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Brexit and International Road Freight Transport to and from the UK by Polish and Irish Transport Companies

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Abstract:

Purpose: *The aim of this article is to determine whether there has been a significant change in the volume of international road freight transport to and from the United Kingdom carried out by Polish and Irish hauliers after Brexit.*
Design/Methodology/Approach: *A thorough analysis of changes in freight volumes (in thousands of tonnes) was conducted on a quarterly basis – before and after 2021. To determine whether there was a statistically significant difference related to the new economic, legal, and logistical situation resulting from Brexit, data published by the UK Department for Transport were used. The data was coded such that a "1" was assigned to negative change (i.e. crisis) and a "0" to all other cases. To assess the significance of differences between two proportions, a quantitative methodology based on the likelihood ratio and Fisher's exact test were adopted.*
Findings: *In the first quarter of 2021, the transportation of goods from the UK by cross-trade trucks decreased by 52% and 37%, respectively, compared to the first quarter of 2017 for vehicles registered in Poland and Ireland. At the same time, transportation to the UK fell by 32% and 27%, respectively. In the context of negative changes related to Brexit, significant discrepancies were identified in the area of transport by Irish-registered trucks (trucking to and from UK) and cross-trade transport from the UK in the case of Polish-registered trucks and to the UK in the case of Irish carriers.*
Practical Implications: *The results are important for identifying challenges and adjusting transport strategies, particularly in the event of further changes in the terms of trade between the EU and the UK. They are also useful for developing Brexit-related recommendations in the area of transport policy and road transport regulation.*
Originality/Value: *The study's value lies in the use of reliable national statistics combined with the small-sample dependence testing method.*

Keywords: *Cross-border freight transport, Brexit, road haulage regulation, Fisher's test.*

JEL Codes: *F13, R41, C12.*

Paper type: *Research article.*

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1. Introduction

The process of the United Kingdom's withdrawal from the European Union, known as Brexit, was an unprecedented event. It began with a referendum held on 23 June 2016, in which 52% of voting British citizens supported leaving the EU (Makuch, 2017; Sîrbu *et al.,* 2024). As a result, the British government, invoking Article 50 of the Treaty of Lisbon, formally initiated the withdrawal procedure. Prime Minister Theresa May signed the relevant document on 29 March 2017 and submitted it to the European Council, notifying it of the intention to leave the Union (Prus, 2018; Sîrbu *et al.,* 2024).

The negotiations on the terms of Brexit and the future relationship between the United Kingdom and the Union proceeded in stages. The first phase focused on the financial issues and citizens' rights, while the second addressed economic relations (Prus, 2018). The negotiation process was difficult, complex, and generated tensions both in British domestic politics and in relations with the EU.

Consequently, the deadlines were repeatedly modified and several versions of the agreement were proposed before a final compromise was reached (Sîrbu *et al.,* 2024). The negotiations also led to significant political changes, including changes in the office of the Prime Minister of the United Kingdom (Ma'arif, Rahmawati and Sahide, 2023). The withdrawal agreement, signed at the end of 2019, covered such key issues such as citizens' rights, financial obligations, and the Irish border issue, which was one of the most difficult negotiation topics (Bressanelli, Chelotti and Lehmann, 2019).

The EU Member States (EU27) adopted a unified position, which enabled the maintenance of the Union's consistency and negotiating strength (Šimunjak and Caliandro, 2020; Bressanelli, Chelotti, and Lehmann, 2021). The formal withdrawal of the United Kingdom from the EU took place on 31 January 2020, followed by a transition period lasting until 31 December 2020. Upon its conclusion, the United Kingdom also left the EU single market and customs union (Prus, 2018; Sîrbu *et al.,* 2024).

The consequences of Brexit have been far-reaching, extending beyond the political realm to impact both the United Kingdom and the European Union. It is a complex phenomenon with a broad influence on international relations, domestic politics, and economic frameworks, and its effects are particularly evident in areas such as trade, migration, and security (Mărginean, Orăștean, and Sava, 2020; Dassanayake, 2023).

