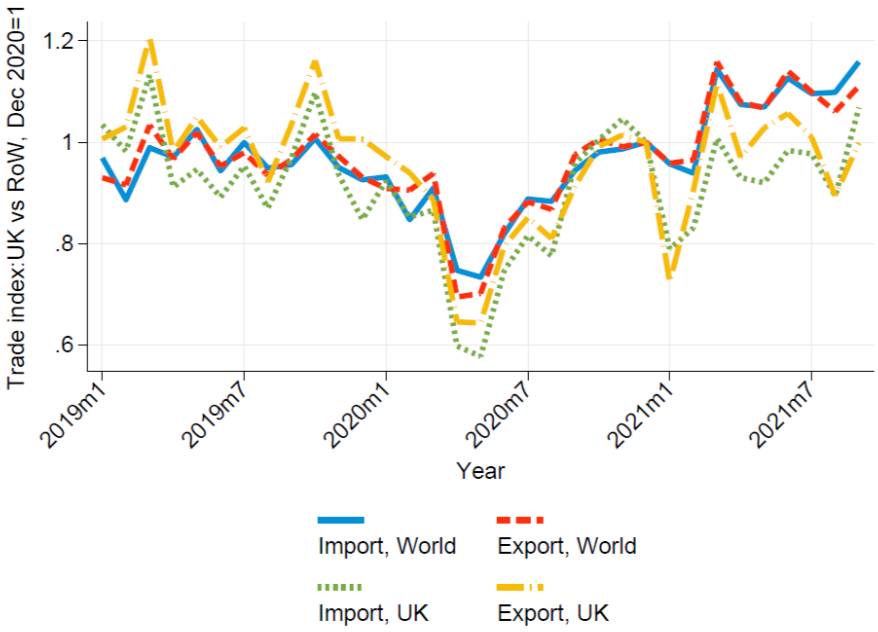
3.1 Recent UK trade dynamics

Since 2020, UK trade has experienced a double-dip decline, the first wave during May-July 2020 and then again in January-February 2021, as illustrated in Figure 1. This is particularly the case for the UK's trade with the EU, as shown in Figure 2.

Du and Shepotylo (2021a) document that the UK's GDP declined by 9.9% in 2020, the worst reduction since 1955 and one that compares poorly with the changes in GDPs of the other advanced OECD economies. They argue that the first UK trade collapse was primarily a negative supply shock phenomenon caused by the COVID-19 pandemic. The index of trade in goods depicted in Figure 1 shows that the UK experienced a more severe decline in trade relative to the rest of the world in the first quarter of 2020. Overall, UK goods exports contracted by 15.5% in 2020 (from 468.3 billion USD in 2019 to 395.7 billion USD in 2020), the worst result among the G7. The UK's goods imports also declined by 8.4% in 2020, which was in line with the rest of the world. As shown in Figure 2, in 2020 there was no discernible difference in the trade patterns of the UK and those of the EU and non-EU countries.

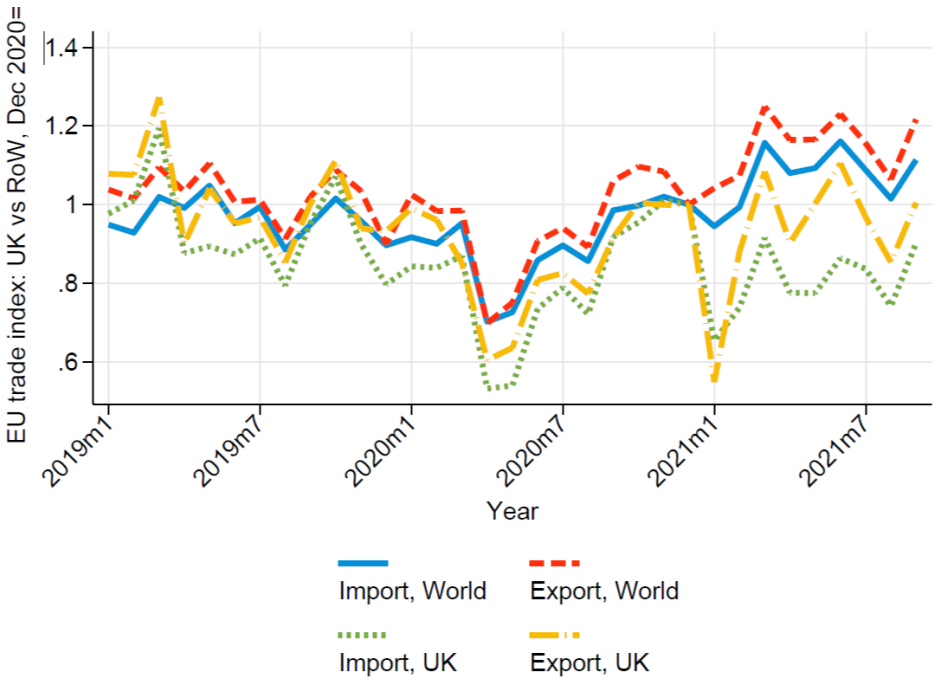
However, the second recession in January-February 2021 appears to be specific to the UK, because at that time the rest of the world's trade with EU and non-EU countries was increasing. This recession occurred at the time when the UK ended its Brexit transition period and started a new trade relationship with the EU countries. Since then, UK exports have recovered, but UK imports have remained significantly below the level of December 2020, especially for UK imports from the EU countries.

Figure 1: UK export and import relative to the rest of the world



Note: COMTRADE Monthly data. Gold is excluded.

Figure 2: UK export and import to the EU countries relative to the rest of the world



Note: COMTRADE Monthly data. Gold is excluded.

Analysis of the monthly trade data shown in Table 1 reveals that during the first six months of 2021 the UK reduced its trade turnover with the EU countries by 17.6% relative to the same period of 2019. Exports declined by 11.6%, while imports declined by 23.5%. The UK trade reduction occurred against the backdrop of a robust recovery of trade in other countries. In the EU, Germany and the Netherlands increased their trade turnover with the other EU countries by 22.5% and 12.5% consequently. Non-EU countries have also recovered, as shown in Table 2. The US trade turnover with the EU was marginally lower than in the last pre-pandemic year, while the turnover of the other non-EU countries with the EU increased by 0.8%.

Table 1: Change in trade with EU countries

	Change in trade, %			
Country/Region	Capital	Consumer	Intermediate	Total*
	A. Export			
Germany	-3.2	7.7	8	26.4
Netherlands	18.5	19.8	25.8	12.7
Rest of EU	12.1	6.8	12.3	8.3
Rest of the World	12.9	-1.4	20.8	1.7
United Kingdom	**-3**	**-21.2**	**-0.2**	**-11.6**
United States	-0.6	-3.1	4.6	-9.2
All	**6.1**	**1.4**	**11.9**	**4.7**
	B. Import			
Germany	-7.5	5.3	4.8	18.5
Netherlands	16	17.8	17.9	12.3
Rest of EU	6.3	6.8	10.5	8.4
Rest of the World	0.3	9.4	7.58	0
United Kingdom	**-24**	**-24.6**	**-10**	**-23.5**
United States	5.5	3.8	7.3	5.3

Note: Data is COMTRADE. Gold is excluded. *Total includes capital, consumer, intermediate goods as well as fuels and goods none else specified.

Looking at the different types of goods, the UK export and import of consumer goods to/from the EU have performed particularly poorly, declining by 21.2% and 24.6% respectively in the first six months of 2021. At the same time, the UK export of intermediate and capital goods remained stable in the first half of 2021, while the UK import of capital and intermediate goods from the EU declined by 24% and 10%. This may reflect the challenges experienced by traders in terms of customer formalities, and the border checks and controls on manufactured goods along the UK-EU borders. It is noteworthy that the decline is seen from both directions of trade,

which suggests that the asymmetric border checks (i.e., only when crossing from the UK to the EU) are not the sole factor at play here.

While the presented decline in the UK's trade with the EU cannot be attributed solely to the increased trade barriers after the end of the transition period, it should be noted that the UK's trade with non-EU countries did not experience a comparable decline, as shown in Table 2. In fact, UK exports increased by 12.4%, and imports increased by 1.3%.

Table 2: Change in trade with non-EU countries

	Change in trade, %			
Country/Region	Capital	Consumer	Intermediate	Total*
	A. Export			
Germany	1.7	1.3	10.3	-0.6
Netherlands	26.4	7.6	14	8.2
Rest of EU	3.3	14.8	12.4	7.3
Rest of the World	4.2	1.5	18.7	5.4
United Kingdom	**-0.5**	**-11.6**	**2.9**	**12.4**
United States	0.1	1.7	12.2	-1.9
All	**5.9**	**2.5**	**11.8**	**5.1**
	B. Import			
Germany	18.4	5.6	10.5	13.6
Netherlands	23.2	19	11.9	5.3
Rest of EU	13.5	-2.7	4.7	3.4
RoW	9.3	8.3	5.3	7
United Kingdom	**21.8**	**3.4**	**17.3**	**1.3**
United States	13.8	8	9.1	7.6
All	**16.7**	**7**	**9.8**	**6.4**
	C. Total			
Germany	10.1	3.5	10.4	6.5
Netherlands	24.8	13.3	13	6.8
Rest of EU	8.4	6.1	8.6	5.4
RoW	6.8	4.9	12	6.2
United Kingdom	**10.7**	-4.1	**10.1**	**6.9**
United States	7	4.8	10.7	2.9
All	**11.3**	**4.7**	**10.8**	**5.8**

Note: Data is COMTRADE. Gold is excluded. *Total includes capital, consumer, intermediate goods as well as fuels and goods none else specified.

3.2 The EU-UK Trade and Cooperation Agreement

The UK officially left the EU on 31 January 2020, at which time it entered a transition period and no longer participated in the EU's decision-making. However, until 1 January 2021, the UK remained in the EU single market and customs union and continued to apply EU law, following the existing rules on trade, travel, and business. The EU-UK Trade and Cooperation Agreement came into force at the end of the transition period; this Agreement sets new rules for trade and cooperation between the parties, making significant changes in the way UK businesses interact with the EU.

The EU-UK TCA applies zero tariffs and zero quotas on all goods that comply with the rules of origin. However, it is more restricted in terms of non-tariff measures; these can be applied to goods that are traded between the two parties but are likely to be more intensively applied on goods exported to the EU by UK companies. For example, to export Atlantic salmon from the UK to Germany tariff-free, the product needs to be accompanied by the appropriate proof of origin. In addition, a raft of other rules apply, relating to anti-dumping, anti-subsidy or other safeguarding measures, origin marking, and non-preferential rules of origin. The shipment should come with a commercial invoice, customs declaration, freight documents and insurance, packing list, and a single administrative document (SAD).[5]

On top of that, since seafood and fish products are highly regulated by sanitary measures, there are 10 non-tariff measures with which the product must comply. Imports of fishery and aquaculture products into the EU must be accompanied by a health certificate signed by the competent authority of the exporting third country, certifying that the products in question are suitable for export to the EU.

The overall assessment of the TCA by Ayele et al. (2021a) notes that it has complex and bespoke rules of origin. Customs and trade facilitation agreements are broad and comprehensive. However, it falls short in terms of non-tariff measures. In particular, since there is no chapter on the mutual recognition of the conformity assessments, the red tape for exporting to the EU, as well as the costs, have increased.

[5] This information is available on the EU Access2Markets website at https://trade.ec.europa.eu/access-to-markets/en/ home.

Regarding food products and animals, the TCA does not introduce any simplifications in terms of SPS checks and formalities. The TCA gives each party the right to insist that imports meet their standards. There is no mutual recognition of either product standards or testing (Ayele et al., 2021a):

> *"TCA… does not include any simplifications for border formalities that could help minimise delays, congestion, and bottlenecks. Indeed, it is important to recognise that leaving the EU creates extra barriers between the UK and the EU, which the TCA does not address. Estimates of the costs of completing customs declarations for the UK economy are estimated to be of the order of £15 billion."*

3.3 The new EU-UK border arrangement

When the new trade regime defined by the TCA became effective on 1 January 2021, the UK and the EU no longer applied the same customs rules, regulatory standards, or enforcement mechanisms, meaning that goods crossing the border between the UK and the EU are now subject to customs formalities, which require new checks and paperwork. The exact requirements depend on the type of goods involved, where they cross the border, and who is transporting them. The Trade and Cooperation Agreement with the EU does little to streamline border processes compared with no agreement, which means traders now face significantly more friction than they did under EU membership.

From the first day of 2021, when the transition period ended, the EU introduced full import controls. The UK government had intended to do the same but this has been delayed three times, and officials can give no specific assurance as to when the border controls will start.[6] This is particularly the case for juxtaposed controls, such as at Dover in Kent, UK, which is a major port for ferries to Calais in France, and where EU officials carry out border checks on the UK side of the border.[7]

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[6] The delays could be due to the UK government's lack of preparation for the implementation of the border checks, which is a huge cross-government operation. The Institute of Government provides a summary of the delays in implementing custom requirements for UK imports from the EU as announced by the UK government: https://www.instituteforgovernment.org.uk/explainers/future-relationship-gb-eu-border. It is expected that by 30 September 2022, all UK import declarations will transfer to the Customer Declaration System (CDS), with all export declarations to follow by 31 March 2023.

[7] There is evidence that ports like Dover have not been prepared for the post-TCA trade flows between the UK and the EU. See UK Parliamentary evidence on border issues at https://publications.parliament.uk/pa/cm5802/cmselect/cmpubacc/746/report.html In particular, evidence by Port of Dover at https://committees.parliament.uk/writtenevidence/40972/html/ and the

4. DATA

4.1 NTM data and Ad valorem equivalents of NTMs

For our analysis, we employ data from multiple sources. UNCTAD I-TIP NTM database provides the most comprehensive data on non-tariff measures, being available for more than 100 countries in 2012-2018 (Mattoo and Peters, 2018). For each 6-digit HS code product line, it reports whether a country applies an NTM of a particular type towards its trading partner country. It records starting and ending times for each NTM, which allows us to construct a panel of NTMs in 2012-2018.

The EU NTMs in the data are reported in the areas of SPS (A), TBT (B), Inspections (C), Licensing (E), Finance (G), and Competition (H) measures, with measures A, B, and E representing 99.5% of all measures as summarised in Table 3. Therefore, we focus on the SPS, TBT, and Licensing NTMs in this study.

