Lisbon School of Economics & Management
Universidade de Lisboa

MASTER IN
INTERNATIONAL ECONOMICS AND EUROPEAN STUDIES

MASTER´S FINAL WORK
DISSERTATION

THE BREXIT IMPACT ON SCOTLAND'S EU EXPORTS

INÊS FILIPA BARROS PEDRO

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SUPERVISION:
ANA P. FERNANDES

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Glossary

UK – United Kingdom

EU – European Union

RUK – Rest of the United Kingdom

GDP – Gross Domestic Product

RoW – Rest of the World

DiD – Difference-in-Differences

ABSTRACT

This dissertation investigates the impact of Brexit on Scotland's export relations with the European Union. The study adopts a quantitative approach, relying on sector-level export data from official Scottish Government sources and covering the period from 2015 to 2024. To distinguish the specific effects of Brexit from other global shocks, the analysis applies a difference-in-differences methodology, with exports to non-EU destinations serving as a control group. The empirical framework further accounts for sectoral heterogeneity and temporal trends, offering a comprehensive assessment of how the United Kingdom's withdrawal from the EU has shaped Scottish trade patterns. The findings reveal significant sectoral variation, with some industries, like raw materials, seeing growth in exports to the EU, while others, such as chemicals, experienced declines. These results provide new insights into the economic implications of Brexit and inform future trade policy decisions

Keywords: Brexit; Scotland; Exports; European Union; Difference-in-Differences; Trade Policy

RESUMO

Esta dissertação investiga o impacto do Brexit nas relações de exportação da Escócia com a União Europeia. O estudo adota uma abordagem quantitativa, recorrendo a dados de exportação por setor provenientes de fontes oficiais do Governo Escocês e abrangendo o período de 2015 a 2024. Para distinguir os efeitos específicos do Brexit de outros choques globais, aplica-se uma metodologia de diferenças-em-diferenças, utilizando as exportações para destinos extra-UE como grupo de controlo. O enquadramento empírico considera ainda a heterogeneidade setorial e as tendências temporais, proporcionando uma avaliação abrangente de como a saída do Reino Unido da UE moldou os padrões comerciais escoceses. Os resultados evidenciam variação setorial significativa: enquanto setores como matérias-primas registaram crescimento nas exportações para a UE, outros, como o químico, sofreram quebras. Estas conclusões oferecem novos contributos para a compreensão das implicações económicas do Brexit e para a definição de políticas comerciais futuras.

Palavras-chave: Brexit; Escócia; Exportações; União Europeia; Diferença-em-Diferenças; Política Comercial

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To all of you, my deepest gratitude.

1. INTRODUCTION

The United Kingdom's decision to leave the European Union - commonly referred to as Brexit – marked a monumental shift in both the political and economic fabric of Europe. Although the implications of Brexit have been widely discussed at the UK-wide level, the specific impacts at a regional level still require further scrutiny. One such case is Scotland, a constituent nation that overwhelmingly voted to remain in the EU in the 2016 referendum. Thereby, this study aims to examine a specific and measurable dimension of that impact: What are the effects of Brexit on Scotland's trade with the European Union?

While political debates often emphasise constitutional or ideological dimensions, a data-driven evaluation of its economic effects – particularly on trade – remains underexplored.

This line of investigation takes on added relevance given the structural characteristics of the Scottish economy. For years, Scotland has been deeply integrated with EU markets, especially in key sectors such as food and drink, chemicals, and manufacturing. The introduction of trade barriers, regulatory divergence, and broader institutional uncertainty brought on by Brexit may have reshaped the scale and nature of these trade flows. Understanding these dynamics is essential not only for academic inquiry, but also for informing public policy and regional economic planning in a post-Brexit landscape.

Academic literature has steadily expanded in response to Brexit, particularly with respect to its macroeconomic implications for the UK as a whole. Numerous studies have highlighted anticipated losses in trade volume, foreign direct investment, and overall productivity (Dhingra et al., 2017; Sampson, 2017). However, less attention has been given to how these effects play out at the regional level. Among the exceptions are works pointing out that devolved nations like Scotland have been affected in distinct ways, often portraying this country as particularly vulnerable due to its trade composition and political divergence from Westminster (Gasiorek et al., 2018; Scottish Government, 2021). Yet, empirical analyses that break these impacts down by region and sector remain scare.

To address this gap, the present study adopts a quantitative methodology grounded in secondary data analysis. Sector-level export data, disaggregated by destination, are sourced from official Scottish Government databases. The temporal scope will span from

2015 to the most recent year available, thereby allowing a comparison of trade patterns before and after the Brexit referendum and its formal implementation. The analysis will be conducted using Stata - the statistical software -, through a set of linear regression models, including difference-in-differences regressions and event study specifications, to assess the average effect of Brexit on trade flows. All models control for sectoral heterogeneity and temporal trends to ensure robust inference. This empirical framework facilitates the isolation of Brexit-specific effects from other macroeconomic variables and cyclical fluctuations.

The contribution of this study lies in its regional specificity and empirical clarity. In contrast to broader UK-wide assessments, this dissertation focuses exclusively on Scotland, providing disaggregated insights that can better inform devolved economic governance. Furthermore, by taking a closer look at the Brexit shock through measurable trade data and a rigorous econometric method, the research provides a clearer understanding of how Brexit has reshaped Scotland's economic configuration. This approach distinguishes the study from purely theoretical discussions or descriptive reports.

The structure of this dissertation is organised as follows. Chapter 2 surveys the key theoretical and empirical literature relevant to Brexit, international trade, and regional economic integration, with a particular emphasis on Scotland's positioning within the broader UK-EU relationship. Subsequently, Chapter 3 outlines the methodological design adopted, including the selection of data sources, the construction of variables, and econometric strategy employed. Chapter 4 presents the empirical results and offers a critical discussion in light of the literature reviewed. Finally, Chapter 5 offers concluding remarks, summarising the main insights, reflections on policy implications, and proposing avenues for further inquiry.

2. LITERATURE REVIEW

2.1. The Economic Logic of Regional Trade Integration

To begin unpacking the outcomes of Brexit, it is first necessary to understand the economic logic underpinning regional trade integration. Before assessing what has been lost, we must grasp what such frameworks are designed to deliver – in terms of efficiency, market access, and economic interdependence. This foundation offers a clearer way to understand what economic disintegration means, particularly in light of the UK's decision to leave the European Union.

2.1.1. Evidence from European Integration and Brexit

A substantial body of empirical research confirms the benefits of regional trade integration, as well as the costs of disintegration. Deep integration in Europe – through the customs union and single market – has greatly increased trade among member states (Baldiwn & Wyplosz, 2020), which in turn has supported higher incomes. For example, ex post analyses using the gravity model find that EU membership dramatically boosts trade flows. One study realized by Baier and Bergstrand (2007) estimated that after 10-15 years, EU membership had increased members' trade by roughly 127%-146% (i.e. more than doubled it), far exceeding the trade growth seen in shallower arrangements. By comparison, joining a mere free trade area (like EFTA) raised trade by only 35% (Magee, 2008). These findings underscore how the EU's deeper integration - including not just zero tariffs but also removal of non-tariff barriers via common standards and regulations - produces especially large gains in internal trade.

Increased intra-EU trade has translated into higher GDP for members; for instance, studies attribute a few percentage points of added GDP to the single market's trade liberalization in several countries. In brief, regional integration in Europe has been a powerful engine of trade creation, allowing firms to scale up across the unified market and consumers to access a wider array of goods at lower prices.

By the same logic, reversing integration should impose significant economic costs, and early evidence from Brexit bears this out. The United Kingdom's departure from the EU – particularly leaving the single market and customs union at the end of 2020 –

reintroduced an array of non-tariff barriers on UK-EU commerce (customs paperwork, regulatory checks, etc, that firms need to fill to import/export to EU), and this has had a measurable negative impact on trade.