Even in the course of negotiations surrounding the UK's withdrawal from the EU, it was anticipated that leaving the single market would result in difficulties for British exporters, increased tariffs, and a reduction in trade exchange (Prus, 2018). These forecasts have been confirmed in reality, a noticeable decline in trade volumes have been observed after Brexit (Kren and Lawless, 2024).

The consequences of these changes have been especially pronounced in the international transport sector, particularly in countries such as Ireland and Poland (Morchid and O'Mahony, 2019; Kłak, Zadworny, and Madej, 2023).

Previous research has addressed the impact of Brexit on trade volumes, customs procedures, and the broader macroeconomic context; however, there is still a lack of empirical analyses on international road freight transport. In particular, the way Brexit has affected the operations of hauliers from individual EU countries remains insufficiently explored.

The aim of this article is to fill this gap by investigating the correlation between the United Kingdom's withdrawal from the European Union on the volume of international freight transport to and from the United Kingdom conducted by Polish and Irish transport companies. The study analyses changes in transport volumes on a quarterly basis—before and after 1 January 2021, in order to determine whether there has been a statistically significant difference related to the new economic, legal, and logistical conditions arising from Brexit.

The analysis allows the identification of the differentiated impact of Brexit and contributes new findings to the discussion on transport policy and adaptive strategies in post-Brexit conditions.

The study poses the following questions:

(1) Has the withdrawal of the United Kingdom from the European Union resulted in a statistically significant decrease in the volume of international freight transport to and from the United Kingdom by carriers from Poland and Ireland compared to the pre-Brexit period?

(2) Does the change in transport volumes after Brexit differ between Polish and Irish hauliers in terms of scale?

The study adopted an approach that treats information on decreases and increases in transport volumes as a qualitative variable, which can be transformed into a quantitative variable taking two values (0 and 1). In the following sections of the article, the term 'value 1' is used to denote an event characterised by unfavourable changes in the volume of goods transported, as well as its percentage change. To determine the relationship between Brexit and freight transport, a quantitative methodology based on the likelihood ratio and Fisher's exact test was used.

2. Literature Review

2.1 International Trade After Brexit

The process of the United Kingdom's withdrawal from the European Union has

become one of the most significant political and economic events of recent years, affecting many sectors of the European economy. The changes affecting international road transport have resulted from both shifts in trade volumes between Poland and the United Kingdom as well as alterations in transport regulations themselves.

The literature offers numerous analyses that highlight substantial disruptions in the trade between the United Kingdom and EU countries following Brexit. Research indicates that exports from the United Kingdom to the EU have decreased by approximately 16%, while deliveries from the Union to the United Kingdom have dropped by 24%. In particular, a sharp decline in trade volumes has been recorded since the UK left the single market and customs union on 1 January 2021 (Kren and Lawless, 2024).

Exports from Poland to the United Kingdom fell by 28.8% between 2019 and 2021, while imports decreased by as much as 59.7%. Sectors such as food, electronics, vehicles, and clothing were particularly severely affected (Ambroziak, 2022). Thus, the dynamics of trade between Poland and the United Kingdom underwent significant changes.

However, in 2020-2021, part of this decline may have been the result of the COVID-19 pandemic. Naturally, the pandemic period in 2020-2021 was associated with trade restrictions, but the findings of Tudorache and Nicolescu suggest that in the case of Poland, the causes were more complex.

Their study found that the number of COVID-19 cases did not negatively affect international trade; in fact, an increase in the number of cases led to a slight rise in both exports and imports. Consequently, instead of declines, stabilisation or even growth was observed, which may have been linked to increased demand for certain goods, including medical products (Tudorache and Nicolescu, 2023).

Brexit ended the operation of the customs union between the EU and the United Kingdom, and in its place, the Trade and Cooperation Agreement (TCA) came into effect on 1 January 2021. The agreement allowed tariff-free trade in goods between the United Kingdom and the EU, provided that specific rules of origin requirements were met in order to benefit from zero-tariff rates.

However, a range of non-tariff barriers have also emerged, including customs formalities and regulatory barriers, which have significantly increased the costs of bilateral trade between the two parties.

