Technical appendix

The objective of this study is to provide an up-to-date estimate of the impact of Brexit on UK-EU trade and to separate out the effects of leaving the customs union from those of leaving the single market. In doing so, we fitted three 'structural gravity' models that allowed us to:

1) assess the impact of Brexit on UK-EU trade across goods and services sectors;

2) estimate the average difference between EU-EU flows and EU-FTA partner flows across goods sectors;

3) assign customs union and single market effects to that difference.

The third model allows us to identify how much of the overall goods trade losses (Model 1) is down to leaving the customs union – the remainder is down to leaving the single market.

Model 1: The overall trade impact

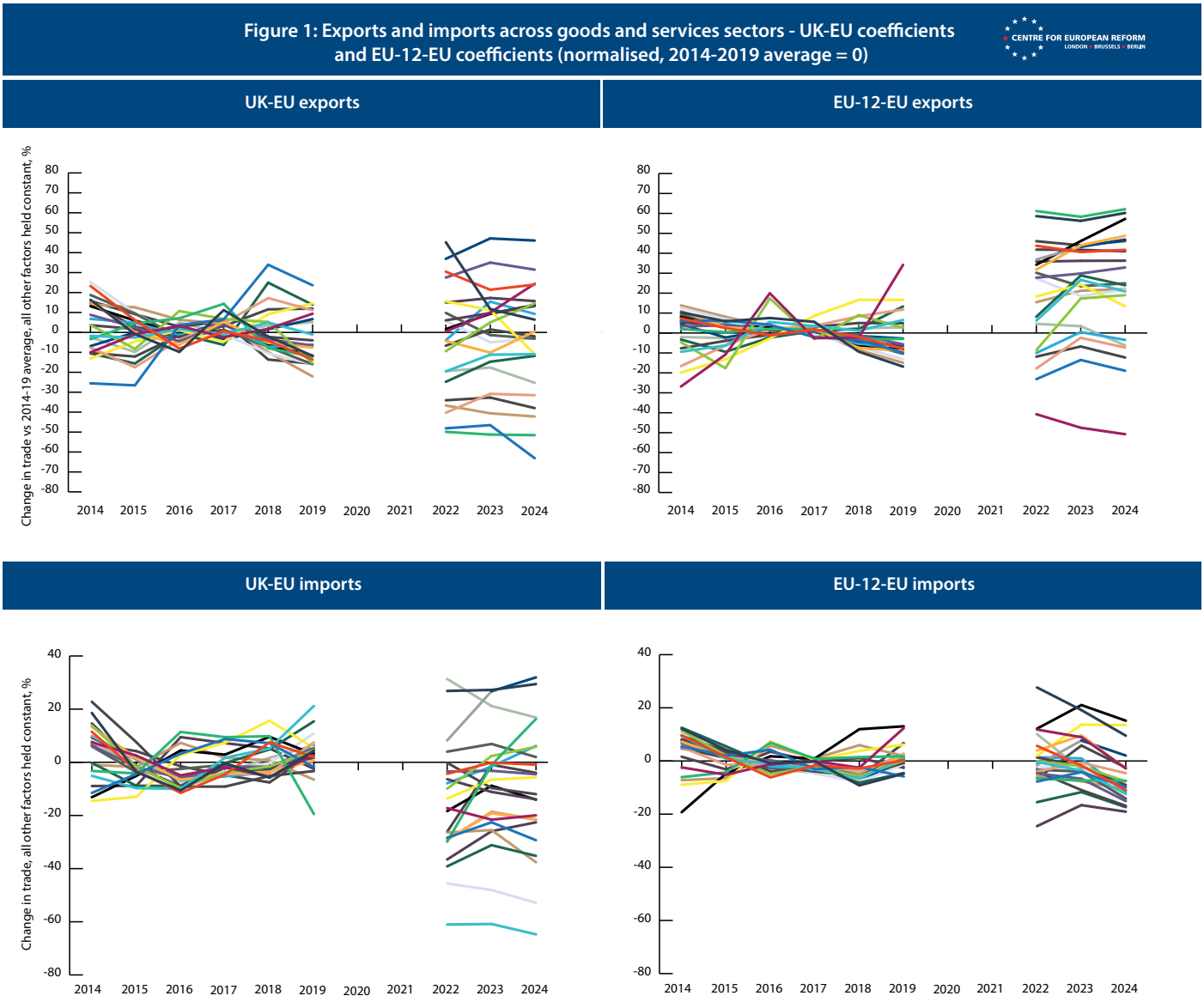
We used bilateral goods trade data at the Harmonised System (HS) section level, in current US dollars, from CEPII, and World Bank/OECD BaTIS data on services sectors. That data is across all global trade partners for 2004 (in goods, to pick up the integration effects of new EU joiners), 2014-19, and 2022-24. Data for 2020 and 2021 were excluded because of the distorting effects of the Covid pandemic on trade flows. To reduce computing time, we limited the number of countries in the model to those that make up 95 per cent of Europe's external trade, as well as EU, UK, Switzerland and European Economic Area countries.

