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# **Unbound: UK Trade post-Brexit**

Authors: Jun Du<sup>×</sup> Aston Business School Xingyi Liu Aston Business School **Oleksandr Shepotylo** Aston Business School Yujie Shi Aston Business School

Date: November 2024

The Productivity Institute



















#### \*The Productivity Institute

#### Key words

Trade, Brexit, exports, imports

#### Authors' contacts

j.du@aston.ac.uk, x.liu29@aston.ac.uk, oshepotylo@aston.ac.uk, y.shi10@aston.ac.uk

#### Acknowledgements

This paper was originally published by the Centre for Business Prosperity (CBP) at Aston University, an independent research centre for global strategies for firms, industries, regions, and nations. The views expressed in this report are those of the authors and do not necessarily represent the views of the funders.

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#### Suggested citation

J. Du, X, Liu, O, Shepotylo, Y. Shi (2024) *Unbound: UK Trade post-Brexit*, Productivity Insights Paper No. 040, The Productivity Institute.

The Productivity Institute is an organisation that works across academia, business and policy to better understand, measure and enable productivity across the UK. It is funded by the Economic and Social Research Council (grant number ES/V002740/1).

The Productivity Institute is headquartered at Alliance Manchester Business School, The University of Manchester, Booth Street West, Manchester, M15 6PB. More information can be found on <u>The Productivity Institute's website</u>. Contact us at <u>theproductivityinstitute@manchester.ac.uk</u>

# Abstract

This study analyses the significant and lasting impact of the Trade and Cooperation Agreement (TCA) on UK-EU trade relations three years after Brexit. The findings reveal sharp declines in UK exports (27%) and imports (32%) with the EU between 2021 and 2023. The contraction in trade is attributed to reductions in both the variety of goods exported (33%) and the intensive margin of imports (28%).

The study highlights that the TCA has caused severe disruptions in the UK-EU supply chain, particularly in consumer and intermediate goods. Sectoral differences suggest that smaller EU economies have been more affected by reduced UK export varieties, while larger ones like Germany and France have seen smaller declines. Non-tariff measures (NTMs), especially in agrifood, textile and material-based manufacturing products, have significantly impacted exports.

The study emphasises the need for policy interventions, including mitigating the adverse effects of the TCA, reconfiguring supply chains, and supporting firms in adapting to new trade barriers. Further research is recommended to understand the long-term consequences of the TCA and guide future trade policy decisions.

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# **Executive Summary**

This study provides a comprehensive analysis of the significant and persistent impact of the Trade and Cooperation Agreement (TCA) on UK-EU trade relations, three years after the UK's departure from the EU Single Market and Customs Union. The findings reveal a sharp decline in both UK exports and imports with the EU, underscoring the enduring challenges posed by Brexit on the UK's trade competitiveness.

Between 2021 and 2023, monthly data show a 27% drop in UK exports and a 32% reduction in imports to and from the EU. Even when considering annual data to smooth short-term fluctuations, the declines remain substantial—17% for exports and 23% for imports. The analysis indicates that exports primarily declined at the extensive margin, with a 33% reduction in the variety of goods exported, while the intensive margin remained stable. Conversely, imports adjusted predominantly at the intensive margin, declining by 28%, with the variety of imported goods remaining stable. The contraction in export varieties highlights a significant reduction in the range of goods the UK trades with the EU.

Robustness checks confirm these findings, indicating the profound and ongoing stifling effects of the TCA on UK-EU trade. The analysis reveals a heavily disrupted and weakening UK-EU supply chain post-TCA, evident across consumer, intermediate, and capital goods. The significant decline in consumer goods exports to the EU and corresponding UK imports suggests a disentanglement of the UK from EU value chains, with a shift towards local production. Despite the TCA's dampening effect on UK exports, the UK remains dependent on the EU for intermediate and capital goods.

The study highlights that the negative impacts of the TCA have intensified over time, with 2023 showing more pronounced trade declines than previous years. This suggests that the transition in UK-EU trade relations post-Brexit is not merely a short-term disruption but reflects deeper structural changes likely to persist.

The analysis also uncovers considerable heterogeneity in the TCA's impact across different goods categories, countries, and sectors. Smaller and more distant EU economies have been more adversely affected by the reduction in UK export varieties, while larger economies like Germany and France have experienced relatively smaller declines. This indicates a decoupling of the UK from EU markets for final goods, with a shift in UK supply chains towards more geographically proximate and smaller trading partners within the EU.

Sector-specific analysis reveals that non-tariff measures (NTMs), particularly in agriculture and food products, have significantly impacted the extensive margins of exports. Industries with larger-scale production and lower product concentration have fared better, while those with higher product differentiation and concentration have experienced more substantial declines.

# **Policy Implications**

The challenges facing UK trade post-Brexit shown in this analysis highlight that the disruptions induced by Brexit remain significant and are likely to be long-term. This necessitates strategic adjustments in UK trade policies and measures that go beyond trade policy. Given the significant and persistent negative impact of the TCA on UK-EU trade, policymakers must carefully prioritise actions to stabilise and enhance the UK's economic position. This study identifies three critical areas for effective policy intervention: mitigating the adverse effects of the TCA, reconfiguring supply chains to bolster efficiency and resilience, and supporting firms in adapting to new trade barriers while enhancing productivity.

## I. Mitigating the Adverse Effects of the TCA

The TCA has introduced considerable barriers to UK-EU trade, particularly through increased NTMs. Addressing these issues through targeted improvements to the TCA is crucial to ensuring that UK businesses remain competitive in the European market. A structured, multi-faceted approach is necessary:

- Sector-Specific Negotiations: The UK government should prioritise sector-specific adjustments to the TCA, particularly in areas like agrifood, textiles, and material-based manufacturing, which have been disproportionately affected. A targeted approach could alleviate barriers, boost trade, and stabilise supply chains, benefiting both large industries and SMEs.
- Streamlining Customs Procedures through Digital Technologies: Simplifying and modernising customs processes through digitalisation is essential to reducing delays and lowering costs. Implementing advanced customs platforms that automate documentation, provide real-time tracking, and integrate with EU systems should be a priority in future negotiations.
- **Reducing Regulatory Divergence:** The divergence in regulatory standards between the UK and the EU has created significant trade barriers. Efforts to reduce unnecessary differences, particularly in highly regulated sectors like chemicals and pharmaceuticals, could significantly lower compliance costs. Negotiating mutual recognition agreements in key sectors would help alleviate the burden of dual compliance for UK firms, enhancing market access and investor confidence.

# II. Strategic Reconfiguration of UK Supply Chains

The post-Brexit landscape indicates a notable shift in the previously tightly integrated EU supply chains. The current global environment where supply chain reliability and resilience are becoming more critical than the earlier focus on efficiency and cost-minimisation means there is an urgent need for a strategic reconfiguration of the UK's supply chains to adapt to new trade realities and strengthen long-term resilience and competitiveness. Key recommendations include:

• Enhancing Trade Infrastructure: Investing in trade infrastructure, including upgrading ports, expanding logistics networks, and improving customs facilities, is essential for reducing transit times and ensuring the seamless movement of goods.

- Strengthening Domestic Supply Chains: Encouraging reshoring and increasing domestic sourcing of critical components can bolster UK supply chains. Government incentives such as tax breaks, grants, and subsidies can support businesses in local manufacturing and supply chain capabilities.
- **Diversifying Global Sourcing:** UK businesses should diversify their sourcing strategies, seeking suppliers in regions like Asia, Africa, and the Americas to reduce dependence on any single market. The government can support this by facilitating trade missions and negotiating new trade agreements.
- Fostering Strategic Partnerships: Building strategic partnerships with countries outside the EU is crucial for securing access to essential materials and components. Negotiating bilateral agreements and participating in multilateral trade initiatives will help reduce the vulnerability of UK industries to external shocks.

# **III.** Supporting Firms in Adapting to New Trade Barriers and Enhancing Productivity

With new trade barriers likely to persist, firms—particularly SMEs—require targeted support to adapt and thrive. Key initiatives include financial assistance, export training, and policies aimed at enhancing productivity through innovation, technology upgrading, and R&D. This could involve tax incentives for R&D, grants for innovation projects, and the creation of innovation hubs that foster collaboration between businesses, research institutions, and government agencies.

# **Future Research Needs**

Further research is needed to understand the long-term impacts of the TCA and inform future policy decisions. Key areas include:

- **Trade-offs and Sectoral Impacts:** Developing metrics to assess and rank the impacts of different trade policy adjustments will help policymakers prioritise actions that deliver the greatest benefits with minimal unintended consequences.
- **EU Impact and Comparative Analysis:** Studying the impact of the TCA on both the UK and the EU, including supply chain reconfigurations and market access, will provide a more balanced view of the trade relationship and help identify best practices.
- Supply Chains and Deeper Impact Analysis: Investigating the long-term consequences of disrupted EU-UK supply chains, particularly in industries reliant on integrated supply chains, will be critical for shaping effective trade policies.
- Wider Spillovers and Brexit's Broader Economic Impact: Examining the broader economic implications of Brexit, including its effects on investment, innovation, and labour markets, will be crucial for addressing regional disparities and supporting long-term growth.
- **Resilience and Adaptation Strategies:** Research should focus on the resilience of UK businesses in adapting to the new trade environment, identifying strategies that firms are employing to mitigate risks and exploring areas where further support is needed.

#### **1. Introduction**

The EU-UK Trade and Cooperation Agreement (TCA), signed in December 2020, marked a pivotal moment in the economic relationship between the two parties. While it granted the UK the sovereignty it sought, it also redefined the trade and investment rules that had previously facilitated seamless market access. By leaving the single market and customs union, the UK gained the ability to negotiate bilateral trade agreements independently. Since 2021, the UK government has secured over 70 free trade agreements, many of which are rollovers of pre-Brexit arrangements. However, in the absence of a comprehensive free trade deal with the US and the modest economic gains from recent agreements with Australia, New Zealand, and accession to the CPTPP, refocusing on the UK-EU relationship appears to be a strategically sound short-term approach. This strategy capitalises on existing trade infrastructure and acknowledges the deep economic interdependence between the UK and the EU, potentially offering some immediate and significant economic benefits.

Despite the UK's pursuit of new trade partnerships, the UK-EU trade relationship remains crucial for both parties. It underpins economic stability, growth, and mutual benefits through integrated supply chains and shared markets. For the UK, the EU continues to be a vital trading partner, while for the EU, the UK remains an important market and investment destination. As shown in Figure 1, even four years post-Brexit, the EU-27 remains the most significant trade partner for the UK, underscoring the enduring importance of this bilateral relationship. Maintaining a strong and effective trade relationship is essential for the economic well-being and competitiveness of both sides.



## Figure 1. UK Trade Partners, by Trade Values, 2023

Note: Data Source: Trade Data Monitor (TDM). Export and import data for 2023 is aggregated to the country level and the top ten exporters and importers in terms of trade values (billions, USD) are selected. Each square represents a country, and the size of the square corresponds to the level of trade values with the UK.

Brexit has posed significant challenges for UK trade. While the impact on the overall UK trade remains under scrutiny – particularly given the absence of concrete causal assessments for services trade – there are signs of resilience in UK services exports (UKICE, 2024). However, the debate surrounding the negative impact of Brexit on UK trade in goods is less contested, with broad assessments suggesting a negative impact, albeit to varying degrees.

Raw data indicates a trend of aggregate export diversion of UK goods from the EU market to extra-EU markets in many products in 2023 compared to 2019 (Figure 2). More than half of the products (13 out of 21) at the HS two-digit level are exported more to extra-EU markets in 2023 than they were in 2019. The agrifood, wood, textile, and footwear products, in particular, have increased their exports to extra-EU markets, likely due to the increased trade costs of exporting to the EU caused by non-tariff measures and rules of origin restrictions. Similarly, UK imports have shifted, with the majority of sectors now importing more from extra-EU markets in 2023 than in 2019 (Figure 3). Sectors such as instruments and apparatus, chemicals, transport equipment, and machinery and mechanical appliances show substantial increases in import diversion from the EU to extra-EU markets. These sectors, often representing intermediate goods integral to global value chains, suggest a weakening or disruption of EU-UK supply chains since Brexit.



#### Figure 2. UK Exports to EU and Extra-EU Markets between 2019 to 2023

Note: Data Source: Trade Data Monitor (TDM). We calculate the share of the EU in total UK exports for 21 HS Classification Sections (2022 edition) in 2019 and 2023, respectively. The x-axis represents the percentage of EU export values in total UK export values, and the y-axis indicates each HS section, including each product section's share in total UK exports. The blue circle represents the EU share in 2019 and the red circle represents the EU share in 2023. We use a grey arrow to describe the evolution of the EU share from 2019 to 2023.

#### Figure 3. UK Imports from EU and Extra-EU Markets between 2019 to 2023



Note: Data Source: Trade Data Monitor (TDM). We calculate the share of the EU in total UK imports for 21 HS Classification Chapters (2022 edition) in 2019 and 2023, respectively. The x-axis represents the percentage of EU import values in total UK import values, and the y-axis indicates each HS sector chapter, including each sector chapter's share in total UK imports. The blue circle represents the EU share in 2019 and the red circle represents the EU share in 2023. We use a grey arrow to describe the evolution of the EU share from 2019 to 2023.

It would be misleading to suggest that trade diversion is the most consequential outcome of Brexit for UK trade. Our previous research has carefully documented the adverse effects of the TCA on UK goods exports from 2021 to early 2022 (Du and Shepotylo, 2022; Du, Satoglu, and Shepotylo, 2023). We found a substantial decline in UK exports, not only in total trade value but also in the variety of exported goods, affecting trade with both the EU and the rest of the world. These findings point to a broader decline in UK trade competitiveness and highlight the significant challenges UK firms are facing. However, there remains a lack of comprehensive understanding regarding how these effects vary across sectors, trading partners, and the mechanisms behind these impacts.

This study extends the analysis period to a full three years, from 2021 to 2023, to assess whether the severe trade declines experienced by the UK have shown any signs of recovery. We investigate the distributional effects across regions and products and the mechanisms driving these impacts, presenting novel evidence with carefully designed methodologies. Our analysis reveals heterogeneous and complex patterns of change across trade margins, products, and trading partners. These patterns exhibit systematic variations, explained by global value chain (GVC) positions, economic sizes, and geographical locations. This granularity enables a detailed understanding of the sectoral and country-specific impacts of the TCA.

To ground these empirical observations within a robust theoretical framework, we draw on Bernard et al.'s (2011) model of multi-product firms, incorporating decreasing returns to scale. Firms adjust both the extensive margin (exporting to fewer countries) and the intensive margin (varying export volume to a given destination). Post-Brexit, we anticipate a significant negative impact on the extensive margin of UK trade with the EU, while the impact on the intensive margin is more ambiguous. We also expect a larger impact on trade with lowerincome and more distant countries. These theoretical insights align our empirical data with broader economic theories, ensuring the findings are statistically significant and economically meaningful.

To ensure the reliability and accuracy of our findings, we address data and methodological challenges by refining data collection techniques, enhancing analytical robustness, and rigorously testing assumptions. We employ the synthetic difference-indifference (SDID) method developed by Arkhangelsky et al. (2021) to provide efficient and reliable estimates, helping disentangle the direct effects of Brexit from other factors such as the COVID-19 pandemic and geopolitical shocks. Additionally, we investigate the mechanisms through which trade impacts are transmitted, offering insights into the underlying processes driving the observed adjustments.

Using multiple data sources and sensitivity checks, we corroborate our findings with monthly data from Trade Data Monitor (TDM) for 91 countries between 2017 and 2023. <sup>1</sup> By cross verifying our results with widely used COMTRADE data that are available for only 65 countries <sup>2</sup>, we confirmed significant declines in both trade value and variety, consistent with our original findings. We also tested the sensitivity of our results to different control groups, and alternative estimation methods, such as Difference-in-Differences and Poisson Pseudo-Maximum Likelihood models, as well as analyse direct and mirror trade data to address issues arising from changes in UK-EU trade statistics collection and data thresholds. <sup>3</sup> Additionally, we utilise annual data to account for seasonality and discrepancies between actual and reported trade from 2021 to 2023. This comprehensive approach not only strengthens our conclusions, but also contributes to broader academic debates on international trade relations post-Brexit.

Our baseline estimates based on monthly data indicate a 27% decline in the value of UK exports to the EU and a 32% decline in UK imports from the EU between 2021 and 2023, compared to a counterfactual scenario without Brexit. This translates to an annual loss of \$80.1 billion (£64.7 billion) in exports to the EU and \$145.2 billion (£117.6 billion) in imports from the EU as of 2023. Compared to Du et al. (2024), who reported a 23% decline in exports and a 13% decline in imports between 2021 and the first quarter of 2022, the three-year results represent a noticeable worsening of EU-UK trade in 2023. This suggests that the long-term nature of economic disintegration takes time to manifest fully, as the benefits of integration can take over a decade to be realised (Larch and Yotov, 2024). The longstanding economic ties formed over the UK's 48-year participation in the EU Common Market are not dismantled overnight.

Our results show that while the declines in exports and imports to the EU are similar in relative terms, the mechanisms of decline differ. The decrease in exports is driven by a lower

<sup>&</sup>lt;sup>1</sup> The changes in the methodology of collecting and measuring trade data in the UK, as documented by ONS (2022, 2023a, 2023b) have made the comparison of UK trade statistics before and after Brexit complex and challenging.

<sup>&</sup>lt;sup>2</sup> The TDM sample includes even larger sample of 109 reporting countries if we limit our study by 2017-2022.
<sup>3</sup> Previous, more positive result on import, was in part caused by the HMRC policy of allowing firms to delay

reporting on its import transactions in 2021. In 2021, the introduction of SCC allowed the customs declaration of Great Britain (GB) imports of non-controlled goods from the EU to be reported up to 175 days after the date of import. There is a potential for the over-recording of imports in 2022, when the delayed customs declarations under SCC is submitted. (Donnarumma, H, 2022 Impact of trade in goods data collection changes on UK trade statistics: 2021 to 2022. ONS, 13 July 2022)

number of exported varieties, <sup>4</sup> which contracted by 33.5%, equating to 1,645 fewer products per EU country at HS6 level. Conversely, the drop in imports is driven by a reduced value per variety, declining by 28.22%. The average shipment in 2023 was \$3.5 million per product type per country, resulting in \$1.37 million lower imports than would have otherwise been expected. These trends indicate worsening trade dynamics over the 2021-2023 period compared to the initial post-TCA phase.

The overall effect varies by the types of goods. We observe a significant decline in consumer goods exports to the EU and UK imports from the EU, with reductions in both the extensive margin and total value. This suggests a possible disentanglement of the UK from EU value chains, shifting production towards local production. For intermediate goods, exports to the EU have decreased mainly at the extensive margin (by 19.85%), while imports have decreased at the intensive margin (by 27.8%). Capital goods show a decline in export value (by 19.9%) and export variety (by 13.1%), but stable imports and even increasing extensive margins of imports (by 19.1%). These trends suggest complex and nuanced patterns in production and trade dynamics, particularly concerning links between trade in intermediate and consumer goods.

We further analyse the heterogeneous impact of the TCA on the UK's trade with EU member states, focusing on variations across countries and product categories. The analysis reveals geographical and economic disparities. The negative impact on UK exports is more pronounced in larger EU economies like Germany and France, while smaller, more remote EU countries have seen less severe effects or even increased import varieties from the UK. Geographical proximity to the UK mitigates some trade barriers, with countries closer to the UK experiencing smaller declines in trade variety. Brexit has led to a marked reduction in the variety of UK exports across most sectors, particularly in agrifood, textile and material-based manufacturing. However, some sub-sectors, like within chemicals and certain high-value goods, showed resilience, with slight increases in export values.

The study identifies that non-tariff measures (NTMs) significantly impact the extensive margins of exports, particularly in agriculture and food products. Industries with large-scale

<sup>&</sup>lt;sup>4</sup> Product varieties are counted by the number of HS6 products exported to the 27 EU countries, such as a bottle of whiskey sent to France.

production and lower product concentration fared better, while those with higher product differentiation and concentration experienced more substantial declines.

In summary, this study underscores the complex and uneven effects of the TCA on UK-EU trade, emphasising the need for nuanced and sector-specific trade strategies to address these challenges. The findings suggest a decoupling of the UK from EU markets for final goods, and a reconfiguration of EU-UK supply chains, towards more geographically proximate and smaller trading partners within the EU. We offer a range of policy implications and the directions of future research.

The following sections of this paper provide a context of Brexit and UK trade in Section 2, beginning with an overview of the raw trade data to highlight key trends post-Brexit in Section 3. The theoretical framework is then discussed in Section 4, providing the basis for the methodological approach used in the study. This is followed by an in-depth analysis of the methodology and results in Section 5-6, examining the changes in trade across different sectors and types of goods. Robustness checks in Section 7 are conducted to validate the findings, and the heterogeneity of the Brexit impact across markets and products is explored in Section 8. The paper concludes with a summary of the findings, followed by policy implications and recommendations in Section 9 and 10.

#### 2. Brexit and the Effects

The TCA between the United Kingdom and the European Union, implemented at the conclusion of the transition period following the UK's departure from the European Union on 1 January 2021, represents a major change in economic and trade relationships between these two entities. For goods, the TCA established the framework for trade, aiming to facilitate the continued movement of goods without tariffs or quotas. However, it introduced new regulatory barriers, rule of origin requirements, customs checks, and non-tariff measures that were absent when the UK was part of the EU's Single Market and Customs Union. The abrupt imposition of border controls and regulatory divergences has increased transaction costs, disrupted supply chains, and required firms to navigate complex new compliance requirements (British Chambers of Commerce, 2021). These changes have had immediate and significant effects on trade flows, particularly in sectors closely integrated with EU markets, leading to widespread disruptions and reduced trade activity.