Table 3: EU NTMs in 2018 reported to UNCTAD I-TIP

Type		Count	Percent	Cum.
A	Sanitary and phytosanitary measures	84,397	33.39	33.39
B	Technical barriers to trade	133,925	52.98	86.36
C	Pre-shipment inspection and other formalities	587	0.23	86.59
E	Non-automatic licensing and quantity control measures; Price control measures, additional taxes and charges	33,144	13.11	99.71
G	Measures affecting competition	364	0.14	99.85
H	Trade-related investment measures	380	0.15	100.00
Total		252,797	100.00	

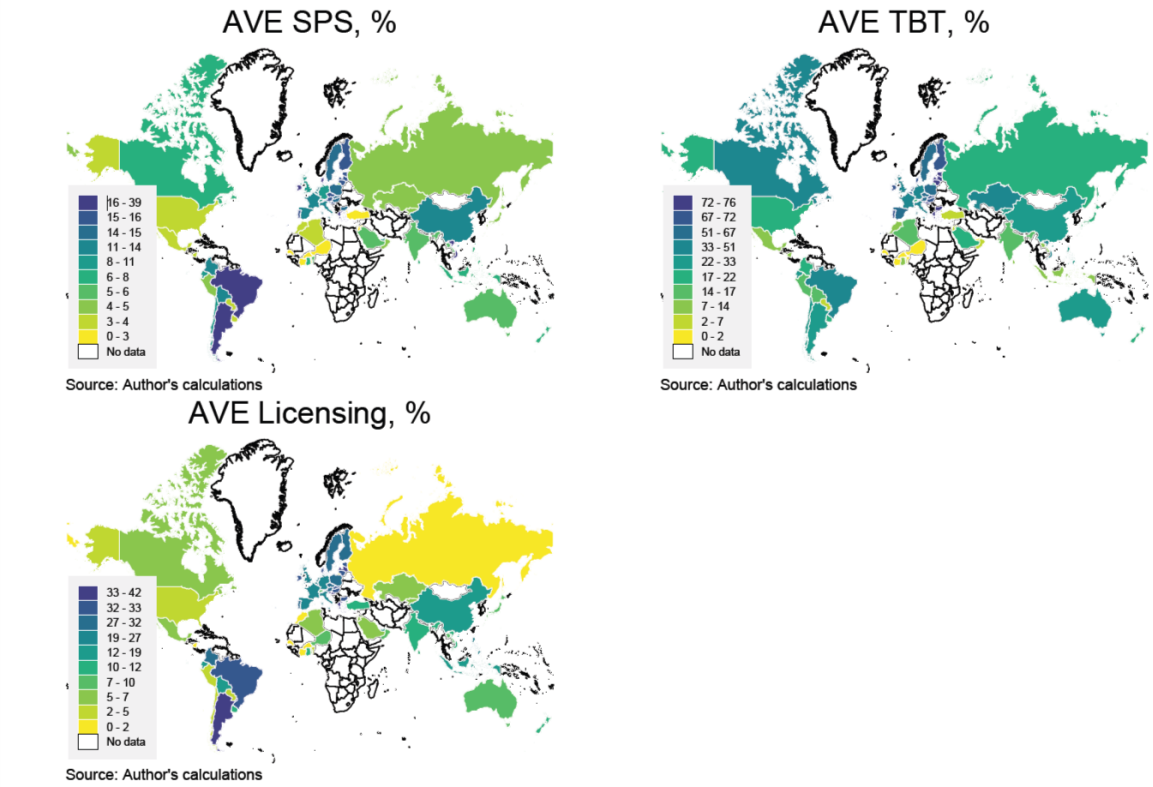
Note: MAST classification. An NTM is recorded as a binary variable at the level of the national classification of products (8 or 10 digit codes). A product line may have multiple NTMs of the same type, representing different requirements.

NTMs that are akin to standards have been increasing in the last two decades (Orefice et al. 2017). They are heterogeneous and at the most granular level have more than 150 categories. In order to integrate all these measures to a common denominator, we calculate an ad valorem equivalent of an NTM (A, B, or E), which is time, country, and product (HS6) specific. Figure 3 presents the average levels of ad valorem equivalents of non-tariff measures on the UK exports in 2018. China, Europe, and Latin America have, on average, higher levels of NTMs

ongoing legal dispute between the UK government and the Port of Dover at https://www.ft.com/content/3cc246e9-3f0c-48be-8626-dc8f288dbdbb.

in all categories. AVE TBT has the highest level of protection, while AVE SPS and AVE Licensing have similar levels. For the whole sample, the simple average AVE SPS is 10%, AVE TBT is 37.2% and AVE Licensing is 18.1%.

Figure 3: AVE NTMs against exports from and imports to the UK in 2018 around the World



Note: Average AVE NTM of each type is calculated across all HS6 digit products in 2018.

4.2 Trade data

We use two separate trade datasets in our analysis. For the AVE NTM calculations, we use COMTRADE import data at the harmonized system (HS) sub-heading level (HS 6-digit) in 2012-2018. It contains both value (in USD) and quantity (in common units, being kilograms in most cases, but also litres and other units). For the SDID analysis and the analysis of the impact of NTMs on the UK trade, we use the monthly bilateral exports and imports of the UK at the HS sub-heading level from COMTRADE. To make the analysis comparable across 2019-2021, we use only the first 6 months of each year (or 9 months for robustness checks) and aggregate these to the annual values. As a result, our dependent variable is the UK's first

half of the year exports and imports with 227 partner countries in all HS6 products in 2019-2021.

To control for the variation in tariff regimes and for the AVE NTM calculations, we draw on the UNCTAD TRAINS database as our source of the applied most-favoured nation (MFN) and preferential tariffs in 2012-2018. Further, we also control for differences in countries' preferential trade agreements (PTA) by making use of Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008). The data for bilateral trade costs, used for the AVE NTM calculations, are drawn from the Centre d'Études Prospectives et d´Informations Internationales (CEPII) database. The common spoken language variable capture the effect of cultural similarities on trade (Melitz and Toubal, 2014).

5. INITIAL BASELINE MODEL: THE TCA AND UK TRADE

5.1 Methodology

To isolate the effect of EU exit from other shocks, such as the COVID-19 shock or the problems with the global supply chains, we start with causal inference tools that have gained considerable popularity and advancement in recent years. There are three methodologies of choice. Du and Shepotylo (2021) show that the magnitude of the estimates of Brexit (Referendum) effect can vary in the case of the UK's trade in services. Difference-in-difference (DID) has been a popular means of evaluating the treatment effect, starting with the seminal work by Card and Krueger (1994). The drawback of DID is its reliance on the parallel trend assumption, which should be met between the treated and control groups. Moreover, the DID is best taken when a considerable number of units are exposed to policy intervention; the Brexit policy directly affects only one country, which means that the number of treated units is too small for valid inference.

As an alternative to the DID approach, the synthetic control (SC) method has been developed (Abadie and Gardeazabal, 2003), which combines the strengths of matching and DID. It builds the synthetic UK, also known as the 'Doppelgänger' UK, as the best possible fit for the UK trade counterfactual that Brexit never happened. It is based on the weighted average of trade of other countries, which comprise a pool of donors. Under certain assumptions, the estimate of the divergence (if any) between the factual UK and the synthetic UK after the intervention is the estimate of the causal impact of the policy intervention. It can be applied when the number of treated units is small and the parallel trend assumption within the control group is unlikely to hold. In the case of Brexit, only a single unit experiences the policy intervention, in

which case it is often not possible to construct a control unit following the parallel trends within the observed data. The SC method reconstructs parallel trends by weighting the units from the donor pool to match the pre-intervention trends. The major drawback of SC is that it is poorly fit to draw statistical inferences. A placebo method of approximating standard errors of the estimate is usually applied, but this is heuristic in nature and lacks a theoretical foundation. Moreover, the standard errors constructed by this method are often too large, leading to rejection of the tested hypothesis.

The synthetic difference-in-difference or SDID (Arkhangelsky et al., 2021) combines the strengths of the DID and SC methods. It estimates the causal inference parameter of interest using a two-way fixed effect (TWFE) regression specification, which allows for making proper inferences about the significance of the coefficient. However, it does not treat all units and time periods equally. Like SC, it uses a pool of donors to construct a counterfactual scenario using the optimally selected weights, so only some countries have non-zero weights. In addition, it weights more heavily the pre-treatment periods that are more similar to the post-treatment period, making it a doubly robust method. These modifications make SDID more efficient by locally fitting the model parameters relative to DID. Essentially, it boosts the internal validity of the causal impact estimate at the expense of the external one. We consider this feature to be a strength, as our main goal is to measure the causal impact of the TCA on the UK as precisely as possible.

We follow the literature and introduce the latent factor model, describing total export/import to EU and non-EU countries thus:

$$T_{it}^{s} = \gamma_i^s \nu_t'^s + \tau^s \times TCA_{it} + \epsilon_{it}^s \qquad (1)$$

where i is the reporting country at time t. $s \in \{EU, ROW\}$ indicates the aggregate partner region: the European Union (EU) and the Rest of the World (ROW). The outcome variable T_{it} is the natural log of either export or import. γ_i is a 1 × K vector of latent unit factors and ν_t is a 1 × K vector of latent time factors. TCA_{it} is the TCA indicator, which takes value 1 for the UK after 1 January 2021, and 0 otherwise. τ is the average causal effect of exposure, which is the main variable of interest, interpreted as the causal impact of the end of the transition period on trade. While the structure seems restrictive, it is nevertheless sufficiently flexible and nests a standard two-way fixed effect model among its possible specifications.

As the number of units for analysis is small, since only 48 countries have submitted the sufficient number of time periods data to COMTRADE, we also look at bilateral trade flows. This allows us to have more observations, multiple treated units, and more efficient estimation

of the standard errors, leading to much higher precision of the estimated impact for the following specification:

$$T_{ij,t} = \gamma_{ij}\nu'_t + \tau_1 \times TCA_{ij,t} + \epsilon_{ij,t} \qquad (2)$$

where *i* is the reporting country and *j* is the partner country. The outcome variable $T_{ij,t}$ is the natural log of either bilateral export or bilateral import at time *t*. $TCA_{ij,t}$ is the TCA binary indicator, which takes the value of 1 for UK trade with any of the EU-27 countries after 1 January 2021, and 0 otherwise. Our parameter of interest is τ_1, which is the average causal effect of the exposure to the TCA.

5.2 Results

Table 4 reports the estimates of the impact of the EU exit under the TCA on UK trade using DID, SC, and SDID methodology for aggregate and bilateral trade flows. We look separately at the impact on exports and imports. For aggregate flows, we divide the sample into exports/imports to EU and the Rest of the World (ROW) countries. The treatment takes values of 1 for the UK since 1 January 2021, and zero otherwise. The coefficient in the table is the treatment effect for the dependent variable log value of export/import. For bilateral trade, we look at logs of bilateral exports or imports as the outcome variable, and the treatment takes the value of 1 if the reporter is the UK and the partner is an EU member after 1 January 2021, and zero otherwise.

Table 4: Causal impact of TCA on the UK trade

	DID		SC		SDID	
	A: UK imports from EU					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.23*	-0.21	-0.2	-0.17	-0.26*	-0.23
σ_τ	0.1	0.13	0.56	0.15	0.11	0.15
	B: UK imports from ROW					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.01	-0.01	-0.04	-0.03	-0.06	-0.06
σ_τ	0.09	0.1	0.28	0.33	0.09	0.07
	C: UK exports to EU					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.18+	-0.22	-0.2	-0.2	-0.19	-0.18
σ_τ	0.11	0.38	0.13	0.46	0.12	0.48
	D: UK exports to ROW					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.08	-0.1	-0.07	-0.07	-0.05	-0.08
σ_τ	0.08	0.15	0.32	0.54	0.09	0.1
	E: Bilateral UK imports from EU					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.22**	-0.23**	-0.13*	-0.12*	-0.26**	-0.26**
σ_τ	0.04	0.04	0.06	0.05	0.04	0.04
	F: Bilateral UK exports to EU					
	6 months	9 months	6 months	9 months	6 months	9 months
τ	-0.21**	-0.19**	-0.15*	-0.16**	-0.22**	-0.2**
σ_τ	0.04	0.04	0.06	0.05	0.04	0.04

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Standard errors for aggregate trade are computed by the placebo method. Standard errors for the bilateral trade are jackknife. See Arkhangelsky et al. (2021) for a detailed description of the placebo and jackknife standard errors algorithms.

At the aggregate level, where each country is observed only one time per period (i.e. month), we find that although the post-Brexit trade has declined for both exports and imports, regardless of the method and destination, only the UK imports from the EU have declined significantly if estimated by DID or SDID methods, which both delivered similar results for the coefficient and the standard error. According to SDID, which is our preferred method, UK imports from the EU have declined by 26% for the first six months, while UK imports from the non-EU countries were not significantly different from before 2021.

For the UK aggregate exports, the results are economically large and negative, with SDID reporting a 19% decline in exports to the EU and a 5% decline to non-EU countries, although they are not statistically significant. However, the standard errors are only available by the placebo method and are imprecise. Figure 4 shows how post-TCA changes have accumulated

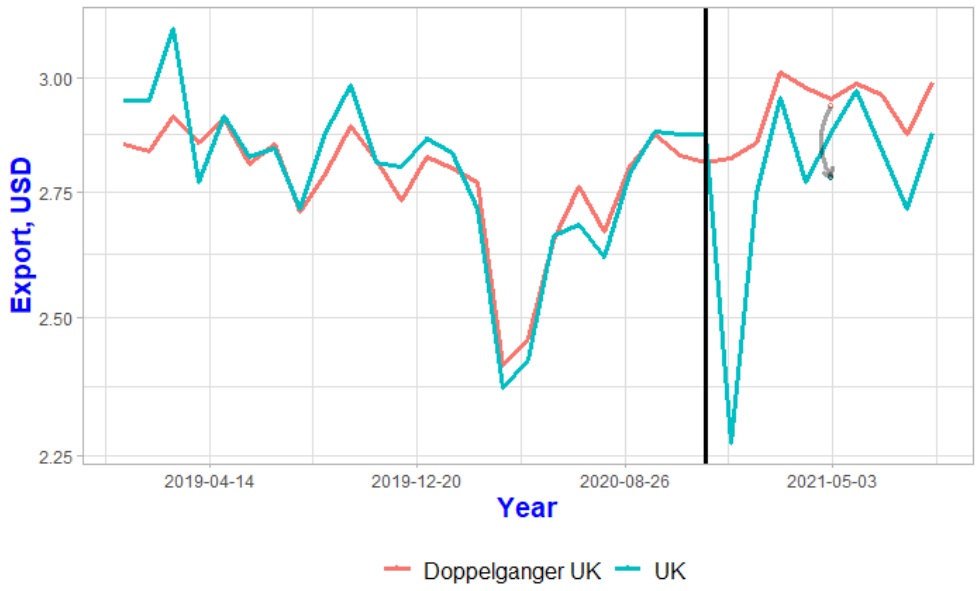
over time. There was initial severe decline in January-February 2021, with the subsequent partial recovery. However, neither exports nor imports have recovered to their pre-TCA levels.