Gasiorek and Tamberi (2023) note that the new regulations concerning import and export declarations and physical border checks have substantially raised transaction costs. Meanwhile, Du, Satoglu, and Shepotylo (2023) found that, as a result of the TCA, exports of goods to the EU decreased by an average of 22.9%, while exports

to the rest of the world fell by 11.3%.

Imports from EU countries were on average 11.3% lower, whereas imports from the rest of the world remained virtually unchanged. Moreover, approximately 42.3% of product categories that had previously been exported to the EU disappeared after the introduction of the TCA. Most exporting firms either suspended shipments to the EU or narrowed their product lines, and reduced support for new exporters (Du, Satoglu and Shepotylo, 2023).

2.2 Customs and Logistical Regulations

The introduction of new procedures also entailed changes regarding the required documentation. The transport of goods to and from the United Kingdom is now conducted under customs transit, which means that each haulier must possess appropriate transit documents (T1 or T2) for the transported goods. A T1 document is required for the export of goods from the UK, while a T2 document concerns Community goods (Hartleb, 2021; Kłak, Zadworny and Madej, 2023).

The preparation of these documents requires possession of a commercial invoice, a goods specification, a CMR consignment note, proof of export clearance, and a certificate of origin. However, the first change in the required documentation for Polish drivers entering the United Kingdom was the introduction of mandatory passports.

Initially, passports were to be required from 1 January 2021; however, the UK authorities extended the period during which entry was permitted with an identity card until 1 October 2021 (Kłak, Zadworny, and Madej, 2023).

Hartleb (2021) highlights that another formality that had a negative impact on hauliers was the requirement to obtain a digital Kent Access Permit (KAP) prior to entry into Kent (Eurotunnel or the Port of Dover).

The introduction of this document was aimed at improving road traffic management in the region and preventing congestion on roads leading to ports and Eurotunnel terminals. It was withdrawn on 20 April 2021 (Department for Transport, 2021).

Maroszyk (2024) draws attention to regulations that limit cabotage operations and the performance of intermodal transport within the United Kingdom. The new provisions concerning companies from the European Union introduce a prohibition on carrying out additional domestic transport operations following the completion of the main international transport.

It should be noted that such operations are also limited to a maximum of two domestic journeys within seven days of delivering the cargo. Furthermore, EU hauliers are not permitted to carry out combined transport operations within the

United Kingdom, and all transport must be conducted using the same vehicle or vehicle combination throughout the entire route. Hauliers must therefore carefully plan routes to minimise empty running.

Regulatory changes necessitated the implementation of new administrative tools, such as the Goods Vehicle Movement Service (GVMS), a system for managing the movement of heavy goods vehicles designed to streamline and automate customs processes at the border by allowing for the pre-lodgement of customs data and for obtaining approval to transport goods prior to arrival at the border.

Associated with the GVMS is the Goods Movement Reference (GMR), which links all essential information regarding transported goods and customs declarations. A valid GMR is required for entry into the United Kingdom from the European Union and for departure from the United Kingdom to the EU (HM Revenue and Customs, 2025a). If a vehicle does not have a valid GMR, it will not be allowed to board a ferry or enter the Eurotunnel, which can result in delays and fines.

Additionally, from 31 January 2025, an additional requirement for submitting an entry summary declaration (ENS) for all goods imported into the United Kingdom was introduced. This obligation aims to enhance security and control over imported goods (HM Revenue and Customs, 2025b).

From 1 September 2025, the use of the Envelope Logistique Obligatoire (ELO) will also become mandatory at the France–United Kingdom border. This system aims to improve customs clearance processes and enhance border control efficiency (Direction générale des douanes et droits, 2025).

The introduction of new customs procedures, border controls, and additional bureaucracy following Brexit has significantly extended road transport times. Hauliers operating on routes from Ireland to the UK reported an increase in delivery times from on to three days to one to five days (Kłak, Zadworny, and Madej, 2023).

In the case of transport from continental Europe, delivery times rose to as much as six days, with border delays potentially lasting up to 20 hours (Maroszyk, 2024; TC Kancelaria Prawna, 2024).