To summarise, both classical and modern economic theories argue that removing barriers to regional trade allows countries to specialize, realise economies of scale, and participate in efficient supply chains – yielding greater trade and welfare for all members. European integration has exemplified these gains in practice, with the single market vastly expanding intra-EU trade and output. Conversely, the act of disintegration (as in Brexit) illustrates the opposite: re-imposing barriers leads to reduce trade, lost efficiency, and economic costs for the affected region. These insights set the stage for analysing Scotland's post-Brexit trade performance, by framing expectations that undoing integration tends to diminish trade flows and economic opportunities, especially with one's closest trading partners. The theorical and empirical consensus is that deeper integration is generally beneficial, and undoing it – as Scotland's experience is beginning to show – comes at a real price in terms of forgone trade and growth.

2.2 The Brexit Shock: From Expectations to Realised Economic Impacts

Prior to and immediately following 2016 referendum, a range of studies – from government bodies to academic institutes – attempted to forecast Brexit's long-run economic effects. A broad consensus emerged that leaving the EU would dampen the UK's GDP growth and trade, with only a few outliers predicting net benefits.

For example, Dhingra et al. (2016) of LSE's Centre for Economic Performance (CEP) projected that reduced trade integration under Brexit would cut real income by about 1,0-2,1% in a static trade model (equivalent to £850-£1,700 per household), rising to as much as 6.3-9.5% including long-run dynamic losses associated with reduced innovations and investment.

The HM Treasury (2016) offered similar projections, forecasting that, even with a free trade agreement, the UK's GDP in 2030 would be around 6% smaller than if the country had remained in the EU. These expectations were echoed by the OECD (2016), which estimate a 4-5% fall in real GDP due to higher trade costs and weaker investment

flows, and by Bruno et al (2016), who projected a 22% decline in foreign direct investment in the decade following Brexit.

The Institute for Government (2018) noted that nearly all pre-referendum studies predicted a long-tern GDP decline from Brexit, with only one outlier projecting significant gains (the "Economists of Free Trade").

In short, the prevailing expectations was that Brexit would make the UK poorer than staying in the EU, with the magnitude of the hit varying by study depending on assumptions about trade barriers, productivity and migration. Overall, the weight of evidence circa 2016-2018 indicated that Brexit would be a net drag on the UK economy, primarily via higher trade costs reducing export competitiveness and productivity, as well as lower investment, while any gains (such as saved EU budget contributions or new free-trade deals abroad) were expected to be comparatively minor.

In the period immediately following the 2016 referendum, the UK began to experience the economic effects of the vote itself, even before any policy changes were enacted. The pound depreciated sharply, leading to a surge in import prices and consumer inflation. According to Dhingra and Sampson (2022), this shock to real incomes was accompanied by a noticeable slowdown in investment. Bloom et al (2019), drawing on survey data from the Bank of England, found that by 2019, business investment had accumulated a shortfall around 11% relative to a no-Brexit baseline. Moreover, productivity growth weakened, with firm-level data indicating a loss of between 2% and 5% over the same period – an effect particularly evident among firm with higher exposure to EU markets. Much of this decline is attributed not to tariffs or customs barriers (which had not yet materialised), but to prolonged uncertainty, delayed decision-making, and the reallocation of resources towards Brexit contingency planning.

Despite the economic turbulence between 2016 and 2020, trade volumes between the UK and the EU remained relatively stable during the transition period, as the UK retained full access to the single market. Sampson (2022) notes that no significant trade reorientation occurred before the end of 2020, as firms were still operating under the same conditions. However, this changed markedly with the full implementation of Brexit in January 2021.

The impact has been disproportionately borne by small and medium-sized firms, many of which lacked the capacity to absorb the administrative burden introduced by the Trade and Cooperation Agreement. According to Sampson et al. (2024), around 14% of UK firms that previously exported to the EU ceased doing so after Brexit came into force. A.P. Fernandes and L.A. Winters (2021) find that the Brexit vote significantly reduced both the probability of entry into and continuation in the UK market, with less productive firms more likely to exit or cut quantities, while more productive and import-intensive firms were better positioned to adjust prices and sustain export volumes.

At the macroeconomic level, Brexit has reduced the UK's overall trade openness and global integration. Comparative data from the Office for Budget Responsibility (2024) shows that while other G7 economies recovered and exceeded their pre-pandemic trade-to-GDP levels, the UK has lagged behind. By 2023, UK trade intensity remained around 1,7% below its 2019 level, whereas its G7 peers had surpassed that benchmark. The OBR estimates that, as of 2023, total UK trade is roughly 12% lower than it would have been if the UK remained in the EU. This underperformance has wider implications: it feeds directly into productivity stagnation and slower GDP growth.

Doppelgänger analyses, such as those conducted by Springford (2022), place the UK's GDP approximately 5% below where it would likely have been without Brexit. Gross investment is estimated to be over 10% lower, reinforcing the link between reduced trade, weaker investor confidence, and declining productivity.

While the most dramatic post-referendum forecasts did not materialise in full, and firms have shown some capacity to adapt, the accumulation evidence suggests that the economic cost of Brexit is real, persistent, and broadly aligned with the more caution projections offered in 2016.

2.3. Scotland's Trade Profile Before Brexit (2015-2019)

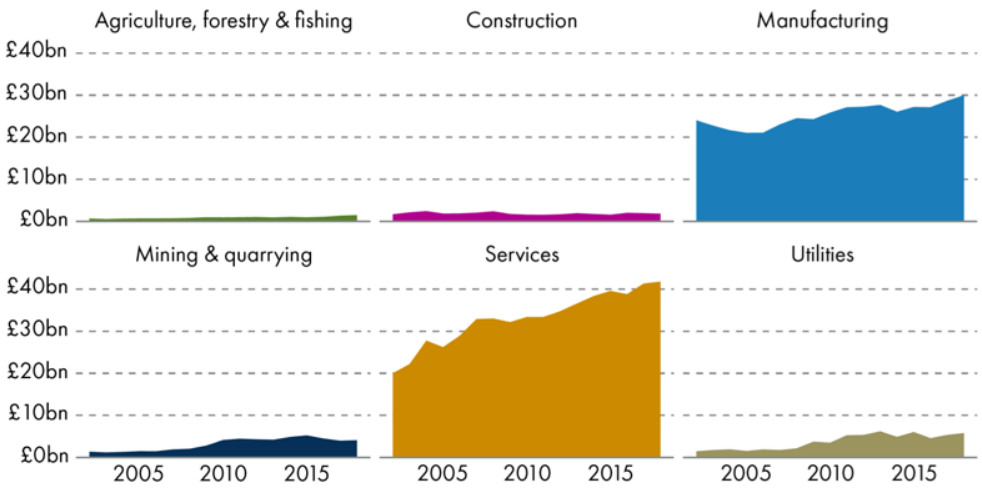
2.3.1. Sectoral Composition of Scottish Exports

In the years immediately before Brexit (2015-2019), Scotland's export economy was dominated by a few key sectors in both goods and services.

The leading goods export was food and drink, particularly Scotch whisky, which generated approximately £5.4 billion in 2019 (HMRC, 2020). The broader food and drink sector reached around £10.1 billion in 2018 (Scottish Government, 2019a). The energy sector, especially oil and gas products, also played a critical role, with petroleum exports valued at around £8.5 billion in 2017 (SPICe, 2018a).

In the services domain, exports accounted for just over half of Scotland's total exports by 2018 - £43 billion out of a total £87 billion (Scottish Government, 2019b). The largest contributor was financial and insurance services, valued at approximately £12.7 billion in 2018 (SPICe, 2018b), followed by professional, scientific, and technical services, which had also led in 2015 (Scottish Government, 2016).