#### **Agri-Food Sector**

The UK agri-food sector is a key player in international trade, exporting £25bn of food, feed, and drink in 2022 (Defra, 2023). Before Brexit, UK agri-food exporters enjoyed seamless access to the EU market, with minimal regulatory barriers and no tariffs or quotas. Post-Brexit, moving agri-food goods across borders usually involves complex rules and requirements, and checks occur on multiple fronts. The introduction of required physical Export Health Certificates and physical inspections by Official Veterinarians, the sourcing of supplier information, documentation production and approval, customs checks, sanitary and phytosanitary (SPS) measures, and additional documentation requirements have significantly disrupted this trade.

Take a specific example of exporting seafood from the UK to Germany; to avoid tariffs, the product must be accompanied by proof of origin. A collection of regulations comes into play, encompassing anti-dumping provisions, anti-subsidy measures, safeguarding protocols, origin labelling requirements, and non-preferential rules of origin (The European Comission, 2019). Then, the stringent sanitary standards governing seafood and fish products necessitate compliance with ten specific non-tariff measures. Importing fishery and aquaculture products into the EU mandates a health certificate endorsed by the competent authority of the exporting country, affirming the suitability of these products for EU-bound export. Further, the intricacies extend to other documentation for shipment prerequisites, including commercial invoices, customs declarations, freight documentation, insurance records, packing lists, and the Single Administrative Document (SAD). Additionally, increased border checks have led to delays, with goods sometimes taking days to clear customs, resulting in spoilage and financial losses. The cost of compliance has risen sharply, making it more challenging for smaller firms to sustain exports (British Chambers of Commerce, 2022).<sup>5</sup>

The British Meat Processors Association reported a 50% drop in exports of some meat products to the EU in the first quarter of 2021 due to increased border checks and delays (BMPA, 2021). Two years after entering the TCA, UK agri-food exports to the EU were 0.93bn USD smaller (-4.9% down) than they were in 2019, a figure that is masked by the 1.58bn USD

<sup>&</sup>lt;sup>5</sup> There are many reports including "Three Trade and Cooperation Agreement Three Years On" by British Chambers of Commerce (2024), <u>https://www.britishchambers.org.uk/wp-content/uploads/2023/12/BCC-Trade-and-Cooperation-Agreement-Three-Years-On.pdf</u>; and the collection of evidence by the EU Goods Sub-Committee <u>https://committees.parliament.uk/committee/445/eu-goods-subcommittee/news/153116/trade-in-goods-significantly-harder-under-brexit-deal/</u>.

growth (12.5%) in UK exports to the rest of world over the same period (Du, Messenger and Shepotylo, 2024).<sup>6</sup>

EU agri-food exporters have also faced challenges, but the impact has been somewhat mitigated by the UK's phased approach to implementing full border controls. Nonetheless, exporters of fresh fruit and vegetables, such as Dutch and Spanish vegetable growers, have experienced delays and increased costs due to new customs procedures and the need for additional export health certificates.<sup>7</sup> Freshfel Europe estimate the cost of Brexit is about €500 per truck, and the total annual increase of charges for EU fresh fruit and vegetable exports to the UK is estimated at €55 million, a cost that will ultimately be borne by UK consumers.<sup>8</sup>

#### **Automotive Sector**

The automotive sector is one of the most globalised industries, and the UK's automotive industry remains deeply connected to international markets, particularly the EU. In 2022, the sector generated £78 billion in turnover and contributed £16 billion in value added to the UK economy. It also ranked as the country's largest goods-exporting sector, accounting for £94 billion in exports and representing over 10% of the UK's total trade in goods. Of these exports, a significant 78.3% of UK-manufactured cars, and nearly 70% of electric vehicles (EVs) by value, were destined for EU markets. <sup>9</sup>

However, the UK's departure from the EU has introduced a series of challenges for the industry, including new tariffs on parts that fail to meet rules of origin (RoO) requirements, customs delays, and higher administrative costs. These issues are particularly problematic for the automotive sector, where just-in-time manufacturing processes are highly vulnerable to increased costs and delays, which can cause disruptions throughout the entire supply chain (Bailey et al., 2023).

In the wave of electrification, it will become a critical challenge under the TCA for EVs to meet the RoO compliance, where batteries contribute 30-40% of a vehicle's overall value

<sup>&</sup>lt;sup>6</sup> The trade diversion of the UK agri-food exports away from its largest foreign market is a manifestation of the new challenges that UK firms and farmers face in exporting to the EU. But the real negative impact of the new trade arrangement between the UK and the EU is expected to be larger than what the raw statistics suggest, considering many firms stopped exporting altogether.

<sup>&</sup>lt;sup>7</sup> See many reports from industrial bodies, such as by freshfel, e.g. <u>https://freshfel.org/freshfel-europe-and-fpc-urge-uk-government-to-extend-derogations-on-phytosanitary-certifications/</u>.

 <sup>&</sup>lt;sup>8</sup> See <u>https://freshfel.org/so-far-worst-case-scenario-avoided-but-brexit-impact-on-fresh-produce-mounting/</u>.
 <sup>9</sup> Authors' calculations based on COMTRADE data for 2019-2022.

and many of the essential raw materials for battery production are sourced outside the UK or EU. The combination of rising raw material prices and the differing industrial policies in the EU and the US further exacerbates these challenges (Du & Shepotylo, 2024). These challenges are particularly acute for the manufacturing process, given the reliance on JIT systems, where additional costs and delays have an outsized impact for both suppliers and manufacturers (Bailey et al., 2023).

#### **Pharmaceutical Sector**

Pharmaceutical products traded between the UK to the EU have faced regulatory divergence issues post-Brexit. Prior to Brexit, UK pharmaceuticals were certified for EU sale under a unified regulatory framework. However, the UK's withdrawal under the TCA has introduced substantial trade and regulatory barriers that have deeply impacted the sector.

The separation of medicine authorisation into distinct systems – one for the EU, managed by member states and the European Medicines Agency (EMA), and another for Great Britain and the UK under the Medicines and Healthcare products Regulatory Agency (MHRA) – has led to additional requirements for applications, processes, and labelling. For instance, while the mutual recognition of production certificates is agreed in the TCA, the EU no longer recognises medicine batches tested in the UK as valid for sale within the single market, nor does it recognise the professionals overseeing these processes (Dayan et al., 2024).

UK pharmaceutical firms now require separate certifications for both the UK and EU markets, resulting in increased costs and delays. According to the Dayan et al. (2024), Brexit has also exacerbated challenges in the sector, including difficulties stemming from the depreciation of the British pound and the UK's removal from EU supply chains. Additionally, BMI (2024) reports that these barriers have prompted a shift in supply chains, moving away from routes that included the UK.

Consequently, there has been a persistent shortage of medicines, with frequent disruptions to the supply of crucial products, a situation that worsened in 2023 (Dayan et al., 2024). Policy Links (2022) further attributes the deteriorating trade balance and weakened investor confidence in the UK pharmaceutical industry, at least in part, to its withdrawal from the EU's single market.

#### **Chemical Sector**

The chemical sector produces around £50 billion worth of exports annually, and 60% of this goes directly to the European Union, and 75% of chemical imports also come from the EU, making the sector one of the most exposed sectors to Brexit shock. 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 aligned with REACH; this is managed by the Health and Safety Executive, with which all businesses are required to re-register. Registration with UK REACH significantly increases costs for businesses, including fees for new commercial data sharing agreements, administrative costs, and costs for further testing if data cannot be shared. The reintroduction of customs checks, and regulatory compliance requirements has increased costs and delayed shipments. This is expected to be disproportionally more challenging for smaller businesses.<sup>10</sup>

#### **Textile and Apparel Sector**

Clothing and apparel exports to the EU were in the top 10 in goods exports in 2019, accounting for 3.1% of total UK exports. Yet, their contribution filter through retail and manufacturing, making significant contribution to the UK economy (British Fashion Council, 2020). The EU is the UK's largest export market for textiles and apparel industries, accounting for 74% of UK exports according to the UKFT.<sup>11</sup>

Before Brexit, the UK textile and apparel industry benefited from duty-free access to the EU market. Post-Brexit, the reintroduction of customs checks and potential tariffs on goods not meeting rules of origin requirements have increased costs. Anecdotal evidence reported British brands and retailers have seen sales to the EU plummet since Brexit, despite a flourishing European e-commerce market.<sup>12</sup> That could be through firms' reconfiguration of supply chains - some UK firms that previously repackaged imports of goods made in Asia for sale in the EU reorganised their supply chains, by setting up offices inside the single market to bypass border regulations. The UK Fashion and Textile Association (UKFT) reported that many small and medium-sized enterprises (SMEs) have struggled to cope with the increased

<sup>&</sup>lt;sup>10</sup> See <u>https://www.ft.com/content/f41e3350-c870-41a7-b350-80d3a483ef8d</u>.

<sup>&</sup>lt;sup>11</sup> See <u>https://www.britishfashioncouncil.co.uk/pressreleases/The-British-Fashion-Industry-Calls-on-</u> <u>Government-for-Support</u>.

<sup>&</sup>lt;sup>12</sup> See <u>https://www.retaileconomics.co.uk/retail-insights/thought-leadership-reports/brexit-to-breakthrought-thought-leadership-retail-economics-tradebyte; and https://uk.fashionnetwork.com/news/Post-brexit-uk-sales-to-eu-plunge-fashion-is-worst-hit-report,1638045.html</u>

bureaucracy, leading to a 38% drop in textile exports to the EU in 2021 (UKFT, 2021, 2023). EU textile exporters have also faced challenges, though to a lesser extent, due to the UK's delayed implementation of full import controls.

#### 3. UK Trade (in Goods) in Raw Data: An Enhanced Overview

Our analysis utilises trade statistics from Trade Data Monitor (TDM), which collects data in goods from 109 countries through customs agencies, statistics institutes, and other sources. For our baseline analysis in 2017-2023, we employ monthly data available for 91 countries. To ensure robustness of our findings, we cross-verify with COMTRADE data, a commonly used dataset for trade analysis that, however, has limited coverage. In line with the methodology of the UK Office for National Statistics (ONS), we exclude gold (HS7108) from our analysis to avoid distortions in the overall trade picture due to the substantial volumes and extreme volatility of gold transfers to and from the UK.

#### **General Overview of UK Trade Flows**

A comparative analysis of UK trade flows in recent years vis-à-vis its European neighbours and the United States reveals a synchronized response to the COVID-19 pandemic, which acted as a universal shock to all these economies. Similar trends were observed in the monthly export and import values to the EU and the rest of the world (ROW) between 2019 and 2020. Figure 4, which presents indices of export and import values to the EU and ROW normalized at 1 for January 2019, illustrates this uniformity.

However, following the UK's exit from the EU in January 2021, the UK's trade dynamics began to diverge significantly from those of the other countries, experiencing a more pronounced decline. This divergence is apparent in the UK's export performance to the EU, which notably lagged behind that of Germany, France, Italy, Poland, and the United States. Regarding exports to the ROW, the UK's performance was on par with France and Germany but trailed behind Italy, Poland, and the United States.

The Russian invasion of Ukraine further accentuated the divergence of UK trade with the EU, especially concerning UK exports to the EU in 2022-2023. UK exports to the EU have shown no signs of improvement since then. UK exports to the ROW show a mild upward trend, similar to others but growing less quickly. The uptick in imports is, to a degree, due to inflation.

The discrepancy between the UK and other peers became even more pronounced in imports. The UK saw a decline in imports from the EU post-January 2021 – a trend not mirrored by other countries. Conversely, the UK's import growth from the ROW was among the

strongest, indicating a shift in the source of imports and a weakening of EU supply chains from the UK perspective. The upward trend in imports from the ROW slowed down in 2023, following a common trend observed in other countries, attributable to the global reduction in energy and food prices.

In summary, from 2019 to 2023, UK trade was influenced by common shocks and UKspecific shocks. To disentangle the specific contributing factors, it is necessary to apply causal inference techniques to unravel the UK-specific TCA shock from the common COVID-19 and war-related shocks.



Figure 4: Trends in UK Exports and Imports, 2019-2023



Note: Data from Trade Data Monitor (TDM). 3 month moving average index with January 2019 equals to 1. Aggregate values to EU and ROW, gold (HS7108) excluded.

#### **Detailed Inspection of UK Trade Margins**

A granular examination of UK trade data, focusing on extensive and intensive margins, provides a deeper understanding of the factors driving overserved changes. This involves decomposing changes in the value of trade (exports and imports) across various products (at the HS6 digit level) into changes in the number of varieties traded with a country (extensive margins) and the average of value traded per variety with that country (intensive margins). In this analysis, the extensive trade margins are measured by the number of product varieties exported or imported, each exceeding USD 1,000 in trade value, normalized at 1 for January 2019. The intensive margins of trade are defined as the average value per product variety.

Typically, changes in trade value driven by extensive margins are related to factors that alter fixed costs of trade, while changes in intensive margins are associated with changes in variable costs of trade (e.g., tariffs) or variety-level changes driven by technologies or price shocks.

#### Extensive margins of trade

Figure 5 shows the extensive margins of UK trade from 2019 to 2023, revealing a stark decline in the variety of UK exports to the EU since January 2021. This indicates a significant reduction in the number of product varieties. These patterns are more pronounced when considering

extensive margins of trade without truncating data below the USD 1,000 threshold or when using mirror data, as shown in Figures A1 and A2 in the appendix.

The pattern for import varieties from the EU is notably different. Initially, UK import varieties from the EU experienced a decline, followed by a rapid recovery in 2021, suggesting stabilisation in the variety of goods imported. However, there was a prolonged decline in import variety from the EU during 2022-2023. In contrast, trade with the rest of the world (ROW) exhibited growth in both export and import varieties, especially since the beginning of 2022.



Figure 5 Extensive Margins of UK Trade, 2019-2023, values above 1000 USD, 2019=1

Note: Monthly values are in blue, 3-month moving average in red. Linear trend is dashed line. Only export and import of values above 1000 USD for each importer-exporter pair are included. Index, Jan 2019=1.

#### Intensive margins of trade

Figure 6 shows that the UK's intensive margin of exports to the EU increased since 2021, whereas imports from the EU remained relatively stable. These stylised facts suggest different mechanisms underlying the changes in UK exports to and imports from the EU, which we will explore in the following sections in econometric analysis.

For trade with the ROW, both exports and imports at the intensive margins saw increases, aligning with global trends of rising goods prices, potentially pushed up by higher

energy prices. This issue will be further examined later, particularly when energy trade (HS27) is excluded from our analysis.

These patterns illustrate the high complexities of the UK trade dynamics in recent years, driven by multiple factors including the COVID-19 pandemic, Brexit, and global economic conditions. This reinforces the need to carry out causal inference techniques to isolate the unique drivers impacting UK trade patterns. Understanding these distinct mechanisms is crucial and will be the primary focus of the subsequent sections.



Figure 6 Intensive Margins of UK Trade in 2019-2023, values above 1000 USD, 2019=1

Source: TDM

Note: Monthly values are in blue, 3-month moving average in red. Linear trend is dashed line. Only exports and imports of values above 1000 USD for each importer-exporter pair are included. Index, Jan 2019=1.

## 4. Theory

To better understand the stylised facts and the empirical results, we consider a simple partial equilibrium theory to illustrate the economic mechanisms through which variable and fixed costs affect the extensive and intensive margins of trade due to Brexit. Unlike the well-known Melitz model approach, as utilised by Chaney (2008) and Bernard et al (2011), we focus on

multiproduct firms operating under decreasing returns to scale. This framework allows us to examine the impact of Brexit on both inter-firm and intra-firm trade margins.

Assume there are *N* countries. In each country  $i \in \{1, 2, ..., N\}$ , similar to Bernard et al (2011), a typical firm in the final goods sector has a brand (or a distinct product) and supplies a variety of the brand in each country where it operates. It produces the product using both labour and intermediate goods with a production function  $Q = \phi \cdot F(L, \{x_i\}_{i=1}^N)$ , where *L* is labour input  $x_i$  are intermediate goods sourced from country *i*. The firm's productivity,  $\phi$ , is randomly drawn from a cumulative distribution function  $G_i(\phi)$ , and the density function  $g_i(\phi)$ . Given the input prices for labour and intermediate goods, the firm's cost function is denoted by  $C\left(\frac{Q}{\phi}\right)$ , which is assumed to be increasing and convex in Q.

The profit function of such a firm in country *i*, when supplying a quantity  $q_{ij}$  to country *j*, is given by

$$\pi = \sum_{j}^{N} R_{ij}(q_{ij}) - C\left(\frac{\sum_{j}^{N} \tau_{ij}q_{ij}}{\phi}\right) - \sum_{j \neq i} \mathbb{I}\left(q_{ij} > 0\right) \cdot f_{ij} - \mathbb{I}\left(\sum_{j \neq i} q_{ij} > 0\right) E, \quad (1)$$

where  $\tau_{ij} \ge 1$  measures the iceberg trade cost, implying that to sell an amount of  $q_{ij}$  in country j, the firm needs to produce an effective quantity of  $\tau_{ij}q_{ij}$  in the home country, with  $\tau_{ii} = 1$ . When the firm exports to country  $j \ne i$ , it incurs a country-specific fixed cost  $f_{ij}$ . Both  $\tau_{ij}$  and  $f_{ij}$  are tariff related. Additionally, the firm incurs a fixed cost E, which is non-tariff related, when it starts exporting to any country.

In a monopolistic competition framework with constant elasticity of substitution (CES) utilities, the revenue function  $R_{ij}(q_{ij})$  can be written as  $\Lambda_j \cdot R(q_{ij})$ , where  $\Lambda_j$  is country-specific and  $R(\cdot)$  is common for all countries. Considering a representative consumer's utility in country *j*:

$$U_{j} = \left[ \int_{\omega \in \Omega} [\lambda(w)q(w)]^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}},$$
(2)

where  $\Omega$  is the set of available varieties,  $\sigma > 1$  is the elasticity of substitution, and  $\lambda(w)$  is the product strength of variety  $\omega$ . The demand for a variety  $\omega$  produced by a firm from country *i* in country *j* with price  $p_{ij}(\omega)$  is:

$$q_{ij}(\omega) = \frac{Y_j \lambda_{ij}(w)^{1-\sigma}}{P_j^{1-\sigma}} p_{ij}(\omega)^{-\sigma},$$

where  $P_j = \left[ \int_{\omega \in \Omega} \left( \frac{p(\omega)}{\lambda(\omega)} \right)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$  is the price index in country *j*, and *Y<sub>j</sub>* is the expenditure on final goods in country *j*. The revenue can be written as

$$R_{ij}(q_{ij}) = \left[\frac{Y_j \lambda_{ij}(w)^{1-\sigma}}{P_j^{1-\sigma}}\right]^{\frac{1}{\sigma}} q_{ij}(w)^{1-\frac{1}{\sigma}} = \Lambda_j \cdot R(q_{ij}),$$

where  $\Lambda_j$  include country-specific expenditure, price index, and product strength, and  $R(q) = q^{1-\frac{1}{\sigma}}$ , which is increasing and concave in q, and  $R'(q) \to \infty$  as  $q \to 0$ .

If the firm supplies to  $j = \{1, 2, ..., J\}$  countries, the profit-maximising quantities satisfy:

$$\Lambda_{j}R'(q_{ij}) = \frac{\tau_{ij}}{\phi}C'\left(\frac{\sum_{j\in J}\tau_{ij}q_{ij}}{\phi}\right)$$
(3)

The marginal revenues in two different countries, j and j', then satisfy

$$\frac{R'(q_{ij})}{R'(q_{ij'})} = \frac{\tau_{ij}/\Lambda_j}{\tau_{ij'}/\Lambda_{j'}}$$
(4)

Define  $v_{ij} = \tau_{ij}/\Lambda_j$  as the quality-adjusted variable trade cost in country *j*, which is increasing in the variable trade cost and decreasing in national income and product strength. The quantities supplied to two countries, *j* and *j'*, satisfy

$$\frac{q_j}{q_{j'}} = \left(\frac{\nu_{ij}}{\nu_{ij'}}\right)^{-\sigma} \tag{5}$$

If we rank and relabel countries in *j* in increasing order of  $\tau_{ij}/\Lambda_j$ , the optimal quantities are determined by

$$R'(q_{iJ}) = \frac{\nu_{iJ}}{\phi} C'\left(\frac{\xi_J q_{iJ}}{\phi}\right) \text{ where } \xi_J = \sum_{j=1}^J \tau_{ij} \left(\frac{\nu_{ij}}{\nu_{iJ}}\right)^{-\sigma} \tag{6}$$

The total profit of the firm is then:

$$\pi^{J} = \sum_{j=1}^{J} \Lambda_{j} \cdot R\left(q_{iJ}\left(\frac{\nu_{ij}}{\nu_{iJ}}\right)^{-\sigma}\right) - C\left(\frac{\sum_{j=1}^{J} \tau_{ij}\left(\frac{\nu_{ij}}{\nu_{iJ}}\right)^{-\sigma} q_{iJ}}{\phi}\right) - \sum_{j\neq i} \mathbb{I}\left(q_{ij} > 0\right) \cdot f_{ij} - \mathbb{I}\left(\sum_{j\neq i} q_{ij} > 0\right) E \quad (7)$$

Given that the marginal revenue is infinite at  $q_{ij} = 0$  and there is no fixed cost of supplying the home market, the firm always serves the home market before exporting. When countries differ only in their variable trading costs, we can summarise the firm's behaviour as follows: **Proposition 1:** 

- (a) There exists a productivity threshold  $\overline{\phi}$  such that the firm only exports if  $\phi > \overline{\phi}$ .
- (b) The firm exports to more countries, in the increasing order of  $\tau_{ij}$ , when it has a higher productivity.

(c) Conditional on exporting to the same countries, the firm exports more to each country when it has higher productivity.