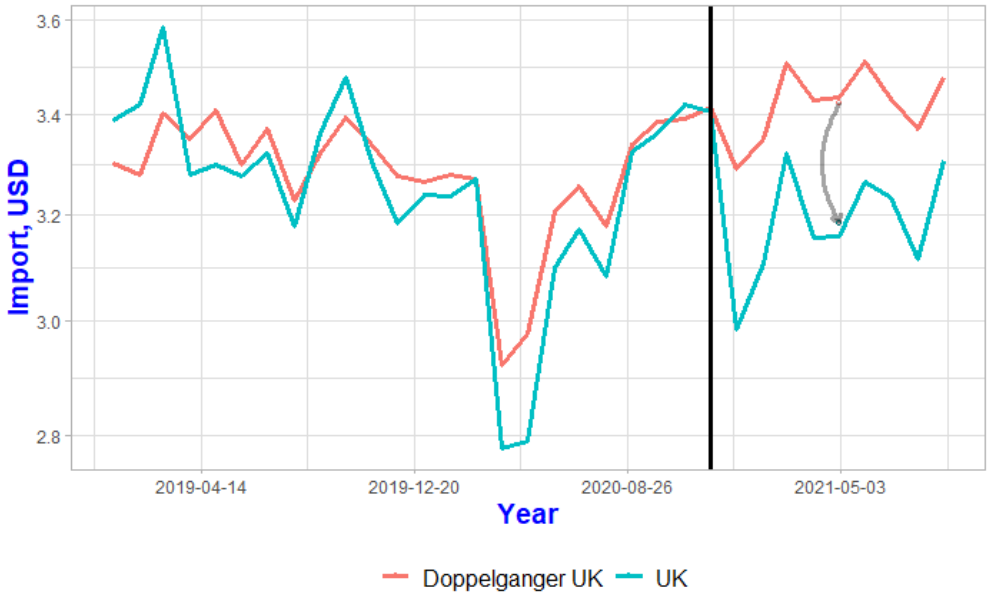
Using bilateral trade, multiple observations for treated units, and a higher number of available control units per period, we can compute the jackknife standard errors. This substantially increases the efficiency of the estimation, while leaving the estimated coefficients very similar to the coefficients estimated for the aggregate trade. According to the results, the TCA has a strong, negative, and significant impact on UK bilateral trade with the EU countries, leading to a 22% reduction in exports and a 26% reduction in imports. Trade with ROW has not been significantly affected. To investigate the mechanisms behind these results requires a more focused look at the trade policy changes caused by the TCA, which is the subject of the rest of the paper.

Longer period

We also consider how our estimates may evolve given longer period into 2021. The estimates based on three quarters of a year rather than for half a year are also reported in Table 4. As the results demonstrate, it does slightly reduce the estimated size of the effect. For instance, the estimated impact on the bilateral exports from the UK to EU is 20% lower. Still, the results for the bilateral trade flows are highly robust and significant. It indicates that while teething problems and the previous months' stockpiling both played their roles, the long-term effect is significant and represents the major trend of the UK trade decline.

Figure 4 Actual and predicted monthly UK trade with EU: SDID results





Note: The trajectories of the actual UK natural log of total monthly exports and imports to EU are shown in blue. The corresponding values for the Doppelganger UK shown in blue are parallelly shifted for better visual comparison.

6. IMPACT OF NTMS ON THE UK TRADE

6.1 NTMs and UK trade prior to the TCA: benefits of being a member

Methodology

We start with the description of the impact of NTMs on UK trade prior to the TCA when UK was a member of the EU. To estimate the impact of NTMs on the UK trade, we employ a reduced form structural gravity model, which is focused on the UK bilateral trade flows with 227 partner countries at HS6 digit level in the first halves of 2019 and 2020. We regress the bilateral trade on the three NTMs: AVE SPS, TBT, and LCN. By interacting these measures with the EU dummy, we test whether the NTMs have differential impact on the UK's EU vs. non-EU trade. The model controls for the full set of destination-year fixed effects and it clusters standard errors at product level to eliminate any heterogeneity and omitted variable bias. The estimated equation is given by

$$X_{UKj,t}^{f,k} = exp\left(\sum_s \beta_s NTM_{UKj,t}^{s,f,k} + \sum_s \beta_{EU,s} EU_{j,t} \times NTM_{UKj,t}^{s,f,k} + D_{j,t}\right) + \epsilon_{UKj,t}^{f,k} \quad (3)$$

where *X* is a bilateral trade flow from/to the partner country j at time t. *f* is an indicator of export or import. *k* is an indicator of product. $s \in \{SPS, TBT, LCN\}$ is an NTM type. The equation is estimated by Pseudo Poisson Maximum Likelihood (PPML) estimator (Silva and Tenreyro, 2006) and all zero trade flows are included in the analysis.

Results

Table 5 reports the model estimates with the dependent variable being export, import or both, while the time period is the first six months of 2019, the first six months of 2020, or both periods (All). As a starting point, we find that AVE NTMs – SPS and TBT – have negative impact on trade (exports, imports, and bilateral). Consistent with our expectations, goods that are subject to higher SPS and TBT trade less. Higher AVE LCN also leads to less imports.

Specifically, SPS measures have a strong negative impact on trade across all slices of the data. A one percent increase in AVE SPS is associated with a 1.5-2% reduction in trade, depending on the sub-sample. TBT measures also have a negative and significant impact on trade, and the effect is smaller for exports and significantly stronger for UK imports, with coefficients that are an order of magnitude higher. This effect may reflect the differences in the composition of the UK's exports and imports and is explored further below by considering trade in intermediate, capital, and final goods. UK imports also sensitive to "red tape" as higher licensing requirements and quantitative restrictions significantly reduce imports.

Turning to the interaction term of NTMs with EU dummy, we find that the goods the UK trades with the EU are less prone to the negative impact of SPS, as shown by the positive and significant coefficient of the interaction term of the EU indicator and the SPS measure. This is consistent with previous evidence about EU single market membership (Egger and Larch, 2011; Campos et al., 2019), and shows the benefits of non-tariff-related barriers reduction within the single market (Disdier et al., 2008; Hoekman and Nicita, 2011; Movchan et al., 2019). This brings down the NTM effect of UK trade in/with an EU country from an overall impact of 1% to approximately 0.5%.

There is no statistically significant difference in the impact of SPS measures on UK exports and UK imports during this period. However, this will change in the next section when we study the SPS impact on the changes in trade in 2021, as the negative impacts of NTMs become more pronounced in exports, but not in imports. The impact of TBT and licensing is more pronounced for imports to the UK, but not for exports. This may reflect differences in the composition of exports and imports, as well as some other factors, which we explore in the next section.

Moving to the interaction effect of TBT with EU dummy, we find that UK imports from the EU benefit from a lessening in the negative effects of TBT. In fact, UK imported more goods subject to TBTs from the EU than from elsewhere, reflecting an easing in the frictions from technical regulations, standards, and conformity assessment procedures for imported goods that originated from the EU. We do not find a similar effect on UK exports.

Finally, there is weak evidence that LCN reduced barriers for LCN-subject, EU-imported goods but over the whole period, being part of the EU does not significantly ease the UK's trade with the EU.

Overall, these findings show that NTMs, as non-discriminatory measures, reduce trade within the EU to a less extent than they do for trade with non-EU countries. The effects are pronounced for SPS-subject goods for both exports and imports between the EU and the UK, strongly for TBT-subject goods for UK imports from the EU, and to a less extent LCN-subject UK imports from the EU. This is evidence of the benefits for being an EU member. The reverse side of this means that exiting the EU is likely to reduce UK trade in goods that are subject to high NTMs.

Table 5: Non-tariff measures and UK trade in 2019-2020

	Export			Import			Export		
	2019	2020	All	2019	2020	All	2019	2020	All
SPS	-1.816**	-1.484**	-1.605**	-1.617**	-1.509**	-1.742**	-1.994**	-1.772**	-1.939**
	(.465)	(.482)	(.485)	(.387)	(.376)	(.399)	(.309)	(.320)	(.321)
TBT	-.228*	-.329**	-.246**	-2.697**	-3.354**	-2.717**	-1.182**	-1.589**	-1.246**
	(.091)	(.096)	(.079)	(.411)	(.513)	(.477)	(.227)	(.280)	(.233)
LCN	-.00886	-.164+	-.0950	-.956**	-.965**	-.751**	-.318*	-.508**	-.395**
	(.115)	(.098)	(.104)	(.217)	(.249)	(.238)	(.128)	(.118)	(.115)
EU=1 × SPS	1.254**	1.011*	1.086*	1.089*	1.214**	1.361**	1.427**	1.378**	1.475**
	(.473)	(.488)	(.493)	(.429)	(.407)	(.432)	(.327)	(.335)	(.336)
EU=1 × TBT	-.0449	.0369	-.0431	2.134**	2.766**	2.148**	.754**	1.144**	.811**
	(.104)	(.111)	(.096)	(.422)	(.521)	(.485)	(.233)	(.284)	(.238)
EU=1 × LCN	-.135	.0805	-.0232	.731**	.767**	.537*	.114	.355**	.214+
	(.121)	(.111)	(.120)	(.224)	(.255)	(.244)	(.133)	(.124)	(.122)
Observations	250801	250801	752403	173983	170309	514353	428136	421110	1270108
R2	.228	.224	.222	.191	.197	.193	.199	.198	.196

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Note: Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module ***ppmlhdfe*** developed by Correia et al. [2020] with a full set of partner-year fixed effects.

We also split our sample into consumer, intermediate, and capital goods according to the Broad Economic Categories (BEC) classification.[8] Results of these regressions for the overall trade (including exports and imports) are presented in Table 6.[9] According to the results, SPS has a stronger negative and significant effect on trade in intermediate and consumer goods. TBT has a stronger negative and significant impact on trade in intermediate and capital goods. Finally, LCN has a significant and negative impact on trade in intermediate and capital goods. EU membership has a strong alleviating effect on SPS for consumer and intermediate goods and on TBT for intermediate and capital goods. We do not find a robust and significant EU impact on LCN effect.

Table 6: Non-tariff measures and UK trade by product type

	2019			2020			**ALL**		
	Cons	Inter	Cap	Cons	Inter	Cap	Cons	Inter	Cap
SPS	-2.270**	-2.147**	-1.490*	-1.719**	-2.196**	-1.253*	-1.956**	-2.289**	-1.[illegible]**
	(.405)	(.613)	(.717)	(.316)	(.729)	(.602)	(.332)	(.694)	(.615)
TBT	-.469*	-1.629**	-.834**	-.572**	-2.291**	-1.040**	-.466**	-1.721**	-.903**
	(.223)	(.390)	(.196)	(.192)	(.582)	(.233)	(.177)	(.465)	(.215)
LCN	-.114	-.426*	-.540**	-.274*	-.806**	-.547**	-.213	-.484*	-.589**
	(.196)	(.180)	(.149)	(.134)	(.268)	(.162)	(.157)	(.211)	(.165)
EU=1 × SPS	1.425**	1.618**	.831	1.114**	1.863*	.679	1.240**	1.935**	.900
	(.458)	(.620)	(.725)	(.369)	(.734)	(.611)	(.392)	(.700)	(.622)
EU=1 × TBT	.0800	1.055**	.696**	.165	1.739**	.851**	.0455	1.140*	.762**
	(.243)	(.399)	(.203)	(.220)	(.589)	(.239)	(.208)	(.473)	(.220)
EU=1 × LCN	-.00408	.196	.152	.137	.671*	.242	.0898	.309	.265
	(.202)	(.188)	(.163)	(.146)	(.278)	(.172)	(.167)	(.229)	(.173)
OBSERVATIO	116830	242774	66597	114916	238799	64914	346609	719995	19649
$\bar{R2}$	.239	.187	.303	.245	.189	.310	.241	.184	.310

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Note: Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module ***ppmlhdfe*** developed by Correia et al. [2020] with a full set of partner-year fixed effects.

6.2 NTMs and UK trade prior to the TCA: costs of Brexit

To identify the trade impact of UK's exit from the EU via the NTM channels, we capitalise on the fact that signing the TCA kept zero tariffs and quota, but the implementation of non-tariff measures may have changed. Moreover, the UK government deliberately postponed the introduction of the new rules on the EU imports for the period of examination to avoid border delays and spikes in the prices of imported goods. Therefore, our identification strategy is

[8] For more detail on BEC, see https://unstats.un.org/unsd/trade/classifications/bec.asp.
[9] We also have results separately for exports and imports; these are available on request.

based on exploiting the variation in AVE NTM calculated for 2018 data and interacting this with the EU dummy. We expect that UK exports to the EU of the products where the EU's AVE NTM rates are higher will be more negatively affected, whereas there should be limited or no impact on the EU imports of such products since there are no changes in the border arrangements. To remove unobserved heterogeneity, we consider the regression in the first differences between the first half of 2019 (or the first half of 2020) and the first half of 2021. The estimated equation is given by

$$\frac{\Delta X_{UKj,t}^{f,k}}{\left[0.5\left(X_{UKj,t}^{f,k}+X_{UKj,t-h}^{f,k}\right)\right]} = \sum_s \beta_s NTM_{UKj,t}^{s,f,k} + \sum_s \beta_{EU,s} EU_{j,t} \times NTM_{UKj,t}^{s,f,k} + D_{j,t} + D_k + \epsilon_{UKj,t}^{f,k} \qquad (4)$$

where *h* is either a one- or two-year lag. The first differences are calculated using midpoints to account for a large number of zero values in the series. All other notations remain the same.

The results are presented in Table 7, reported for the UK exports, imports, and both flows (labelled as trade) in the first six months of 2021 relative to the same period of 2019. For each type of flow, we also report results from different model specifications with country-year fixed effect and with product fixed effect to control for the multilateral resistance impact on the growth in trade and to allow for product-specific trends. Standard errors are clustered at destination-product level.