FIGURE 1: Value of exports from Scotland by broad sector – 2002 to 2018



Source: Exports Statistic Scotland 2018

An analysis of sectoral export values between 2002 and 2015 reveals:

- **Utilities** experienced the highest proportional growth in exports, rising by 296% (£4.3 billion);
- **Services** exports increased by £21.8 billion over the same period;
- In contrast, **construction** recorded the smallest growth at just 9%;

- Looking at the most recent year (2017-2018), **manufacturing** saw the highest absolute increase in export value (£1.3 billion), whereas **agriculture**, **forestry** and **fishing** registered the largest proportional rise (10.5%). **Construction**, however, declined by 5.6% in that year.

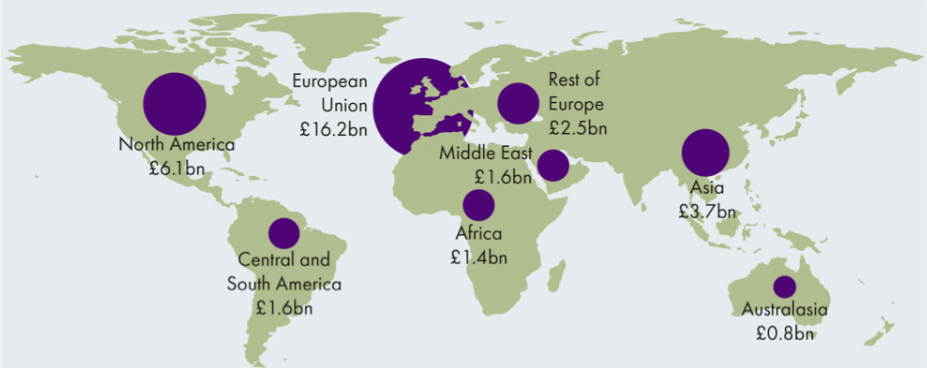
A critical distinction was geographical: 68% of services exports were directed to the rest of the UK, while manufacturing goods were predominantly exported abroad (Scottish Government, 2019b). This unique structural pattern – sectoral strength in globally competitive goods and reliance on intra-UK service trade – helps justify the separate analysis of Scotland's trade profile from the UK's, considering this specializations differ from the UK's overall export profile.

In 2019, the Scottish Government launched the "Scotland: A Trading Nation" strategy in response to the fact that exports accounted for only around 20% of Scotland's GDP – a figure notably lower than that of comparable European economies (Scottish Government, 2019c). The strategy emphasized the need to strengthen international export performance and identified key sectors – such as premium food and drink, life sciences, energy, and financial services - as areas where Scotland holds a competitive advantage.

2.3.2. Key Export Destinations and Dependence on the EU Market

Scotland's geographic trade pattern has long been dominated by its integration with the rest of the United Kingdom (rUK). In the late 2010s, the rUK was by far Scotland's largest trading partner, eclipsing any overseas market. In 2019, exports to the rUK totalled approximately £52 billion, compared to £16.4 billion to the EU and £18.7 billion to non-EU countries (Scottish Government, 2019b). In 2017, trade with the rUK made up 61% of all Scottish exports, while only 15% went to the EU (Sampson et al., 2018), highlighting Scotland's deep economic integration within the UK internal market.

FIGURE 2: Value of international exports by region - 2018

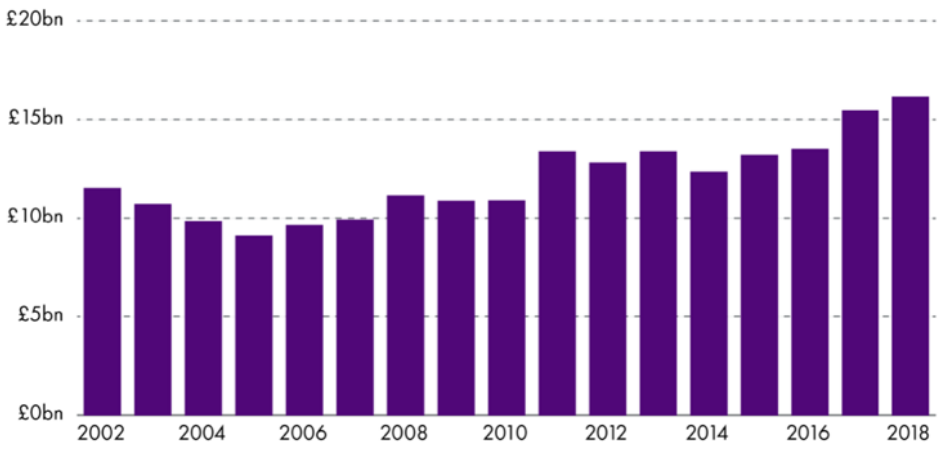


Source: Exports Statistic Scotland 2018

Among international destinations, Scotland's exports were nearly evenly divided between the EU and non-EU countries. In 2018, 48% of international exports went to the EU, with remaining 52% going to non-EU markets (Scottish Government, 2019b). This balance, however, is slightly less EU-dependent than the UK average, where 45% of exports went to the EU (House of Commons Library, 2018).

The United States stood out as Scotland's largest non-EU market, accounting for roughly 16% of international exports in 2015, followed by Netherlands, France, and Germany (Scottish Government, 2016). The Netherlands' high ranking is partially explained by the "Rotterdam effect" - the tendency for UK exports shipped through Dutch ports to be recorded as Dutch-bound, even if their final destination is elsewhere (SPICe, 2018a).

FIGURE 3: Value of exports to the EU – 2002 to 2018



Source: Exports Statistic Scotland 2018

As shown in Figure 3, between 2002 and 2018, Scottish exports to the EU rose by £4.6 billion (40%). After an initial decline of £2.4 billion between 2002 and 2004 (-21%), exports rebounded strongly, growing by 47% between 2005 and 2011. By 2018, they had nearly doubled (an 80% increase) from the 2005 low point (SPICe, 2018).

As noted earlier, Scotland's trade structure exhibits clear regional dependencies, particularly in the distribution of goods exports. Within this framework, seafood stands out: in 2017, 77% of Scotland's seafood exports went to the EU, making the sector particularly exposed to changes in access to the single market (Transport Scotland, 2018). Moreover, Scotland maintains a trade surplus in fish with the EU, in contrast to the overall UK position as net importer.

Similarly, beverages – notably Scotch whiskey – are heavily reliant on EU markets. These industries hold greater relative importance for Scotland than for UK as a whole, underscoring Scotland's distinct export structure.

In summary, while the EU represents crucial market for specific high-value Scottish exports, Scotland's overall trade is heavily reliant on the UK internal market. The country's external trade patterns reflect a balance between EU and global markets, reinforcing the rationale for treating Scotland's trade dynamics as analytically distinct from the wider UK context.

2.4. Empirical Evidence on Regional and Sectoral Trade: Impacts of Brexit

2.4.1. Post-Brexit Trade Performance in Scotland: Exports and Imports (2020 - present)

Empirical data show that Scotland's trade openness had eroded since Brexit. In 2021 – the first year under the new EU-UK trade arrangements – Scotland's total exports (goods and services) were about £80 billion, a 2.6% decline in value from 2019 (Scottish Government, 2023). This average conceals a significant fall in exports to the EU, which were around 11-12% lower in 2021 compared to 2019 (a drop of roughly £2 billion).

TABLE I

EXPORTS BY DESTINATION (RUK, EU, NON-EU), 2019-2021 (£ MILLION)

Destination	2019	2020	2021	2019–2021% Change
Rest of the UK (RUK)	46 695	42 325	48 585	4,0
International: Total	35 360	29 475	31 305	-11,5
International: EU	16 950	14 890	14 970	-11,7
International: Non-EU	18 390	14 585	16 335	-11,2
Total (RUK + International)	82 055	71 800	79 890	-2,6

Source: Export Statistic Scotland (2021).