(d) Conditional on exporting, the firm exports more to countries with lower variable trade costs.

(e) Given  $\phi$  and  $v_{ij}$ , the firm exports more to each country when it exports to fewer countries.

#### **Proof:**

When countries differ only in their variable costs, the order of exporting follows the increasing order of  $\tau_{ij}$ . If the firm exports to country *j*, it must also export to all countries *j'* with  $\tau_{ij'} < \tau_{ij}$ . If  $\tau_{ik} < \tau_{ij}$  but the firm does not serve country *k*, then the firm can increase profit by shifting products from country *j* to country *k* instead, reducing costs.

As the firm exports to more countries, the added revenue diminishes due to higher production costs. The firm will export up to *J* countries until the added revenue no longer covers the added fixed cost of exporting, i.e.

 $\Delta^{J} = \pi^{J} - \pi^{J-1} \ge 0 \text{ and } \Delta^{J+1} = \pi^{J+1} - \pi^{J} < 0.$ 

*J* then defines the optimal extent of exporting if the firm starts exporting. However, if  $\pi^{J} < E$ , the firm then refrains from exporting entirely. Since the profits in all countries uniformly increase in productivity, it follows naturally that the higher the productivity a firm has, the more countries it exports to. When the scale of exporting is large enough to cover the cost of entering the exporting market, *E*, the firm is then active in exporting. This proves Proposition 1(a) and 1(b).

From Equation (3), a higher productivity lowers the marginal cost on the right-hand side and hence increases sales in all countries, which proves Part (c). Part (d) follows immediately from Equation (5), which shows that the exporting quantity is negatively related to variable trading costs. Part (e) follows from Equation (6). To see this, given productivity  $\phi$ and trade costs  $v_{ij}$ , suppose the firm stops exports to country J + 1 but continues to export to the first J countries at the same scale  $q_{ij}$ , this profile of quantities still satisfies Equation (5) but lowers the right-hand side of Equation (6), i.e., the marginal cost of production, since the firm no longer exports to country J + 1. Therefore, the firm must increase exports to each of the first J countries.

In light of the theoretical model, we have the following hypotheses on trade dynamics between the UK and the EU given Brexit shock, which results in a bilateral increase in both tariff-related trading costs,  $\tau_{ij}$  and  $f_{ij}$ , and the non-tariff related entry cost into exporting, *E*. **Impact of Brexit on the extensive margin**  There is a clear negative impact of Brexit on the extensive margin of trading with the EU. This occurs at both inter-firm level and intra-firm level.

At the intra-firm level, an increase in the fixed costs of exporting to country j  $(f_{ij})$  reduces the profit from being active in country j, and an increase in the variable costs  $(\tau_{ij})$  further pushes country j down the exporting order. Both mean that a firm is likely to exit country j and shift resources to more profitable countries or new destinations.

The intra-firm reduction in the extensive margin and the increase in the fixed costs of entering the exporting market further lead to a reduction of extensive margin at the inter-firm level. As the firm retreats from some destinations, the overall profit from exporting is reduced. Together with increase in non-tariff related trading costs (E), this means that the firm may be forced to exit from exporting altogether, not just from the EU. This implies that, we may observe some firms not only stopping exporting to the EU but also to other destinations such as the US.

**Hypothesis 1(a).** Increased variable trade costs reduce the variety of exporting from the UK to the EU and vice versa.

**Hypothesis 1(b).** Increased fixed costs reduce the variety of exporting from the UK to the EU and vice versa.

**Hypothesis 1(c).** Increased non-tariff measures reduce the variety of exporting from the UK to the EU and vice versa.

#### Impact of Brexit on the intensive margin

Compared to the extensive margin, the impact of Brexit on the intensive margin is less clearcut. Consider first an increase in E, it forces some firms out of exporting altogether, but it does not affect the exporting intensity of firms that continue to export. Since these remaining firms are more efficient and export to a greater intensity, it follows that the average export per variety is higher.

Consider then an increase in  $f_{ij}$ , similarly, this does not affect the exporting intensity of firms that continue to export to the same countries. However, when this causes a firm to exit country *j*, according to part (e) of Proposition 1, the firm exports more to other countries where it is still active. This reflects the reallocation of resources within the firm to focus on the more profitable markets.

Consider lastly an increase in  $\tau_{ij}$ , if the firm continues exporting to the same countries, this reduces the intensity of exporting in all countries due to the increase in

marginal costs, but the reduction is more significant in country j as it moves down the order of exporting. However, if such an increase induces the firm to stop exporting to country j, then similarly according to part (e), the firm exports more to other countries where it remains active.

**Hypothesis 2(a).** Increased variable trade costs have an ambiguous impact on the export per variety from the UK to the EU and vice versa.

**Hypothesis 2(b).** Increased fixed costs increase the export per variety from the UK to the EU and vice versa.

**Hypothesis 2(c).** Increased non-tariff measures increase the export per variety from the UK to the EU and vice versa.

#### The role of distance

The reduction of extensive margin and intensive margin is more significant for countries that appear further down the order of exporting, for example, countries that locate farther away from the UK and face higher variable costs. This is because when trading costs increase across EU countries, the adjustment at the intra-firm level has the greatest impact on these countries where firms are more likely to exit. This means that trading with these countries not only suffer more on the extensive margin, but also more on the intensive margin due to resource reallocated towards other EU countries.

**Hypothesis 3.** Higher costs will significantly affect exports from the UK to EU countries at a greater distance and vice versa.

#### The impact on intermediate goods

Proposition 1 also has implications on the impact of Brexit on the intermediate goods market. Apparently, as importing inputs from the EU becomes more expensive, standard economic theory of production suggests that firms import less from the EU and rely more on other sourcing countries or the home market, and vice versa for EU firms. However, the impact on intermediate goods is likely smaller than final consumption goods, not only because intermediate goods are normally subject to less tariff protection, but also because of resource reallocation within firms. Namely, the reduction in exports to the EU is partly compensated by increase in exports to other unaffected markets or increase of sales in the home market. Therefore, the demand for intermediate goods does not drop as much as the reduction of demand for final goods between the UK and the EU.

**Hypothesis 4.** Higher trading costs will significantly affect exports of consumption goods from the UK to the EU and vice versa, compared to intermediary goods.

#### The impact on SMEs

An important consequence of Brexit is the heightened non-tariff measures, e.g., standards and sectoral regulations. This impacts particularly industries facing more regulations such as agriculture and chemicals. Furthermore, the impact could differ across firms. In particular, SMEs often rely heavily on their competitive advantages in specific destinations, and therefore lack the scale to cover the rising entry costs into exporting. Hence, compared to larger corporations, SMEs will be more heavily affected.

**Hypothesis 5.** Higher trading costs will significantly affect SMEs and industries with higher fixed entry costs.

#### 5. Methodology and Data

#### **5.1 Identifying the Brexit Effect**

To identify the Brexit impact on UK trade, we need to estimate what would have happened to UK trade if it had continued trading under the EU Common Market regime rather than under the TCA. This specific inquiry focuses on the UK case, differentiating it from the broader question of the impact of exiting a preferential trade agreement (PTA) on trade in general. Head and Mayer (2014) estimated that the coefficient of a PTA in the gravity model of trade is 0.28, which translates to an average increase of 32% in exports after joining a PTA. However, Baier et al. (2019) have reported significant heterogeneity in the impact of PTAs, with variations across different PTAs and even within a single PTA for different country pairs.

An important question is whether the disintegration from a PTA impacts trade in a similarly magnitude with joining in it but opposite in direction. Quantitative research on the effects of PTAs, initiated by Tinbergen (1962), has predominantly observed the process of uninterrupted globalisation, particularly following the collapse of the Soviet Union and China's accession to the WTO. Given the scarcity of disintegration examples, examining the TCA as a case study is critical, especially due to the unique level of integration among European economies that Brexit has begun to unravel.

The tools of causal inference econometrics, particularly the synthetic difference-indifferences (SDID) method (Archangelsky et al., 2021), are ideally suited for such analysis. These tools focus on estimating the impact of a specific policy change rather than determining an average effect across numerous instances of the policy. Following the literature on causal inference (Rubin, 1991; Angrist and Pischke, 2009), the causal impact of Brexit boils down to calculating the average treatment effect on treated to get to estimate the impact of TCA on the UK trade with EU:

$$\delta_{TCA} = E(Y_{UK}^1 - Y_{UK}^0 | TCA = 1) = E(Y_{UK}^1 | TCA = 1) - E(Y_{UK}^0 | TCA = 1)$$
  
=  $Y_{UK} - E(Y_{UK}^0 | TCA = 1)$  (8)

where  $Y_{UK} = Prob(TCA = 1) \times Y_{UK}^{1} + (1 - Prob(TCA = 1)) \times Y_{UK}^{0}$  is actual UK trade, while  $Y_{UK}^{1}$  and  $Y_{UK}^{0}$  are potential outcomes in the UK trade in case of TCA and if the TCA was not implemented. To identify the causal impact, we need estimate the UK trade in the counterfactual scenario where the UK did not exit the EU.

We use the SDID approach to estimate the counterfactual  $E(Y_{UK}^0|TCA = 1)$  and determine the causal impact of TCA on UK trade. SDID combines the strengths of differencein -differences (DID, Card and Krueger, 1994) and synthetic control (SC, Abadie and Gardeazabal, 2003) methods. SDID automates the process of adjusting for covariates and selecting appropriate time periods, applying a consistent logic to both units and time periods.

Similar to the SC method, SDID reweights and matches per-treatment trends, while like DID, it enables valid inference for large panels. This approach makes the estimation more localised, providing estimates of the effects for treated units in the most comparable circumstances, and more flexible compared to the standard DID or SC methods. SDID is more robust to violations of the parallel trends assumption and can handle interactive fixed effects, allowing for valid inference with large panels and serial correlation. Furthermore, by optimally weighting time periods, SDID substantially reduces the requirement of a long pre-treatment sample typical in other methods.

A key consideration is selecting the best donor pool of countries to construct a counterfactual UK. The control group should be unaffected by the treatment. Freeman et al. (2022) uses the UK trade with the rest of the world, while Kren and Lawless (2023) use EU bound trade in their selection. We argue that using UK trade with the rest of the world is inappropriate due to the global impact of TCA through supply chains. Similarly, using only EU trade data may introduce bias due to the indirect impact of the withdrawal of the UK on the remaining EU countries trade, which violates the stable unit treatment value assumption (SUTVA; Rubin, 1980) that states that for the unbiased casual interpretation of the estimated

effect a unit's response to the treatment is only dependent on the treatment it was assigned, and not the treatments of other units. Therefore, we use all available bilateral trade pairs as the control group and allow SDID to select the trade flows that best construct the pre-TCA doppelganger for the UK. As a robustness check, we repeat the analysis using samples restricted to non-EU countries, EU countries, and OECD countries, ensuring the results are stable and robust across different samples.

Our approach is focused on measuring the causal impact of transition from EU to TCA which occurred on 1 January 2021 on UK-EU trade. We do not attempt to measure the impact of Brexit referendum or the uncertainty it caused from 2016 to 2020, or the anticipation effect. We also do not model the COVID-19 shock. Our methodology isolates the impact of TCA on UK trade, accounting for other economic shocks. The COVID-19 shock affected all countries, while the TCA specifically impacted the UK (and the countries trading with the UK but likely to a less extent). Our measure relies on identifying treated bilateral pairs and controlling for time and country-pair fixed effects within the SDID framework.

#### **5.2 Decomposition of Trade Margins**

To understand the dynamics of international trade, assess the impact of trade policies, and identify opportunities for reducing trade costs and improving market efficiency, we proceed to decompose trade margins. This analytical approach is instrumental for the purpose of our analysis. For each country pair,  $x_{ij,t}^g$  represents the value of export in USD of product g (HS6) from country i to country j at time t. Bilateral exports from country i to country j at time t are defined as:

$$X_{ij,t} = \sum_{g} x_{ij,t}^{g} \tag{9}$$

Exports from country *i* to a group of countries  $B=\{EU, ROW\}$  as:

$$X_{iB,t} = \sum_{j \in B} X_{ij,t} \tag{10}$$

We define extensive margin of trade for each country pair as the number of positive exports with value exceeding 1000 USD from country i to country j at time t, given by

$$XEM_{ij,t}^{1000} = \sum_{g} 1(x_{ij,t}^{g} > 1000)$$
(11)

Where 1(.) is an indicator function that takes value of 1 for exports above 1000 USD and 0 otherwise. The extensive margin measures the number of varieties that country *i* exports to country *j*. Setting a threshold of 1000 USD reduces noise in the data caused by differences in

the methodology of recording trade flows after the UK transitioned from Intrastat Survey to customs declarations administered by HMRC.<sup>13</sup>

The intensive margin of trade for country pair *ij* is the average value of trade, defined as

$$XIM_{ij,t}^{1000} = \frac{X_{ij,t}^{1000}}{XEM_{ij,t}^{1000}}$$
(12)

Where  $X_{ij,t}^{1000}$  is the value of bilateral exports from *i* to *j* at time *t* for goods where  $x_{ij,t}^g > 1000$ . The intensive margin measures the average value of export per variety exported from *i* to *j*, reflecting the size of firms in country *i* and the depth of the market in *j*. Intensive margins are determined by the market size and bilateral variable trade costs.

The corresponding measures for imports use similar definitions. Let  $m_{ij,t}^g$  denote the bilateral import value from country *j* to *i* for product *g* at time *t*. Bilateral imports are defined as:

$$M_{ij,t} = \sum_{g} m_{ij,t}^{g} \tag{13}$$

Imports from EU and ROW are defined as:

$$M_{iB,t} = \sum_{j \in B} M_{ij,t} \tag{14}$$

The  $M_{iB,t}$  extensive margin of imports is:

$$MEM_{ij,t}^{1000} = \sum_{g} 1(m_{ij,t}^{g} > 1000)$$
(15)

And intensive margin of imports is:

$$MIM_{ij,t}^{1000} = \frac{M_{ij,t}^{1000}}{XM}$$
(16)

#### **5.3 Statistical Issues and Data Description**

Our analysis utilises two distinct trade datasets. For our primary specification, we rely on TDM import and export data at the harmonized system (HS) sub-heading level (HS 6-digit) in 2017-2023. This dataset includes both value (in USD) and quantity (in net weight kilograms). Our primary analysis focuses on the monthly bilateral exports and imports of the UK at the HS sub-

<sup>&</sup>lt;sup>13</sup> Starting from January 2021, upon the conclusion of the UK's transition period, the method for collecting data on goods exports from Great Britain (GB) to the EU shifted from the Intrastat Survey to customs declarations managed by HMRC. A subsequent change occurred in January 2022, with the transfer of data collection on GB imports from the EU to customs declarations. The Intrastat Survey, which was previously completed by VAT-registered UK businesses involved in importing or exporting goods, did not include some smaller traders, businesses not registered for VAT, and parcel post transactions. Additionally, with the introduction of the customs declaration requirement for EU imports to GB in January 2021, a policy known as Staged Customs Controls was implemented. This policy permitted importers to postpone their customs declarations for up to 175 days following the arrival of the goods in the country during 2021. Also see the discussion in data section about minimum value thresholds. Source: <a href="https://blog.ons.gov.uk/2023/02/10/trading-places/">https://blog.ons.gov.uk/2023/02/10/trading-places/</a>

heading level obtained from TDM. Additionally, we incorporate annual trade data from TDM as supplementary information.

To enhance the robustness of our analysis, we cross-verify with monthly and annual trade data at the HS 6-digit level from COMTRADE, although this database only offers data up to 2022. Summary statistics are presented in Table 1. The full list of the countries with data included in our study is provided in the Appendix Table A1.

	A: Monthly data					
Variables	Mean	Std. Dev	Min	Max		
Export values, bln USD	0.062	0.676	0	57.262		
Import values, bln USD	0.064	0.641	0	52.081		
Export varieties (No.) 93.796		327.871	0	4772		
Import varieties (No.) 101.491		354.906 0		4721		
Average export values,	227512.4	2446910	2446910 0			
bln USD						
Average import values,	456436.7	6359702	0	1.28e+09		
bln USD						
Observations	1,872,780					
	B: Annual data					
Variables	Mean	Std. Dev	Min	Max		
Export values, bln USD	0.893	8.920	0	578.821		
Import values, bln USD	0.907	8.465 0		538.5125		
Export varieties (No.)	274.173	650.654	0	5261		
Import varieties (No.)	234.535	620.761	620.761 0			
Average export values, 741187		5172805	0	4.76e+08		
bln USD						
Average import values, 1839184		1.97e+07	0	2.67e+09		
bln USD						
Observations		126,91	10			

Table 1: Summary Statistics of Trade Data (TDM sample)

Note: All trade values are bilateral.

Since the UK left the EU, the arrangements for how the UK trades with the EU have changed. From January 2021, when the UK's transition period ended, data collected on goods exports from Great Britain (GB) to the EU moved from the Intrastat Survey to HMRC customs declarations. This was followed in January 2022 by data on GB imports from the EU moving to customs declarations. The ONS has issued several reports about changes in the methodology and system that collect trade statistics. The introduction of Staged Customs Controls in 2021 allowed some imports to be reported up to 175 days after the day of import. Customs declarations with commodity line values below the statistical threshold of £873 (in value) and 1,000kg (in net mass) are aggregated into 'low value aggregates'. The Trade Statistics and Customs Analysis (TSCA) team does not receive business, product or partner country information on these movements. Consequently, the TSCA cannot assign this trade to a UK region, and thus, the value is assigned to the Unallocated-Unknown region. This applies to goods exports from GB to EU countries from 2021 and imports into GB from EU countries

from 2022. Below Threshold Trade Allocation (BTTA), which was previously estimated, is now drawn directly from customs declarations.

We address these data issues in three ways:

- 1) Counting varieties only above 1000 USD, which is above the BTTA threshold.
- Reporting annual data results, which are less prone to the delayed reporting of imports in 2022.
- 3) Reporting results for mirror data, collected and reported by government agencies in other countries, which did not experience such changes in methodology as UK data.

By employing these strategies, we aim to ensure the robustness and reliability of our analysis on the decomposition of trade margins in the context of the UK's new trading arrangements.

## 6. Results

The sections provide detailed evidence of our findings using various analytical approaches and robustness checks. We carefully evaluate the average effects across different trade margins and analyse heterogeneity in both product and geographical spaces. Finally, we discuss the determinants of heterogeneity through the lens of our theoretical model.

#### **6.1 Overall Results**

The main results, presented in Table 2, highlight the substantial negative impact of the TCA on UK trade with the EU. Analysing the coefficients in the TDM Monthly Data (panel A), we observe a significant negative effect on both exports and imports during 2021-2023. The coefficient for exports to the EU is -0.308, indicating a 27% decrease, while the coefficient for imports from the EU is -0.389, representing a 32% reduction in the UK trade with the EU.

The negative and significant coefficients persist when examining the TDM Annual Data (Panel B), though with smaller estimated impacts of 17% for value of exports and 23% for value of imports. This can be attributed to smoothing effect of annual data, which masks large and rapidly changing short-term volatility in trade flows, especially at the extensive margins. The comparison of the results confirms that the annual data results downplay the impact of TCA on the extensive margins, while exaggerate the impact on the intensive margins as was documented in the literature (i.e. Bloom at al., 2007): the disruption of trade on the extensive margin over the course of the year is not recorded in the annual data as long as a product is traded at least in a single month. Moreover, the overall impact is smaller for the annual data indicates that the higher value trade flows were relatively less impacted than the smaller value ones. In other words, the decline in trade is heterogenous among trading partners and impacted

more the trading partners who trade with the UK less in percentage terms. We test this conjecture more formally in Section 8.

Comparing the coefficients across different trade margins reveals important insights. Even though both the values of exports to and imports from the EU declined by similar magnitudes, the mechanisms of adjustment differed: **exports** primarily declined at **extensive margins** by 33% and remained stable at intensive margin, while **imports** adjusted at **intensive margins**, declining by 28%, and remained stable at extensive margins. The annual data (Panel B) consistently demonstrate smaller magnitudes of decline compared to the monthly data (Panel A), due to the aggregation bias combined with the heterogeneity of the impact.

#### Stability and dynamics: does the effect dissipates over time?

Is the transition of the UK trade from post-EU equilibrium over? What are the dynamics of changes: some commentators predicted rapid response, while others point to the fact that changes in trade cause by changes in trade policies are much longer term and may take decades (Larch and Yotov, 2024). Panels C and D of Table 2 present the results based on the sample period 2017-2022. This serves two purposes. The first is to evaluate whether the TCA impact softened or intensified over time. The second is to later on compare the results of the TDM sample with the COMTRADE sample, commonly used for empirical trade flow analysis, which is available only until the end of 2022.

The results reveal that the negative tendencies intensified in 2023, leading to more negative estimates of the impact. Based on 2017-2022 TDM sample, the UK exports to the EU declined by 20% and UK imports from the EU by 25%. These results show strong persistence and consistency, with the effects on values, extensive and intensive margins remaining qualitatively identical. This demonstrates the stability and robustness of our method, which captures long-term trends and is not driven by short-term fluctuations in the data.

In summary, these findings provide comprehensive evidence of the TCA's impact on UK-EU trade, highlighting significant declines in trade volumes and shifts in trade dynamics.