2.3 Impacts on the Road Haulage Sector

Institutional reports and survey-based research indicate significant changes in transport companies' operational strategies. A study conducted by the Polish Road Transport Institute on a sample of 130 companies showed that 60% of firms experienced a sharp decline in the number of orders to the United Kingdom and 10% completely withdrew from this market.

The main reasons cited were customs clearance problems, inefficiencies of the

British systems, driver shortages, and the complexity of new regulations (Świeboda, 2021). Similar results were observed in a case study conducted on Euro24, which reported a decrease in transport volumes in the first two months following the implementation of Brexit compared to the corresponding period of the previous year (Kłak, Zadworny, and Madej, 2023).

Despite a rich body of literature presenting qualitative research findings and an increasing number of institutional reports and research, comprehensive quantitative analyses based on statistical data disaggregated by carrier registration country and transport directions are still lacking.

In particular, there is a shortage of studies comparing quarterly trends in international freight movements by hauliers from EU countries before and after the end of the transition period. The aim of this article is to address this gap by employing statistical analysis methods using data from the UK Department for Transport.

3. Methodology

3.1 Data for the Analysis

The volume of freight transported by road within the EU in 2023 was more than 13.2 billion tonnes. In terms of transport performance, measured in tonne-kilometres (t-km), road transport accounted for 25% of all freight transport, ranking second only to maritime transport. Road freight transport is primarily carried out using vehicles with a gross vehicle weight exceeding 30 tonnes, representing approximately 83% of the transport performance (in t-km).

These are mainly articulated vehicles, i.e., tractor units with semi-trailers, which in 2023 accounted for more than three-quarters (78.3%) of EU road freight transport measured in tonne-kilometres (transport performance) and nearly two-thirds (65.6%) of transport measured in vehicle-kilometres (Eurostat, 2024).

This high percentage was a significant factor in the emphasis placed on this mode of transportation in the article. The analysis was conducted using data for Poland and Ireland. Poland was included as the country with the largest heavy goods vehicles among EU countries (in 2023, the Polish fleet accounted for 18.0% of the EU fleet, while Germany had the second largest fleet at 14.2%, followed by France and Spain at 10.2% and 9.5%, respectively).

Moreover, for many years, Polish hauliers have held a leading position in international road freight transport to and from the United Kingdom using vehicles registered outside the UK. In 2022, trucks registered outside the UK and carrying goods to and from the United Kingdom transported a total of 29.8 million tonnes, of which Polish hauliers accounted for 8.4 million tonnes. Irish hauliers, who have also

maintained a strong position for many years, ranked second.

Trucks registered in Ireland transported a total of 4.3 million tonnes to and from the UK in 2022 (Department for Transport, 2024b). Furthermore, Ireland recorded the highest average annual positive growth rate of heavy goods vehicles between 2019 and 2022 (8.2%).

It should also be noted that between 2004 and 2023 the quantity of goods transported by trucks registered in the United Kingdom declined significantly for both imports and exports, with UK-registered trucks generally importing more goods than they export (Department for Transport, 2024b).

The impact of Brexit on transport to and from the United Kingdom continues to unfold, and a full assessment of its long-term effects still requires time. This article analyses the relationship between Brexit and road freight transport carried out by Polish and Irish hauliers. The study uses quarterly data from Q1 2017 to Q4 2022 published by the UK Department for Transport (Department for Transport, 2024a).

The analysis is based on variables related to international freight transport between the United Kingdom and Poland and Ireland: (1) by heavy goods vehicles registered outside the United Kingdom, disaggregated by country of vehicle registration, and (2) by heavy goods vehicles engaged in so-called cross-trade operations, also disaggregated by country of registration.

The data were transformed and coded using binary variables indicating increases and decreases in transport volumes.

To identify patterns of change in road freight transport between the United Kingdom and Poland and Ireland, the study distinguishes between: (1) heavy goods vehicles registered outside the United Kingdom, by country of vehicle registration (Poland, Ireland) and (2) heavy goods vehicles engaged in cross-trade operations.

The data used for the analysis are presented in Table 1 and illustrated in Figures 1 and 2. Polish hauliers recorded the highest average volume of transport to the UK, at approximately 737.6 thousand tonnes per quarter, slightly ahead of Irish hauliers at approximately 722.7 thousand tonnes (kt). In contrast, Irish trucks transported more freight from the UK (approximately 452.4 kt) than Polish trucks (approximately 351.3 kt).