By contrast, exports to non-EU countries also fell by ~11% over the same period, and exports to the rest of the UK (Scotland's largest trading partner) actually rose by about 4%. These patterns align with pre-Brexit expectations that new trade barriers would chiefly dampen EU-bond trade while internal UK trade remained frictionless. Indeed, Scotland has long exported more to the rest of the UK than to all international markets combined, so the post-Brexit decline in EU trade was only partially offset by modest gains in domestic (UK) trade. As a result, the export-to-GDP ratio for Scotland slipped from roughly 21% in 2019 to 18.6% in 2021 (Scottish Government, 2023), indicating a step back in internationalization.

More recent statistics suggest some rebound in nominal export values by 2022-2023, aided by the global recovery from COVID-19 and high commodity prices. For example, good exports to EU surged by 28-29% in 2022 (Scottish Government, 2023), driven in

part by strong energy exports (oil and gas) and a post-pandemic recovery in demand. Despite this uptick, which will be analysed in the sections that follow, analysts note that Scottish trade with the EU remains below its pre-2019 trend once inflation and broader pandemic effects are accounted for (Ward & Webb, 2024). The Office for Budget Responsibility estimates UK trade intensity is around 15% lower post-Brexit than it would have been otherwise (OBR, 2023).

Scotland's export performance since 2020 has been weaker than prior years and has lagged that of many comparable small economies, reinforcing evidence of Brexit-induced drag on trade (Duparc-Portier & Figus, 2022).

Although export performance has understandably drawn the most focus in post-Brexit analyses, it is also important to consider how Scotland's imports from the EU have been affected. These new barriers have impacted sectors dependent on EU inputs and are a key part of the broader adjustment in Scotland's trade structure.

By the fourth quarter (Q4) of 2021, UK goods imports from the bloc were still about 18% below their 2019 level, a significantly larger drop than the decline in UK exports to the EU (OBR, 2024). This weakness in EU imports was partly offset by substitution toward non-EU suppliers – UK imports from non-EU countries were up by around 10% over the same period (OBR, 2024).

Scotland's overall goods imports did rebound in 2021 after the pandemic shock – rising 24% in value from 2020 and ending about 4.8% higher than in 2019 – but analysts attributed this modest net growth to Brexit-related distortions such as pre-emptive stockpiling and supply-chain adjustments (Scottish Government, 2023a). Notably, the EU's share of total UK imports fell from roughly half in the 2010-2020 period to around 47% in 2021-2022 (Ward & Webb, 2024), indicating a relative shift away from EU sourcing after Brexit. Survey evidence supports this trend: for example, around 17% of German firms stopped selling into the UK market following Brexit, citing increased complexity and costs (Ward & Webb, 2024). Similarly, Portuguese firms also reduced their export values to the UK by approximately 6.6% following the Brexit referendum, with the decline largely driven by lower quantities and adjusted prices (A.P. Fernandes & L.A. Winters, 2021).

Recent data show a partial recovery in the value of Scotland's EU imports, with the Scottish Government reporting a rise of over 50% in 2022 compared to 2021 (to approximately £11.8 billion), driven by post-Covid trade resumption and high energy prices (Scottish Government, 2023a). Even so, overall EU import levels have not fully caught up with the trajectory expected had the UK remained in the EU. One recent econometric study estimates that UK goods imports from the EU were around 32% lower between 2021 and 2023 than they would have been in a no-Brexit scenario (OBR, 2024).

2.4.2. Sectoral Export Impacts and Resilience

The impact of Brexit on Scotland's trade has varied markedly across sectors.

Early post-Brexit data (up to 2021) revealed significant challenges for certain industries, particularly agriculture, food, and fisheries. According to Export Statistics Scotland, between 2019 and 2021, exports of agriculture and fishing to the EU fell by 11.5% between 2019 and 2021, with many businesses citing customs delays and increased compliance costs (Scottish Government, 2023). Perishable seafood products were among the most vulnerable. Parliamentary evidence indicates that 42% of manufacturing exporters experienced new administrative burdens, and more than half reported higher transportation costs in 2021 (Scottish Parliament, 2021; Food and Drink Federation, 2022).

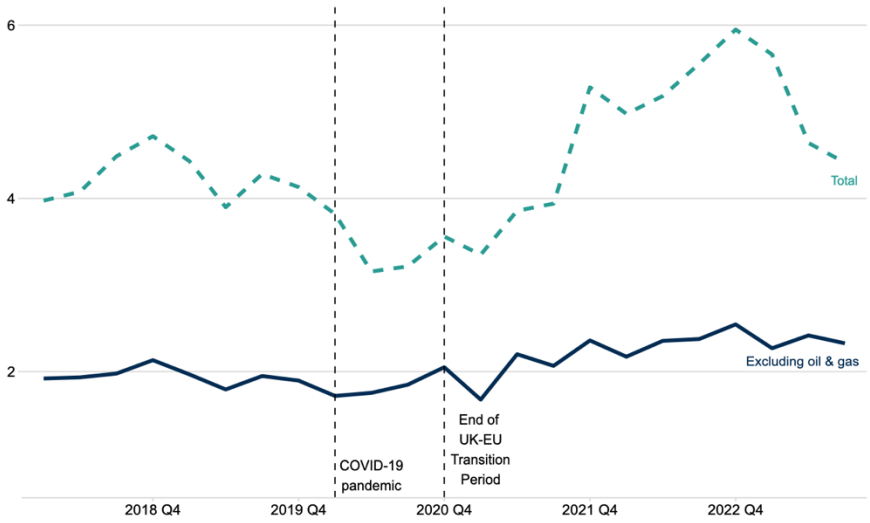
However, more recent data offer a more comprehensive view. Drawing on the Scottish Government's Q3 2023 report[1], a direct comparison between 2019 and 2023 reveals a more nuanced outcome. While certain sectors remain exposed to trade friction, many of Scotland's top exports to the EU have grown in nominal value. Over this four-year interval, petroleum oil exports stayed steady at around £9.0 billion, drink exports rose from £1.4 billion to £1.7billion (+22%). Additionally, increases were also observed in the following categories: power generation machinery (+156.9%), general industrial machinery (+44.2%), and transport equipment (321.2%). On the other hand, sectors like chemical products and fish and shellfish saw more modest or stagnant performance.

[1] Data labelled as "Q3 2023" refer to the 12-month period ending in September 2023, i.e., from October 2022 to September 2023, as reported by the Scottish Government in quarterly trade bulletins.

Despite these increases, not all sectors experienced consistent growth. Natural gas exports to the EU were worth 0.5£ billion in 2019, jumped sharply to 3.4£ billion in 2022 before easing to 2.0£ billion in 2023 – still over three times higher than pre-Brexit levels, representing a 325.9% increase overall (Scottish Government, 2023). This surge can be largely attributed to increased European demand for alternative energy sources following the reduction in imports of Russian gas after the war in Ukraine broke out. As EU member states sought new suppliers, UK-including Scottish-gas became a key substitute, driving a post-Brexit export spike. While volumes fell slightly after 2022, overall sectoral performance since Brexit has been uneven, with some industries adapting successfully, while other struggled with regulatory barriers or declining Europe demand.

This updated figure bellow (Fig. 4) provide a more complete view of the post-Brexit adjustment. While initial analysis based on 2021 data painted a largely negative picture, the 2023 statistics suggest that several of Scotland's core export sectors have shown resilience or even expansion.

FIGURE 4: Evolution of Scottish Goods Exports in Q4, 2018-2022



Source: HMRC RTS, Q3 2023

Such evidence strengthens the case for sector-specific policy responses rather than a one-size-fits-all approach to post-Brexit trade strategy. Industries with rising exports may benefit from targeted support to enter new EU niches, while more exposed sectors may require investment in compliance capacity or diversification assistance.