	Export to EU			Import from EU				
	Value	Extensive	Intensive	Value	Extensive	Intensive		
		A: TDM Monthly data. 2017-2023						
Coefficient	-0.308	-0.408	-0.091	-0.389	-0.038	-0.332		
Standard error	(0.050)	(0.025)	(0.055)	(0.051)	(0.042)	(0.032)		
T-ratio	-6.11	-16.23	-1.67	-7.60	-0.89	-10.24		
Change in %	-26.54	-33.49	-8.72	-32.25	-3.73	-28.22		
	B: TDM Annual data. 2017-2023							
Coefficient	-0.191	-0.262	-0.251	-0.256	-0.120	-0.601		
Standard error	(0.054)	(0.021)	(0.058)	(0.052)	(0.035)	(0.042)		
T-ratio	-3.52	-12.55	-4.33	-4.96	-3.48	-14.44		
Change in %	-17.41	-23.07	-22.19	-22.62	-11.32	-45.17		
	C: TDM Monthly data. 2017-2022							
Coefficient	-0.227	-0.309	0.051	-0.285	-0.018	-0.227		
Standard error	(0.057)	(0.028)	(0.063)	(0.048)	(0.027)	(0.030)		
T-ratio	-4.01	-10.87	0.80	-5.95	-0.67	-7.54		
Change in %	-20.29	-26.56	5.18	-24.81	-1.83	-20.33		
	<b>D: TDM Annual data. 2017-2022</b>							
Coefficient	-0.103	-0.195	0.030	-0.211	-0.116	-0.331		
Standard error	(0.062)	(0.019)	(0.085)	(0.046)	(0.037)	(0.085)		
T-ratio	-1.67	-10.05	0.35	-4.60	-3.14	-3.90		
Change in %	-9.76	-17.74	3.06	-19.03	-10.95	-28.20		

Table 2: Impact of TCA on UK Trade with EU, Main Results

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelksy et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec, 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner. Data is TDM for 2017-2023. List of countries included in the sample is in the appendix. For extensive and intensive margins, only transactions with value above 1000 USD are considered.

#### **6.2 Different Types of Goods**

We now examine how the TCA impacts different categories of goods – consumer, intermediate, and capital goods – to gain nuanced insights into UK-EU trade dynamics and policy implications. Our analysis categorises the TDM monthly bilateral sample according to the Broad Economic Category (BEC) classification, Rev.5.<sup>14</sup> As outlined in Table 3, intermediate goods account for 37.37% of total world trade, consumer goods for 17.41%, and capital goods for 10.98%. An additional category, comprising 34.24% of total trade, includes other goods that are difficult to classify, such as refined oil, monetary gold, or unidentified goods in HS 99, and is therefore not included in this analysis. The results are reported in Table 4.

<sup>&</sup>lt;sup>14</sup> See <u>https://unstats.un.org/unsd/trade/classifications/bec.asp</u>
Type of good	Observations	Mean	Std. Dev	Min	Max	Share of total (%)
Consumer	3498600	0.007	0.113	0	14.4	17.41
Intermediate	3663240	0.024	0.262	0	31.9	37.37
Capital	3498600	0.007	0.113	0	14.4	10.98
Total	3745560	0.063	0.659	0	57.3	100 <sup>a)</sup>

**Table 3: TDM Monthly Data for Different Types of Goods** 

Notes: Goods are classified into types according to BEC5 classification.

a) The excluded group are goods that are not falling into any of the category, such as gold and oil. Such products are categorized as other goods and their share in total export is 34.24%.

## **Consumer Goods**

Consumer goods trade reflects final demand in the economy, indicating the strength of the UK consumer market (for imports) and the competitiveness of the domestic industry in the EU market (for exports). Our finding suggests that UK exports of consumer goods to the EU saw the most significant decline, with a 39.18% decrease in total export value and a 43.51% drop in extensive margins. As consumer goods markets are competitive, the sharp decline is likely due to new customs procedures, increased paperwork, and shifts in consumer preferences, leading to higher costs and price increase, and therefore reduced competitiveness for UK producers. Similarly, imports of consumer goods from the EU to the UK also fell by 22% in value and 15% in varieties, despite the absence of UK-EU border checks in the UK during the examined period. These indicate a notable trend of separation in final goods production and consumption between the UK and the EU.

## **Intermediate Goods**

Trade in intermediate goods is crucial for understanding the integration of the UK economy into EU and global supply chains. UK exports of intermediate goods to the EU declined by 21.71% in value and 19.85% at the extensive margin, reflecting the diminished role of UK goods in EU supply chains due to Brexit-related disruptions. While imports of intermediate goods from the EU remained stable at the extensive margin with a slight increase, the overall import value decreased by 28%. New customs barriers and complex rules of origin requirements under the TCA have introduced delays and additional costs, complicating the integration of UK firms into European supply chains, especially for industries reliant on just-in-time delivery systems.

## **Capital Goods**

The trade of capital goods, such as machinery and equipment, is essential for understanding investment trends and future production capacity. UK exports of capital goods to the EU

declined similarly to intermediate goods, suggesting a diversion of EU countries from UK suppliers for capital-intensive production factors. However, imports of capital goods from the EU remained stable in value and expanded by 19% at the extensive margin, demonstrating resilience in the UK's import of capital goods from the EU despite broader trade disruptions.

Together, these patterns reveal a picture of heavily disrupted and the weakening of UK-EU supply chains post-TCA, evident across consumer, intermediate, and capital goods. These findings underscore the significant negative impact of Brexit and the TCA on UK exports to the EU, due to heightened regulatory and logistical barriers. Overall import patterns suggest that while the UK is moving away from reliance on the EU for final goods, it remains dependent on the EU for intermediate and capital goods.

The pronounced impact on final stages of supply chains aligns with literature on protectionist trade policies, which escalate as goods progress through the supply chain.<sup>15</sup> Following the TCA, consumer goods were particularly affected by new non-tariff measures, leading to decreases in both exports and imports from the EU. Additionally, the reduction in exports of final consumer goods, which rely on EU-imported intermediate goods, may further reduce intermediate goods imports. Literature on Global Value Chains (GVCs) as reviewed by Antràs and Chor (2022) highlights that tariff escalation both results from and drives the prominence of GVCs, with lower tariffs on intermediate goods facilitating long supply chains that cross borders multiple times without prohibitive costs.

<sup>&</sup>lt;sup>15</sup> According to Bown and Crowley (2016), capital goods and materials typically receive the lowest levels of protection, whereas final goods face the highest.

	Ex	port to EU	Impo	ort from EU		
	Value	Extensive	Value	Extensive		
Coefficient	-0.497	-0.571	-0.246	-0.157		
Standard error	(0.048)	(0.051)	(0.090)	(0.052)		
T-ratio	-10.29	-11.11	-2.74	-3.01		
Change in %	-39.18	-43.51	-21.82	-14.57		
		B: Interr	nediate goods			
Coefficient	-0.245	-0.221	-0.325	0.046		
Standard error	(0.065)	(0.017)	(0.047)	(0.040)		
T-ratio	-3.76	-13.33	-6.99	1.15		
Change in %	-21.71	-19.85	-27.78	4.71		
	C: Capital goods					
Coefficient	-0.222	-0.140	-0.064	0.175		
Standard error	(0.057)	(0.017)	(0.097)	(0.052)		
T-ratio	-3.88	-8.05	-0.66	3.37		
Change in %	-19.89	-13.07	-6.16	19.09		

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelksy et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Data is TDM for 2017-2023. List of countries included in the sample is in appendix. For extensive margins, only transactions with value above 1000USD are considered. We report results by value and extensive margin of trade in this section, as the intensive margin can be easily inferred form the coefficient on the value and extensive margin. Results for 2017-2022 sample are shown in Table A2 in the appendix.

# 7. Robustness

We rigorously tested the robustness of our findings on the TCA's impact on UK-EU trade. Cross-verifying with COMTRADE data and using different control groups and methods consistently confirmed significant declines in trade value and variety. Additional checks, including non-censored data and adjustments for energy price volatility, further validated that the negative effects observed are reliable and not influenced by specific data choices or external factors. Overall, the results are consistent and robust across all tests.

## 7.1 Cross-verification with COMTRADE Data

The COMTRADE data, which is typically used for studies of trade at product level, is available for a smaller set of countries and only up to 2022. Given its popular use, we report results for the COMTRADE dataset to check for robustness. The results, presented in Table 5, confirm the TDM results.

In the COMTRADE Monthly Data (Panel A), both export and import coefficients are negative, indicating a decline in trade. Specifically, the coefficient for exports to the EU is - 0.214, representing a 19% decrease, while the coefficient for imports from the EU is -0.282, indicating a more substantial 25% reduction. These coefficients are statistically significant,

with T-ratios of -3.82 and -6.48, respectively. Both the extensive and intensive margins show consistent patterns of decline, with larger effect on the extensive margins.

Examining the COMTRADE Annual Data (Panel B), the negative coefficients persist for both exports and imports, reinforcing the downward trend. The coefficient for exports to the EU is -0.248, corresponding to a 21.97% decrease, and the coefficient for import from the EU is -0.260, indicating a 22.86% reduction. These coefficients are statistically significant, with T-ratios of -4.18 and -5.53, respectively. Similar to the TDM data Table 2, the extensive margin consistently exhibits more substantial declines compared to the intensive margin.

Comparing the results between Table 2 and Table 5 reveals notable consistency in the observed patterns. Both datasets, TDM and COMTRADE, consistently show negative effects for UK exports and imports to the EU post-TCA implementation. The negative coefficients similar values for both extensive and intensive margins of trade, further validating the robustness of the findings across different datasets.

	Export to	EU		Import fro	om EU	
	Value	Extensive	Intensive	Value	Extensive	Intensive
	A: COMT	RADE Monthly	data			
Coefficient	-0.214	-0.273	0.068	-0.282	-0.012	-0.238
Standard error	(0.056)	(0.024)	(0.057)	(0.044)	(0.030)	(0.030)
T-ratio	-3.82	-11.37	1.19	-6.48	-0.42	-7.84
Change in %	-19.27	-23.92	7.02	-24.58	-1.24	-21.19
	B: COMT	RADE Annual o	lata			
Coefficient	-0.248	-0.113	-0.133	-0.260	-0.005	-0.272
Standard error	(0.059)	(0.017)	(0.065)	(0.047)	(0.025)	(0.034)
T-ratio	-4.18	-6.80	-2.06	-5.53	-0.21	-8.02
Change in %	-21.97	-10.71	-12.48	-22.86	-0.53	-23.78

Table 5: Impact of TCA on UK Trade with EU, Using COMTRADE Data

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Intensive margin is the natural log of average value of exports/imports between reporter and partner. Data is COMTRADE for 2017-2022. List of countries included in the sample is in appendix. For extensive and intensive margins, only transactions with value above 1000 USD are considered.

#### 7.2 Sensitivity to the Control Group

For a robust interpretation of the causal impact of Brexit/the TCA, two key conditions must be satisfied. First, the countries that are used to construct a synthetic control (doppelganger) for the UK should exhibit similar pre-treatment behaviour to the UK. Second, these countries should not be impacted by the policy change, ensuring that that observed effects can be attributed to the TCA rather than other confounding factors.

The first condition suggests that the UK's European neighbours would be ideal candidates due to their similar economic behaviours. However, the second condition may just exclude these countries, as they are also likely to have been impacted by Brexit through the introduction of new trade barriers.

It is therefore important to check the sensitivity of the control group composition. To do this, we empirically estimate the impact of the TCA on UK exports to the EU and use six different pools of bilateral trade partners as controls. Specifically, among our control groups, reporters can be divided into three categories: the UK and non-EU countries, the UK and EU countries, as well as OECD countries, while partners include either all countries or exclusively EU countries. The results are presented in Table 6.<sup>16</sup>

First, our baseline results are robust and conservative. All coefficients are negative, indicating a consistently negative TCA impact on UK exports to the EU. Second, the results are robust to the choice of control group. Notably, the analysis reveals a particularly pronounced effect for the control group that consists of non-EU reporters, especially when considering only EU countries as partners. This scenario shows that post-TCA, non-EU countries experienced a better-than-average performance in their exports to EU countries, whereas the UK did not capitalize on the post-COVID trade boom.

Overall, the analysis highlights significant challenges for UK exporters to the EU in the wake of Brexit, with declines in exports ranging from approximately 20% to over 28% across different model specifications. This consistent pattern reinforces the robustness of our conclusion regarding the adverse impact of the TCA on UK-EU trade dynamics.

Value of Export to EU TDM Monthly data							
Coefficient	-0.319	-0.261	-0.299	-0.335	-0.236	-0.220	
Standard error	(0.053)	(0.051)	(0.049)	(0.060)	(0.047)	(0.058)	
T-ratio	-6.04	-5.17	-6.09	-5.60	-4.97	-3.79	
Change in %	-27.29	-22.98	-25.83	-28.44	-20.99	-19.77	
Control group composit	Control group composition						
Reporters	EU and UK	EU and UK	Non-EU and UK	Non-EU and UK	OECD	OECD	
Partners	All	EU	A11	EU	A11	EU	

Table 6: Sensitivity of the Choice of the Control Group

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The outcome variable is the log of export value. Control group varies across different columns, as indicated by the values in reporters and partners rows. For example, the first column with results performs estimation for reporters from EU or UK and partners are all countries. Treated group is UK exports to EU post Dec 2020. Data is TDM for 2017-2023. List of countries included in the sample is in appendix. Results for 2017-2022 sample are shown in Table A3 in the appendix.

<sup>&</sup>lt;sup>16</sup> The analysis for the value of imports and trade along extensive margins are also robust and available upon request.

### 7.3 Alternative methodology

Our results may be sensitive to the choice of the causal inference methodology and the functional form. The standard difference in differences (DID) methodology with two-way fixed effects, is the most common method to evaluate the policy response. The gravity model of trade, which is the workhorse of the international trade research, can be fit using the Poisson distribution to capture zero trade as well as heteroskedasticity in the error. As a result, the current default way to estimate the model with trade flow is by the Poisson pseudo maximum likelihood (PPML) method (Silva and Tenreyro, 2006). Table 7 provides alternative estimation methods, employing the linear two-way fixed effect DID and Poisson Pseudo-Maximum Likelihood (PPML) two-way fixed effect models, to assess the robustness of our estimation of the impact of the TCA on UK trade with the EU.

#### Difference-in-Differences (DID) Model (Panel A)

Using the TDM sample, the DID model estimation shows a substantial negative impact on both export to and import from the EU. Specifically, we find that for exports, the coefficient is - 0.262, corresponding to a 23% decrease in the value of exports to the EU. For imports, the coefficient is -0.205, reflecting a 19% reduction. These results are statistically significant, with T-ratios of 4.91 and 4.68, respectively. The analysis reaffirms the differences in the impacts along extensive and intensive margins, consistent with the findings presented earlier.

#### Poisson Pseudo-Maximum Likelihood (PPML) Model (Panel B)

The PPML results mirror the trends observed in the DID model, confirming the negative impact on UK-EU trade. The coefficients, T-ratios, standard errors, and percentage changes in both models consistently show a decline across extensive and intensive margins.

Comparing the results in Table 7 with our baseline model in Table 2, both estimation methods consistently indicate a significant and negative impact of the TCA on UK trade with the EU. This alignment across different datasets and methodologies reinforces the robustness of our findings. The negative impact is evident in both the extensive margin (number of varieties traded) and the intensive margin (value per variety traded).

	Export to EU			Import						
	Value	Extensive	Intensive	Value	Extensive	Intensive				
		A: TDM Sample. Difference in difference								
Coefficient	-0.262	-0.324	0.0752	-0.205	-0.0523	-0.125				
Standard error	(0.0534)	(0.0267)	(0.0570)	(0.0438)	(0.0317)	(0.0260)				

Table 7: Alternative estimation methods, DID and PPML result

T-ratio	4.91	12.13	-1.32	4.68	1.65	4.81			
Change in %	-23.05	-27.67	7.81	-18.54	-5.10	-11.75			
			B: TDM Sample. PPML						
Coefficient	-0.169	-0.288	-0.108	-0.37	-0.0483	-0.251			
Standard error	(0.0678)	(0.0276)	(0.0615)	(0.0487)	(0.0226)	(0.0483)			
T-ratio	2.49	10.43	1.76	7.60	2.14	5.20			
Change in %	-15.55	-25.02	-10.24	-30.93	-4.72	-22.20			

Note: Estimation is performed by two-way difference in difference (Panel A) and Poisson Pseudo Maximum Likelihood (PPML, Panel B. Silva and Tenreyro, 2006). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Intensive margin is the natural log of average value of exports/imports between reporter and partner. Data is TDM for 2017-2023. List of countries included in the sample is in appendix. For extensive and intensive margins, only transactions with value above 1000 USD are considered. Results for 2017-2022 sample are shown in Table A4 in the appendix.

#### 7.4 Extensive Margins with Non-censored Data

Table 8 present the results at extensive margins using all available data, without censoring transaction below 1000 USD. The analysis shows that if we did not impose this censoring threshold, the decline in trade at extensive margins would be much higher. For monthly data, the extensive margins of exporting decline by 56.65% (33.5% decline with censored data) and for import by 28.1 (3.7% decline with censored data). For annual data, differences are smaller due to higher aggregation data masking the extensive margins of trade, which change from one month to another, similar to what we observe for the censored extensive margins data.

	Expo	rt Import		
	Monthly	Annual	Monthly	Annual
Coefficient	-0.836	-0.467	-0.329	-0.347
Standard error	(0.063)	(0.039)	(0.046)	(0.036)
T-ratio	-13.25	-12.11	-7.08	-9.53
Change in %	-56.65	-37 34	-28.05	-29 32

Гab	ole	8:	Extensive	margin	results	with	non-censored	data
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Note: The estimation is based on the TDM data. Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec 2020. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Data is TDM for 2017-2023. List of countries included in the sample is in appendix. Results for 2017-2022 sample are shown in Table A5 in the appendix.

#### 7.5 Robustness to the volatility on energy prices in 2022-2023

To address concerns that the results might be driven by fluctuations in energy prices, we remove trade in energy products (HS27) from the analysis. As shown in Table 9, this adjustment does not significantly impact the overall value of trade. Specifically, the exclusion of energy-related trade does not alter the observed declines in trade values, indicating that the broader trends we identified are not solely driven by the recent hikes in energy prices.

By isolating the trade of energy products, we ensure that our findings reflect the underlying trade dynamics more accurately. This approach strengthens the robustness of our conclusions, confirming that the negative impact of the TCA on UK-EU trade extends beyond the volatility associated with energy markets.

	Exp	oort	Import			
	Monthly	Annual	Monthly	Annual		
Coefficient	-0.337	-0.216	-0.383	-0.234		
Standard error	(0.047)	(0.051)	(0.054)	(0.056)		
T-ratio	-7.12	-4.24	-7.10	-4.19		
Change in %	-28.64	-19.45	-31.80	-20.83		

Table 7. Impact of 1 Chi on value of thate with 120, chergy product excluded
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Note: The estimation is based on the TDM data. Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The control group is bilateral pairs exporting/importing to EU excluding UK. The treated group is bilateral trade of UK with EU. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Data for 2017-2023, excluding HS27 products. Results for 2017-2022 sample are shown in Table A6 in the appendix.

#### 7.6 Mirror Trade Data

An analysis of the mirror trade data, as reported by the UK trading partners and presented in Table 10, indicates a significantly higher decline in export value – around 40%. This discrepancy may be attributed to two factors. The first factor is the inclusion of non-VAT and small parcel trade. The ONS explains that UK export data post-TCA includes non-VAT registered trade and small parcel shipments, which might not be fully captured in the mirror data. This inclusion can lead to a lower reported decline in UK-exported values compared to the mirror data. <sup>17</sup>

Sample composition also plays a role. The mirror trade data includes only those partner countries that report data to the TDM, which tends to skew towards more developed and European countries. In contrast, direct trade data cover all global trading partners provide a more comprehensive view. This difference in the sample composition may contribute to the higher decline observed in the mirror data.

Table 10: Impact of TCA on UK trade with EU. Mirror trade results

	Export to EU			Import from EU		
	Value	Extensive	Intensive	Value	Extensive	Intensive
		A	TDM Mont	hly mirroi	r data	
Coefficient	-0.530	-0.207	-0.322	-0.166	0.096	-0.037
Standard error	(0.050)	(0.034)	(0.048)	(0.042)	(0.097)	(0.218)
T-ratio	-10.67	-6.06	-6.72	-3.97	0.99	-0.17

17 https://blog.ons.gov.uk/2023/02/10/trading-places/

Change in %	-41.14	-18.66	-27.52	-15.32	10.12	-3.61
		B: TDM Monthly mirror data. 2017-2				
Coefficient	-0.523	-0.180	-0.336	-0.119	0.076	-0.050
Standard error	(0.059)	(0.035)	(0.053)	(0.044)	(0.029)	(0.149)
T-ratio	-8.87	-5.21	-6.29	-2.71	2.63	-0.33
Change in %	-40.74	-16.49	-28.52	-11.25	7.91	-4.86

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelksy et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post December 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Intensive margin is the natural log of average value of exports/imports between reporter and partner. Data is TDM for 2017-2022. Mirror trade data is used by taking imports of i from j as exports of j to i and exports of i to j as imports of j from i. List of countries included in the sample is in appendix, but reporters are now partners and partners are reporters. For extensive and intensive margins, only transactions with value above 1000USD are considered.

# 8. Heterogeneity of Markets and Products

Having established the TCA's overall negative impact on UK-EU trade, we explore how it varies across EU partners and different product categories. The literature suggests that the impact of preferential trade agreements is highly heterogeneous (Baier et al., 2019), influenced by factors such as market size, distance, and firm productivity and creating a pecking order of destinations (Eaton et al., 2011). According to the pecking order theory, firms tend to prioritise export destinations where they can achieve a larger market share, which, other things being equal, is increasing with market size and declining with distance. This way, firms prefer entering markets that offer higher returns on investment and greater potential for market this strategic selection process forms the core motive regarding destination choices among French exporters. Brexit in this case, increasing trade costs, is expected to reverse the benefits seen under trade liberalisation, with the size of the effect varying systematically across markets and products.