Cross-trade operations recorded significantly lower volumes for Ireland, averaging around 38-54 kt per quarter, compared to approximately 617-722 kt in the Polish category. Quarterly volume variability was relatively high across all data series, with coefficients of variation ranging from approximately 15% to over 40%.

Table 1. *Descriptive Statistics for the data used in the analysis*

Variable*		Mean (kt)	Median (kt)	CV [%]*	CS*	Shapiro-Wilk Test
Freight transport from the UK by Heavy Goods Vehicles Registered Outside the United Kingdom, by Country of Vehicle Registration (thousand tonnes)	$HGVf\_PL$	351.29	344.50	20.46	0.12	W=0.98 p=0.83
	$HGVf\_IE$	452.35	470.00	16.46	-0.58	W=0.95 p=0.26
Freight transport to the UK by Heavy Goods Vehicles Registered Outside the United Kingdom, by Country of Vehicle Registration	$HGVt\_PL$	737.61	722.00	28.37	0.86	W=0.94 p=0.20
	$HGVt\_IE$	722.74	726.00	15.52	0.50	W=0.94 p=0.18
Freight Transport from the UK by Heavy Goods Vehicles – Cross-Trade Operations, by Country of Vehicle Registration	*HGVf_PLcs*	617.09	646.00	30.03	-0.10	W=0.95 p=0.29
	HGVf_IEcs	38.37	36.00	34.69	0.77	W=0.89 p=0.02
Freight Transport to the UK by Heavy Goods Vehicles – Cross-Trade Operations, by Country of Vehicle Registration	$HGVt\_PLcs$	722.43	688.00	28.77	0.89	W=0.91 p=0.04
	$HGVt\_IEcs$	54.34	46.00	40.72	1.16	W=0.90 p=0.03

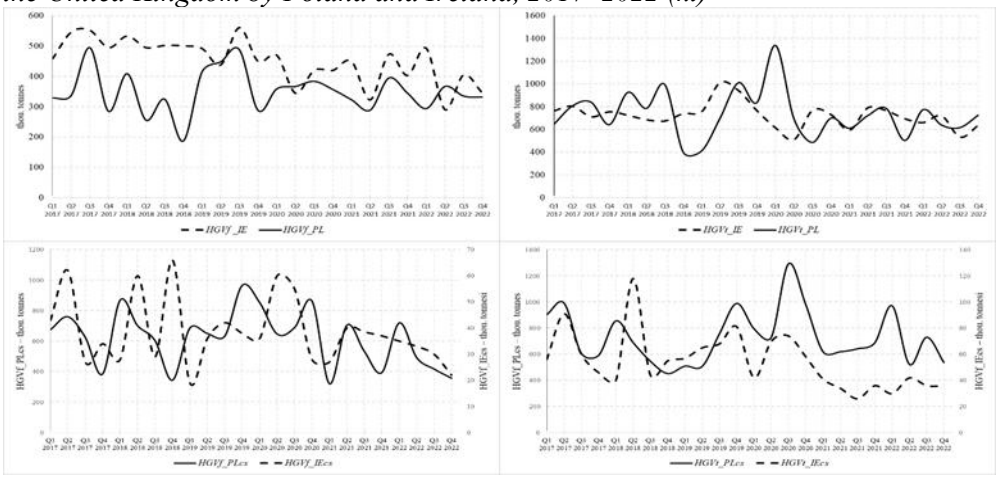
Note: **CV - coefficient of variation, CS - coefficient of skewness, in the variable names, the abbreviations PL and IE were added to denote Polish and Irish hauliers, respectively; the letter t indicates transport to the United Kingdom, and f indicates transport from the United Kingdom.*

Source: *Own elaboration based on data from UK Department for Transport (2024a).*

It can be assumed that all variables included in the analysis exhibited an approximately normal distribution. The highest variability (CV over 40%) and positive skewness were observed in cross-trade freight transport to the UK by vehicles registered in Ireland. Skewness indicates that, over the study period, transport volumes were more frequently below the mean.