This model assesses the impact of Brexit on UK goods and services exports and imports, by sector (vehicles or financial services, for example). It allows us to hold all factors that affect trade constant – geographical distance, recessions in one trade partner, changes in exchange rates, for example – and assess how much more the UK trades with the EU, and EU member-states with themselves – than other trade partners do. The model is estimated using 'pseudo-poisson maximum likelihood' (PPML), with separate dummies for UK-EU and EU-12-EU trade flows. We used 12 older EU member-states as the control to assess whether their trade with each other and the newer member-states grew after Brexit (minus Ireland, which was more affected by Brexit than other EU states, and Luxembourg, whose trade data is skewed by multinational tax strategies). We also included dummies for the top-10 non-EU trade partners in each trade sector, to account for trade diversion. We added time-varying importer and exporter and time-invariant country-pair fixed effects, as is standard in the recent literature – these control for distance, fluctuations in GDP, currency moves and other factors that affect trade. Using PPML is also standard in the recent literature.

We then applied a 'difference-in-differences' (DiD) framework to the model's output. We compared the annual UK-EU coefficients and assessed how they changed before Brexit (2014-19) and after (2022-24), using the change in EU-12-EU coefficients over the same period as the control. The DiD is the UK-EU average post-Brexit (2022-24) minus the UK-EU average pre-Brexit (2014-19), minus the EU-12-EU post-Brexit minus the EU-12-EU pre-Brexit. This procedure allows us to account for the fact that intra-EU trade itself has changed over the Brexit period.

Figure 1 compares the UK-EU coefficients and the EU-12-EU coefficients for goods and services sectors over time, each normalised so that the 2014-19 average = 0. When the UK lines fall, this means that UK trade integration with the EU is going into reverse relative to the pre-Brexit period. When the EU-12 lines rise, trade integration within the EU is increasing. Before Brexit the series move broadly in parallel, consistent with the parallel trends assumption required for DiD to be valid. After Brexit, the majority of UK sectors fall relative to the EU-12, suggesting that leaving the EU is the cause of the loss of trade integration and that the DiD is valid.

Figure 1: Exports and imports across goods and services sectors - UK-EU coefficients and EU-12-EU coefficients (normalised, 2014-2019 average = 0)



Source: CER model analysis.
Note: Sectors with small trade values have been removed because their coefficients are volatile. Data for 2020 and 2021 were not modelled because of the impact of the Covid pandemic on trade flows.

To validate the results, we ran a 'placebo test' – so-called because each of the 12 EU member-states is modelled as though it too had been given the 'treatment' of leaving the EU. Each of the EU-12 entered the model just as the UK did, with specific coefficients testing whether their trade integration had fallen between the 2022-24 period, compared to 2014-19. The results are shown in Table 1 below. On average, EU-12 trade integration improved somewhat after Brexit, shown by the positive means. The UK falls outside the 5th percentile of worst performance in goods exports, goods imports and services imports – meaning that no other EU-12 country matched the UK's underperformance across all trade sectors. In services exports, the UK performs better than the 5th percentile, but this may reflect weak tourism revenues in some EU-12 countries in 2022-23, and the strong growth of UK exports in other business services.

Table 1: Placebo test results				
	UK	EU-12 mean	EU 5th percentile	EU 95th percentile
Goods exports	-16%	+5%	-10%	+38%
Goods imports	-14%	+7%	-12%	+31%
Services exports	-7%	+3%	-11%	+18%
Services imports	-19%	+2%	-15%	+18%

Model 2: The EU customs premium

Models 2 and 3 together answer the question: how much of the overall Brexit trade loss is attributable to leaving the customs union, and how much to leaving the single market? Because there is only limited data for effects of customs barriers on the UK's trade performance since Brexit, we used data for all 27 member-states trade with all of the EU's 43 FTA partners, including the UK. This allowed us to establish a measure of how much the customs-related costs reduce the EU's trade with its FTA partners, and then to apply the trade costs of EU-FTA 'rules of origin' to the UK, to estimate how much they contribute to the overall goods trade losses.

Model 2 does the first step, which is to establish how much higher EU-EU trade is than EU-FTA trade (and how much EU-FTA trade is higher than the EU's trade partners that have no FTA). We used the same 'structural gravity' approach, but dropped country-pair fixed effects because they were collinear with the EU-EU and EU-FTA flows dummies in this specification. We replaced them with distance, contiguity and common language variables – consistent with the approaches using country-pair effects – and retained importer and exporter fixed effects.

Model 3: The customs union effect

This model zooms in on EU-FTA trade to assess the costs of 'rules of origin' – the friction that would be eliminated if the UK were in a full customs union with the EU.