This divergence in sectoral performance also echoes broader macroeconomic patterns.

A range of studies and official evaluations converge on the view that Brexit has had negative macroeconomic effect on Scotland, primarily through the trade channel. According to the Scottish Government's Chief Economist, the introduction of new trade barriers under the EU-UK Trade and Cooperation Agreement has led to a loss of approximately £3-4 billion in GDP each year, compared to a no-Brexit scenario in. This is equivalent to a long-run contraction of around 6% (Scottish Government, 2023).

Particularly exposed sectors reliant on EU inputs, such as chemicals and pharmaceuticals have faced increased costs due to regulatory divergence and supply chain disruptions, while food and drink exporters continue to report notable friction in accessing EU markets (Scottish Government, 2023; Scottish Parliament, 2022). These impacts reflect the structural difficulty of maintaining trade intensity under conditions of reduced market access.

Although some businesses have responded by diversifying to non-EU markets or adapting to new UK frameworks, aggregate growth remains weaker than projected under continued EU membership. Fraser of Allander Institute modelling, published prior to Brexit, had anticipated a long-run 5% GDP loss under a basic trade agreement – a forecast that now appears broadly consistent with post-2020 performance (Duparc-Portier & Figus, 2022).

In sum, the available macroeconomic evidence supports the sector-level trends: while some industries have adjusted or expanded post-Brexit, the broader economic costs remains both tangible and ongoing.

3. METHODOLOGY

3.1. Data and Variables

This dissertation follows a quantitative research strategy aimed at empirically assessing the effects of Brexit on Scotland's trade with the European Union. Given the impossibility of observing a counterfactual scenario-i.e., how Scottish exports would have evolved had Brexit not occurred – a quasi-experimental approach is employed.

The database underpinning this analysis consists of annual export values by sector and destination, compiled from official Scottish Government sources. It covers the years prior to and following the UK's withdrawal from the EU, beginning in 2015 and extending through 2024, depending on data availability.

The export data is structured by destination region – namely, the EU and the RoW – and further disaggregated into economic sectors such as agro-food, chemicals, raw materials, and other manufacturing categories. This structure allows for sectoral-level analysis and controls for variation in trade performance that may be inherent to certain industries. Only goods exports are included, as service data is typically harder to disaggregate consistently and is subject to greater volatility in reporting.

The main outcome variable is the value of Scottish exports for a given sector, year, and destination region. Key explanatory variables include a binary post-Brexit indicator (equal to 1 for years 2021 onward and 0 otherwise); a dummy variable for EU destinations (equals 1 if the destination is in the EU and 0 for non-EU destinations), and interaction terms between the two. The model also incorporates fixed effects for year and sector, to account for time-specific global shocks and sectoral structural characteristics, respectively.

These data characteristics facilitate the application of a difference-in-differences (DiD) framework, as well as its extensions. Specifically, they support the comparison of export trends between EU and RoW destinations and allow for the construction of sector – and year -specific analyses. However, full methodological implementation is elaborated in the following section.

3.2. Empirical Model

The primary identification strategy is based on a difference-in-differences (DiD) model, capturing the average treatment effect of Brexit by comparing trends between EU-bound and RoW-bound exports, before and after 2021. The treatment group comprises exports to the EU, while exports to the RoW serve as a control. The assumption is that, in the absence of Brexit, exports to both regions would have followed parallel trends. Any divergence post-Brexit is therefore interpreted as the causal impact of the policy implementation.

Equation 1: Baseline DiD specification

$$Exports_{ist} = \alpha + \beta_1 EU_i + \beta_2 Post_t + \beta_3 (EU_i \times Post_t) + \gamma_s + \delta_t + \epsilon_{ist}$$

Where:

- $Exports_{ist}$, is the value of exports in sector s, to destination i, in year t;
- EU_i equals 1 if the destination is within the EU;
- $Post_t$ is 1 for years after the Brexit transition (i.e., post-2021);
- γ_s and δ_t are sector and year fixed effects;
- ϵ_{ist} is the error term.

The coefficient of interest is β_3, which captures the interaction between EU destinations and the post-Brexit period. A positive or negative and statistically significant β_3 would suggest that Brexit caused a shift in export volumes to EU countries, relative to exports to the RoW. All regressions are estimated using robust standard errors to account for heteroskedasticity.

To enhance robustness, several extensions of the baseline DiD model were implemented. In addition to estimating the main regressions using disaggregated panel data at the region-sector-year level, separate analyses were also conducted with exports aggregated at the regional level. This dual approach – using both aggregated and disaggregated export data – allowed for a clearer distinction between overall effects on Scottish exports to the EU and any underlying variation masked at the sectoral level.

Recognizing the impact of Brexit could differ substantially across industries, the difference-in-differences framework was applied separately to each major sector, such as agro-food, chemicals, manufacturing and raw materials. This enabled the analysis to

capture sector-specific responses to post-Brexit trade barriers and regulatory adjustments, providing a more nuanced understanding of the heterogeneity effect.

To complement the full-sample analysis covering 2015-2024, additional regressions were performed on a restricted time window (2017-2024). This was motivated both by the availability and reliability of recent data, and by the need to focus on export dynamics more closely linked to the Brexit event, while controlling for potential confounding influences such as the COVID-19 pandemic.

Furthermore, to capture the timing and persistence of Brexit's impact over time, a dynamic event study specification was implemented. Event studies were estimated with two baselines – 2015 and 2020 – allowing for an assessment of whether the results are sensitive to the choice of reference year. This method allowed a year-by-year look at the effects, and also helped check if the parallel trends assumption was met by looking at the years before Brexit.

As an additional validity check, a placebo DiD regression was estimated by artificially assigning the "treatment" to an earlier period – using 2018 as the fictitious intervention year. If the identification strategy is sound, no statistically significant effect should be detected for this placebo interaction. The results from this exercise help rule out the possibility that any observed treatment effect is driven by pre-existing trends or spurious correlations, thus strengthening the credibility of the main findings.

Finally, to complement the formal regression analysis, visual inspection of export trajectories was performed. Export values were plotted by year for each sector, separately for EU and the RoW destinations. This figure served to illustrate underlying trends, support the assessment of the parallel trends assumption, and highlighting the role of global shocks – such as pandemic or inflation – in shaping trade patters alongside the policy change itself.

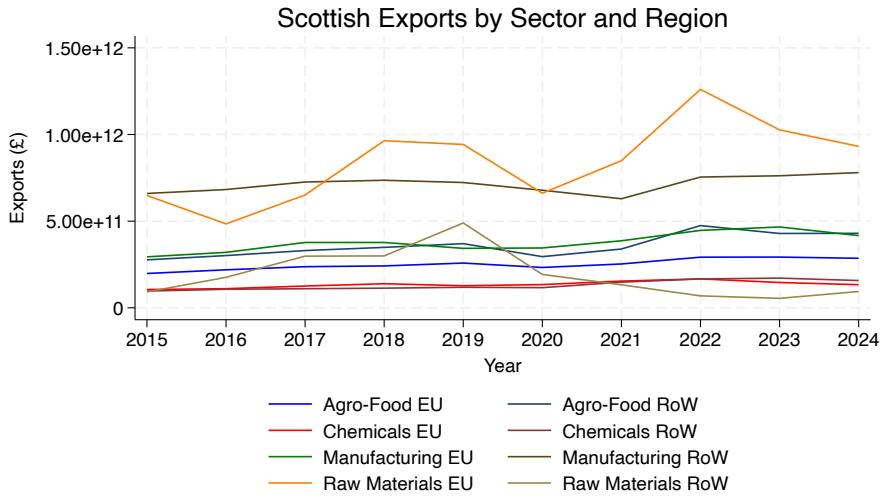
Altogether, this combination of econometric strategies ensure that the analysis is both robust and nuanced, offering a comprehensive evaluation of Brexit's trade implications across sectors and over time.