Focusing on the interaction terms of NTMs and EU dummy, we find that the introduction of the SPS and TBT measures had a negative impact on UK exports to the EU in 2021, while for imports we do not observe such an effect. The results are robust to controlling for country-time and product fixed effects. The magnitude of the impact on UK exports is substantial, as a 1% increase in AVE SPS results in a 13-15% reduction in exports to the EU, while a 1% increase in TBT leads to a 2-3% reduction in exports.[10]

These results are consistent with our prior expectations about the hypothesised TCA effects discussed above. On the one hand, exiting from the EU single market is expected to raise the frictions due to non-tariff related barriers, thereby reducing trade. On the other hand, although the EU started to apply stricter customs controls for UK goods after the end of the transition period in 2021, the UK has not taken similar steps, and the effect of this asymmetry is clearly demonstrated by the results contrasting the effects on imports and exports. This seems

[10] To calculate a partial effect of the increase in, for example SPS, on exports, we take $\beta_{SPS} + \beta_{EU,SPS}$.

particularly strong for SPS compared with TBT and LCN, since the negative effect of SPS on both exports and overall trade with the EU is also significant.

The second important point to highlight is that the growth of UK exports of products with high levels of AVE SPS and TBT to all countries has been stronger, which indicates a diversion of exports of such products away from the EU and towards other countries. This is evident in the positive and significant coefficients for AVE SPS and TBT for the UK exports. This applies also for imports of products with high level of SPS, indicating the UK imported more than average of these products from the extra-EU markets in 2021, despite that the level of friction due to SPS in UK imports from EU remains the same.

We find marginally significant effect of increased frictions due to LCN measure on UK imports from the EU. In absence of border checks, the still negative impact on importing goods from EU could indicate diversion of imports from EU towards other countries as an effect of uncertainty and a pre-emptive measure.

Table 7: Non-tariff measures and change in UK trade in 2021 relative to 2019

	Export			Import			Trade		
SPS	.0224**	.0244**	.0655**	.0592**	.0521**	.0520*	.0433**	.0376**	.0332**
	(.008)	(.008)	(.012)	(.010)	(.010)	(.023)	(.006)	(.006)	(.009)
TBT	.0156**	.0134**	.0146**	-.00113	-.000134	.00211	-.00129	.00480+	-.00642+
	(.004)	(.004)	(.005)	(.004)	(.004)	(.008)	(.003)	(.003)	(.004)
LCN	-.0209**	-.0173**	-.0140+	.00115	.00184	-.0169	-.0133**	-.00838+	-.0183**
	(.006)	(.006)	(.007)	(.007)	(.007)	(.015)	(.005)	(.005)	(.006)
EU=1 × SPS	-.125**	-.129**	-.151**	-.0200	-.0116	-.00360	-.0941**	-.0904**	-.0936**
	(.012)	(.012)	(.012)	(.015)	(.015)	(.015)	(.009)	(.009)	(.010)
EU=1 × TBT	-.0272**	-.0192**	-.0208**	.00773	.00543	.00232	-.00625+	-.00930*	-.00653+
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)	(.004)	(.004)	(.004)
EU=1 × LCN	.0168+	.0177*	.0119	-.0196*	-.0211*	-.0173+	.000000782	-.00328	-.00655
	(.009)	(.009)	(.009)	(.010)	(.009)	(.010)	(.006)	(.006)	(.007)
Country-Year FE		Yes	Yes		Yes	Yes		Yes	Yes
Product FE			Yes			Yes			Yes
Observations	254153	254153	254129	174003	174003	173974	428156	428156	428152
R2	0.027	0.039	0.099	0.001	0.021	0.069	0.011	0.019	0.053

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module ***reghdfe*** developed by Correia [2016].

We next look closer into different types of goods – consumer, intermediate, and capital goods – to investigate if there is a heterogeneous effect of NTMs. We also investigate 2021 relative to different base year, 2020 and 2019, aiming to check if the impact of the pandemic on trade in 2020 matters. Table 8 reports our findings for the UK exports. First, we find a strong negative impact from the increased frictions due to SPS on the UK exports of intermediate goods to EU, which is consistent when comparing 2021 with 2019 or 2020. Also strongly and consistently, TBT on the UK exports to the EU reduced all types of goods, irrespective of COVID. We also observe that the trade diversion effect is statistically significant for the

intermediate goods subject to SPS, pinning down to the types of exports the UK seems to redirect more towards extra-EU markets.

Table 8: Non-tariff measures and changes in UK exports by product groups

	2021 relative to 2020			2021 relative to 2019		
	Cons	Inter	Cap	Cons	Inter	Cap
SPS	.0249	.0496**	.00373	.0349+	.0505**	-.0615
	(.020)	(.014)	(.038)	(.021)	(.015)	(.042)
TBT	-.0154+	.00888	.00352	-.00244	.00685	.0142
	(.009)	(.007)	(.013)	(.009)	(.007)	(.014)
LCN	.0279*	-.0173+	-.0240	.00357	-.0226*	.0328+
	(.013)	(.010)	(.017)	(.013)	(.010)	(.018)
EU=1 × SPS	.0313+	-.117**	.0777	-.0235	-.121**	.106+
	(.019)	(.017)	(.052)	(.019)	(.018)	(.056)
EU=1 × TBT	-.0295**	-.0188**	-.0284*	-.0439**	-.0173*	-.0403**
	(.010)	(.007)	(.013)	(.010)	(.008)	(.014)
EU=1 × LCN	.0437**	.0110	-.0128	.0526**	.00548	-.0317
	(.016)	(.013)	(.020)	(.016)	(.013)	(.020)
Observations	63998	150165	39384	63998	150165	39384
R2	.197	.087	.068	.184	.082	.069

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module reghdfe developed by Correia [2016]. All models have country-year and product fixed effects.

We do not find a similar effect on UK imports, as shown in Table 9. However, the UK has been importing more capital goods from the EU than usual that are subject to higher degree of TBT following the TCA. This may suggest higher investment in capital goods in the UK occurring in 2021 that might be driven by production relocation or investment in new production sites, a sign of restructuring of UK's global value chains. The effect is stronger when comparing 2021 to 2019 than to 2020, possibly reflecting the COVID trade destruction.

Table 9: Non-tariff measures and changes in UK imports by product groups

	2021 relative to 2020			2021 relative to 2019		
	Cons	Inter	Cap	Cons	Inter	Cap
SPS	.0408	-.0130	.0263	.0344	.0247	.180*
	(.037)	(.030)	(.096)	(.038)	(.032)	(.092)
TBT	-.000753	-.0188*	-.0387*	.0215	.00760	.00196
	(.016)	(.009)	(.019)	(.017)	(.010)	(.019)
LCN	-.0445	.0176	-.0301	-.0323	-.00404	-.0386
	(.027)	(.019)	(.031)	(.028)	(.021)	(.033)
EU=1 × SPS	.0295	.0000917	.0397	.0483+	-.00991	-.00291
	(.024)	(.021)	(.048)	(.025)	(.023)	(.050)
EU=1 × TBT	-.0128	-.00154	.0291**	-.0213	-.00771	.0462**
	(.012)	(.007)	(.011)	(.013)	(.007)	(.012)
EU=1 × LCN	-.00911	-.0114	.00366	-.0296	.000361	-.0223
	(.018)	(.013)	(.020)	(.019)	(.014)	(.021)
Observations	52924	92706	27748	52924	92706	27748
R2	0.071	0.059	0.053	0.089	0.063	0.077

Note $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module reghdfe developed by Correia [2016].

6.3 Teething problems

A popular conjecture on what UK trade faced when the TCA put into force is so-called 'teething problem'. It implies that the difficulties experienced by UK exporters to the EU countries were temporary, for exporters were unprepared to deal with new trade requirements due to lack of knowledge and experience. Then over time, the negative impact on UK exporters would phase out as they learn how to comply with new rules. However, if the difficulties do not lessen over time, the increased friction due to NTMs then actually represent additional costs of exporting. In that case the effects on exports become permanent. We test the teething problems hypothesis in two ways. First, we examine if the negative effect of NTMs diminishes over time over a longer time frame. Second, we remove the first two months, which were reportedly the most chaotic.

Three quarters vs six months

We collected additional monthly data on trade for July-September 2021 and repeat our analysis by comparing UK trade performance in the first nine months in 2021 relative to the same periods in 2019 and 2020. The results are presented in Table 10.

Table 10: Non-tariff measures and change in UK trade in 2019-2021 (3 quarters)

	Export			Import			Trade		
SPS	.0219**	.0264**	.0746**	.0454**	.0388**	.0402+	.0369**	.0322**	.0303**
	(.008)	(.008)	(.012)	(.011)	(.010)	(.023)	(.007)	(.007)	(.009)
TBT	.0112**	.00865*	.0107*	-.00232	-.00057	-.00383	-.00381	.00288	-.009*
	(.004)	(.004)	(.005)	(.004)	(.004)	(.008)	(.003)	(.003)	(.004)
LCN	-.0227**	-.0181**	-.0135+	-.00022	.00051	-.0277+	-.0152**	-.00944*	-.0169**
	(.007)	(.007)	(.008)	(.007)	(.007)	(.015)	(.005)	(.005)	(.006)
EU=1 × SPS	-.138**	-.145**	-.167**	.00311	.0102	.0179	-.0917**	-.0896**	-.0943**
	(.012)	(.012)	(.013)	(.015)	(.015)	(.015)	(.009)	(.009)	(.010)
EU=1 × TBT	-.0195**	-.0108*	-.0138*	.00635	.00450	.00185	-.00189	-.00489	-.00242
	(.005)	(.005)	(.006)	(.005)	(.005)	(.005)	(.004)	(.004)	(.004)
EU=1 × LCN	.0156+	.0157+	.0123	-.0156	-.0168+	-.0143	.00193	-.00181	-.00405
	(.009)	(.009)	(.009)	(.010)	(.010)	(.010)	(.007)	(.007)	(.007)
Country-Year FE		Yes	Yes		Yes	Yes		Yes	Yes
Product FE			Yes			Yes			Yes
Observations	254203	254203	254178	174018	174018	173987	428221	428221	428216
R2	0.021	0.036	0.098	0.001	0.025	0.074	0.010	0.020	0.055

Notes: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Standard errors clustered at partner-product level are in parentheses. All models are estimated by Stata module reghdfe developed by Correia [2016].

Based on comparisons of the results in Tables 7 and 10, we do not observe a phasing-out effect of the negative impact of SPS or TBT measures on the UK exports to EU. The negative effects remain significant. Moreover, the negative impact of SPS restriction has only increased.

Net January-February effect

Another way of addressing the teething issue vs the long-run impact of TCA is to remove the data for January and February of 2021. During these months the decline in trade was at its most severe due to a) stockpiling in the previous months and b) unfamiliarity with new rules and procedures. For instance, Jerzewska (2021) reports confusions among businesses about the new rules and, as a result, a widespread lack of compliance.

The results in Panel A of Table 11 indicate that it does not change our conclusions about negative impact of SPS and TBT on exports to EU.

6.4 Additional robustness checks

Year 2018 as the base year

The results may be driven by the choice of the comparison year. So far our results stand regardless of the choice of reference year being 2019 or 2020, suggesting that COVID did not change the pattern. Some might argue that 2019 was the last 'normal' trading year before COVID, the UK was even then preparing for Brexit, making adjustments in anticipation of a Brexit that might include the threat of a hard Brexit where there was no trade deal with the EU. Having 2018 data as the basis for comparison gives an additional robustness check. The

results in Table 11 Panel B of the table show that the negative impact of SPS and TBT remains robust and stable. Interestingly, we observe a negative impact of licensing requirements on the 2018-2021 growth of imports from the EU, which is not observed by looking at the 2019-2021 or 2020-2021 exports growth. This could indicate that the UK businesses had been making adjustment as early as 2018 to be ready to the changes in licensing procedures, which have mitigated the negative impact in the later periods.

Tariffs

It may be argued that tariffs are correlated with NTMs and therefore should be controlled for when evaluating the impact of NTMs on trade. However, arguments can be made for a positive correlation and a negative correlation between these policy instruments, which makes the overall effect and potential direction of a bias ambiguous. However, this issue can be resolved empirically, as shown in Panel C of the table. We control for tariffs and report our main coefficients of interest. The results for SPS and TBT on the UK exports to the EU remain very stable.

Table 11: Non-tariff measures and change in UK trade, additional robustness checks

	Export			Import			Trade		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A: No Jan and Feb									
EU=1 # SPS	-.107**	-.112**	-.132**	-.0213	-.0135	-.00479	-.0821**	-.0795**	-.0825**
	(.012)	(.012)	(.012)	(.014)	(.014)	(.015)	(.009)	(.009)	(.009)
EU=1 # TBT	-.0283**	-.0197**	-.0215**	.00474	.00278	.000614	-.0111**	-.0116**	-.00880*
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)	(.004)	(.004)	(.004)
EU=1 # LCN	.0140	.0137	.00759	-.0108	-.0118	-.00976	.000532	-.00174	-.00517
	(.009)	(.009)	(.009)	(.009)	(.009)	(.010)	(.006)	(.006)	(.006)
Observations	254091	254091	254068	173961	173961	173936	428052	428052	428048
R2	.023	.036	.095	.001	.019	.066	.010	.018	.051
B: 2018 vs 2021									
EU=1 # SPS	-.117**	-.118**	-.141**	-.0410**	-.0303*	-.0231	-.0979**	-.0926**	-.0974**
	(.012)	(.012)	(.012)	(.014)	(.014)	(.015)	(.009)	(.009)	(.009)
EU=1 # TBT	-.0187**	-.0100+	-.0123*	.0143**	.0102*	.00716	.000280	-.00322	-.00203
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)	(.004)	(.004)	(.004)
EU=1 # LCN	.0204*	.0198*	.0113	-.0204*	-.0232*	-.0186+	-.000140	-.00466	-.00914
	(.009)	(.009)	(.009)	(.009)	(.009)	(.010)	(.006)	(.006)	(.007)
Observations	242687	242687	242661	165349	165349	165315	408036	408036	408031
R2	.038	.049	.120	.001	.021	.074	.015	.022	.063
C: Including tariffs									
EU=1 # SPS	-.131**	-.137**	-.150**	-.0151	-.0109	.00362	-.0953**	-.0965**	-.0919**
	(.016)	(.016)	(.017)	(.018)	(.018)	(.019)	(.012)	(.012)	(.012)
EU=1 # TBT	-.0368**	-.0272**	-.0231**	.00795	.00605	.00150	-.0153**	-.0133**	-.00989*
	(.007)	(.007)	(.007)	(.006)	(.006)	(.006)	(.005)	(.005)	(.005)
EU=1 # LCN	.0229*	.0233*	.0156	-.0204+	-.0231*	-.0183	-.000229	-.00182	-.00544
	(.011)	(.011)	(.012)	(.012)	(.012)	(.012)	(.008)	(.008)	(.008)
Tariff	.185**	-.0119	.814**	-.573**	-.487**	-.0447	.117*	-.0973	.368**
	(.060)	(.072)	(.081)	(.142)	(.168)	(.189)	(.053)	(.062)	(.066)
Observations	186716	186716	186684	144874	144872	144830	331590	331588	331576
R2	.021	.036	.129	.002	.011	.070	.010	.016	.064

Note: + p < 0.1, * p < 0.05, ** p < 0.01. Additional controls include SPS, TBT and Licensing. Models (2), (5), and (8) have Country-Year fixed effects. Models (3), (6), and (9) have Country-Year and Product fixed effects. Standard errors clustered at partner-product level are in parentheses.