To understand the relationship between the pre-Brexit and post-Brexit periods (to identify differences between the groups) and the volume of transport, binary (0-1) variable coding was applied. One difficulty lies in the lack of a clearly defined concept of a crisis in the international freight transport sector. In the industry literature, including the Eurostat analysis of the impact of the global financial crisis on road transport in 2008-2009, the effect of the crisis was defined as quarterly declines of more than 10% year on year (e.g., Q2 2008 vs Q2 2009), which led to a reduction in freight volumes to levels last seen six years earlier (Wrzesinska, 2011).

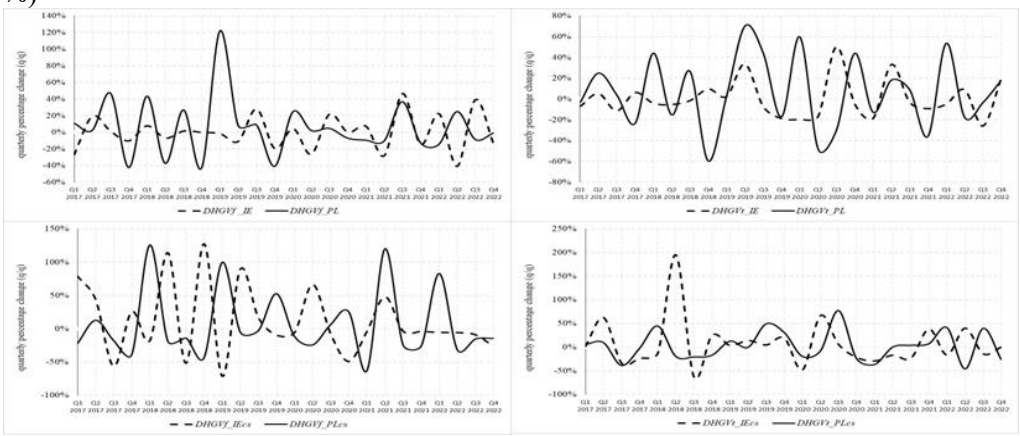
***Figure 1**. Quarterly Volume of International Road Freight Transport to and from the United Kingdom by Poland and Ireland, 2017–2022 (kt)*



***Source:** Own elaboration based on data from Department for Transport (2024a).*

In this study, due to the limited time span (24 observations) and the lack of seasonally adjusted data, a simplified approach was adopted. The threshold for distinguishing between "crisis" and "non-crisis" conditions was set as: (1) for quarterly transport volumes (kt), a level below the average for the entire study period (2017-2022); and (2) for the percentage change in transport volumes from quarter to quarter, a decrease greater than 5%.

***Figure 2.** Quarterly Percentage Change in Volume of International Road Freight Transport to and from the United Kingdom by Poland and Ireland, 2017–2022 (q/q, %)*



***Source:** Own elaboration based on data from Department for Transport (2024a).*

As outlined above, the following variables were defined:

(1) based on quarterly transport volumes

$$HGVf\_PL\_crisis\_mean = \begin{cases} 1, if HGVf\_PL \leq mean_{HGVf\_PL} \\ 0, otherwise \end{cases} \quad (1)$$

$$HGVt\_PL\_crisis\_mean = \begin{cases} 1, if HGVt\_PL \leq mean_{HGVt\_PL} \\ 0, otherwise \end{cases} \quad (2)$$

where $mean_{HGVf\_PL}$, $mean_{HGVt\_PL}$ denotes the mean for series *HGVf_PL* and *HGVt_PL, respectively;*

(2) based on the percentage change in transport volumes from quarter to quarter

$$DHGVf\_PL\_crisis\_0.05 = \begin{cases} 1, if \left(\frac{HGVf_{PL(t)}}{HGVf_{PL(t-1)}} - 1 \right) 100\% \leq 5\% \\ 0, otherwise \end{cases} \quad (3)$$

$$DHGt\_PL\_crisis\_0.05 = \begin{cases} 1, if \left(\frac{HGVt_{PL(t)}}{HGVt_{PL(t-1)}} - 1 \right) 100\% \leq 5\% \\ 0, otherwise \end{cases} \quad (4)$$

The variables for Ireland and cross-trade transport were defined analogically.