4. EMPIRICAL ANALYSIS AND RESULTS

This chapter presents the empirical findings derived from the application of the difference-in-differences (DiD) methodology, event study analysis, placebo testing, and sector-specific regressions. Each approach provides complementary insights into the trade impact of Brexit on Scottish exports to EU countries.

Before presenting the econometric results, it is instructive to examine the evolution of Scottish exports to the EU and the RoW across key sectors over the study period. Figure 5 displays the annual export values by sector and destination from 2015 to 2024. This visualization provides context for subsequent analyses by highlighting general trends, potential shocks, and sectoral heterogeneity in export performance.

FIGURE 5: Evolution of Scottish Exports by Sector and Destination (2015-2024)



Source: own elaboration based on Scottish Government data.

4.1. Difference-in-Differences Results Analysis

The analysis of the impact of Brexit on Scottish exports to the European Union reveals a striking contrast between results obtained with aggregated data and those using a more disaggregated approach. When total exports are considered – aggregated by region and year, both the full sample (2015-2024) and the restricted sample (2017-2024) – the DiD models consistently point to a positive and statistically significant effect of Brexit on Scotland's exports to the EU (Appendix A and E). In broader sample, the interaction

coefficient "$eu\#post$" is estimated at 0.270 ($p \approx 0.03$), and in the more focused period it remains similar at 0.257 ($p \approx 0.01$). These results suggest that, on average, Brexit was associated with a relative increase of around 27% in Scottish exports to the EU after 2021 – a finding that holds across specifications and appears robust.

However, when the data are examined at a more granular level – using a panel of region, sector, and year – the picture changes considerably as seen on Appendix B and D. Here the "$eu\#post$" coefficient remains positive (0.325 for the full sample and 0.354 for the restricted sample), but it is never statistically significant (in all models, $p > 0.10$). This implies that, at a more disaggregated level, there is no strong evidence to confirm a Brexit effect on Scottish exports to the EU, regardless of whether year or sector fixed effects are included. The divergence between the aggregated and disaggregated results raises the possibility that the positive effect identified in the pooled data is in fact driven by specific sectors or regions, rather than being a general pattern.

Turning to the sectoral analysis (Appendix C), the results reveal considerable heterogeneity in Brexit's impact across different branches of Scottish exports. In the agro-food sector, the estimated coefficient is negative but far from significant ($-0.0672,\ p > 0.10$), indicating no robust evidence of any Brexit-related effect. The chemicals sector, by contrast, displays a negative and statistically significant result ($-0.183, p < 0.05$), suggesting that exports of chemicals to the EU declined meaningfully in the wake of Brexit. In manufacturing, the effect reverses: the coefficient is positive and significant at the 10% level ($0.186,\ p < 0.10$), pointing to a modest but detectable increase in post-Brexit exports to the EU for this sector. The most striking result, however, is observed in the raw materials sector, where the Brexit effect is both large and highly statistically significant ($1.362,\ p < 0.01$). This suggests a substantial surge in exports to the EU, likely reflecting broader shifts in supply chains and global demand, possibly accentuated by post-pandemic adjustments and geopolitical events affecting energy and commodities.

Taken together, these results show that aggregate increase in Scottish exports to the EU after Brexit is not evenly distributed across the economy. The overall positive effect is largely attributable to exceptional growth in raw materials and, to a lesser extent, manufacturing, while chemicals sector has experienced clear difficulties and the agro-food sector has been no discernible change. These findings highlight the importance of

accounting for sectoral differences when assessing the economic consequences of major policy shifts such as Brexit.

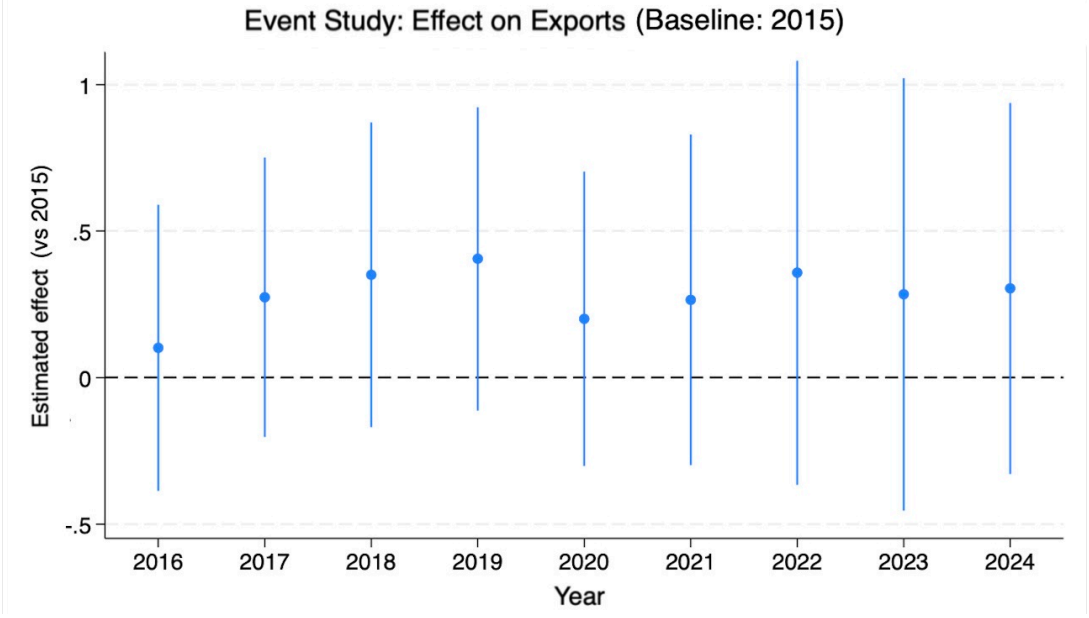
4.2. Event Study Analysis

To further investigate the temporal dynamics of Brexit's impact on Scottish exports to the EU, an event study specification was estimated with two alternative baselines: 2015 and 2020. The use of multiple baselines serves as a robustness check, allowing for the assessment of whether the choice of reference year influences the results. Taking 2015 as the baseline provides a comparison against the pre-referendum, pre-Brexit "normal" year, while using 2020 as the baseline centers the analysis directly on the period immediately surrounding the UK's formal exit from the EU.

The results of these event study regressions are presented in Appendix F, and the corresponding graphical representations can be found in Figures 6 and 7.