To analyse these variations, we use the PPML method with trade-pair and time-fixed effects, focusing on two key questions.<sup>18</sup> First, which EU member states have experienced the most substantial reduction in trade with the UK, and what factors might explain the differences? Second, which products have seen the most significant downturns, and how can we explain the variation in product space?

<sup>&</sup>lt;sup>18</sup> The SDID is not designed to estimate multiple causal impacts within a single model and is sensitive to the ratio the signal-to-noise ratio, measured by variance of the explained part of the model to the variance of the disturbance term, which is higher for more disaggregated data. Moreover, as the robustness section demonstrate, the results are robust to the methodology, giving similar results for SDID, DID and PPML methods.

We utilise monthly bilateral TDM data in January 2017 to December 2023, examining trade value and product variety. The analysis is conducted at both the HS 6-digit product level (only for trade flows exceeding 1000 USD) and aggregated to the HS 2-digit industry level to identify the products most affected post-TCA.

#### **8.1 Model Specification**

The first model specification measures the heterogeneous impact of TCA on UK trade with individual EU countries by interacting a TCA indicator (which takes value of 1 post-January 2021 and 0 otherwise) with each EU country indicator variable. The model includes two-way fixed effects to control for time, bilateral and partner-specific fixed effects:

$$Y_{ij,t} = \exp(\sum_{k} \beta_k \times D_{UK,k \in EU} \times TCA_t + \alpha_{ij} + \gamma_t + \varepsilon_{ij,t})$$
(17)

where *i* is the source country and *j* represents the partner country at time *t*. The dependent variable  $Y_{ij,t}$  is either number of varieties  $N_{ij,t}$  or value of trade  $V_{ij,t}$  either for exports or imports.  $D_{UK,k\in EU}$  is an indicator variable that takes value of 1 if trade is between UK and EU country k, which captures partner-specific fixed effects for bilateral UK trade with any partner *k* that is in the EU-27 countries.  $TCA_t$  takes value of 0 before January 2021 and 1 afterwards.  $\beta_k$  denotes the interaction terms between TCA and each EU partner *k*, serving as the main variable of interest and quantifying the effect of Brexit on trade between the UK and each EU-27 partner.  $\varepsilon_{ij,t}$  is the error term.

Moving on to our second objective, our unit of observation is the UK trade in product h from country j at time t, with product specific fixed effect  $D_h$  interacted with the TCA variable, while controlling for product and time fixed effects:

$$Y_{jh,t} = \exp(\sum_{h} \beta_{h} T C A_{t} \times D_{h} + D_{h} + \gamma_{t} + \varepsilon_{jht})$$
(18)

where, *h* signifies HS chapter. For trade varieties, the dependent variable  $N_{jht}$  is the number of products at the HS 2-digit industry level from the partner country *j*, either for export or import. In the case of trade values, the dependent variable changes to the trade value,  $V_{jh,t}$  of products at the HS 2-digit industry level from the partner country *j*, again for either export or import. The variable *TCA*<sub>t</sub> serves as the TCA indicator, assuming a value of 1 after 1 January 2021, and 0 otherwise. The coefficients  $\beta_h$  represents the interaction terms between TCA and product fixed effects, serving as the primary coefficient of interest and capturing the effect of TCA on different products traded by the UK with EU.  $D_h$  and  $\gamma_t$  are product and time fixed effects.  $\varepsilon_{jht}$  is the error term.

#### **8.2 Differences in EU Countries**

Estimating Equation (16) yields coefficient plots that illustrate the effects of the TCA on UK trade with the EU-27 countries. These plots visualise the estimated impact on both exports to (along the horizontal axis) and imports from (along the vertical axis) these 27 EU countries. In the graphs below, Quadrant I shows UK trade partners that experienced positive effects in both imports and exports. Conversely, Quadrant III contains countries where the UK trade was negatively affected in both trade flows. The size of each point in the figure corresponds to the economic size of respective EU.

Figure 7 illustrates the TCA effect on the values of UK exports and imports with EU, revealing significant variations among EU countries. While UK export values to most EU countries have declined, the extent of these declines varies, with mild reductions in countries like Belgium and Ireland and more substantial drops in Germany, Spain, and Greece. Notably, Lithuania, Slovakia, and the Netherlands saw positive impacts on UK exports, although this did not extend to export variety. Interestingly, the economic size of EU trade partners does not strongly predict the impact on UK exports.

For UK imports, three out of five EU countries experienced declines, with larger economies like the Netherlands, Germany, and France seeing significant drops of 51%, 32%, and 23%, respectively. Smaller economies, however, showed positive effects, indicating increased UK imports. The relationship between export and import effects is weakly U-shaped, with countries most and least affected on the export side performing better on the import side than those in the middle.

There are also concerns about data accuracy due to the Rotterdam-Antwerp Effect, which may overstate trade with the Netherlands and Belgium. We discuss this in more detail at the end of this section.



Figure 7: Impact of TCA on UK trade values with EU

Note: Value is a HS6 product exported to/imported from a country. Line represents quadratic fit; shadowed area is 95% confidence interval. Luxembourg with 60% change in exports and -28% change in imports is not shown.

Figure 8 illustrates the impact of the TCA on the variety of goods traded between the UK and the EU, again showing notable heterogeneity among EU-27 countries, similar to the pattern observed in trade values. There is a negative correlation between changes in export and import varieties, suggesting the countries experiencing the largest declines in UK exports saw increases in imports.

A consistent decline in UK export varieties was observed across all EU member states, with the Netherlands experiencing the smallest reduction, at -16.5%. Medium to large economies saw an average decrease of 30.9%, while smaller to medium economies faced a sharper decline of 32.82%. Slovenia and Croatia were the most impacted, with export reductions of -45% and -44%, respectively. These findings align with findings from previous studies (Du et al., 2022 and Spital and van Aerssen, 2023), confirming that larger economies experienced smaller declines in export variety compared to smaller economies.

In contrast, UK imports from EU countries showed more stability, with just over half of the EU countries (15 out of 27) experiencing adverse effects in terms of import varieties, while the remaining countries saw positive impacts. Smaller EU economies tended to import more varieties to the UK post-Brexit, such as Estonia (79.69%), Croatia (55.59%), Bulgaria (53.36%), and Slovenia (39.90%). Conversely, large EU economies experienced a decline in import varieties to the UK, such as Germany (-11.93%), French (-10.42%), and the Netherlands (-17.96%). Consequently, unlike export variety, larger economies saw a greater decline in import variety, while smaller economies exhibited an increase in import variety to the UK. It's important to note that this period coincides with the UK government's delayed implementation of new trade regulations and the absence of clear timelines for initiating border controls.



Figure 8: Impact of TCA on UK trade varieties across EU countries

Note: Variety is a HS6 product exported to/imported from a country. Line represents quadratic fit; shadowed area is 95% confidence interval. Only varieties with values exceeding 1000 USD are shown. Luxembourg with -55% change in exports and -29% change in imports is not shown.

#### **Geographical Proximity**

Shifting the focus from economic size to geographical proximity uncovers distinct patterns in UK trade margins with EU member states post-Brexit. The distance between the UK and each EU country influences the dynamics of trade variety and volume. Our findings, illustrated in Figure 9, suggest that geographical closeness plays a crucial role in trade dynamics, a factor

that has become even more pronounced in the wake of new trade barriers and increased trade costs introduced by the TCA. This proximity is further highlighted by changes in transport logistics, where UK companies increasingly consolidate shipments to the nearest logistic centres across borders, reducing costs and border crossings.



Figure 9: UK Export varieties with EU and distance

Note: Variety is a HS6 product exported from/imported to a country. Line represents quadratic fit; shadowed area is 95% confidence interval. Only varieties with values exceeding 1000 USD are shown. Luxembourg with -55% change in exports is not shown.

On the import side, as shown in Figure 10, the pattern is reversed: UK imports from nearby EU countries (such as Belgium and Ireland) showed more significant declines in variety compared to those from more distant EU countries (such as Bulgaria, Croatia and Estonia). This trend may reflect strategic adjustments by UK importers to source products from countries with similar standards, reducing complexity and potential delays. Additionally, closer economies may have de-prioritised or avoided the UK market due to increased trade costs, while more distant, less competitive exporters continued to seize opportunities in the UK.

Conversely, distant EU members like Cyprus and Greece faced substantial challenges, experiencing significant declines in both export and import varieties. This features the compounded difficulties distant countries face in maintaining trade with the UK post-Brexit. The potential reorientation of EU trade patterns in this case suggests the importance of geographical proximity in mitigating post-Brexit disruptions.



Figure 10: UK import varieties with EU and distance

Note: Variety is a HS6 product export from/imported to a country. Line represents quadratic fit; shadowed area is 95% confidence interval. Only varieties with values exceeding 1000 USD are shown. Luxembourg with -29% change in imports is not shown.

### What Else Explains the Differences?

We further analyse the relationships between changes in trade, the economic size of EU partners, and their distance from the UK, while considering GDP per capita as an indicator of economic development. The regression results confirm the "pecking order" theory for export markets (Table 11), showing a significant negative relationship between changes in export variety and distance from the UK, and a positive relationship with economic size. Specifically, a 1% increase in distance from the UK corresponds to a 7% decline in UK export varieties, while a 1% increase in GDP correlates with a 2.3% increase in export varieties. This suggests that smaller and more distant EU economies are more likely to experience greater reductions in UK export varieties.

For imports, the pattern is reversed: larger and wealthier EU economies are more likely to see reductions in UK import varieties, while smaller and less affluent EU countries appear to benefit from the TCA, possibly gaining comparative advantages as the UK disentangles from EU-centric global value chains, which are primarily based in larger, more developed EU economies.

The impact of the TCA on UK export patterns aligns with Eaton et al. (2011)'s pecking order theory, but in reverse, reflecting the effects of trade disintegration. Unlike integration, which typically broadens market access, the disintegration process under the TCA has led to increased trade frictions, particularly due to heightened non-tariff measures (NTMs) as highlighted by Du and Shepotylo (2022). As a result, UK exporters have been forced to prioritise key products and markets, often withdrawing from smaller markets (in terms of firm's market penetration) where the potential returns are lower and market penetration opportunities are more limited.

At the same time, UK imports from smaller and more remote markets have been less affected, likely driven by cost-saving and comparative advantage motives. As trade costs increased, firms sought better alternatives, often found in more distant, niche markets in non-EU or smaller EU economies.

These frictions have impacted multiple sectors, including food and drink, wood, and chemicals, resulting in a strong negative correlation between changes in export and import varieties. For instance, countries like Ireland and the Netherlands, which experienced the smallest decline in UK export varieties, also saw substantial declines in UK import varieties. Conversely, smaller and more remote EU countries, such as Estonia (79.69%), Croatia (55.59%), Bulgaria (53.36%), and Slovenia (39.90%), registered the largest increases in import varieties. This pattern suggests that as the UK withdraws from EU supply chains, particularly those linked to closer and more developed EU economies like France, Germany, Ireland, and the Netherlands, the relative importance of these countries in UK trade diminishes, creating opportunities for smaller and more remote trading partners.

Notable outliers include Luxembourg and Cyprus, which faced considerable declines in both exports to and imports from the UK. Among larger economies, Belgium saw a significant decline in import varieties to the UK, while Italy was the only major economy to register a slight increase in import variety at 2.74%.

## Table 11: Change in varieties and country characteristics

	Dependent variables:			
	Export varieties change, %	Import varieties change, %		
	(1)	(2)		
Ln GDP	2.273**	-4.943*		
	(0.813)	(2.689)		
Ln GDP per capita	1.618	-23.813***		
	(2.427)	(8.031)		
Ln Distance	-7.146**	-9.663		
	(2.763)	(9.144)		
Observations	26	26		
$\mathbb{R}^2$	0.707	0.467		

Note: OLS results are shown, with changes in exports and imports varieties regressed on country characteristics are show. Standard errors in parenthesis p<0.1; p<0.05; p<0.01

# Are Consumer, Intermediate and Capital Goods Impacted Similarly?

The results indicate a widespread decline in UK consumer goods exports to the EU, while exports of intermediate goods exhibit greater variability, and capital goods exports have experienced relatively smaller changes (see more details in Appendix C and TableA9), which is consistent with the theoretical model. This suggests a decoupling of the common final goods market, with the UK's value chains becoming more differentiated and localised. The UK's trade is increasingly concentrated with closer partners like Belgium, Ireland, and the Netherlands, while there is a noticeable shift away from the EU's largest markets, such as Germany and France.

The impact of the imports to the TCA is more heterogenous, with small and more remote markets, including the Baltic states and Eastern Europe EU member, showing more positive results in varieties and value of imports of intermediate and capital goods to the UK. This may indicate the increasing competitiveness and GVC participation of smaller EU countries relative to the large economies when trade costs are increasing, and the UK companies are in search of new trading partners.

Overall, the evidence points to a decoupling of the UK from EU final goods markets and a reconfiguration of UK supply chains, characterised by greater upstream diversification and increased downstream localisation. This shift aims to enhance efficiency and reduce exposure to the heightened trade costs post-TCA. There is also potential for a move towards substituting EU imports with those from non-EU countries, particularly for lower-value goods, as observed in the early period following the TCA by Freeman et al., (2022) and Spital and van Aerssen (2023).<sup>19</sup>

#### **Re-export Phenomenon: Rotterdam-Antwerp Effect**

The results indicate that the Netherlands and Belgium have experienced the least negative impact on UK exports and the most negative impact on UK imports. This could be partly attributed to the re-export phenomenon, commonly known as the "Rotterdam-Antwerp Effect."

This phenomenon occurs when international traders in the EU consolidate goods or consignments in the major port cities of Rotterdam in the Netherlands and Antwerp in Belgium, before exporting them to other countries. These ports serve as significant hubs for European trade due to their advanced infrastructure, strategic locations, and efficient customs processes, making them ideal points for further distribution across Europe and beyond.

The Rotterdam-Antwerp Effect can distort trade statistics by misreporting the true origin and destination of goods passing through these ports. While some studies suggest that this effect can lead to overstatements in trade volumes between the UK and the EU, the evidence is limited, and the details are not conclusive, leading some to view it as more theoretical.<sup>20</sup>

In the context of Brexit, as UK goods are increasingly routed through these ports to streamline the export process and bypass additional procedures at multiple EU destinations, UK export statistics to the Netherlands and Belgium could be inflated, reducing the apparent negative impact of Brexit. Similarly, with fewer imports directly from the EU, a disproportionate amount of UK imports might now be reported as coming from these two countries.

The magnitude of the Rotterdam-Antwerp Effect remains a subject of debate. Estimates vary, with the Office for National Statistics (ONS) suggesting that accounting for this effect could reduce reported UK exports to the EU by approximately 4.3% and imports by 4.2% (ONS, 2015). Nigel (2011) from the Institute for the Study of Civil Society (Civitas) estimates the effect to be less than 5%. More recent research by Mion and Aznar from the Economic Statistics Centre of Excellence (ESCOE) utilises data from the National Bank of Belgium (NBB) and Statistics Netherlands (CBS) to further investigate the effect across 9,500 products

Spital, T., & van Aerssen, K. F. (2023). The impact of Brexit on UK trade and labour markets. Economic Bulletin Articles, 3.

<sup>&</sup>lt;sup>19</sup> Freeman, R., Manova, K., & Sampson, T. (2022). Brexit: The major trade disruption came after the UK- EU agreement took effect in 2021. *LSE Business Review*.

<sup>&</sup>lt;sup>20</sup> See for example <u>https://researchbriefings.files.parliament.uk/documents/LLN-2018-0125/LLN-2018-0125.pdf</u>.

and 250 partner countries. Although promising, their findings have yet to be made publicly available.<sup>21</sup> Overall, empirical evidence suggests that the Rotterdam-Antwerp Effect, while present, is not large.

#### **8.3 Sector Heterogeneity**

Trade performance varies markedly across different product sectors. The TCA's one-size-fitsall approach has not been equally impactful across all sectors, with certain industries facing greater challenges than others. This section delves into the product heterogeneity of the Brexit effect. Figures 14 and 15 illustrate the percentage changes of the estimated coefficients from Equation 12, highlighting the impact on both the value and varieties of the UK's imported products (along the horizontal axis) and exported products (along the vertical axis).

## Value of Trade

Figure 14 illustrates the estimated TCA impact on the value of the UK's exported and imported products, with all affected industries detailed in Appendix Table A8. The estimates reveal a strong positive correlation between changes in export and import values across various sectors, indicating that industries experiencing significant declines in imports often faced similar downturn in exports.

Overall, an overwhelming majority of sectors have been negatively and significantly impacted by Brexit, in terms of both exports and imports, albeit with some variations. Among the most adversely affected are agrifood, textile and clothing, and material-based manufacturing (such as wood, paper and pulp) with several HS2 categories within these sectors registering substantial decreases. Notably, HS08 (Edible fruit and nuts) experienced the most dramatic decline in UK export value, plummeting by 73.46%.

Moreover, there is large heterogeneity even within narrowly defined sectors, and not all sectors experienced the same level of decline. For instance, some of subsectors in chemicals products, anticipated to be heavily impacted, demonstrated resilience amidst the post-Brexit trade landscape, such as H31 (Fertilisers) and H28 (Inorganic or organic chemicals). HS71 (Natural or Cultured Pearls and Gold) had considerable growth in export values by 22.08%, while not many others showcasing growth. HS31 (Fertilisers) in chemical sectors is the next highest growth sector with increased exports value of 0.19%.

<sup>&</sup>lt;sup>21</sup> See <u>https://www.escoe.ac.uk/projects/the-rotterdam-antwerp-effect-in-the-context-of-uk-trade-statistics/</u>.

On the import side, again all sectors witnessed contractions in import value post-TCA implementation. The notable exception is HS27 (Mineral Fuels), which maintained import levels comparable to the pre-TCA period. This stability can be attributed to the surge in energy prices during 2022 and 2023, which bolstered the value of imports in this category despite broader negative trends.



Figure 14: Brexit effect on UK values of trade with EU across products

## **Varieties of Products**

Figure 15 illustrates the impact of the TCA on the variety of the UK's exported and imported products, with detailed percentage changes provided in Table A8 in the appendix. The analysis reveals a widespread reduction in the variety of UK exports to the EU across most sectors. Consistent with the aggregate picture, the export decline in most sectors is largely through contraction of export extensive margins.

The agrifood sectors were particularly hard-hit. Notably, HS14 (Vegetable products) experienced the most significant decline in exported varieties, with export variety dropping by 68.5%. The significant decline in exports of HS14 can potentially be attributed to two specific

HS6-digit level goods: HS140000 and HS140490. Notably, the top 10 partners for these goods are EU members. Also, HS08 (Edible fruit and nuts), HS10 (Cereals), HS12 (Seeds and fruits) and HS07 (Edible vegetables and certain roots and tubers), which saw reductions of 65.3%, 58.8%, 58.7%, and 56.6%, respectively. Raw material, Wool and Paper manufacturing sectors and the Textile sector also faced significant declines, such as HS46 (Manufactures of straw, 61.2%), HS45 (Cork and articles of cork, 58.7%), HS43 (Furskins and artificial fur, 54.2%), and HS52 (Cotton, 55.5%).

Despite the general trend of decline, a few sectors exhibited modest increases in export varieties, including HS24 (Tobacco, 17.5%), HS86 (Railway, 11.7%), and HS88 (Aircraft, 1.49%). Although not seeing growth, H94 (Furniture), H87 (Cars) and HS22 (Beverage) have shown resilience in maintaining the level of export varieties.

On the import side, the varieties of UK imports from the EU in most sectors also contracted, with HS91 (Clocks and watches and parts thereof) experiencing the largest decline at 25.78%, followed by HS50 (Silk) and HS45 (Cork), with declines of 24.27% and 23.29%, respectively. The range of decline for imported varieties is between 0.01% and 25.78%, and more importantly, 82% of sectors experienced the decline in the varieties of imports from the EU. <sup>22</sup> Textiles product imports contracted considerably, including HS66 (Umbrellas, 21.12%), and HS64 (Footwear, 19.68%). Similarly, Material-based manufacturing also reduced imported varieties, such as HS45 (Cork, 23.3%) and HS66 (Umbrella, 21.1%).

While manufacturing sectors were generally more affected than agricultural ones, with agricultural goods showing an average imported varieties decline of around 4.75%, some goods decline drastically, such as HS03 (Fish, 51.2%) and HS10 (Cereals, 21.61%). Some products bucked the trend by increasing imported varieties - HS01 (Live animals) saw a significant increase in variety, rising by 24.7%.

Other sectors like HS89 (Ships, boats, and floating structures), HS06 (Live trees), and HS94 (Furniture, beddings, etc.) also demonstrated noticeable increase in import variety. These variations underscore the uneven and complexity in the sector-specific effects of Brexit and the TCA on UK-EU trade dynamics, highlighting the need for understanding the nuances and tailored trade strategies in response to the new regulatory environment.

 $<sup>^{22}</sup>$  There are 80 out of 98 HS-2 import sections that experienced a decline in import varieties, amount to 82% of all sections.

The strong positive correlation between changes in export and import varieties suggests that intra-industry trade dynamics drive these changes, as highlighted by the new trade theory (Krugman, 1980). This contrasts with the predictions of traditional trade theories based on comparative advantage and factor endowments, which would typically generate a negative correlation. The new trade theory emphasises scale economies and efficiency gains from market expansion. Brexit, as a rare example of decoupling and the introduction of higher trade barriers, has led to reduced scale and lower efficiency. This reduction in scale is consistent with the loss of competitiveness of UK exports to the rest of the world (ROW), due to increased production costs in UK industries with increasing returns to scale. This decline in competitiveness affects the UK's position in all markets.

Moreover, the UK's participation in EU supply chains and the high share of intermediate goods trade also reinforce this positive correlation, especially if intermediate goods are traded predominantly within industries. This is evident from input-output tables, where diagonal values – representing intra-industry trade – are relatively larger than off-diagonal values (Gallegati et al., 2019).