3.2 Fisher's Exact Test

The study focuses on the analysis of the relationship between categorical variables. The data for the analysis were compiled into two-dimensional contingency tables (as shown in Table 2), specifying the number of occurrences of the defined coincidence between the categorical Brexit variable and the variables defined by formulas (1-4).

Table 2. *2×2 Contingency Table Used in the Study*

	above the cut-off point $Y = 0$	below the cut-off point $Y = 1$	total
before 2021 $X = 0$	n_{00}	n_{01}	$N - n'$
after 2021 $X = 1$	n_{10}	n_{11}	n'
Total	$N - n$	n	N

Source: *Own elaboration.*

The most common non-parametric technique for testing the hypothesis of independence between two variables. and thus for comparing two proportions, is the chi-square test. Guidelines for selecting the appropriate statistical test indicate that the chi-square test is valid only if the expected frequency in each cell of the contingency table is at least 5; otherwise, Fisher's exact test (also known as the Fisher–Irwin test) is recommended (Campbell, 2007).

It is also important to note that in the chi-square test, the distribution of the test statistic is only approximately equal to the theoretical chi-square distribution.

Therefore, only an approximate p-value is obtained, and the approximation is reliable when the sample size is large. In Fisher's exact test, in contrast to most statistical tests, the exact probabilities for all possible configurations of outcomes in the table are calculated (assuming fixed total sample size and fixed marginal totals), rather than estimating the probability of obtaining the observed test statistic.

Due to the limited sample size of 24 observations in the present study, Fisher's exact test was employed to determine whether there was a statistically significant difference in the proportions of the two group variables, i.e., to assess changes in emergency frequency before and after Brexit. According to Fisher's formula, the probability of a particular distribution of outcomes is determined by a hypergeometric distribution.

$$p = \frac{\binom{n_{00}+n_{01}}{n_{00}}\binom{n_{10}+n_{11}}{n_{10}}}{\binom{N}{n_{00}+n_{10}}} \tag{5}$$

If the hypothesis of independence is rejected, it is considered useful to determine the strength of association between the study variables. For 2×2 arrays, the most commonly used measure is Yule's Q coefficient (also referred to as Kendall's Q), which is calculated using the following formula:

$$Q = \frac{n_{00}n_{11} - n_{01}n_{10}}{n_{00}n_{11} + n_{01}n_{10}} \tag{6}$$

It ranges from [-1; 1] taking the value 0 when the row and column are independent and the value 1 or 1 when there is complete positive or negative association.

The results of Fisher's exact test, including the exact two-tailed and one-tailed p-values, the likelihood ratio, and the value of the test statistic, are presented in Table

3. A comprehensive review of arguments and evidence on the most appropriate test for analysing 2×2 tables with small sample sizes can be found in (Campbell, 2007)[3].

4. Research Results and Discussion

4.1 Changes and Dynamics of Freight Transport

The analysis revealed a differentiated associacion (or its lack thereof) between Brexit on the freight transport operations carried out by Polish and Irish hauliers, particularly in the area of cross-trade transport to the UK.

Between 2017 and 2019, road freight transport between Ireland and the UK in both directions, conducted by Irish hauliers, remained stable, with a predominance of transport to the UK (an average of approximately 780 kt per quarter to the UK and approximately 500 kt from the UK) (Figure 1, first row).

During the same period, transport performed by Polish hauliers was much more volatile, similarly showing a significantly higher volume for imports (an average of approximately 750 kt per quarter to the UK and approximately 355 kt from the UK, with a strong downward trend in the case of export) (Figure 1, second row). In the fourth quarter of 2019, a marked decline was observed in transport from the UK to Poland performed by Polish hauliers (200 kt), while in the second quarter of 2020, volumes carried by Irish hauliers from the UK to Ireland dropped to 345 kt. These declines were related to the disruptions associated with the Brexit transition period and, to some extent, to the effects of the COVID-19 pandemic.

In the second half of 2020, transport volumes increased again, as companies accelerated deliveries before the entry into force of new regulations related to the UK's departure from the single market and customs union as of 1 January 2021.