6.5 Sensitivity of building the synthetic UK

Non-EU countries only for constructing synthetic UK

SC and SDID methods may be sensitive to the pool of countries available for creating the synthetic control. If the pool of control countries includes those that are negatively impacted by TCA, it may lead to an attenuation bias (Abadie, Diamond, and Hainmueller, 2015). Likewise, if those countries are positively affected, the SC and SDID coefficients will exaggerate the TCA effect. Since the TCA introduces new trade costs, the impact on most countries is likely to be negative and the estimated effect is a lower bound of the actual effect.

To test whether this is the case, we remove the EU countries from the donor pool, as they are indirectly most impacted by the TCA. The results are presented in Table 12. The exclusion of the EU countries from the pool does not significantly change the estimated coefficients for the UK exports and imports (comparing Tables 12 and 4). Also, the standard errors of the estimated coefficients for the aggregate trade flows get larger. This reflects the fact that the pool of control observations for aggregate flows is quite limited, and the precision of the estimation declines when we reduce it even further. This problem is not as severe for bilateral flows, as the number of available observations is much larger. Therefore, the results for the bilateral trade flows remain very stable and highly significant. We do not see any significant bias in the bilateral results as compared with the results in Table 4.

Excluding January and February 2021

Excluding January and February of 2021, when the decline in UK trade was most sizable, allows us to check whether the reported impact was temporary or longer term. Comparing the results of Tables 6 and 12, we indeed observe a smaller decline (from 22% to 17%) in the UK exports in March-September 2021 than in January-June 2021 for the aggregate flows. However, we find that the TCA effect on UK imports has worsened slightly in later months after January-February (26% to 28%). Overall, the SDID estimates for bilateral trade suggest there were a 28% decline in imports and a 17% decline in exports between March to September 2021. The other two methods, DID and SC, also confirm a significant decline in trade, which is unlikely to be caused by temporary factors and indicates a long-run decline in UK trade.

Table 12: Causal impact of TCA on the UK trade: Additional results

	DID		SC		SDID	
A: UK imports from EU						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ	-0.2	-0.21	-0.19	-0.15	-0.26	-0.21
σ_τ	0.17	0.14	0.88	0.16	0.26	0.17
B: UK imports from non-EU						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ	0	-0.02	-0.04	-0.04	-0.1	-0.06
σ_τ	0.11	0.11	0.48	0.33	0.09	0.08
C: UK exports to EU						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ	-0.16	-0.2	-0.1	-0.15	-0.18	-0.14
σ_τ	0.22	0.38	0.54	0.42	0.2	0.55
D: UK exports to non-EU						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ	-0.07	-0.12	-0.05	-0.08	-0.06	-0.09
σ_τ	0.08	0.15	0.49	0.54	0.09	0.1
E: Bilateral UK imports						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ_1	-0.21**	-0.25**	-0.11	-0.13*	-0.24**	-0.28**
σ_τ	0.04	0.04	0.06	0.06	0.04	0.04
F: Bilateral UK exports						
	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb	non-EU synthetic UK	no Jan-Feb
τ_1	-0.22**	-0.16**	-0.1	-0.13*	-0.24**	-0.17*
σ_τ	0.05	0.05	0.06	0.05	0.05	0.05

Note: * p < 0.05, ** p < 0.01. Standard errors for aggregate trade are computed by the placebo method. Standard errors for the bilateral trade are jackknife. See Arkhangelsky et al. (2021) for a detailed description of the placebo and jackknife standard errors algorithms.

6.6 Results by EU countries

We next ask if all EU countries' responses to the shock are the same, in an exploration of the heterogeneity of the impact of TCA on exports along the EU destination countries. We break the EU indicator variable in Equation (4) into two parts: the first part is an EU country *l*, while the second part is any other EU country.

$$\frac{\Delta X_{UKj,t}^{f,k}}{\left[0.5\left(X_{UKj,t}^{f,k}+X_{UKj,t-h}^{f,k}\right)\right]} = \sum_s \beta_s NTM_{UKj,t}^{s,f,k} + \sum_s(\beta_{l,s}D_{l,t} \times NTM_{UKl,t}^{s,f,k} + \beta_{EU,s}EU_{j,t} \times NTM_{UKj,t}^{s,f,k}) + D_{j,t} + D_k + \epsilon_{UKj,t}^{f,k} \quad (5)$$

We estimate this regression for each EU country and report the coefficient of the interaction term between the EU country *j* and NTM measure *s* for each EU country. The results are presented in Figures 3-5 for each NTM measure separately. The dot represents the coefficient value, while the lines around the dot represent the 95% confidence interval.

Figure 4 shows the results of the SPS effect across the UK's trading partners. The growth in UK exports to its main UK trading partners, such as Germany, Italy, and Spain, is impacted more for products with higher SPS barriers to trade. However, the UK exports to new EU members, such as Croatia and Slovakia, did not experience a significant decline for such high-SPS products.

Figure 4 Interaction between SPS measure and each EU country indicator

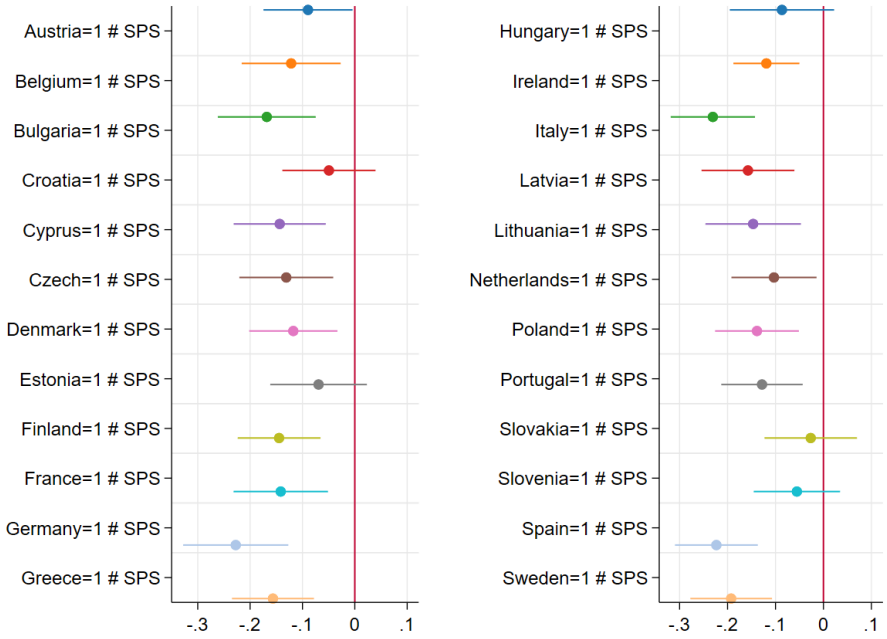


Figure 5 shows the results of the TBT effect across the UK's trading partners. According to the results, UK exports to the smaller and relatively young EU members, such as Estonia, Hungary, and Slovakia have been impacted more negatively by the TCA than have the UK exports to the larger and older EU members, such as Ireland, France, and Italy. Figure 6 shows the results of the LCN effect across UK's trading partners. There was no negative impact on the UK exports for the products that have significant barriers to trade caused by increased licensing requirements.

Figure 5 Interaction between TBT measure and each EU country indicator

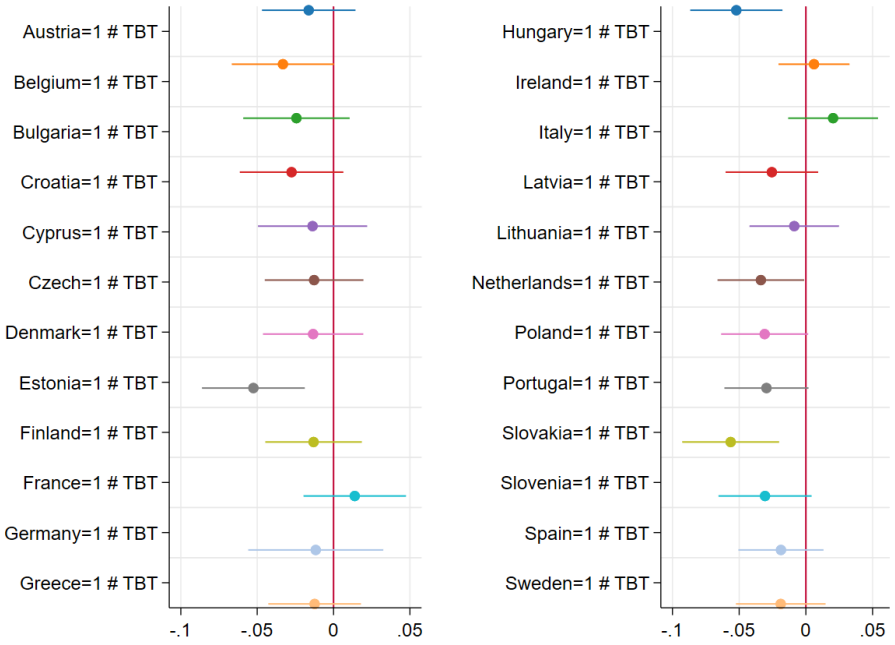
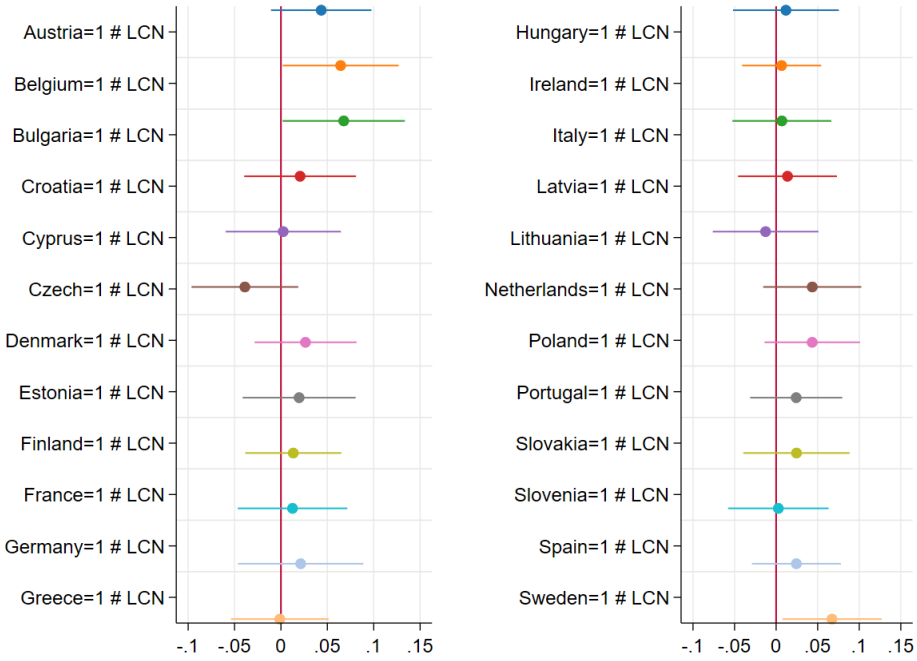


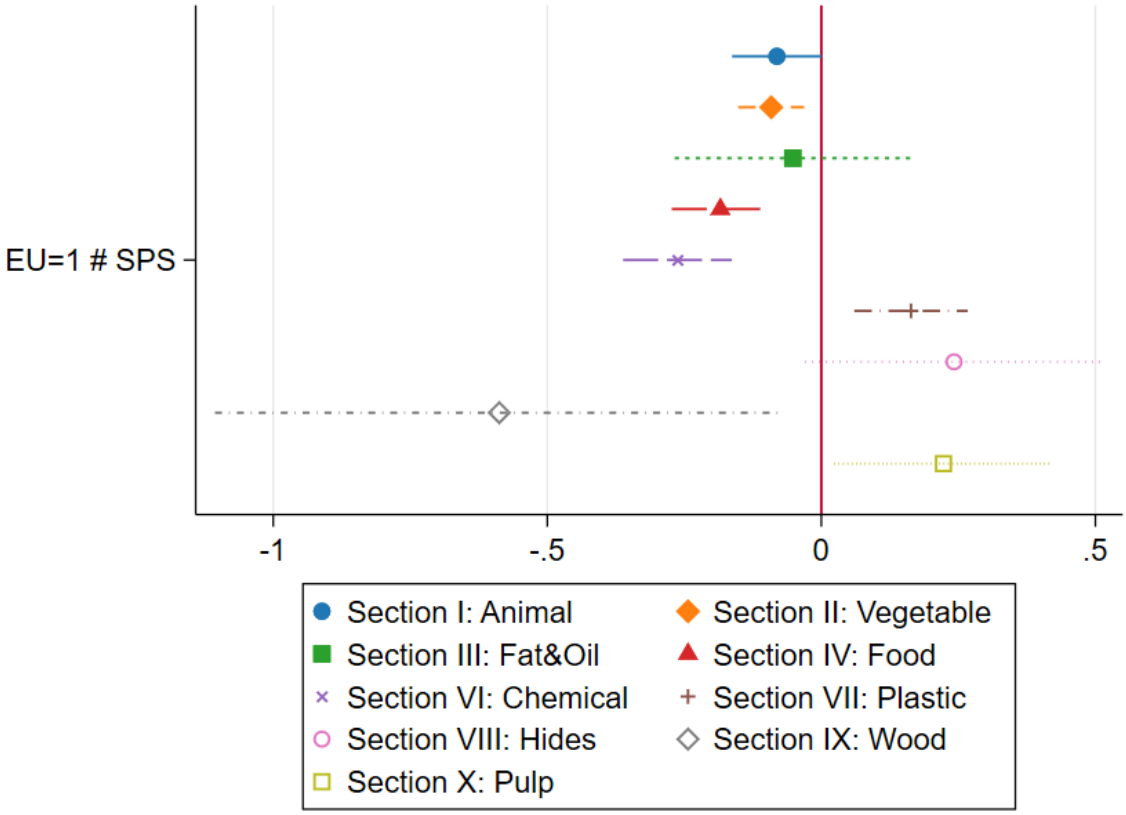
Figure 6 Interaction between Licensing measure and each EU country indicator