Additionally, there is a strong positive correlation between changes in export and import values and varieties across different product categories. For instance, a strong decline in the export of footwear (HS64) is closely associated with a corresponding decrease in footwear imports. This pattern differs from the geographical heterogeneity of Brexit's impact, as reported in the previous section, where factors such as comparative advantage, economic size, and distance were more influential in shaping the geographical aspects of UK value chains. In contrast, the correlation observed here suggests that intra-industry linkages are more dominant in the product dimension, indicating that global value chains in industries like footwear are breaking down. Meanwhile, the sourcing of materials for the UK footwear industry is increasingly reliant on a more geographically diversified pool of countries, reflecting a strategic shift to mitigate the risks associated with Brexit.



Figure 15: Change in UK varieties of trade with EU across products

Note: we exclude data for HS97 (Works of art, collectors' items, and antiques) and HS98 (Items reserved for special uses by Contracting Parties) due to their exceptionally high percentage changes, though their overall contribution to the dataset is minimal.

## What Drives the Differences?

To systematically analyse changes in export varieties, we use two simple regressions relating the estimated changes in export varieties at the HS2 level to key variables reflecting trade policy variation and market structure.

First, we regress changes in export varieties on a measure of NTMs within HS2 product categories, quantified by the number of NTMs faced by UK exporters in each category, along with the level of MFN tariff (Table 12). The data for NTMs and tariffs are from UNCTAD's Trade Analysis Information System (TRAINS). NTMs are measured by the total number of instances applied to HS2 product categories and are further categories into sanitary and phytosanitary measures (SPS), technical barriers to trade (TBT), inspections, or licensing requirements. Additionally, we account for product differentiation within each product category by including the number of HS6 lines within the HS2 chapter as a control variable.

Our findings reveal that NTMs significantly negatively impact the extensive margins of exports. Specifically, a 1% increase in NTMs within a product category leads to a 2.6 percentage point reduction in export varieties. This decline is predominantly driven by SPS measures, which are extensively applied within agriculture and food products (HS1-HS24) but also affect other product categories. This outcome is partially in line with previous research of the impact of NTMs on UK trade in value (Du and Shepotylo, 2022). We do not find significant impact of TBT on changes in exported varieties.

Moreover, price variation in exports, measured by unit price, is found to negatively impact export varieties, indicating that higher prices may reduce the diversity of exported goods. Conversely, the degree of product differentiation within HS2 categories, measured by the number of HS6 lines, has a positive but not statistically significant effect on export varieties.

			8		-	v			
	Dependent variable:								
	Change in the UK exports varieties since 2021, %								
_	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
NTM	-2.576*								
	(1.434)								
SPS		-1.885***					-2.533***		
		(0.700)					(0.840)		
TBT			-0.409				-0.864		
			(2.121)				(2.173)		
Inspections				-0.262			-2.490		
				(7.185)			(7.007)		
Licensing					0.974		3.656**		
0					(1.285)		(1.475)		
Price						-7.718*	-4.056		
						(4.629)	(4.973)		
MFN tariff	1.277	-3.369	-14.926	-17.141	-20.121	-9.218	-1.537		
	(31.454)	(29.565)	(32.312)	(30.287)	(30.437)	(30.188)	(31.042)		
Num. of product lines	1.149	0.449	1.018	0.931	0.903	0.713	0.402		
	(1.492)	(1.466)	(1.593)	(1.536)	(1.509)	(1.496)	(1.545)		
Observation s	94	94	94	94	94	94	94		
<b>R</b> <sup>2</sup>	0.042	0.082	0.008	0.008	0.014	0.038	0.147		

Table 12: Change in varieties and trade policy

Note: Dependent variable is  $\beta_h$  coefficient from the regression model (17) with the dependent variable export varieties, estimated by the PPML method, where h is the HS2 product chapter. Explanatory variables are HS2 level averages of NTMs faced by the UK exporters, unit price of the chapter products, level of MFN tariffs faced by the chapter UK exporters, and number of products in the chapter. \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

We further explore how changes in extensive margins of exports are influenced by market structure (Table 13). The key variables considered include industry scale, represented

by the average export value per product; product concentration, measured by the Hirsch-Herfindahl Index (HHI); and product differentiation, indicated by the number of product lines within each HS2 category. Additionally, we control for changes in import varieties over the same period to assess whether intra-industry trade is driving the observed export adjustments, along with controlling for trade policy measures.

Product scale plays a critical role as a stabilizing factor in trade dynamics. Industries with high export values per product variety, such as vehicles (HS87), aircraft (HS88), and ships (HS89), demonstrated resilience, avoiding declines along the extensive margins. In contrast, industries characterized by high product concentration—where one or a few HS6 products dominate the HS2 exports, such as in the case of HS36 (Explosives, pyrotechnic products, matches, pyrophoric alloys, and certain combustible preparations)—exhibited more pronounced negative changes in export varieties. This is evidenced by the negative and significant coefficient in our analysis. Furthermore, HS2 chapters with a higher degree of product differentiation, as indicated by the number of product lines within categories like articles of apparel (HS61 and HS62), also experienced more substantial declines in UK export varieties. This suggests that sectors with greater diversification and complexity in product offerings are more vulnerable to disruptions in trade variety.

Moreover, there is a positive association between changes in export and import varieties: a 1 percentage point decline in import varieties to the UK corresponds to a 0.73 percentage point decline in export varieties. This relationship suggests that the decline in trade was primarily driven by intra-industry trade dynamics rather than traditional factors like comparative advantage and resource endowment.

In summary, consistent with the discussions in Helpman and Krugman (1987), the impact of changes in trade policy on trade is strongly conditional on market structure. Industries with smaller product scale, highly concentrated, and more product differentiation experienced more significant reductions. Even after accounting for market structure, the impact of trade policy, particularly NTMs, remains negative and significant, underscoring their detrimental effect on export varieties.

			U						
			De	ependent variable:					
	Change in the UK exports varieties since 2021, %								
	(1)	(2)	(3)	(4)	(5)	(6)			
Ln (Average export value)	3.055**		3.141**	3.309***	4.358***	4.165***			

Table 13: Change in varieties and concentration

	(1.251)		(1.237)	(1.232)	(1.308)	(1.121)
HHI		-2.456	-2.599*	-2.763*	-6.423***	-4.829**
		(1.485)	(1.444)	(1.433)	(2.238)	(1.936)
NTM				-2.888**	-2.688**	-3.109***
				(1.369)	(1.346)	(1.155)
MFN tariff				5.825	-3.392	-2.761
				(30.404)	(30.156)	(25.827)
Log (Num. of lines)					-4.802**	-3.979**
					(2.284)	(1.961)
Import varieties change, %						0.730***
						(0.127)
Observations	94	94	94	94	94	94
R <sup>2</sup>	0.061	0.029	0.093	0.139	0.180	0.405

Note: Dependent variable is  $\beta_h$  coefficient from the regression model (17) with the dependent variable import varieties, estimated by the PPML method, where h is the HS2 product chapter. Explanatory variables are HS2 level averages of NTMs faced by the UK importers, unit price of the chapter products, level of MFN tariffs faced by the chapter UK importers, and number of products in the chapter. \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

# 9. Summary of Findings

#### Significant, Persistent and Worsening Brexit Impact on UK Trade

This analysis confirms a significant and negative impact of the Trade and Cooperation Agreement (TCA) on UK-EU trade three years after leaving the EU Single Market and Custom Union. Monthly data reveal a 27% decline in UK exports and a 32% reduction in imports to and from the EU between 2021 and 2023. When considering annual data, which smooths out short-term volatility, the declines are somewhat smaller -17% for exports and 23% for imports - yet they still underscore the pronounced impact of the TCA on UK trade. A comprehensive set of robustness checks confirms these significant reductions in both trade value and variety.

Although the decline in the value of exports to and imports from the EU occurred at similar magnitudes, the mechanisms driving these changes differ. UK exports primarily decreased along the extensive margin, with a 33% reduction in the variety of goods exported, while the intensive margin remained stable. Conversely, imports adjusted predominantly along the intensive margin, declining by 28%, while the variety of imported goods remained relatively stable. The loss of variety in UK exports, particularly in consumer and intermediate goods, signifies a decoupling of final goods markets and supply chains between the UK and the EU, as well as a decline in competitiveness and market access for UK exporters. In contrast, the import patterns suggest that while the UK market has contracted, EU exporters have largely retained their access, indicating a diversion of UK imports from the EU to non-EU markets.

The negative effects of the TCA have intensified over time, with more pronounced declines in trade observed in 2023 compared to previous years. This persistent downward trend suggests that the transition in UK-EU trade relations post-Brexit is ongoing and that the negative impacts are not merely temporary disruptions but rather indicative of a deeper structural shift.

## **Considerable Heterogeneity and Complexity**

The impact of the TCA on UK-EU trade is marked by considerable heterogeneity across countries, sectors, and product categories.

## Decoupling of Final Goods Markets and Disrupted EU-UK Supply Chains

The TCA's effects vary significantly across different types of goods. Consumer goods have been hit hardest, experiencing a 43.51% drop in export varieties and a 39.18% decrease in value. Intermediate goods also faced substantial disruption, with a 21.71% decline in export value, reflecting significant interruptions in supply chains. However, capital goods displayed greater resilience, showing only a modest decline in exports and a 19% increase in import varieties. These findings suggest a decoupling of the UK from the EU in final goods markets, while the UK remains dependent on the EU for intermediate and capital goods.

## The Pecking Order of EU Trade Partners

The impact of the TCA varies significantly across EU countries. The steepest declines in UK export varieties are observed in smaller and more distant EU economies, while larger economies like Germany and France have experienced relatively milder effects. Conversely, the import patterns reveal that smaller and less prosperous EU countries have benefitted from increased UK imports, likely gaining comparative advantages as the UK gradually disentangles from EU-centric supply chains. This "pecking order" of trade adjustment indicates a shift in UK supply chains toward more geographically proximate and smaller trading partners within the EU.

#### Significant Variations Across Sectors

The TCA's uniform approach has not affected all products equally, leading to pronounced challenges for certain sectors. While the majority of sectors have experienced negative effects from Brexit, the extent of these impacts varies considerably. Sectors such as agrifood, textile and clothing, and material-based manufacturing (including wood, paper, and pulp) have been among the hardest hit, with substantial declines in both export value and variety. However,

some sub-sectors within chemicals demonstrated resilience, and a few sectors, such as Tobacco, Railway and Aircraft manufacturing, have even seen modest increases in export varieties.

On the import side, most sectors have contracted in both value and variety post-TCA, particularly in optical, textile, material-based manufacturing, and agrifood products. Yet, certain sectors, like Ships and Furniture, have demonstrated noticeable increases in import variety.

These sector-specific variations and complexities underscore the uneven effects of Brexit and the TCA on UK-EU trade dynamics, highlighting the need for understanding the nuances and tailored trade strategies that address the unique challenges of each sector within the new regulatory environment.

The analysis demonstrates a strong positive correlation between changes in export and import values across various sectors, indicating that industries experiencing significant declines in imports often face parallel downturns in exports. This relationship is largely attributable to the UK's deep integration within EU supply chains and the predominance of intermediate goods trade within industries. The robust correlation between changes in export and import varieties further underscores the role of intra-industry trade dynamics as a key driver of these shifts.

As a result, the reduction in trade scale due to Brexit, particularly in sectors burdened by higher trade barriers, has led to decreased efficiency and a loss of global competitiveness for UK exports. This at least partially explains the wider decline in UK exports outside the EU. The disruption of global value chains in sectors such as footwear is particularly evident, with corresponding declines in both exports and imports. This suggests that UK industries are increasingly diversifying their sourcing and markets to a broader geographical range of countries to mitigate the risks associated with Brexit.

## Key Drivers of the Impact: NTMs, Geographic Proximity, and Market Structure

The adverse effects of the TCA on UK-EU trade are statistically associated with non-tariff measures (NTMs), geographic proximity, and the underlying market structure of industries. NTMs, most notably sanitary and phytosanitary (SPS) standards, have disproportionately affected sectors with stringent regulatory requirements, notably in agrifood and material-based manufacturing. Geographic proximity plays a crucial role in moderating these impacts; countries closer to the UK, such as the Netherlands and Ireland, have experienced less severe declines in trade varieties due to shorter supply chains and reduced logistical complexities. Conversely, more distant EU countries have encountered heightened trade barriers, leading to

greater disruptions. Market structure further amplifies these effects, with industries characterized by large-scale production and lower product concentration demonstrating greater resilience. In contrast, sectors with higher product differentiation and concentration, such as textiles and certain manufacturing categories, have been more vulnerable to the adverse consequences of Brexit, highlighting the compounded challenges of adjusting to the new trade landscape.

# **10.Policy Implications**

The challenges facing UK trade post-Brexit shown in this analysis highlight that the disruptions induced by Brexit remain significant and are likely to be long-term. This necessitates strategic adjustments in UK trade policies and measures that go beyond trade policy. Given the significant and persistent negative impact of the TCA on UK-EU trade, policymakers must carefully prioritise their actions to stabilise and enhance the UK's economic position. Our analysis identifies three critical areas for effective policy intervention: mitigating the adverse effects of the TCA, reconfiguring supply chains to bolster efficiency and resilience, and supporting firms in adapting to new trade barriers while enhancing productivity.

#### I. Mitigating the Adverse Effects of the TCA

The current TCA framework has introduced considerable barriers to UK-EU trade in goods, most particularly through increased NTMs. Addressing these issues through targeted improvements to the TCA is therefore crucial, despite formidably difficult, for ensuring that UK businesses remain competitive in the European market. A structured, multi-faceted approach is necessary:

## I.1. Sector-Specific Negotiations

Given the uneven impact of the TCA across different sectors, the UK government should prioritise sector-specific adjustments to the agreement. The agrifood sector, for instance, has been disproportionately affected by SPS measures, leading to significant declines in both export and import varieties. Beyond food and drink, sectors like textile, material-based manufacturing have also suffered. A targeted approach, addressing specific challenges within these sectors, could alleviate some of these barriers, boosting trade and stabilising supply chains. This strategy would not only benefit large industries but also support SMEs, which are particularly vulnerable to the disruptions caused by Brexit.

In the case of *Agrifood sectors*, which we show in this study that has registered the most significant adverse Brexit impact, a potential UK-EU Veterinary Agreement could lead

to tangible benefits (Du, Messenger and Shepotylo, 2024). Negotiating it successfully, as the UK government has committed to do, would strategically enhance agrifood trade dynamics between the UK and EU, laying the groundwork for a strengthened economic relationship.

#### I.2. Streamlining Customs Procedures through Digital Technologies

The complexity and inefficiency of current customs procedures have added significant friction to UK-EU trade flows. Simplifying and modernising these processes is essential to reducing delays and lowering costs for businesses. Digitalisation offers a clear path forward – by adopting advanced customs platforms that automate documentation, provide real-time tracking, and integrate seamlessly with EU systems, the UK can create a more efficient trading environment. This modernisation should be a priority in any future negotiations with the EU, ensuring smoother trade flows and expanded market access for UK exporters. The UK's leadership in digital customs could also offer a competitive advantage in global trade.<sup>23</sup>

## I.3. Reducing Regulatory Divergence

The potential divergence in regulatory standards between the UK and the EU has created significant trade barriers, increasing costs and complicating market access for businesses. While some level of regulatory divergence is inevitable post-Brexit, targeted efforts to reduce unnecessary differences – particularly in sectors that are highly regulated, such as chemicals, pharmaceuticals, and food safety – could significantly lower compliance costs and ease trade frictions.

One effective strategy could be to negotiate mutual recognition agreements in key sectors. These agreements would enable both the UK and the EU to accept each other's regulatory standards, thus alleviating the burden of dual compliance for UK firms. This approach would be particularly beneficial for manufacturing sectors that have been heavily impacted by the regulatory split, such as material-based manufacturing industries, by enhancing market access, reducing operational costs, and bolstering investor confidence.

However, the appeal and feasibility of dynamic alignment with EU regulations may vary across sectors. In some industries, closer alignment could bring significant benefits, while in others, the costs of alignment might outweigh the advantages. Therefore, a sector-specific approach is more feasible, where the UK government prioritises alignment in areas where the

<sup>&</sup>lt;sup>23</sup> The joint statement initiative on E-commerce led by the WTO and signed in July 2024 by 91 countries including the UK presents tangible opportunities to make progress.

trade benefits are most substantial, while maintaining flexibility in sectors where divergence may offer competitive advantages. This balanced approach would help mitigate the adverse effects of regulatory divergence, support business competitiveness, and foster a more stable and predictable trading environment with the EU (Berg, 2024; Foster, 2024).

# II. Strategic Reconfiguration of UK Supply Chains : Enhancing Resilience and Competitiveness

The post-Brexit landscape indicates a notable shift in the previously tightly integrated EU supply chains. This shift is especially significant in today's global environment, where supply chain reliability and resilience are becoming more critical than the earlier focus on efficiency and cost-minimisation. As a result, there is an urgent need for a strategic reconfiguration of the UK's supply chains to adapt to new trade realities and strengthen long-term resilience and competitiveness. Key recommendations include:

### **II.1. Enhancing Trade Infrastructure**

To support the reconfiguration of supply chains, the UK must invest in its trade infrastructure, including upgrading ports, expanding logistics networks, and improving customs facilities. Efficient infrastructure is essential for reducing transit times, lowering costs, and ensuring the seamless movement of goods. Investment in digital infrastructure, such as advanced customs processing systems, can further enhance trade operations and position the UK as a more attractive hub for global commerce.

## **II.2. Strengthening Domestic Supply Chains**

One of the key strategies for improving UK trade involves bolstering domestic supply chains. This can be achieved by encouraging reshoring of production and increasing domestic sourcing of critical components. The government can play a pivotal role by offering incentives such as tax breaks, grants, and subsidies to businesses that invest in local manufacturing and supply chain capabilities. Additionally, fostering innovation in supply chain management through technology adoption and digitalization can help UK firms streamline operations, reduce costs, and mitigate risks associated with global disruptions.

#### **II.3. Diversifying Global Sourcing**

Given the UK's reduced access to certain EU supply chains, diversifying global sourcing strategies is crucial. UK businesses should be encouraged to seek alternative suppliers in regions such as Asia, Africa, and the Americas, to reduce dependence on any single market.

This diversification spreads risk and opens up opportunities for new trade partnerships and markets. The government can facilitate this shift by organising trade missions, providing market intelligence, and negotiating new trade agreements offering preferential access to non-EU markets.

## **II.4. Fostering Strategic Partnerships**

Building strategic partnerships with countries outside the EU is another critical component of supply chain reconfiguration. These partnerships should focus on securing access to essential materials and components that are vital to key industries such as automotive, pharmaceuticals, and technology. By negotiating bilateral agreements and participating in multilateral trade initiatives, the UK can secure stable supply chains and reduce the vulnerability of its industries to external shocks.

## **II.5. Encouraging Sustainability in Supply Chains**

As the UK reconfigures its supply chains, there is an opportunity to integrate sustainability into trade practices. Promoting the use of environmentally friendly materials, reducing carbon footprints, and adopting circular economy principles can enhance the long-term viability of UK supply chains. Sustainability initiatives can also boost the competitiveness of UK products in international markets, where demand for green and ethically produced goods is growing.

## **II.6. Supporting SMEs in Supply Chain Participation**

SME play a crucial role in the UK's supply chains, but they often lack the resources to adapt to new trade challenges. Targeted support for SMEs, including financial assistance, training, and access to technology, can help them integrate into reconfigured supply chains and contribute to the overall resilience of the UK economy. Policies that simplify export processes, reduce bureaucratic hurdles, and provide clear guidance on compliance with international standards will be essential in enabling SMEs to thrive in the new trade environment.

By strategically reconfiguring its supply chains, the UK can not only mitigate the adverse effects of Brexit but also position itself as a competitive and resilient player in the global market. This approach will require coordinated efforts from government, industry, and trade partners, but the long-term benefits in terms of economic stability, growth, and global trade leadership are well worth the investment.

## III. Supporting Firms in Adapting to New Trade Barriers and Enhancing Productivity

The TCA's impact was more pronounced on smaller businesses which suggests that they may have struggled more to adapt to the new trade environment.<sup>24</sup> With the trade barriers likely to persist, firms – particularly SMEs – require targeted support to adapt and thrive. Key initiatives include:

- Financial assistance and export training: Grants for export activities, subsidies for compliance with new regulations, and training programmes focused on international trade logistics, customs procedures, and market entry strategies.
- **Boosting Productivity Through Innovation:** Policies aimed at enhancing productivity through technological upgrading, training, and R&D are crucial. This could involve tax incentives for R&D, grants for innovation projects, and the creation of innovation hubs that foster collaboration between businesses, research institutions, and government agencies.

# **IV. Future Research Needs**

As the UK continues to navigate the post-Brexit trade landscape, several areas warrant further research to better understand the long-term impacts of the TCA and to inform future policy decisions. These research needs can be grouped into several key areas:

1. Trade-offs and Sectoral Impacts: Understanding the trade-offs involved in prioritising certain trade policies is essential for effective decision-making. Future research should focus on developing metrics and analytical frameworks that can assess and rank the potential impacts of different trade policy adjustments. This involves not only identifying the sectors and areas most affected by current policies but also evaluating the relative benefits and costs of implementing changes in those areas. Such analysis could consider factors like economic impact, ease of implementation, potential for international cooperation, and long-term benefits versus short-term disruptions. By building a comprehensive set of metrics, policymakers could better understand the implications of prioritising certain trade policies over others, allowing for a more strategic approach to enhancing UK-EU trade relations. This kind of research would provide the tools needed to make informed decisions about where to focus efforts, ensuring that trade policy adjustments deliver the maximum possible benefit while minimising unintended consequences.