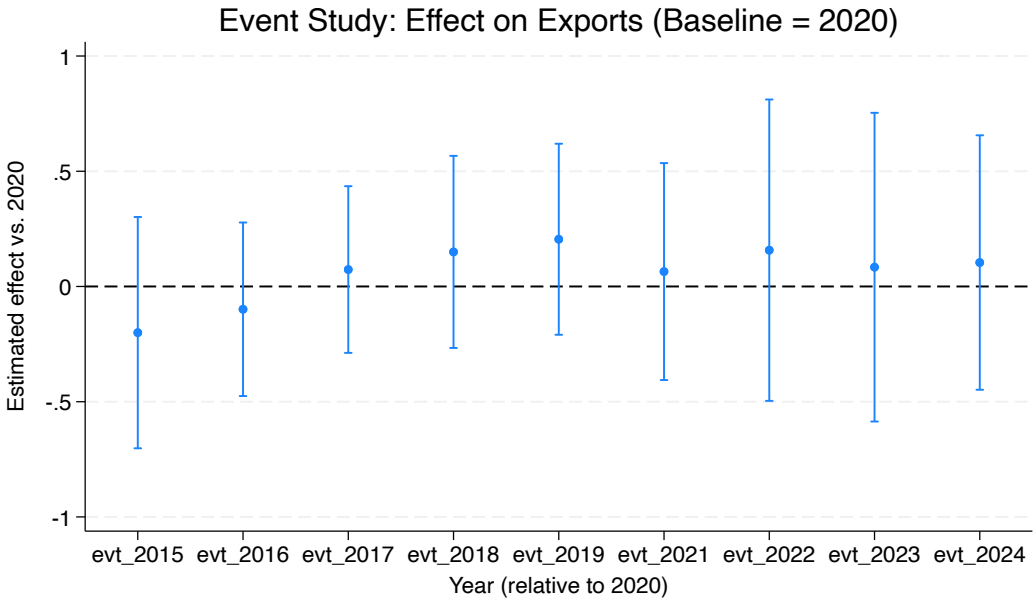
In both event study specifications – whether using 2015 or 2020 as the baseline – the estimated year-by-year coefficients remains stable and statistically insignificant throughout the entire period. This applies to both the pre- and post-Brexit years, with no noticeable shifts in export trends relative to the chosen base year. The wide confidence intervals, consistently overlapping zero, further indicate the absence of any statistically meaningful impact of Brexit on Scottish exports during this timeframe.

FIGURE 6: Event Study – Estimated Brexit Impact on Scottish Exports (Baseline: 2015)



Source: own elaboration based on Scottish Government data.

FIGURE 7: Event Study – Estimated Brexit Impact on Scottish Exports (Baseline: 2020)



Source: own elaboration based on Scottish Government data.

The graphical event study plots in Figure 6 and 7 visually reinforces this conclusion. The figures display a series of point estimated and confidence intervals for each year relative to the baseline. Notably, the estimates for the post-Brexit years (2021-2024) do not exhibit any marked increase or decrease, and the confidence intervals consistently cross zero. This visual evidence is consistent with the regression outputs, and suggest that Brexit did not result in a sharp or persistent shift in Scottish export performance to the EU.

In summary, the event study analysis – regardless of the baseline year – provides no evidence of statistically significant or lasting impact of Brexit, in both cases, the key findings are unchanged. The stability of the coefficients across specifications, the lack of statistically significant effects, and the overlapping confidence intervals int eh graphical analysis all point to the same conclusion.

4.3.Placebo Test

As a robust check, a placebo difference-in-differences regression was estimated by artificially assigning the Brexit treatment to an earlier period (2018 instead of 2021). This approach tests for the presence of spurious or pre-existing differences that could otherwise bias the estimated Brexit effect in the main analysis. If the identification strategy is valid, the interaction term in the placebo regression should not be statistically significant, as no actual treatment occurred during the placebo period.

The results of the placebo regression are reported in Appendix G. The coefficient of interest – corresponding to the interaction between the EU destination and the placebo post-treatment period – is positive but not statistically relevant (0.163 in both model specifications), with a wide confidence interval that includes zero. This finding indicates that, prior to the actual implementation of Brexit, there is no evidence of a differential change in Scottish exports to the EU relative to non-EU destinations.

The lack of statistical significance in the placebo interaction provides support for the validity of the identification strategy used in main DiD and event study analyses. In other words, it suggests that the main results are unlikely to be driven by spurious trends or unobserved factors that predate the Brexit policy change.

4.4. Interpretation in Light of the Literature

The findings of this empirical analysis offer nuanced insights into the impact of Brexit on Scottish exports to the European Union, both in aggregate and across specific sectors. Interpreting these results in the context of the existing literature provides important perspective on their broader significance.

A significant body of prior research has predicted that Brexit would generate substantial trade frictions between UK and the EU, largely caused by the reintroduction of custom barriers, regulatory divergence, and heightened uncertainty (Dhingra et al., 2017; Sampson, 2017). Several studies have found evidence of overall declines in UK-EU trade volumes following the end of the transition period, particularly in goods sector most exposed to non-tariff barriers (Freeman et al. 2022; Office for National Statistics,

2023). However, the extent and distribution of these effects have been found to be heterogenous across regions and industries.

The aggregate results from the present analysis are consistent with recent empirical literature that suggests the effects of Brexit on UK-EU trade, while present, may be less dramatic or immediate than originally feared (Crowley, 2023). The absence of a statistically significant Brexit effect on total Scottish exports to the EU, relative to the RoW, aligns with findings from Lawless et al. (2022), who emphasize the role of global shocks – most notably, the COVID-19 pandemic – in shaping recent trade dynamics. This suggests that, for Scotland as a whole, Brexit has not resulted in a dramatic or uniform contraction in EU-bound exports when controlling for broader international disruptions.

Nonetheless, the sector-specific analysis does reveals important divergences beneath the aggregate trends. The observed decline in chemical's exports to the EU is consistent with the literature emphasizing this sector as particularly vulnerable to post-Brexit trade barriers, due to their high regulatory sensitivity and the prevalence of just-in-time supply chains (Gasiorek & Lawless, 2022; Chen et al. 2018). In contrast, the positive effects observed in manufacturing and especially raw materials exports mirror findings in recent studies that document selective resilience or even gains for certain industries, often linked to shifts in global demand and supply conditions (De Lyon & Dhingra, 2022).

It is also important to situate the results for raw materials within the context of external shocks, such as the war in the Ukraine and the resulting reconfiguration of European energy markets. The surge in Scottish raw materials exports to the EU may therefore reflect both Brexit-induced reorientation and extraordinary geopolitical circumstances – a nuance echoed in the most recent international trade analyses (World Bank, 2023).

Taken together, these findings reinforce the literature's central themes: the effects of Brexit on UK trade are highly heterogeneous, sector-dependent, and shaped by concurrent global events. The Scottish case provides further evidence that aggregate outcomes may mask substantial variation at the sectoral level and that the interpretation of Brexit's trade impact requires careful consideration of overlapping shocks and structural change.

5. CONCLUSION

This dissertation has examined the evolution of Scottish exports to the European Union in the wake of Brexit, applying a robust difference-in-differences approach and exploiting a unique sectoral dataset spanning 2015-2024. By using exports to the rest of the world as a comparator, the study aimed to disentangle the specific effect of Brexit from wider global developments during this period.

The results indicate that Brexit did not lead to a uniform brutal shift in Scotland's export patterns as many people think so. However, a closer look at the individual sectors revealed a much more varied picture. While sectors like chemicals recorded marked decreases in exports to the EU, other – particularly manufacturing and raw materials – registered significant increases. These divergent outcomes highlight the complex reality facing Scottish exporters in the post-Brexit period. The findings also suggest that external factors, such as geopolitical disruptions, can substantially amplify or offset the effect of major policy changes.

From a policy perspective, these results underscore the importance of sector-tailored interventions. Sectors that have experienced declining exports may benefit from targeted support, not only to adapt to new trading conditions but also to seek alternative international markets. Meanwhile, areas of growth should be identified as potential foundations for economic resilience going forward.

Naturally, several limitations should be acknowledged. The relatively limited post-Brexit timeframe restricts the ability to capture longer-term adjustments and emerging trends. The use of aggregated export data, while necessary for analysis, means that underlying dynamics at the firm or product level may not be reflected. In addition, it is important to recognize that global events coinciding with Brexit – most notably the COVID-19 pandemic and the war in Ukraine – could not be entirely disentangled from the effects identified here.

Further research would benefit from longer time series, more granular trade data, and a focus on firm – or product level responses to ongoing regulatory and market changes. Comparative studies involving other UK regions or EU trading partners would also provide valuable additional context.

In conclusion, the response of Scottish exports to Brexit has been far from homogenous, underlining the importance of nuanced and flexible policy measures. Continued monitoring and adaptive policy responses will be key as Scotland's international trade landscape continues to develop.