6.6 Results by HS code sections

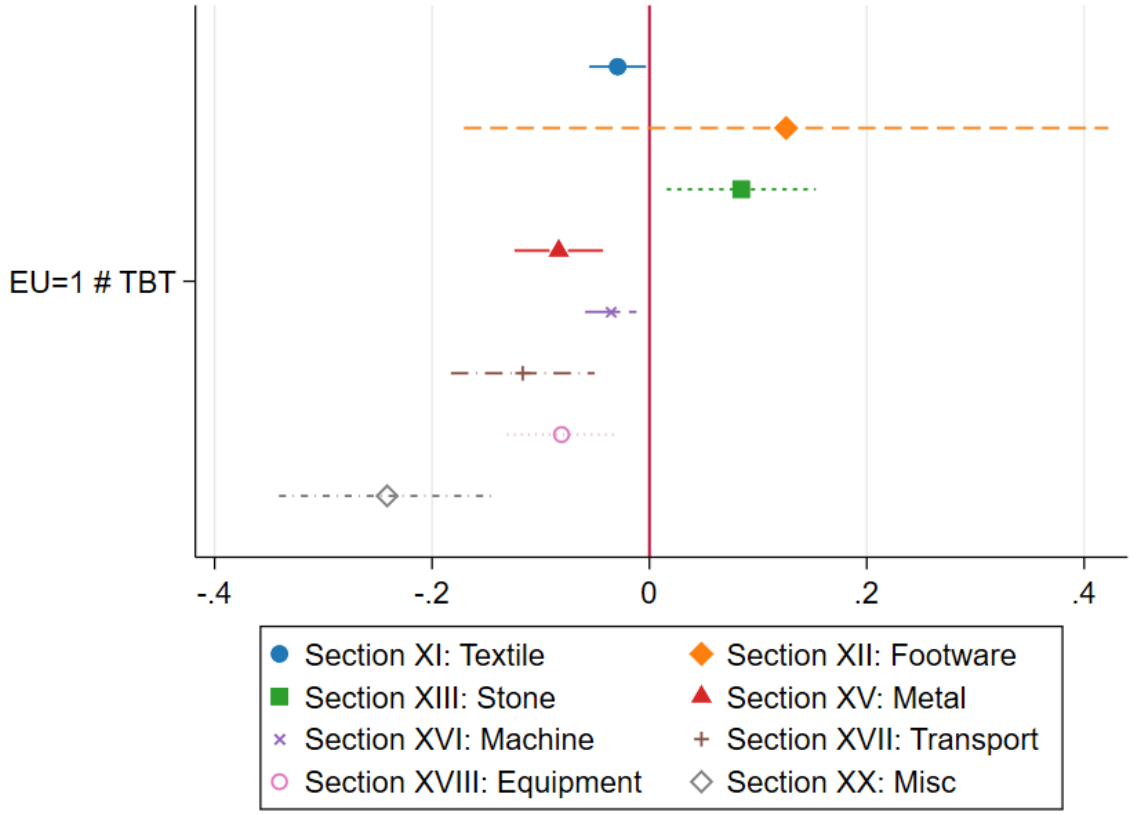
We also estimate Equation (4) separately for each section of the HS classification codes and report results of the impact of SPS and TBT on trade with EU for selected sections. The choice of sections is driven by the fact that SPS measures are mostly applied to products in Sections I-X (shown in Figure 7), while TBT are mostly applied on products in Sections XI-XX (Figure 8). As expected, SPS measures strongly and negatively reduce UK exports of Food, Chemicals, and Wood products to EU countries. To a lesser extent, the negative effects are also found in Fat and Oil, Vegetable and Animal goods.

Figure 7 SPS results for selected HS sections



TBT measures have significant negative impact on the UK exports of Metals, Equipment, Machines and Miscellaneous Industrial products to the EU. There is also a large negative impact on exports of Transport.

Figure 8 TBT results for selected HS sections



7. DISCUSSION

NTMs and UK trade post TCA

Our results suggest that in 2021 enacting the EU-UK Trade and Cooperation Agreement has had a large, negative, statistically significant impact on UK bilateral trade with the EU countries. This occurred immediately after the new trade regime became effective. Using the synthetic difference-in-difference methodology we estimate that this amounts to a 22% reduction in exports and a 26% reduction in imports over the first half of 2021 relative to the counterfactual scenario of the UK remaining in the EU (or a consequent 20% and 26% reduction over the three quarters of 2021). Our estimate of the reduction in exports is higher than previous estimates that rely on the synthetic control approach (15% by UKTPO based on the first three months of 2021; Ayele et al., 2021), and is also higher than the estimate from the Centre for European Reform, which is a 15.7% overall reduction in total UK trade in October 2021, and 14.9% lower in December 2021 (Springford, 2022 a, b). However, our six-month estimate for the reduction in imports is lower than that of Ayele et al. (2021), who found it to be 32% for the first three months of 2021.

A battery of robustness checks show that these results are robust to excluding the EU countries from the pool of donors, to excluding the first two months of 2021 to eliminate potential short-term and anticipation effects, to use 2018 as a base year, and to extending the time frame to three quarters. The TCA was introduced in the UK without sufficient time to plan and prepare because the regulatory changes and key information was made available only at the very last minute (Jerzewska, 2021). However, we find that the negative effect of TCA lasted beyond the first two months. In fact, the effect did not dwindle over the time of our examined period.

Our key question in this paper is about the role of NTMs in the TCA effect on UK trade. We find that their role is substantial, with a 1% increase in AVE SPS resulting in a 13-15% reduction in exports to the EU, while a 1% increase in TBT leads to a 2-3% reduction in exports according to our baseline results.[11] A simple back-of-envelope calculation based on our

[11] For 9 months, 1% increase in AVE SPS resulting in a 14-17% reduction in exports to the EU, while a 1% increase in TBT leads to a 1-2% reduction in exports.

estimates suggests that for the first six months period of 2021, the increased frictions due to SPS and TBT led to a reduction of UK exports by £12.4 billion.[12]

Existing evidence on tariffs suggest a typical elasticity of -5.6%, with large variation across HS sections (Fontagné et al. 2022), while a global simple average MFN tariff is 8.9% (World Bank Databank, 2). In this study, our AVE NTM calculations show that for all countries, the simple average AVE SPS is 10%, AVE TBT is 37.2% and AVE Licensing is 18.1% over the period of 2012-2018 (for exports to the EU, AVE SPS is 11.8%, AVE TBT is 51% and AVE Licensing is 24%).[13] This demonstrates that tariffs for trade frictions are only 'the tip of the iceberg'[14]. The issues behind borders can have direct and, in some cases, very significant impacts on trade. This is also found in Shepherds and Peters (2020), who use trade flow data for 1990-2015 that, after controlling for tariffs, there is still a significant effect for European Union membership but not for the other trade arrangements.

Non-tariff measures are usually imposed to address market failures, such as information asymmetries or negative externalities. They can provide a signal of quality, strengthening consumer confidence that foreign products abide by domestic regulations. But while countries may share the same objectives, they often apply different standards or methods to ensure compliance with regulatory measures. Clearly, being part of the EU single market allows a member to enjoy minimal non-tariff barriers when trading within the bloc; hence moving out of the bloc would likely cause the reintroduction of barriers with border arrangements being put in place to check compliance. Our finding confirms that this is indeed the case. Measures that are unrelated to tariffs and tariff-rate quotas created frictions to UK trade as soon as the UK stepped out the EU.

We estimate the distinct effects of different NTMs on trade volumes, allowing us to understand the likely channels of increasing trade barriers through non-tariff measures. Given the context of our examination, these increased frictions due to non-tariff trade barriers are more likely to

[12] This is calculated using the average marginal effects of AVE SPS (reported in Table 7 column 3, -0.151), multiplied by the average export flow per observations, £0.71 million, and multiplied by the number of total observations of exports to EU included in the estimation, 194,735. This results in an estimate of £10.9 billion (13.7 percent reduction relative to the first half of 2019). A similar calculation is done by AVE TBT gives us a further effect of £1.5 billion (1.9% reduction). Together, AVE SPS and TBS effects are estimated £12.4 billion (15.6%) for the six months in 2021 of examination.
[13] The simple averages of NTMs are calculated based on our AVE NTM calculations for 2018. See Figure 3 for detailed breakdown.
[14] See OECD on NTMs at https://www.oecd.org/trade/topics/non-tariff-measures/.

reflect a tightening implementation of NTMs at the end of the EU transition, rather than demand enhancing NTMs to improve transparency and reassure consumers sufficient standards of imported goods. Practically, identifying these two distinct effects can help measure the costs, intended or unintended, of new trade barriers and improve the effectiveness of policy interventions. In this study, we find that the negative effect on trade is more severe where 'technical' measures were applied. These include regulations, standards, testing and certification, and are primarily related to sanitary and phytosanitary (SPS) and Technical Barriers to Trade (TBT) measures. The results are weaker for 'non-technical' measures, which in this study are specific to non-automatic import licensing.

SPS

Our finding suggests that the negative impacts of the TCA on UK exports due to SPS are being felt across a wide range of sectors, rather than simply by the Food and Drink sectors as is frequently reported in the media. The most acutely affected sectors are Wood products, Chemicals, and Food and Drink according to our estimates. Notably, negative effects on these UK exports are found for each and every EU destination.

The worst affected goods are Wood products. The total value of UK wood product exports in 2020 was £1.5 billion, a 10% decrease from 2019, of which £1.3 billion was pulp and paper.[15] More than 80% of UK exports in pulp and paper are concerned with recovered paper (also known as 'waste paper' or 'paper for recycling') with 64% of this going to Sweden, Germany, and Finland. Exporters in this sector have reportedly experienced significant delays at ports and there are paperwork issues around exports.[16]

The second sector most affected by the TCA is the Chemical sector. The UK chemical sector exports around £50 billion worth of products annually, making the sector one of the largest exporters of manufactured goods in the UK. The UK also imports around £50 billions of chemical products. In 2019, 60% of all exports of the sector went to the EU, while 75% of chemical imports came from the EU. The sector had been regulated under EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulations prior to UK's EU exit. From 1 January 2021, it became regulated by a UK system equivalent to and closely

[15] See Statistics compiled by Forest Research based on the HMRC Overseas Trade Statistics, https://www.forestresearch.gov.uk/documents/8141/Ch3_Trade_FS2021.pdf.
[16] See reports on challenges faced by exporters of Wood products due to the Brexit by industries https://www.letsrecycle.com/news/post-brexit-pressures-hit-waste-paper-sector/. This has lasted beyond January and February 2021: https://www.letsrecycle.com/news/brexit-increases-bureaucracy-around-waste-exports/.

aligned with REACH; this is managed by the Health and Safety Executive, with which all businesses are required to re-register. During our examined period, custom formalities and checks for chemical goods led to delays at the border and hence presented challenges to successful exporting.

In addition, the implementation of UK REACH is expected to impact on several industries and sectors, not only on UK businesses supplying chemical products to the European Economic Area (EEA) or those importing chemical products from the area, but also on those doing business in the UK.[17] Registration with UK REACH may generate significant costs for businesses, including fees for new commercial data sharing agreements, administrative costs, and costs for further testing if data cannot be shared. This is expected to be disproportionally more challenging for smaller businesses. In the longer term, there is a possibility that the UK's inputs in producing final chemical goods may lose their current integration in the European supply chains.

The Food and Drink sector is typically severely affected by trade barriers, whether these are tariff-related or not. Indeed, the sector has been at the centre of the debate about the Brexit impact on UK industries. Our results suggest that the Food sector has indeed suffered adverse effects from the new trade arrangement.

TBT

We find that negative impacts of the TCA on UK exports due to TBT across a wide range of sectors that produce goods in HSXI-XX. The largest reduction in exports is most pronounced in Miscellaneous goods, Transport, Equipment, Metal, Machinery, and Textile goods.

It is reported that because of higher administrative costs and regulatory uncertainty, Machinery & transport equipment has experienced nearly half of the decline in UK-EU trade, despite having a grace period for the rules of origins for many of the sector's goods.[18] Since 2001, Machinery has been one of the UK's largest product exporting sectors, accounting for a significant portion of both UK exports and global trade. While machinery goods are generally not subject to a very high tariff, most nations have strict product safety regulations. Taking

[17] See SLR consulting report for the Brexit prospect of the UK Chemical sector https://www.slrconsulting.com/en/news-and-insights/insights/brexit-and-uk-reach-what-happens-now.

[18] See statistics provided by https://group.atradius.com/publications/economic-research/brexit-disrupts-UK-EU-trade-june-2021.html.

electrical commodities as an example, IT and communication products are subject to export control. Exporters of electronic machinery must comply with licensing, certification, safety and environmental regulations, and they must consider consumer safety standards, especially if the machinery contains hazardous chemicals or metals. The manufacturer, retailer, or distributor are usually obliged to commit to returning and recycling unwanted electronic machinery under the Waste Electrical and Electronic Equipment Regulations, and these must be stated in export orders. Therefore, these strict regulations give grounds for inflicting non-tariff measures on goods passing through border controls.

Under the TCA, there is no general provision for the mutual recognition of conformity assessment processes. Instead, the EU and the UK have agreed to resort to international standards as the basis for assessing technical regulations. As such, all businesses moving goods between the EU and UK need to submit customs declarations, and they can gain access if proving origin. It is though costly for UK exporters to the EU to adjust to the new customs procedures and checks.