<sup>&</sup>lt;sup>24</sup> Also, as our previous analysis documents, the product varieties that have disappeared are mostly those with low export value, as the average export value increased as the number of varieties declined (Du et al 2024). These products are typically exported by small firms or new exporters, or are exported to new markets (Albornoz et al., 2012; 2021).

- 2. EU Impact and Comparative Analysis: The effects of Brexit are not confined to the UK; the EU also faces changes in its trade dynamics. Comparative studies that examine the impact of the TCA on both the UK and the EU could provide a more balanced view of the trade relationship. Understanding how EU member states are adjusting to the new trade environment, particularly in terms of supply chain reconfiguration and market access, would be valuable for both policymakers and businesses. Additionally, research could compare the UK-EU relationship with other major trade agreements to identify best practices and lessons learned.
- 3. **Supply Chains and Deeper Impact Analysis**: The disruption of EU-UK supply chains is a critical issue that requires further investigation. Research should focus on the long-term consequences of these disruptions, particularly in industries heavily reliant on integrated supply chains, such as Automotive, Aerospace, and Electronics. Studies could examine how supply chains are being reconfigured, the role of intermediate goods, and the potential for new trade relationships outside the EU. Moreover, research could explore the resilience of these supply chains to future shocks and how they might evolve in a post-Brexit, post-pandemic world.
- 4. Wider Spillovers and Brexit's Broader Economic Impact: The broader economic implications of Brexit, beyond just trade, are another important area for future research. Think about the drug shortages and soaring medicine price that the UK has been facing since Brexit due to the challenges faced by pharmaceutical sectors. This includes studying the spillover effects on investment, innovation, and labor markets. Research could also investigate how changes in trade patterns are influencing the UK's economic geography, particularly in regions that were previously more integrated with EU markets due to distance (e.g. Northern Ireland) or industrial clusters (e.g. Midlands due to the concentration of Automotive or East England because of pharmaceutical sectors). Understanding these broader impacts will be crucial for shaping economic policies that address regional disparities and support long-term growth.
- 5. **Resilience and Adaptation Strategies**: Finally, research should focus on the resilience of UK businesses and industries in adapting to the new trade environment. This could involve examining the strategies that firms are employing to mitigate the risks associated with Brexit, such as diversification of supply chains, investment in technology, and exploration of new markets. Additionally, studies could explore how government policies, such as financial assistance, export training, and R&D incentives,

are supporting businesses in this transition and identify areas where further support is needed.

In summary, future research should aim to provide a comprehensive understanding of the complex and evolving impacts of Brexit on UK-EU trade. By focusing on these key areas, researchers can offer valuable insights that will help policymakers and businesses navigate the challenges of the post-Brexit era and build a more resilient and competitive economy.

# **11.Conclusion**

This paper has examined the significant and persistent impacts of the Trade and Cooperation Agreement (TCA) on UK-EU trade three years after Brexit. The analysis confirms that the TCA has introduced substantial barriers, resulting in marked declines in both the value and variety of UK exports and imports. These effects have been particularly pronounced in sectors such as Agrifood, Textiles, and Raw material, Wood and Paper manufacturing, underscoring the uneven and complex nature of Brexit's consequences across different industries and regions.

The findings highlight the urgent need for targeted policy interventions to mitigate these adverse effects. Key recommendations include sector-specific adjustments to the TCA, streamlining customs procedures through digital technologies, and reconfiguring UK supply chains to enhance resilience and competitiveness. Furthermore, supporting firms, especially SMEs, in adapting to new trade barriers will be crucial for sustaining UK trade in the post-Brexit landscape.

As the UK navigates this new trade reality, future research must continue to explore the long-term impacts of the TCA, providing the insights necessary for informed policymaking. By addressing these challenges strategically, the UK can work to stabilise its economic position, enhance trade relations with the EU, and secure its place in the global market.

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# **Appendix A: Additional Tables and Figures**

# **Appendix Tables**

	Monthly bilateral TDM 2022	Monthly bilateral COMTRADE 2022	Annual bilateral TDM 2022	Annual bilateral COMTRADE 2022	Monthly bilateral TDM 2023	Annual bilateral TDM 2023
# of obs	3,525,120	2,180,880	320,460	286,752	3,745,560	253,820
Countries	ALB	ARG	ALB	AGO	ARG	ARM
	ARG	AUS	ARG	ALB	AUS	AUS
	ARM	AZE	ARM	AND	AUT	AUT
	AUS	BDI	AUS	ARE	AZE	AZE
	AUT	BEL	AUT	ARG	BEL	BEL
	AZE	BGR	AZE	ARM	BGR	BGR
	BEL	BIH	BEL	AUS	BHR	BHR
	BGR	BLZ	BGR	AUT	BIH	BIH
	BHR	BOL	BHR	AZE	BLZ	BRA
	BIH	BRA	BIH	BDI	BOL	BRB
	BLZ	BRB	BLR	BEL	BRA	BRN
	BMU	BWA	BLZ	BEN	BWA	BWA
	BOL	CAN	BMU	BGR	CAN	CAN
	BRA	CHE	BOL	BHR	CHL	CHL
	BRB	CHL	BRA	BIH	CHN	CHN
	BRN	CHN	BRB	BLZ	CIV	COL
	BWA	СҮР	BRN	BMU	COL	CYP
	CAN	DEU	BWA	BOL	CRI	CZE
	CHL	DNK	CAN	BRA	CYP	DEU
	CHN	DOM	CHE	BRB	CZE	DNK
	CIV	EGY	CHL	BRN	DEU	ESP
	COL	ESP	CHN	BWA	DNK	EST
	CRI	FIN	CIV	CAN	DOM	ETH
	СҮР	FJI	COL	CHE	ECU	FIN
	CZE	GBR	CRI	CHL	EGY	FJI
	DEU	GEO	СҮР	CHN	ESP	FRA
	DNK	GRC	CZE	CYP	EST	GBR
	DOM	GRD	DEU	CZE	ETH	GEO
	ECU	HKG	DNK	DEU	FIN	GRC
	EGY	HRV	DOM	DNK	FRA	GUY
	ESP	HUN	ECU	DOM	GBR	HKG
	EST	IND	EGY	EGY	GEO	HRV
	ETH	IRL	ESP	ESP	GHA	HUN
	FIN	ISL	EST	EST	GRC	IND
	FJI	JPN	ETH	FIN	GTM	IRL
	GBR	LTU	FIN	FJI	HKG	ISL
	GEO	LUX	FJI	FRA	HND	ITA
	GHA	LVA	FRA	GBR	HRV	JPN

### Table A1. Countries in the sample

GRC	MAC	GBR	GEO	HUN	KAZ
GTM	MDA	GEO	GRC	IDN	KEN
GUY	MEX	GHA	GRD	IND	KHM
HKG	MKD	GRC	GTM	IRL	KOR
HND	MMR	GRD	GUY	IRN	LKA
HRV	MUS	GTM	HKG	ISL	LTU
HUN	NLD	GUY	HRV	ISR	LUX
IDN	NOR	HKG	HUN	ITA	LVA
IND	NZL	HND	IND	JPN	MAC
IRL	PAK	HRV	IRL	KAZ	MAR
IRN	PHL	HUN	ISL	KEN	MDA
ISL	POL	IDN	ISR	KHM	MEX
ISR	PRT	IND	JAM	KOR	MKD
ITA	QAT	IRL	JOR	LKA	MLT
JOR	ROU	IRN	JPN	LTU	MNE
JPN	RWA	ISL	KAZ	LUX	MNG
KAZ	SGP	ISR	KGZ	LVA	MUS
KEN	SLV	ITA	KOR	MAC	MYS
KHM	SRB	JOR	LBN	MAR	NLD
KOR	STP	JPN	LTU	MDG	NOR
LKA	SVK	KAZ	LUX	MEX	NZL
LTU	SVN	KEN	LVA	MKD	PAK
LUX	SWE	KHM	MAC	MLT	PER
LVA	TGO	KOR	MAR	MNE	PHL
MAC	TUR	LKA	MDA	MNG	POL
MAR	USA	LTU	MEX	MOZ	PRT
MDA	ZAF	LUX	MKD	MUS	ROU
MDG		LVA	MLT	MYS	SGP
MEX		MAC	MMR	NLD	SRB
MKD		MAR	MNE	NZL	SVK
MLT		MDA	MOZ	PAN	SVN
MMR		MDG	MUS	PER	SWE
MNE		MEX	NAM	PHL	THA
MNG		MKD	NER	POL	UKR
MOZ		MLT	NIC	PRT	USA
MUS		MMR	NLD	PRY	ZAF
MYS		MNE	NOR	QAT	
NAM		MNG	NZL	ROU	
NGA		MOZ	PAN	SAU	
NLD		MUS	PHL	SEN	
NZL		MYS	POL	SGP	
PAK		NAM	PRT	SLV	
PAN		NGA	PRY	SRB	
PER		NLD	PYF	SVK	
PHL		NOR	QAT	SVN	
POL		NZL	ROU	SWE	

PRT	PAK	RWA	THA	
PRY	PAN	SGP	TUR	
QAT	PER	SLV	UKR	
ROU	PHL	SRB	URY	
SAU	POL	STP	USA	
SEN	PRT	SUR	ZAF	
SGP	PRY	SVK	ZMB	
SLV	QAT	SVN		
SRB	ROU	SWE		
SVK	RUS	TGO		
SVN	SAU	TUN		
SWE	SEN	TUR		
THA	SGP	TZA		
TUR	SLV	UKR		
UKR	SRB	URY		
URY	SVK	USA		
ZAF	SVN	UZB		
ZMB	SWE	ZAF		
	THA	ZWE		
	TUR			
	UKR			
	URY			
	USA			
	ZAF			
	ZMB			

	Export to EU Import from EU			ort from EU		
	Value	Extensive	Value	Extensive		
		A: Cons	sumer goods			
Coefficient	-0.447	-0.527	-0.195	-0.117		
Standard error	(0.049)	(0.043)	(0.074)	(0.037)		
T-ratio	-9.16	-12.35	-2.64	-3.14		
Change in %	-36.03	-40.94	-17.75	-11.07		
	B: Intermediate goods					
Coefficient	-0.179	-0.191	-0.207	0.033		
Standard error	(0.059)	(0.016)	(0.047)	(0.029)		
T-ratio	-3.05	-12.19	-4.39	1.14		
Change in %	-16.43	-17.40	-18.66	3.41		
		C: Ca	pital goods			
Coefficient	-0.159	-0.114	-0.049	0.128		
Standard error	(0.056)	(0.016)	(0.080)	(0.040)		
T-ratio	-2.84	-7.19	-0.61	3.21		
Change in %	-14.73	-10.81	-4.76	13.70		

Table A2:	<b>Results</b> fo	r Different Type	es of Goods.	. 2017-2022
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Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelksy et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec, 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Data is TDM for 2017-2022. List of countries included in the sample is in appendix. For extensive margins, only transactions with value above 1000USD are considered. We report results by value and extensive margin of trade in this section, as the intensive margin can be easily inferred form the coefficient on the value and extensive margin.

Value of Export to EU TDM Monthly data										
Coefficient	-0.215	-0.249	-0.226	-0.321	-0.146	-0.206				
Standard error	(0.058)	(0.052)	(0.046)	(0.056)	(0.052)	(0.061)				
T-ratio	-3.70	-4.74	-4.86	-5.71	-2.80	-3.40				
Change in %	-19.31	-22.04	-20.22	-27.48	-13.62	-18.64				
Reporters	EU and UK	EU and UK	Non-EU and UK	Non-EU and UK	OECD	OECD				
Partners	All	EU	All	EU	All	EU				

### Table A3: Sensitivity of the Choice of the Control Group. 2017-2022

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The outcome variable is the log of export value. Control group varies across different columns, as indicated by the values in reporters and partners rows. For example, the first column with results performs estimation for reporters from EU or UK and partners are all countries. Treated group is UK exports to EU post Dec, 2020. Data is TDM for 2017-2022. List of countries included in the sample is in appendix.

	Export to EU			Import	Import from EU					
	Value	Extensive	Intensive	Value	Extensive	Intensive				
	<b>A: T</b>	DM Sample. D	ifference in dif	ference						
Coefficient	-0.262	-0.324	0.0752	-0.205	-0.0523	-0.125				
Standard error	(0.0534)	(0.0267)	(0.0570)	(0.0438)	(0.0317)	(0.0260)				
T-ratio	4.91	12.13	-1.32	4.68	1.65	4.81				
Change in %	-23.05	-27.67	7.81	-18.54	-5.10	-11.75				
	B: TDM Sample. PPML									
Coefficient	-0.169	-0.288	-0.108	-0.37	-0.0483	-0.251				
Standard error	(0.0678)	(0.0276)	(0.0615)	(0.0487)	(0.0226)	(0.0483)				
T-ratio	2.49	10.43	1.76	7.60	2.14	5.20				
Change in %	-15.55	-25.02	-10.24	-30.93	-4.72	-22.20				
	C: COM	TRADESampl	e. Difference in	difference						
Coefficient	-0.231	-0.304	0.081	-0.109	-0.031	-0.097				
Standard error	(0.055)	(0.026)	(0.059)	(0.043)	(0.033)	(0.026)				
T-ratio	-4.19	-11.65	1.36	-2.56	-0.96	-3.76				
Change in %	-20.63	-26.21	8.43	-10.33	-3.09	-9.27				
	D: COM	<b>1TRADESam</b> p	ole. PPML							
Coefficient	-0.196	-0.241	-0.029	-0.334	-0.049	-0.208				
Standard error	(0.067)	(0.026)	(0.085)	(0.050)	(0.024)	(0.045)				
T-ratio	-2.93	-9.31	-0.34	-6.75	-2.05	-4.61				
Change in %	-17.80	-21.42	-2.83	-28.39	-4.74	-18.78				

### Table A4: Alternative estimation methods, DID and PPML result. 2017-2022

Note: Estimation is performed by two way difference in difference (Panels A and C) and Poisson Pseudo Maximum Likelihood (PPML, Panels B and D. Silva and Tenreyro, 2006). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec, 2020. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Intensive margin is the natural log of average value of exports/imports between reporter and partner. Data is TDM for 2017-2022. List of countries included in the sample is in appendix. For extensive and intensive margins, only transactions with value above 1000 USD are considered.

	Export				Import			
	TDM		COM	ГRADE	TDM		COM	ГRADE
	Monthly	Annual	Monthly	Annual	Monthly	Annual	Monthly	Annual
Coefficient	-0.728	-0.401	-0.704	-0.318	-0.236	-0.291	-0.247	-0.167
Standard error	(0.065)	(0.039)	(0.061)	(0.035)	(0.032)	(0.042)	(0.032)	(0.027)
T-ratio	-11.15	-10.28	-11.56	-9.18	-7.36	-6.95	-7.70	-6.17
Change in %	-51.70	-33.01	-50.55	-27.23	-21.06	-25.24	-21.90	-15.40

Table A5: Extensive margin results with non-censored data. 2017-2022

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The control group is bilateral pairs exporting/importing to EU and the Rest of the World. The treated group is bilateral trade of UK with EU post Dec 2020. Extensive margin is the natural log of total number of HS6 product exported/imported between reporter and partner countries. Data is TDM and COMTRADE for 2017-2022. List of countries included in the sample is in appendix.

### Table A6: Impact of TCA on Value of Trade with EU, Energy Product Excluded. 2017-

2022									
	Export				Import				
	TDM		COM	TRADE	TDM		COM	TRADE	
	Monthly	Annual	Monthly	Annual	Monthly	Annual	Monthly	Annual	
Coefficient	-0.251	-0.128	-0.229	-0.263	-0.286	-0.209	-0.275	-0.249	
Standard error	(0.052)	(0.057)	(0.052)	(0.056)	(0.052)	(0.049)	(0.048)	(0.047)	
T-ratio	-4.84	-2.25	-4.45	-4.69	-5.53	-4.30	-5.78	-5.25	
Change in %	-22.17	-11.99	-20.50	-23.15	-24.85	-18.82	-24.00	-22.03	

Note: Bootstrapped standard errors in parentheses. Estimation is performed by synthetic difference in difference (Arkhangelsky et al., 2021). The control group is bilateral pairs exporting/importing to EU excluding UK. The treated group is bilateral trade of UK with EU. Value is the natural log of total bilateral export/import in USD between reporter and partner countries. Data for 2017-2022, excluding HS27 products.

	Trade	values	Trade	varieties
	Import	Export	Import	Export
AUT	-13.1***	-32.7***	-5.4***	-40.9***
BEL	-43.1***	-1.4	-23.0***	-30.0***
BGR	9.4**	-39.9***	53.4***	-40.4***
СҮР	-19.5***	-36.1***	-20.9***	-43.0***
CZE	-5.0	-26.8***	-1.5	-34.7***
DEU	-31.7***	-30.8***	-11.9***	-24.0***
DNK	-41.7***	-21.3***	-15.9***	-31.2***
ESP	-10.6***	-33.6***	-2.0**	-32.9***
EST	32.6***	-10.8***	79.7***	-42.6***
FIN	-15.2***	-26.2***	3.0*	-38.4***
FRA	-22.6***	-22.9***	-10.4***	-24.1***
GRC	17.4***	-36.4***	15.3***	-40.0***
HRV	19.8***	-47.2***	55.6***	-43.9***
HUN	12.6***	-28.6***	18.1***	-38.5***
IRL	-29.9***	-4.2*	-19.7***	-20.1***
ITA	-9.4***	-26.4***	2.7***	-28.8***
LTU	11.2***	21.6**	27.7***	-29.8***
LUX	-28.2***	60.4***	-28.6***	-55.3***
LVA	7.4	-24.7***	28.6***	-43.5***
MLT	3.3	-63.6***	-9.3***	-38.9***
NLD	-51.1***	$4.8^{*}$	-18.0***	-16.5***
POL	-4.1**	-14.5***	0.4	-29.3***
PRT	-9.9***	-36.2***	19.5***	-40.6***
ROU	30.4***	-36.5***	21.9***	-37.2***

### Table A7 Trade values and varieties by country. PPML

SVK	20.7***	10.9*	14.6***	-39.2***
SVN	21.4***	-33.2***	39.9***	-44.7***
SWE	-17.7***	-23.4***	-10.6***	-29.3***

Note: We present the percentage changes of each coefficient. See Figure 7 for trade values and Figure 8 for trade varieties. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A8 Change	in trade values across	product catego	ories
scription	Trada	Values	Trade

HS code	Description	Trade	Values	Trade Varieties		
		Import, %	Export, %	Import, %	Export, %	
HS01	Live animals	-45.4***	-26.1***	24.7***	-23.3***	
HS02	Meat and edible meat offal	-51.9***	-36.9***	-6.0***	-33.8***	
HS03	Fish and crustaceans, molluses and other aquatic invertebrates	-50.7***	-42.7***	-18.0***	-51.2***	
HS04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	-53.5***	-37.5***	-10.0***	-37.5***	
HS05	Products of animal origin, not elsewhere specified or included	-41.5***	-18.7***	-3.0*	-44.4***	
HS06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.	-46.7***	-56.6***	19.7***	-57.5***	
HS07	Edible vegetables and certain roots and tubers	-53.1***	-42.1***	-11.3***	-56.6***	
HS08	Edible fruit and nuts; peel of citrus fruit or melons	-56.2***	-73.5***	-11.3***	-65.3***	
HS09	Coffee, tea, mate and spices	-50.3***	$-48.0^{***}$	-7.5***	-47.8***	
HS10	Cereals	<b>-</b> 41.9 <sup>***</sup>	-23.4**	-21.6***	-58.8***	
HS11	Products of the milling industry; malt; starches; inulin; wheat gluten.	-43.7***	-38.7***	-3.4**	-42.4***	
HS12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.	-29.5***	-60.5***	-0.1	-58.7***	
HS13	Lac; gums, resins and other vegetable saps and extracts	-53.8***	-25.4***	-1.9	-37.8***	
HS14	Vegetable plaiting materials; vegetable products not elsewhere specified or included.	-56.8***	-56.9***	-13.1***	-68.5***	
HS15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes.	-33.7***	-21.5***	-8.4***	-47.9***	
HS16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates.	-51.2***	-48.2***	-4.9***	-50.2***	
HS17	Sugars and sugar confectionery.	$-40.8^{***}$	-48.8***	-10.6***	-38.8***	
HS18	Cocoa and cocoa preparations.	-46.6***	-34.7***	1.4	-25.7***	
HS19	Preparations of cereals, flour, starch or milk; pastrycooks' products.	-40.1***	-34.2***	1.4	-17.5***	
HS20	Preparations of vegetables, fruit, nuts or other parts of plants.	-47.4***	-54.8***	-3.2**	-39.4***	
HS21	Miscellaneous edible preparations.	-51.6***	-39.3***	-0.4	-16.2***	
HS22	Beverages, spirits and vinegar.	-44.9***	-31.8***	8.1***	-2.2**	
HS23	Residues and waste from the food industries; prepared animal fodder.	-40.8***	-41.9***	-8.0***	-28.5***	