We use the European Commission data on preference utilisation rates (PURs) for EU FTAs, covering 2022-24. PUR data measures the extent to which businesses make use of the tariff preferences provided by trade agreements. The data records the share of bilateral trade with EU FTA partners conducted on a preferential basis and the share conducted on a 'most favoured nation' (MFN) basis, for each EU member-state, FTA partner, and goods section.

MFN trade is, in most cases, subject to tariffs – either because goods fail 'rules of origin' requirements, importers find compliance costs too onerous, or businesses are simply unaware of the preferential rates available to them. PUR data is not a fine-grained measure of all customs-related costs – it does not, for example, capture customs declarations, physical checks and other administrative barriers. But it provides a comprehensive measure of the trade share affected by 'rules of origin' requirements, which is the main driver of the customs union effect we seek to isolate.

We fitted a model on EU-FTA partner trade only, using the same structure as Model 2: importer and exporter fixed effects, plus distance, contiguity and common language variables. The variable of interest is the MFN-treated share of trade with each FTA partner. Where the MFN-treated share is high in a given goods sector – meaning more trade fails 'rules of origin' requirements, or traders do not bother to apply preferences – bilateral trade with the EU is lower. The resulting sector-level coefficients give us the trade elasticity with respect to 'rules of origin' compliance,

as a measure of the customs union effect. We use these elasticities to answer the following question: If no trade flows were treated as MFN – that is, if all trade with that FTA partner passed 'rules of origin' tests – how much would trade rise? Applying these coefficients to the UK's actual MFN-treated share in each goods sector gives us an estimate of how much UK-EU trade would rise if all trade had no tariffs applied – to simulate the UK being outside the single market but inside a customs union with the EU.

The gain from joining the EU is the difference in the coefficients between the EU-EU and EU-FTA trade in Model 2. The share of that gain from joining the EU's customs union is when MFN trade is zero, per Model 3. The share of the gain from joining the single market is the overall EU gain, less the losses imposed by the goods that failed 'rules of origin' requirements and had tariffs applied. These customs union and single market shares are then applied to the overall Brexit losses that we estimated in model 1, with the signs reversed so that they were losses, not gains.

Two final methodological notes to conclude: we attempted to combine Models 2 and 3, with the 'rules of origin' data interacted with EU-FTA dummy within a single model. However, because we only have 'rules of origin' data for 2022-24, there was insufficient variation to avoid collinearity with the dummy, as the model included, by necessity, prior years of data. It is not ideal to have separate models, but Model 3 is nested perfectly within Model 2 – covering only EU-FTA trade, with the same structure.

Furthermore, within goods sectors, it might be that the UK's trade with the EU is less affected by MFN treatment than other EU FTA partners. The PUR data is at section level, and UK trade within sections may be skewed towards products in which MFN treatment does not make much difference to trade, or makes a substantial difference. This may bias the results. But across sections the UK's sector-weighted overall share of trade that is treated as MFN is 18 per cent, and the average share of all the EU's FTA partners is 22 per cent. By section, the difference between the UK and the average EU FTA partner is large in plastics and rubber, raw hides and leather, wood products and textiles, but similar in the sectors with the largest UK-EU trade values – machinery, vehicles, chemicals, prepared food and base metals. This gives us confidence that the UK is not an outlier on MFN trade among the EU's FTA partners.

The losses/gains across all goods and services sectors included in the analysis are shown in Table 2.

Table 2: Model results for all goods and services sectors included in the analysis				
Losses/gains, %	UK exports to EU	UK imports from EU	Customs union effect, exports	Customs union effect, imports
Live Animals & Animal Products	-33	3	0	0
Vegetable Products	-37	2	-2	0
Animal or Vegetable Fats & Oils	-24	8	-3	0
Prepared Foodstuffs	-26	19	-6	0
Chemical Industries	-21	-24	-2	0
Plastics & Rubber	-19	-7	-1	0
Raw Hides & Leather	-50	-24	-50	0
Wood & Wood Products	-14	27	-7	0
Pulp & Paper	-19	4	0	0
Textiles	-55	-46	-17	0
Footwear	-69	-60	-20	-1
Stone & Cement	-15	12	-2	0
Base Metals	-12	1	-4	0
Machinery	1	-26	0	-11
Vehicles	-10	-10	-1	0
Optical & Medical	1	-21	0	-2
Miscellaneous Manufactures	-23	6	-11	0
Manufacturing services on physical inputs	-12	-14		
Maintenance and repair services	-28	-38		
Transport	-21	-24		
Travel	-39	-11		
Construction services	-43	-25		
Insurance and pension services	-5	0		
Financial services	-27	-21		
Charges for intellectual property	108	-44		
Telecommunications, computer & IT	12	-26		
Other business services	9	-17		
Personal, cultural & recreational	-31	-13		

Source: CER model analysis.
Note: Arms, precious metals, fuels and works of art are not included.

Contact the authors for access to the datasets and model scripts.

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