Companies in the UK who import intermediate inputs, such as machinery parts, for the manufacture of outputs for export to the EU, will have to comply with these regulations, often several times over, leaving them in a precarious position as regards costs and efficiency. Bailey and Rajic (2022) provide great details in the adverse impact of TCA on automatic industry, one of the key manufacturing sectors in the UK. This is in addition to the fact that UK firms have already absorbed extra costs for exporting to the EU since the UK's exit (Jerzewska, 2021), which therefore means they are already less profitable. This threatens the UK's position in the Europe's regionalised GVC in an age when businesses operate with just-in-time model with high efficiency and low profit margins, particularly when UK firms embed with the EU market which is a much bigger than their own. This represents a heightened risk for the UK because it poses a threat to the job and value creation of manufacturing sectors that have historically tended to provide high paid jobs, many in geographic areas of high discontent (Billing et al, 2019).

Further, our evidence suggests that while products subject to a higher level of SPS seem to be being diverted towards the non-EU destinations, the same cannot be said for products with heavy TBT. This may imply that that the UK industrial sectors subject to higher TBT may not have implemented a diversionary response to the EU export frictions following enactment of the TCA. This could be because, given the nature of the goods, it takes longer and costs more to divert exports to markets that are farther away. It could also indicate that many UK exporters have been unable to redirect their goods to alternative markets because they are now quite

simply unable to continue exporting. Although it is beyond the scope of this analysis to investigate the real reasons behind this pattern, what is safe to conclude is that many UK exporters have become less competitive in the global market after the EU exit.

Border arrangements

The large negative impact of NTMs on UK exports post the EU exit presents a striking contrast to the absence of such impact on UK imports from the EU. Although UK exports faced increased frictions once the UK stepped out of the EU due to measures that are unrelated to tariffs and tariff-rate quotas, there is no evidence that the UK imports were affected in a similar way. This is, at least in part, because of the asymmetric imposition of border arrangements. It further demonstrates the effect of trade barriers in the form of customs formalities.

The imposition of border arrangements is a matter of choice for the UK government. Has it made a good choice in delaying this? Since the TCA became effective, the UK has seen a large drop in imports. While we estimate there has been a staggering 26% reduction of imports from the EU markets (based on the SDID) estimate, there is no evidence of any statistically significant reduction of EU imports due to the increased NTM effect. This implies that the reduction in imports could be even higher due to more increased levels of NTMs should customs formalities were applied at the border. Given that UK firms were already experiencing snags in the global supply chains, the UK's choice to delay the implementation of border controls should have been helpful as regards businesses being able to access global sourcing. This is especially the case for sourcing from the EU where the UK was closely integrated into the regionalised global value chains (Amador et al., 2015).

However, it would not be a viable long-term strategy for the UK to keep its border check-free for goods coming from the EU. At the time of writing (May-2022), the UK is ready to embrace a fourth delay in the introduction of controls that should, in theory, have been in place from 1 January 2021. Clearly, deferring the decision to impose border arrangements has offset the risk of further disruptions to UK goods supplies from EU countries amidst the various ongoing supply chain problems.[19] However, there are concerns related to food imports that are unscrupulous enough to amount to food crime.[20] UK exporters could also be put in a

[19] This is according to Chris Horseman's analysis at https://borderlex.net/2022/04/21/week-in-london-indonesia-fta-border-checks-china-glass-fibre-ad-duties/.
[20] See evidence gathered by the House of Commons Environment, Food and Rural Affairs Committee on Tuesday 16 March, at https://committees.parliament.uk/event/3744/formal-meeting-oral-evidence-session/.

disadvantaged position in that they have to meet border requirements when they export to the EU, whereas EU exporters to the UK benefit from the asymmetric border controls, which reduces their exporting costs. Non-EU exporters to the UK, who are subject to border checks, are also disadvantaged in comparison to their EU counterparts.

The UK–EU TCA sets a general aim of keeping the frequency of checks to a minimum, and the UK government has expressed an ambition to create 'the most effective border in the world' by 2025. Understanding the current issues and burdens that firms are encountering when trading with the EU is important, so is an assessment of business readiness to deal with import controls, and the identification of ways for making it easier and simpler for traders to submit information about goods crossing the border.

Policy implications

It is likely that some areas of the TCA will evolve over time, given that its coverage is limited. To reduce or even remove some of the NTMs between the EU-UK, the UK government could aspire to a mechanism that creates equivalence in SPS measures or at least reduces their burden to the minimum level possible. however, this may represent an area where an economic rationale, political incentive, and potential feasibility collide to achieve further cooperation. The EU-New Zealand veterinary agreement makes only 1% of goods subject to SPS checks. It may be challenging for the UK to create a similar agreement while staying highly aligned with the EU's regulatory framework.

An area that is more complicated and challenging is perhaps the technical barriers to trade. As we have argued, the implications for the UK economy of the adverse effects of TBT on UK exports in several key industrial sectors could be far more serious than the effects of SPS. The UK's hitherto well-integrated position in Europe's supply chains becomes questionable over time if UK businesses can no longer maintain their low cost and high efficiency, as seems inevitable. This threat may be compounded by other risks, such as the lack of skills and talents in advanced manufacturing and other high value-adding manufacturing sectors, a lack that is worsened by the EU exit.[21] In a scenario where productivity is strained, skills are immobile,

[21] See evidence presented to UK Trade & Business Commission on "Protecting UK Manufacturing in a global supply chain", at https://www.tradeandbusiness.uk/past-sessions/protecting-uk-manufacturing-in-a-global-supply-chain.

and capital flow remains free, it is possible that private investment may decay, exacerbated by the fact that there is still so much uncertainty about the future UK-EU trading relationship.

To counter this scenario, one must be reminded that the EU's approach to dealing with NTMs is through its distinctive program of mutual recognition; this, more so than the other options, has been effective at promoting trade within the bloc (Shepherds and Peters, 2020). During the Brexit negotiations, the UK unsuccessfully sought mutual recognition of conformity assessments, which would have enabled the UK and EU certifying bodies to certify that products produced in one territory met the regulations of the other. Still, the TCA has sectoral annexes that allow for specific measures, i.e., some form of mutual recognition of specific practices or international regulations will allow for the removal of separate inspections or will simplify the paperwork required at the border. Leveraging these specific measures might smooth trade in the automotive, chemical, pharmaceutical, organic products, and wine sectors. Efforts should be made to maintain and broaden the established arrangements between the two parties so that mutual recognition can be exercised. This will ease the TBT trade barriers.

To achieve, this, future EU-UK co-operation is critical. For the mutual benefit of the UK and the EU, it is important to look beyond the initial exit period and identify avenues for targeted co-operation between the two bodies in designing NTMs to achieve regulatory objectives, while minimising trade costs due to NTMs. However, given that suspicion and mistrust between the two sides became deeply rooted during the Brexit negotiation (Adam, 2021), it might require political will and effective leadership for headway to be made.

This may be more challenging for the UK than for the EU, as the UK would need a set of systems is in place to ensure coherence and interoperability across national regulatory regimes. Doing this effectively will have important implications at a time when the government is committed to the levelling up agenda. Supporting firms, especially small and medium sized firms, to continue to access the global markets, while enabling the economy to take better advantage of the welfare-enhancing benefits from trade becomes crucial. It is necessary for government policymaking and operations to adopt a joined-up approach. which draws on strategies related to industry, innovation, skills, and trade and investment (Du and Shepotylo, 2021a). Given the welfare gains of new FTAs are expected to be limited and effective only in

the long term[22], domestic policies should be the focus to improve the competitiveness of UK exporters and their ecosystem.

Implications for businesses

The new customs and regulatory border requirements burden business with many new direct and indirect costs, and this matters for any business that trades with either the EU or Northern Ireland (the UK region that is staying in the EU's goods regulatory regime). Therefore, continued alignment was a demand from many businesses throughout the Brexit process (Rutter, 2021), and it is no less important post Brexit; a fact that must be conveyed to policy makers.

In the short term, businesses that are prepared to adapt to changes and quickly learn how to do so are likely to respond to disruptions in a more organised way. In fact, the degree of preparedness for the Brexit changes by UK business was astoundingly low.[23] There is near consensus that the UK government ought to have done more and done it earlier to prepare businesses for so major a change in their international trading arrangements. While some businesses were fairly prepared for the changes, many others, struggling with the ambiguity and uncertainty that typified the end of the transition period, were far less so. Even now, the need for learning and training remains paramount.

Apart from adapting to practical challenges, actively seeking for alternative markets, and learning from past exporting experience to open to new markets are expected to bring benefits (Gkypali et al 2021). At the meantime, firms' global strategy needs to evolve with changes in business conditions, which is increasingly more important in the current geopolitical environment.

In the medium and longer term, export self-selection driven by productivity is, by some distance, the rule that dictates. Businesses will have to stay competitive to retain access to

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[22] See for example the impact assessment of the FTA between the UK and Australia, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1073969/impact-assessment-of-the-free-trade-agreement-between-the-united-kingdom-of-great-britain-and-northern-ireland-and-australia.pdf; or with the US https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/869592/UK_US_FTA_negotiations.pdf.

[23] See for example https://www.theguardian.com/business/2020/jul/13/three-in-four-uk-firms-unprepared-for-brexit-iod-study-shows; https://www.cbi.org.uk/media/1316/cbi-brexit-preparedness-survey.pdf.

the global market, to perform better in it, and to gain benefit from it (see a comprehensive review in Du et al., 2021). This is the case for all firms even if the ways in which they gain productivity and competitiveness may differ. The classic 'exporter premia' literature suggests a variety of factors that impact on productivity, such as firm size, capital intensity, skill intensity, higher wages, importing higher quality material inputs, spending more on R&D, and producing more and better-quality products (see Du and Shepotylo, 2021 for the full list of the references in the literature). In the current context, firms may stand out by being more resilient to change (van Bergeijk et al., 2017), achieving operation optimisation, redistributing work, adopting technology (Andrews et al., 2015), and more automation (Koch et al., 2019). In addition, businesses need to consider adopting new business models through which they can balance the need for lean production with resilience, as well as weighing up economic, social, and environmental gains. Despite the many considerable challenges, there are boundless avenues where opportunities for breaking through are present.

8. CONCLUSION

This study shows that UK exports have experienced a large, negative, statistically significant decline in 2021 at the end of transition and the TCA was put in force. Using the synthetic difference-in-difference methodology we estimate that this amounts to a 22% reduction in exports and a 26% reduction in imports over the first half of 2021 relative to the counterfactual scenario of the UK remaining in the EU (or a consequent 20% and 26% reduction over the three quarters of 2021). A range of robustness checks carried out do not produce qualitatively different results, including am extended period of examination, exclusion of January-February, controlling for tariff, building synthetic UK only using non-EU countries, and using 2018 as the base year instead of 2019 or 2020 for comparison. These results underscore the heavy costs of erecting trade barriers on the UK's side with its largest trade barriers.

We confirm the hypothesis that NTMs are responsible for the adverse TCA effect on UK trade with EU. Our estimate suggest that the magnitude of loss was significant. Put together, the increased frictions due to the AVE SPS and TBT measures have due to SPS and TBT led to a reduction of UK exports by £28 billion over the first six months period of 2021. Specifically, the increased trade friction on UK exports since the TCA due to SPS spread across a wide range of sectors, including Food and Drink sectors, Wood and Chemicals sectors, and it is found in all EU countries, with the highest severity in Germany, Italy, and Spain. Morever, the negative TCA impacts on UK exports due to TBT was also across a wide range of sectors, with the largest is in Miscellaneous goods, Transport, Equipment, Metal, Machinery, and

Textile goods, and again across most EU trading partners. The TCA effect through licencing requirements was minimal.

Contrasting with strong and large negative effects on UK exports, we find no evidence that UK imports from the EU experienced similar increased trade frictions due to the NTMs post TCA. This is attributed to the lack of border formality for the goods passing from the EU to the UK.

UK's policy options include reduction in some of the NTMs between the EU-UK, by exploring mechanisms such as equivalence in SPS measures to reduce businesses' burden to the minimum level possible. Maintaining and broadening the established arrangements of the current TCA provision, despite of being limited, on some form of mutual recognition of specific practices or international regulations for selected sectors, should be considered as practical approach to ease the TBT trade barriers. Future EU-UK co-operation is nevertheless beneficial for both sides.

APPENDIX

A1. Sample

Our sample includes COMTRADE monthly trade data for 48 countries that provided trade data in all months from January 2019 till June 2021, namely: Armenia, Australia, Azerbaijan, Belgium, Bosnia and Herzegovina, Belarus, Belize, Canada, Switzerland, Cyprus, the Czech Republic, Germany, Den- mark, Egypt, Spain, Finland, the United Kingdom, Georgia, Greece, Guatemala, Hong Kong, Croatia, Hungary, India, Iceland, Israel, Japan, Lithuania, Luxembourg, Latvia, Macao, Moldova, Mexico, Macedonia, Mauritius, the Netherlands, New Zealand, Pakistan, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden, the United States, and Uzbekistan.

A2. NTM types

It is important to develop a consistent and comprehensive classification of NTMs that captures the different types of trade related regulations. Table 10 presents the typology of NTMs by chapters A through to P, according to the taxonomy developed by the UNCTAD Multi-Agency Support Team (MAST) (UNCTAD, 2013). Technical measures, A to C, are designed to regulate health and safety, technical standards, and pre-shipment inspections. They set requirements and regulate conformity-assessment procedures, such as certification, inspection, and quarantine. Their main goal is to meet public policy concerns and address market externalities that are not trade related. Non-technical measures, D to O, are often trade related, such as quotas and subsidies. However, they cover a wide range of topics, such as finance, competition, intellectual property, and government procurement. Measures regulating exports are recorded under the single code P. This includes a wide range of topics that are much less frequent.

Each chapter is further divided into more detailed groups of NTMs. For instance, chapter A has 9 groups, some of which are further categorised into more fine-grained types. Thus, A1 covers the prohibition/restriction of imports for sanitary and phytosanitary reasons, while A11 contains temporary geographic prohibitions for SPS reasons. NTM data is notorious for its incompleteness across countries, products, and time. It is highly heterogeneous in design and implementation. It also does not capture stringency in most cases. Bearing this in mind, we discuss the NTM data source and the existing NTM measures in the next two sub-sections.