HS24	Tobacco and manufactured tobacco	-33.5***	-48.5***	12.0***	17.5**
11025	substitutes.	20 7***	22 1***	10.0***	25 2***
н523	Sait; support; earlies and stone; plastering	-38.7	-33.1	-10.9	-25.2
11026	materials, lime and cement.	20.2***	50 4***	7 (***	21 5***
H520	Ores, slag and asn.	-30.2	-52.4	-/.0 4.9***	-31.3
H527	their distillation; bituminous substances;	-12.2	-21.7	-4.8	-17.2
11020	mineral waxes.	-0 <***	10.2	***	<b>22</b> 0***
H528	Inorganic chemicals; organic or inorganic	-50.6	-10.5	-14.4	-32.8
	compounds of precious metals, of rare-earth				
	metals, of radioactive elements or of				
11020	isotopes.	40 0***	~~ ~***	11 0***	o 4 <b>-</b> ***
HS29	Organic chemicals.	-42.0	-33.2	-11.8	-34.7
HS30	Pharmaceutical products.	-54.5	-41.7	0.0	-15.4
HS31	Fertilisers.	-22.1	0.2	-6.1	-12.5
HS32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other	-57.0	-40.8	-2.6*	-8.4
	colouring matter; paints and varnishes; putty				
	and other mastics; inks.				***
HS33	Essential oils and resinoids; perfumery,	-51.6***	-38.0***	-6.0***	-7.5***
	cosmetic or toilet preparations.				
HS34	Soap, organic surface-active agents, washing	-46.8***	-36.3***	-7.2***	-6.1***
	preparations, lubricating preparations,				
	artificial waxes, prepared waxes, polishing				
	or scouring preparations, candles and similar				
	articles, modelling pastes, "dental waxes"				
	and dental preparations with a basis of				
	plaster.				
HS35	Albuminoidal substances; modified starches;	-43.3***	-19.1***	-2.3*	-17.5***
	glues; enzymes.				
HS36	Explosives; pyrotechnic products; matches;	-48.9***	-49.9***	-15.6***	-40.2***
	pyrophoric alloys; certain combustible				
	preparations.				
HS37	Photographic or cinematographic goods.	-67.3***	-54.1***	-15.8***	-33.3***
HS38	Miscellaneous chemical products.	-27.5***	-30.8***	1.5	-5.5***
HS39	Plastics and articles thereof	-49.2***	-34.4***	-0.1	-8.2***
HS40	Rubber and articles thereof	-51.1***	-42.2***	-6.4***	-17.2***
HS41	Raw hides and skins (other than furskins)	-55.1***	-51.2***	-8.5***	-13.9***
	and leather.				
HS42	Articles of leather; saddlery and harness;	-57.4***	-45.9***	-13.7***	-11.0***
	travel goods, handbags and similar				
	containers; articles of animal gut (other than				
	silk-worm gut).				
HS43	Furskins and artificial fur; manufactures	-70.4***	-69.9***	-15.3***	-54.2***
	thereof.				
HS44	Wood and articles of wood; wood charcoal	-42.4***	-10.5*	$8.4^{***}$	-23.5***
HS45	Cork and articles of cork.	-20.9***	-20.7***	-23.3***	-58.7***
HS46	Manufactures of straw, of esparto or of other	-33.9***	-32.0**	-18.5***	-61.2***
	plaiting materials: basketware and				
	wickerwork.				
HS47	Pulp of wood or of other fibrous cellulosic	-59 3***	-22 3***	-15 5***	-33 4***
11517	material: recovered (waste and scrap) paper	59.5	22.5	15.5	55.1
	or paperboard.				
HS48	Paper and paperboard: articles of paper pulp	_/10 7***	-40.8***	-7 8***	_27 0 <sup>***</sup>
115-10	of naper or of naperboard		-10.0	-7.0	-27.0
H270	Printed books newspaners nictures and	-65 1***	-40 6***	-14 5***	<u>_</u> 20 6***
11547	other products of the printing industry.	-03.1	-+9.0	-14.3	-20.0
	manuscripts, typescripts and plans				
1620	manuscripts, typescripts and plans.	66 2***	57 2***	74 2***	10 (***
11220	JIIK.	-00.5	-37.3	-24.3	-40.0

HS51	Wool, fine or coarse animal hair; horsehair varn and woven fabric.	-57.8***	-47.1***	-4.0**	-27.0***
HS52	Cotton	-55.8***	-35.8***	-12.8***	-55.5***
HS53	Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn	-36.8***	-25.8***	-6.4***	-42.3***
HS5/	Man made filaments	55 2***	51 0***	0 8***	<i>11 1</i> ***
HS54	Man made stanle fibres	-33.2 57 °***	-51.7 64 7***	-5.0	-+1.+ 51 5 <sup>***</sup>
11855	Wadding falt and nonveyange anapial yama	-37.0	-04./	-13.1	-31.3
H830	twine, cordage, ropes and cables and articles thereof	-47.2	-34.9	-6./	-24.8
HS57	Carpets and other textile floor coverings.	-51.6***	-47.4***	-8.0***	-37.5***
HS58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery.	-57.6***	-53.8***	-18.1***	-43.4***
HS59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use.	-49.5***	-43.0***	-1.2	-21.0***
HS60	Knitted or crocheted fabrics.	-59.7***	-38.2***	-10.3***	-39.9***
HS61	Articles of annarel and clothing accessories	-55 1***	-65 5***	-17 9***	-35.0***
11501	knitted or crocheted.	-55.1	-05.5	10 5***	22 0***
П302	Articles of apparer and clothing accessories,	-03.4	-03.8	-18.3	-33.9
HS63	Other made up textile articles; sets; worn	-63.9***	-48.3***	-8.4***	-35.5***
110 ( )	clothing and worn textile articles; rags.	***	***		***
HS64	Footwear, gatters and the like; parts of such articles,	-61.3	-71.9	-19.7	-24.7
HS65	Headgear and parts thereof	-51.1***	-58.8***	-18.5***	-22.2***
HS66	Umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof	-36.9***	-57.5***	-21.1***	-48.4***
HS67	Prepared feathers and down and articles made of feathers or of down; artificial flowers: articles of human hair	-37.8***	-34.1***	-14.1***	-41.2***
HS68	Articles of stone, plaster, cement, asbestos, mica or similar materials	-44.3***	-35.7***	$8.0^{***}$	-16.6***
H260	Ceramic products	/3 1***	<i>/</i> 1 3 <sup>***</sup>	7 3***	20 7***
11509	Class and alassystem	-45.1	-41.3	-7.5	-20.7
ПЗ/0 ЦС71	Material an automatic analysis and a series	-48.4	-34./	-0.0	-24.3
H5/1	natural of cultured pearls, precious of semi- precious stones, precious metals, metals clad with precious metal and articles thereof; imitation jewellery; coin	-57.0	22.1	-1.9	-9.8
HS72	Iron and steel	-45 6***	-22 1***	-0.7	-17 5***
HS72	Articles of iron or steel	-+5.0 51 4***	-22.1 28 2***	2 8**	13 0***
11373	Conner and articles thereof	-31.4 50.6***	-20.2	-2.0 10.4***	-13.0
ПЗ/4 ЦС75	Nielest and articles thereof	-30.0	-22.9	-10.4	-21.0
H5/3	Nickel and articles thereof.	-49.2	-9.4	-1.5	-/.9
HS/6	Aluminium and articles thereof	-46.2	-24.9	1.0	-13.9
HS/8	Lead and article thereof	-54.2	-32.4	-9.0	-17.0
HS79	Zinc and article thereof	-60.1	-61.1	-9.3	-23.4
HS80	Tin and articles thereof	-50.6***	-36.2***	-19.0**	-42.9***
HS81	Other base metals; cermets; articles thereof	-56.1***	-23.5***	-3.8***	-18.6***
HS82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof base	-52.3***	-46.4***	-13.0***	-26.7***
H283	Miscellaneous article of base metal	_17 1***	-33 0***	_5 1**	-186***
HC61	Nuclear reactors boilers machinery and	7 / . I /0 0***	-33.2	-J.1 2 2***	-10.0 7 0***
п304	machanical applications, machinery and	-49.0	-30.3	3.3	-/.0
11005	Electrical appliances; parts thereof	40 2***	20.7	1 4***	10 0***
н585	Electrical machinery and equipment and parts thereof; sound recorders and	-48.2	-39.7	-1.4	-10.3
	reproducers, television image and sound				
	recorders and reproducers, and parts and				

accessories of such articles,

HS86	Railway or tramway locomotives, rolling- stock and parts thereat railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical)	-69.3***	-1.3***	1.4	11.7**
HS87	Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof	-51.1***	-45.1***	1.5**	-1.8
HS88	Aircraft spacecraft and parts thereof	-59 5***	-53 8***	4 9***	1.5*
HS80	Ships boats and floating structures	$-71.7^{***}$	- <i>47</i> 2***	28.0	_3 3***
HS90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and	-48.1***	-31.9***	0.5***	-7.2***
	accessories thereof				
HS91	Clocks and watches and parts thereof.	-48.4***	-39.6***	-25.8***	-39.2***
HS92	Musical instruments; parts and accessories of such articles.	-52.3***	-40.6***	-7.6***	-32.4***
HS93	Arms and ammunition; parts and accessories thereof.	-60.7***	-51.0***	-8.6***	-25.8
HS94	Furniture; bedding, mattress, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated nameplates and like; prefabricated buildings.	-45.7***	-43.3***	13.2***	-0.3***
HS95	Toys, games and sports requisites; parts and accessories thereof	-44.4***	-48.3***	-8.7***	-21.2***
HS96	Miscellaneous manufactured articles	-56.3***	-56.9***	-17.0***	$-29.0^{***}$
HS97	Works of art collectors' prices and antiques	-62.6***	-46 3***	45 0***	46.1***
HS98	(Reserved for special uses by Contracting Parties)	-96.3***	-92.4***	-42.8***	-81.4***

Note: \* Results are relative to the HS99 group. We present the percentage changes of each coefficient. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

## Table A9 The change of import and export for capital, consumption, and intermediate goods, PPML

			Values				
Category	Consumption		Intern	Intermediate		Capital	
Country	Import, %	Export, %	Import, %	Export, %	Import, %	Export, %	
AUT	-11.6**	-45.4***	-14.9***	-37.9***	43.3***	-0.8	
BEL	-57.4***	-25.6***	-33.6***	8.7***	-61.1***	17.8***	
BGR	66.7***	-50.5***	2.9	-39.0***	174.1***	-4.4	
СҮР	11.1*	-23.5***	-13.2	-10.5	-67.7**	-50.7***	
CZE	37.7***	-27.2***	-13.6***	-27.6***	-7.1***	-13.0***	
DEU	-32.9***	-42.0***	-25.9***	-36.1***	-17.3***	-4.6*	
DNK	-29.7***	-41.9***	-48.6***	-17.6***	-12.6	-22.0***	
ESP	-7.4**	-49.5***	3.2	-25.9***	-23.5***	-30.4***	
EST	42.4***	-21.2***	32.6***	-0.1	223.6***	-1.1	
FIN	110.2***	-50.7***	-10.0***	-31.3***	-4.7	-26.6***	
FRA	-25.9***	-16.8***	-18.3***	-41.1***	-11.5**	-2.6	

GRC	-8.4***	-44.1***	47.4***	-20.5***	156.4***	-22.4***
HRV	94.3***	-55.5***	10.7	-40.4***	169.2***	-41.3***
HUN	87.4***	-40.6***	-3.0	-25.0***	$10.6^{*}$	-3.7
IRL	-31.6***	-33.6***	-6.5	19.8***	-1.7	-4.8
ITA	1.0	-37.9***	-6.8***	-23.9***	27.2***	-20.4***
LTU	42.9***	24.9***	$8.8^*$	-20.0***	98.6***	19.0**
LUX	-82.0***	-42.3***	-3.0	155.2***	-30.7***	-8.9
LVA	26.8***	-25.8***	18.3***	-9.4*	162.4***	-36.1***
MLT	-0.3	-48.1***	23.9	-41.0***	-1.7	-88.0***
NLD	-46.7***	-11.5***	-53.9***	6.2***	-61.7***	47.9***
POL	1.1	-40.3***	-7.2***	-17.9***	49.5***	-17.6***
PRT	16.6***	-40.9***	-14.3***	-28.5***	-17.8***	-33.3***
ROU	124.5***	-17.9***	-7.6*	-38.2***	50.9***	-29.4
SVK	48.4***	-39.4***	-3.1	33.4***	14.5	2.7***
SVN	67.4***	-21.9***	22.7***	-28.9***	133.4***	-21.8***
SWE	-41.0***	-42.1***	-7.2***	-25.1***	1.8	-24.2***

variety

Category	Consu	mption	Interm	Intermediate C		Capital	
Country	Import, %	Export, %	Import, %	Export, %	Import, %	Export, %	
AUT	-26.6***	-51.1***	3.0**	-30.4***	$10.2^{***}$	-17.8***	
BEL	-30.9***	-34.0***	-17.7***	-21.8***	-22.4***	-12.0***	
BGR	49.0***	-55.9***	58.1***	-24.3***	105.6***	-18.4***	
СҮР	-26.7***	-50.2***	-19.4***	-26.8***	17.7**	-16.8***	
CZE	-22.9***	-43.3***	9.2***	-22.8***	14.1***	-18.2***	
DEU	-22.0***	-27.4***	-8.6***	-16.6***	-2.9***	-5.2***	
DNK	-33.9***	-38.8***	-7.3***	-20.3***	9.7***	-11.4***	
ESP	-12.5***	-39.5***	6.7***	-23.3***	6.7***	-15.8***	
EST	46.3***	-54.3***	84.4***	-26.8***	175.4***	-22.2***	
FIN	-17.9***	-47.6***	6.1***	-27.0***	21.3***	-21.2***	
FRA	-18.3***	-26.5***	-6.1***	-15.7***	-3.0***	-9.2***	
GRC	2.1	-48.6***	41.7***	-26.6***	48.8***	-21.6***	
HRV	24.2***	-60.3***	81.2***	-26.0***	128.9***	-17.2***	
HUN	28.1***	-51.2***	13.7***	-25.0***	29.1***	-22.2***	
IRL	-27.9***	-20.7***	-14.9***	-14.5***	-12.7***	-8.3***	
ITA	-4.9***	-32.2***	7.3***	-20.9***	9.8***	-10.5***	
LTU	$11.7^{***}$	-39.5***	40.7***	-15.1***	63.0***	-8.5***	
LUX	-53.1***	-72.7***	-17.0***	-35.1***	-24.1***	-31.6***	
LVA	2.6	-54.5***	45.2***	-26.8***	130.1***	-25.0***	
MLT	-38.5***	-46.9***	15.7***	-20.4***	20.6**	-20.9***	
NLD	-27.6***	-19.5***	-14.4***	-6.3***	-5.9***	-0.4	
POL	-13.3***	-35.6***	9.8***	-19.3***	14.2***	-12.9***	
PRT	21.5***	-49.4***	22.5***	-28.4***	35.7***	-23.7***	
ROU	15.7***	-46.7***	31.2***	-26.3***	52.0***	-17.3***	

SVK	4.1	-55.4***	18.3***	-21.1***	32.0***	-21.4***
SVN	25.4***	-57.2***	46.6***	-30.6***	73.2***	-29.1***
SWE	-33.6***	-33.8***	-0.9	-20.3***	9.2***	-11.6***

Note: We present the percentage changes of each coefficient. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

### **Appendix Figures**



### Figure A1: UK trade dynamics in 2019-2023

Note: 3 month moving average aggregate UK data split into EU vs the rest of the world, normalized by the corresponding values as of January 2019.





### **Appendix B:** Technical Appendix

To test this hypothesis, a causal analysis required is intrinsically hard with a counterfactual scenario being unobservable. We derive the causal inference of the TCA effect on UK trade over the period ending 2022Q1 using the Synthetic Difference-in-Difference (SDID) methodology (Arkhangelsky et al., 2021). SDID has been shown consistent, asymptotically normal, and more efficient relative to the popular approaches including Synthetic Control and Difference-In-Difference methods. Hence the causal analysis holds promise to allow us to separate the impact of the TCA from the impact of other factors, such as COVID-19, global value chain disruptions, and global price increases.

Briefly, the SDID methodology constructs a synthetic UK, also known as a doppelganger UK, which exports and imports identically to the UK, but did not experience the change in its trade relationships with the EU. It further estimates the synthetic UK's exports and imports since January 2021 and compares these estimates with the actual UK exports and imports. This method allows to calculate the percentage change in exports and imports of the UK relative to the counterfactual scenario of UK remaining in the EU and to perform usual statistical inference tests, to ascertain whether the effect is statistically significant.

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

$$T_{it}^{R} = \gamma_{i}^{R} \nu_{t}^{\prime R} + \tau^{R} \times TCA_{it} + \epsilon_{it}^{R}$$

where *i* is the reporting country at time *t*.  $R \in \{EU, ROW\}$  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.  $\gamma_i$  is a  $1 \times K$  vector of latent unit factors and  $v_t$  is a  $1 \times K$  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.  $\tau$  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.

More formally, we observe trade for T period for a balanced panel of N units. Without loss of generality, the first  $N_c$  units are never exposed to a treatment. The remaining  $N_{tr} = N - N_c$  units are exposed to the treatment after time  $T_{pre} \leq T$ . The SDID estimator constructs the doppelganger synthetic control from the pool of never-treated units using weights  $\hat{\omega}_i^{sdid}$  that trace the actual outcome of the treated group before  $T_{pre}$ . It also selects time weights  $\hat{\lambda}_t^{sdid}$  to balance the pre-treatment and post-treatment time periods. The role of time weights is to remove the bias stemming from comparing the post-treatment periods with pre-treatment periods that are very different for the whole sample of control units. The time- and pair-specific weights are further applied to the standard difference-in-difference estimator in a two-way panel as follows:

$$(\hat{\tau}^{sdid}, \hat{\mu}_1, \hat{\alpha}_1, \hat{\beta}_1) = \arg\min_{\tau, \mu, \alpha, \beta} \left( \sum_{i=1}^N \sum_{t=1}^T (T_{it}^R - \mu - \alpha_i - \beta_t - \tau^R \times TCA_{it})^2 \widehat{\omega}_i^{sdid} \hat{\lambda}_t^{sdid} \right)$$

SDID uses weights to emphasise units and time periods that are comparable to the treated units in the post-treatment period. The weights for the synthetic control are selected to follow closely the pre-treatment trend of the treated units. In addition, a penalty is imposed on using too many units for comparison. The unit weights are estimated as the outcomes of the following optimisation problem:

$$\left(\omega_{0},\widehat{\omega}^{sdid}\right) = \arg\min_{\omega_{0}\in R_{1},\omega\in\Omega} \sum_{t=1}^{T_{pre}} \left(\omega_{0} + \sum_{i=1}^{N_{c}} \omega_{i} T_{it}^{R} - \frac{1}{N_{tr}} \sum_{i=N_{c+1}}^{N} T_{it}^{R}\right)^{2} + \xi^{2} T_{pre} \left||\omega|\right|_{2}^{2}$$

where  $\Omega = \{ \omega \in \mathbb{R}^N_+ : \sum_{i=1}^{N_c} \omega_i = 1, \omega_i = \frac{1}{N_{tr}} \text{ for all } i = N_c + 1, \dots, N \}.$ 

We draw on COMTRADE data at the harmonised system (HS) sub-heading level (HS 6-digit) for the period Q1 2019 – Q1 2022.

## Appendix C: Additional Results on Differences in EU Countries by Product Category Consumer Goods

Figure A3 below illustrates the changes in export and import varieties for consumer goods between UK and EU since 2021, with the upper figure in Panel A shows changes in export (vertical) and import (horizontal) values, while the lower figure in Panel B shows changes in export and import varieties. Table A9 in the appendix report all coefficients presented as percentage changes. Panel A reveals that primarily smaller EU economies in GDPs experiencing increased changes. Only Lithuania has exhibited a significant increase in export values, reaching 24.94%, despite its smaller GDP. The changes in import values mirror the trends observed in import varieties, with Nevertheless, Italy stands out for its increased change in import values, albeit at a more modest 0.96%.

Moving on to Panel B, we observe a consistent negative change in export varieties for consumption goods among all EU countries. Similar to capital goods, the Netherlands stands out with a relatively smaller decline in export varieties compared to other EU countries. However, many EU members also experienced a decrease in import varieties, especially those with larger GDPs. Conversely, only EU countries with smaller GDPs have observed an increase in import varieties.

#### **Intermediate Goods**

To examine the intermediate goods' change pattern in Figure A3, we have applied the same specifications as in Figure A4. For intermediate goods, examining Panel A shows that similar to capital goods, several EU countries, including Slovakia, Ireland, Belgium, and the Netherlands, have exhibited increased changes in export values. In contrast to the other two types of goods, Germany and France have witnessed a relatively substantial decline in export values, along with Spain and Italy, the other two major economies. Another difference is that only a few EU members, all of which are small economies except for Spain, have seen a positive increase in import values.

Turning now to Panel B reveals a significant decrease in export varieties among all EU members, with the Netherlands experiencing the smallest decline. Moreover, while most EU countries have seen a positive increase in import varieties, Germany and France, the two largest economies, have experienced declines.

### **Capital Goods**

For capital goods, from Figure A5 Panel A, we observe that some EU countries have seen an increase in changes in export values, with the highest being the Netherlands at 47.93%. Positive changes are also noticeable for Belgium, Lithuania, and Slovakia. Surprisingly, only EU countries with small and medium-small GDPs have experienced positive changes in export values. The situation is the opposite when it comes to changes in import values; EU countries with large and medium-large GDPs consistently show a decline, with Cyprus being particularly pronounced at 67.72%. Instead, Estonia, with a small GDP, exhibited the largest increase in changes in import values.

The results in Panel B differ from those in Panel A. Specifically, it is evident that all EU countries have experienced a decline in export varieties to the UK. Notably, Slovenia saw the most significant decline at 29.07%, followed by Latvia (25.02%) and Portugal (23.65%). On the import side, only five EU countries registered a decline in import varieties, namely Belgium, the Netherlands, Germany, France, and Ireland. In general, EU members with larger GDPs tend to have a smaller decline in export varieties but a noticeable drop in import varieties.

Figure A3: Trade in consumer goods between the UK and EU since 2021





Figure A4: Trade in intermediate goods between the UK and EU since 2021 Panel A: Trade Values







Figure A5: Trade in capital goods between the UK and EU since 2021



**Panel A: Trade Values**