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APPENDICES

Appendix A. Difference-in-Differences Regressions: Total Log Exports (2015–2024)

Variable	(1)	(2)
eu	0.0217 (0.0915)	0.0217 (0.0404)
post	0.0131 (0.0713)	0.171* (0.0777)
eu#post	0.270** (0.1140)	0.270*** (0.0572)
2016.year	—	0.0122 (0.0867)
2017.year	—	0.187** (0.0608)
2018.year	—	0.305** (0.0799)
2019.year	—	0.0344 (0.0502)
2020.year	—	0.114 (0.0521)
2021.year	—	-0.115* (0.0547)
2022.year	—	0.103 (0.0479)
2023.year	—	0.0289 (0.0575)
_cons	23.35*** (0.0614)	23.29*** (0.0494)
No. Obs.	20	20
R^2	0.479	0.941

Notes:

- Robust standard errors in parentheses.
- ***p < 0.01, **p < 0.05, *p < 0.1
- (1) reg ln_exports eu##post, r
- (2) reg ln_exports eu##post i.year, r
- The dependent variable is the logarithm of total exports by region and year (aggregated exports).

Appendix B. Difference-in-Differences Regressions Results (2015–2024)

Variable	(1)	(2)	(3)	(4)
1.eu	0.0509 (0.2091)	0.0509 (0.2101)	0.0509 (0.1271)	0.0509 (0.142)
1.post	0.2034 (0.267)	0.2109 (0.369)	0.1271 (0.369)	0.142 (0.369)
1.eu#1.post	0.325 (0.349)	0.325 (0.366)	0.325 (0.272)	0.325 (0.285)
3.sector_fe (Chemicals)		-0.822*** (0.0848)	-0.822*** (0.0881)	
3.sector_fe (Manufacturing)		0.551*** (0.122)	0.551*** (0.129)	
4.sector_fe (Raw Materials)		0.166 (0.166)	0.168 (0.168)	
_cons	21.73*** (0.150)	21.51*** (0.314)	21.02*** (0.0990)	21.53*** (0.227)
No. Obs.	80	80	80	80
R^2	0.0296	0.0521	0.493	0.515
Year Fes	Yes	Yes	No	No

Notes:

- Standard errors in parentheses.
- * p < 0.10, ** p < 0.05, *** p < 0.01.
- Dependent variable: ln(exports).
- This table reports the results of DiD regressions using the panel data for region-sector-year observations. The dependent variable is the logarithm of exports (not aggregated). Each column shows a different model specification:
- (1) Basic DiD regression (no fixed effects);
- (2) With year fixed effects;
- (3) With sector fixed effects;
- (4) With both year and sector fixed effects.

Appendix C. Difference-in-Differences Regression Results by Sector (2015–2024)

	(1) Agro-Food	**(2) Chemicals**	**(3) Manufacturing**	**(4) Raw Materials**
1.eu	-0.325***	0.112*	-0.718***	1.134***
	(0.0596)	(0.0547)	(0.0442)	(0.263)
1.post	0.264***	0.378***	0.0399	-1.007***
	(0.0828)	(0.0438)	(0.0514)	(0.304)
1.eu#1.post	-0.0672	-0.183**	0.186*	1.362***
	(0.0971)	(0.0778)	(0.0763)	(0.333)
_cons	21.88***	20.82***	22.67***	21.54***
	(0.0459)	(0.0306)	(0.0186)	(0.240)
No. Obs.	20	20	20	20
R^2	0.832	0.779	0.954	0.869

Notes:

- Standard errors in parentheses.
- p<0.10, ** p<0.05, *** p<0.01

Appendix D. Difference-in-Differences Results (2017–2024)

	(1)	(2)	(3)	(4)
1.eu	0.0219	0.0219	0.0219	0.0219
	(0.243)	(0.255)	(0.139)	(0.144)
1.post	–0.181	–0.146	–0.181	–0.146
	(0.282)	(0.444)	(0.221)	(0.321)
1.eu#1.post	0.354	0.354	0.354	0.354
	(0.375)	(0.394)	(0.284)	(0.296)
2.sector_fe			–0.815**	–0.815**
			(0.102)	(0.107)
3.sector_fe			0.535**	0.535**
			(0.139)	(0.147)
4.sector_fe			0.187	0.187
			(0.253)	(0.265)
_cons	21.88***	21.79***	21.85***	21.82***
	(0.174)	(0.282)	(1.108)	(0.158)
No. Obs.	64	64	64	64
R-sq	0.0324	0.0390	0.483	0.489
Year FEs	No	Yes	No	Yes

Notes:

- Robust standard errors in parentheses.
- $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
- Column (1): Basic DiD regression (no fixed effects)
- Column (2): DiD with year fixed effects
- Column (3): DiD with sector fixed effects
- Column (4): DiD with both year and sector fixed effects

Appendix E. Difference-in-Differences regressions: Total Log Exports (2017–2024)

	(1)	**(2)**
1.eu	0.0347	0.0347
	(0.0829)	(0.0431)
1.post	–0.0584	–0.00960
	(0.0689)	(0.0823)
1.eu#1.post	0.257**	0.257***
	(0.109)	(0.0600)
_cons	23.42***	23.36***
	(0.0578)	(0.0542)
No. Obs.	16	16
R_sq	0.574	0.935
Year FEs	No	Yes

Notes:

- Standard errors in parentheses.
- p<0.10, ** p<0.05, *** p<0.01.
- Column (1): Simple DiD regression.
- Column (2): DiD with year fixed effects.

Appendix F. Event Study – Different Baselines

	(1) Baseline: 2020	(2) Baseline: 2015
evt_2015	–	0
		(.)
evt_2016	–0.099	0.101
	(0.189)	(0.244)
evt_2017	0.073	0.274
	(0.181)	(0.239)
evt_2018	0.150	0.350
	(0.209)	(0.260)
evt_2019	0.205	0.405
	(0.208)	(0.259)
evt_2020	0	0.200
	(.)	(0.251)
evt_2021	0.068	0.265
	(0.236)	(0.282)
evt_2022	0.157	0.358
	(0.328)	(0.363)
evt_2023	0.083	0.284
	(0.336)	(0.370)
evt_2024	0.104	0.304
	(0.277)	(0.317)
sector_fe2	–0.822***	–0.822***
	(0.059)	(0.059)
sector_fe3	0.551***	0.551***
	(0.096)	(0.096)
sector_fe4	0.166	
	(0.242)	

_cons	21.76***
	(0.147)
No. Obs.	80
R_sq	0.489

Notes:

- Standard errors in parentheses.
- ***p<0.01, **p<0.05, *p<0.10.
- Column (1): Baseline is 2015; Column (2): Baseline is 2020.
- The coefficients show the estimated effect on exports relative to the baseline year, controlling for sector fixed effects.

Appendix G. Placebo Test – Difference-in-Differences Regressions (Aggregated Exports, Fictitious Post-2018 Treatment)

	(1)	**(2)**
0.eu		
1.eu	0.0666	0.0666
	(0.297)	(0.297)
0.post_placebo		
1.post_placebo	0.103	0.223
	(0.269)	(0.466)
0.eu#0.post_placebo		
1.eu#1.post_placebo	0.163	0.163
	(0.350)	(0.367)
_cons	21.62***	21.50***
	(0.221)	(0.340)
No. Obs.	80	80
R_sq	0.0308	0.0430
Year Fes	No	Yes

Notes:

- Standard errors in parentheses.
- *** p<0.01, ** p<0.05, * p<0.10
- Column (1) reports results without year fixed effects; column (2) includes year fixed effects.
- Dependent variable: log(exports), data aggregated by region and year.
- This placebo test assumes a fictitious treatment date in 2018 (i.e., the "post" period is years ≥ 2018)