Appendix Table 1: Classification of NTMs

Type	Code	Description
Technical measures	A	Sanitary and phytosanitary measures
	B	Technical barriers to trade
	C	Pre-shipment inspection and other formalities
Non-technical measures	D	Contingent trade protective measures
	E	Non-automatic licensing and quantity control measures
	F	Price control measures, additional taxes and charges Finance measures
	G	Measures affecting competition
	H	Trade-related investment measures
	I	Distribution restrictions Restriction
	J	on post-sales services Subsidies
	K	Government procurement restrictions
	L	Intellectual property
	M	Rules of origin
Export Measures	P	Export related measures

Source: UNCTAD (2013)

A.3 Ad valorem equivalents of NTMs

Using the NTM data, we follow the methodology of Kee et al. (2009) and Kee and Nicita (2016) to compute the ad valorem equivalent (AVE) of an NTM, as follows. The idea is to bring different NTMs to a common denominator by estimating NTMs as an equivalent tariff that would lead to the same quantitative effect on trade as the NTM. We briefly explain the procedure below.

4.3.1 Model

We assume that the global trade is described by a two-tiered nested constant elasticity demand system, where the sectoral expenditures are derived from the following upper-level utility maximisation problem:

$$U(C) = \prod_{s=1}^{S} C_s^{\beta_s} \qquad \text{(A1)}$$

subject to the budget constraint

$$P_s C_s = E \qquad \text{(A2)}$$

where C_s is consumption, P_s is the price index for goods in sector *s,* and *E* is total expenditure. We will discuss both aggregate variables later on in more detail.

Solving the utility maximisation problem A1 subject to the budget constraint (A2) leads to a well-known result, which is specific to the Cobb-Douglas utility function:

$$C_s = \frac{\beta_s \times E}{P_s} \qquad \text{(A3)}$$

It means that share of expenditure on goods produced in sector *s* is exogenously fixed by the parameter of the utility function β_s. This is convenient because we can focus on how goods are traded within a sector without worrying about their impact on consumption at the upper level.

A sector consists of monopolistically competitive firms that produce differentiated varieties. Consumers value variety and the utility function of a representative consumer at the sectoral level is given by

$$U(C_s) = \left(\sum_n C_{sn}^{\rho_s} \right)^{1/\rho_s} \qquad (A4)$$

subject to

$$\sum_n P_{sn} C_{sn} = \beta_s E \qquad \text{(A5)}$$

yielding the following demand representation

$$C_{sn} = \frac{\beta_s \times E}{P_s} \times \left(\frac{P_{sn}}{P_s} \right)^{-\sigma} \qquad \text{(A6)}$$

To sell a variety produced in country i to country j incurs a trade cost: $\tau_{nij} \geq 1$ units of good i is required to deliver one unit of this good, with $\tau_{nij} = 1$ only when $i = j$. In particular, we assume that trade cost is parametrically described as

$$\tau_{nij}^{1-\sigma_s} = exp\left(\gamma_{nij}^{NTM} NTM_{nij} + \gamma_{nij}^{t} t_{nij} + \gamma_Z Z_{ij}\right) + e_{ij}$$

where $dist_{ij}$ is distance, NTM_{nij} is NTM measure, t_{nij} is bilateral MFN tariff, and Z is the set of additional controls that captures bilateral trade costs. In our analysis, we use a full set of country-pair fixed effects, so only bilaterally varying factors, such as regional trade agreements and distance, are included.

4.3.2 Equilibrium

We end up with a standard model that is well-described in the literature. A consumer maximises a symmetric utility function

$$U_j = \left[\sum_i C_{ij}^{(\sigma_s-1)/\sigma_s}\right]^{\sigma_s/(\sigma_s-1)}$$

subject to the budget constraint

$$\sum_j P_{ij}C_{ij} = \beta_s E_j.$$

The global equilibrium is described by trade flows

$$X_{ij} = \frac{Y_{si}E_{sj}}{Y_{sw}}\left(\frac{\tau_{ij}}{\Omega_{si}\mathrm{P}_{si}}\right)^{1-\sigma_s}$$

where the total value of output is either consumed internally or exported

$$Y_i = P_i Q_i = \sum_j X_{ij}$$

where P_i is price index of variety i.

The outward resistance term is given by

$$\Omega_{si}^{1-\sigma+s} = \sum_j \frac{Y_{si}}{Y_{sw}}\left(\frac{\tau_{ij}}{\Omega_{sj}}\right)^{1-\sigma_s}$$

The inward resistance term is given by

$$\mathrm{P}_{sj}^{1-\sigma_s} = \sum_i \frac{Y_{si}}{Y_{sw}}\left(\frac{\tau_{ij}}{\Omega_{sj}}\right)^{1-\sigma_s}$$

4.3.3 Estimation

We estimate the following equation:

$$q_{nij} = exp\left(\gamma_{nij}^{NTM} NTM_{nij} + \gamma_{nij}^{t} t_{nij} + \gamma^{PTA} PTA_{ij} + \gamma_Z Z_{ij} D_{in} + D_{jn}\right) + \epsilon_{nij} \quad \text{(A7)}$$

where

$$\beta_{nij}^{NTM} = \beta_n^{NTM} + \beta_n^{NTM} PTA_{ij} + \beta_1^{NTM} share_{ni} + \beta_2^{NTM} share_{nj}$$

and

$$\beta_{nij}^{t} = \beta_n^{t} + \beta_1^{t} share_{ni} + \beta_2^{t} share_{nj}$$

In this specification, Z_{ij} includes distance, contiguity, and other standard determinants of bilateral trade costs. This specification does not include bilateral fixed costs, as is common in the modern approach to estimation of the structural gravity, because we consider a cross-section of data. However, it is possible to control for all time-invariant bilateral fixed effects if the model is estimated on a panel.

4.2.4 Computing AVE NTMs

Once we estimate the model A7 we obtain the estimates β_{nij}^{NTM} and β_{nij}^{t} for all product lines *n*. To compute the ad valorem equivalent of an NTM, we need to find the level of tariff t_{nij} that would impact trade by the same amount as the NTM.

The proportionate change in trade due to an NTM is defined as

$$\frac{E\left(q_{nij}\middle|NTM_{nij}=1\right) - \left(q_{nij}\middle|NTM_{nij}=0\right)}{E\left(q_{nij}\middle|NTM_{nij}=0\right)} = \exp\left(\beta_{nij}^{NTM}\right) - 1.$$

Likewise, the proportionate change in trade due to an increase in tariff by 1 percentage point equals

$$\frac{E\left(q_{nij}\middle|t_{nij}=t+1\right) - \left(q_{nij}\middle|NTM_{nij}=0\right)}{E\left(q_{nij}\middle|NTM_{nij}=0\right)} = \exp\left(\beta_{nij}^{t}\right) - 1.$$

Finally, AVE NTM is defined as an equivalent tariff that has the same impact on imports as the NTM. It is defined as

$$AVE_{nij} = \frac{\exp\left(\beta_{nij}^{NTM}\right)}{\exp\left(\beta_{nij}^{t}\right)-1}.$$

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Additional results

Table 11: Non-tariff measures and UK exports by product type

	2019			2020			All		
	Cons	Inter	Cap	Cons	Inter	Cap	Cons	Inter	Cap
SPS	-2.742**	-1.522+	-.929**	-1.783*	-1.311	-.742+	-2.103*	-1.369	-.852**
	(1.047)	(.873)	(.305)	(.814)	(.832)	(.389)	(.882)	(.865)	(.325)
TBT	-.0531	-.363+	-.201+	-.154	-.466	-.279*	-.0804	-.392+	-.183+
	(.152)	(.214)	(.108)	(.190)	(.285)	(.116)	(.151)	(.231)	(.099)
LCN	.145	-.124	-.0975	-.0220	-.337	-.0746	.0644	-.268	-.0889
	(.149)	(.302)	(.094)	(.128)	(.242)	(.096)	(.133)	(.300)	(.094)
EU=1 × SPS	1.964*	1.083	.437	1.112	1.029	.298	1.323+	1.103	.362
	(.942)	(.870)	(.358)	(.697)	(.829)	(.336)	(.762)	(.861)	(.326)
EU=1 × TBT	-.101	-.0603	.140	-.00224	-.00420	.201+	-.0980	-.0889	.129
	(.161)	(.251)	(.127)	(.175)	(.345)	(.112)	(.156)	(.308)	(.100)
EU=1 × LCN	-.292+	.0129	-.126	-.124	.319	-.0656	-.211	.212	-.0997
	(.175)	(.250)	(.120)	(.141)	(.246)	(.107)	(.152)	(.288)	(.108)
Observations	63171	148279	38779	63171	148279	38779	189513	444837	116337
r2 p	.258	.209	.346	.263	.206	.345	.260	.205	.350

Note: p < 0.1, * p < 0.05, ** p < 0.01; Standard errors clustered at product level are in parentheses. All models are estimated by Stata module ppmlhdfe developed by Correia et al. [2020] with full set of partner-year fixed effects.

Table 12: Non-tariff measures and UK imports by product type

	2019			2020			All		
	Cons	Inter	Cap	Cons	Inter	Cap	Cons	Inter	Cap
SPS	-.957*	-3.271*	-.559	-.974*	-3.268+	-.439	-1.007**	-3.659*	-.525
	(.403)	(1.612)	(.606)	(.384)	(1.887)	(.470)	(.385)	(1.744)	(.526)
TBT	-1.331*	-3.352*	-1.355*	-1.252*	-4.740+	-1.607**	-1.184*	-3.412+	-1.527*
	(.542)	(1.430)	(.566)	(.580)	(2.505)	(.584)	(.514)	(1.742)	(.597)
LCN	-.805*	-1.012	-.612+	-.476	-1.505	-.609*	-.673*	-.675	-.641*
	(.341)	(.822)	(.317)	(.376)	(1.313)	(.303)	(.304)	(.627)	(.311)
EU=1 × SPS	.168	2.651+	-.240	.499	2.878	-.236	.422	3.197+	-.0452
	(.455)	(1.510)	(.299)	(.427)	(1.812)	(.279)	(.424)	(1.653)	(.274)
EU=1 × TBT	.706	2.646+	1.164*	.592	4.127+	1.308*	.532	2.756	1.305*
	(.499)	(1.354)	(.516)	(.549)	(2.446)	(.511)	(.485)	(1.676)	(.528)
EU=1 × LCN	.773*	.643	.0947	.414	1.202	.139	.628*	.339	.195
	(.308)	(.802)	(.279)	(.376)	(1.291)	(.232)	(.283)	(.603)	(.234)
Observations	52829	92555	27183	51745	90505	26048	156254	273183	79346
r2 p	.253	.190	.306	.254	.207	.318	.253	.194	.315

Note: p < 0.1, * p < 0.05, ** p < 0.01; Standard errors clustered at product level are in parentheses. All models are estimated by Stata module ppmlhdfe developed by Correia et al. [2020] with full set of partner-year fixed effects.

Table 13: Non-tariff measures and change in UK trade in 2020-2021

	Export			Import			Trade		
	Cons	Inter	Cap	Cons	Inter	Cap	Cons	Inter	Cap
SPS	-.00619	-.00320	.0674**	.00542	.00386	.0310	-.000995	-.00202	.0244*
	(.008)	(.008)	(.013)	(.010)	(.010)	(.023)	(.007)	(.007)	(.010)
TBT	.00691+	.00261	.00947+	-.00187	-.000546	-.0255**	.00294	.00220	-.00780+
	(.004)	(.004)	(.005)	(.004)	(.004)	(.008)	(.003)	(.003)	(.004)
LCN	-.00852	-.00311	-.0161+	-.00135	-.000222	-.00513	-.00435	-.00177	-.0186**
	(.007)	(.007)	(.009)	(.007)	(.007)	(.015)	(.005)	(.005)	(.007)
EU=1 × SPS	-.112**	-.117**	-.128**	-.00727	-.00372	-.00358	-.0748**	-.0767**	-.0798**
	(.021)	(.021)	(.021)	(.016)	(.016)	(.016)	(.015)	(.015)	(.016)
EU=1 × TBT	-.0180*	-.00672	-.0138	.00734	.00622	.00490	-.0107+	-.00556	-.00534
	(.009)	(.009)	(.009)	(.005)	(.005)	(.006)	(.006)	(.006)	(.006)
EU=1 × LCN	.00865	.00874	.0181	-.0133	-.0144	-.0115	-.00499	-.00495	-.000267
	(.014)	(.014)	(.015)	(.010)	(.010)	(.010)	(.010)	(.010)	(.010)
Observations	254153	254153	254129	174003	174003	173974	428156	428156	428152
R2	.027	.043	.103	.013	.058	.016	.057		

Note: p < 0.1, * p < 0.05, ** p < 0.01; Standard errors clustered at product level are in parentheses. All models are estimated by Stata module ppmlhdfe developed by Correia et al. [2020] with full set of partner-year fixed effects.

Table 14: Non-tariff measures and changes in UK trade by groups

	2020-2021			2019-2021		
	Cons	Inter	Cap	Cons	Inter	Cap
SPS	-.00761	.0127	.0186	-.00838	.0333*	.00872
	(.019)	(.013)	(.027)	(.021)	(.013)	(.034)
TBT	-.0325**	-.000424	-.00326	-.0162+	-.00160	-.00851
	(.008)	(.005)	(.010)	(.009)	(.005)	(.010)
LCN	-.00810	-.00621	-.0254+	-.0231+	-.0157+	.0183
	(.013)	(.009)	(.013)	(.012)	(.009)	(.017)
EU=1 × SPS	.0253	-.0713**	.0586	.000528	-.0796**	.0381
	(.022)	(.023)	(.051)	(.024)	(.022)	(.058)
EU=1 × TBT	-.0322**	-.0107	-.00284	-.0440**	-.00972	.00586
	(.009)	(.008)	(.011)	(.011)	(.008)	(.012)
EU=1 × LCN	.0122	-.00771	.00111	.00901	-.00661	-.0185
	(.018)	(.013)	(.022)	(.018)	(.014)	(.025)
Observations	116933	242908	67133	116933	242908	67133
R2	.094	.052	.037	.046	.043	

Note: p < 0.1, * p < 0.05, ** p < 0.01; Standard errors clustered at product level are in parentheses. All models are estimated by Stata module ppmlhdfe developed by Correia et al. [2020] with full set of partner-year fixed effects.

ERC
Enterprise Research Centre

Centre Manager
Enterprise Research Centre
Warwick Business School
Coventry, CV4 7AL
CentreManager@enterpriseresearch.ac.uk

Centre Manager
Enterprise Research Centre
Aston Business School
Birmingham, B1 7ET
CentreManager@enterpriseresearch.ac.uk

UKRI Economic and Social Research Council
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