From early 2021, a sustained decline in transport volumes was observed for Irish companies, whereas Polish hauliers stabilised their volumes at approximately 700-800 kt per quarter (for imports), indicating greater operational resilience and adaptation to the new trading conditions.

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[3] *„(...) arguments presented here provide a compelling body of evidence that the best policy in the analysis of 2×2 tables from either comparative trials or cross-sectional studies is: (1) Where all expected numbers are at least 1, analyse by the 'N − 1' chi-squared test (the K. Pearson chi-squared test but with N replaced by N − 1). (2) Otherwise, analyse by the Fisher–Irwin test, with two-sided tests carried out by Irwin's rule (taking tables from either tail as likely, or less, as that observed). This policy extends the use of the chi-squared test to smaller samples (where the current practice is to use the Fisher–Irwin test), with a resultant increase in the power to detect real differences" (Campbell, 2007).*

Interestingly and somewhat surprisingly, the data for Polish hauliers did not exhibit a clear downward trend in transport to and from the United Kingdom (HGVf_PL; HGVt_PL).

During the analysed period (Q1 2017 – Q4 2022), cross-trade operations conducted by vehicles registered in Poland were consistently much higher than those performed by Irish hauliers. Although Polish companies reached levels exceeding 900 to 1,000 kt per quarter between 2017 and 2020 (with a peak of 1,292 kt in Q3 2020), Irish hauliers operated at an average level of approximately 50 to 70 kt.

The most significant decline for both countries was recorded in Q1 2021, immediately after the full implementation of Brexit-related regulations. These declines were the result of new customs barriers, increased costs, and administrative restrictions at the borders.

However, Polish hauliers demonstrated a faster volume recovery: By Q1 2022, they had reached 971 kt (transport to UK). For Ireland, cross-trade volumes after 2020 stabilised at much lower levels, 30-42 kt per quarter, with no signs of sustained growth.

In the case of Irish freight transport to and from the United Kingdom (HGVf_IE; HGVt_IE), as well as cross-trade operations (HGVf_IEcs; HGVt_IEcs), the pronounced downward trend suggests that the effects of Brexit were not merely temporary disruptions but represent a long-term structural shift in the transport market.

The analysis of quarterly dynamics (Figure 2) shows that changes in transport volumes conducted by Polish hauliers were noticeably more pronounced than those of Irish companies—this applies to both transport from and to the UK. In the case of Poland, the highest increases were recorded in Q1 and Q2 of 2019, while sharp declines occurred between Q1 2020 and Q2 2021, linked to the pandemic and Brexit. Transport to the UK was particularly volatile.

For Ireland, the dynamics were more stable, with smaller quarterly fluctuations. In the cross-trade segment, a time lag in changes between Poland and Ireland was observed for transport from the UK, while transport to the UK followed a similar pattern for both countries, suggesting common influencing factors such as regulatory changes.

4.2 Statistical Significance of Brexit Effects

The results of the tests conducted are presented in Table 3 and Figure 3. The first part concerns dichotomous variables defined on the basis of transport volumes, while the second relates to variables based on percentage changes. The results of Fisher's exact test and the likelihood ratio test clearly demonstrated that Brexit had a

significant impact on the decline in freight volumes carried out by Irish transport companies to and from the United Kingdom, as well as on their cross-trade operations to the United Kingdom.

Table 3. *Likelihood Ratio and Fisher's Exact Test Results (Exact Significance[4])*

Variables	Likelihood ratio (2-sided)	Fisher's Exact.Sig (2-sided)	Fisher's Exact.Sig (1-sided)	Yule's Q
HGVf_IE_crisis_mean	0.082	0.082	0.055	0.737
HGVf_PL_crisis_mean	0.211	0.211	0.156	0.588
HGVf_IEcs_crisis_mean	0.189	0.189	0.142	0.690
HGVf_PLcs_crisis_mean	0.021	0.021	0.013	0.857
HGVt_IE_crisis_mean	0.082	0.082	0.055	0.737
HGVt_PL_crisis_mean	0.388	0.388	0.234	0.500
HGVt_IEcs_crisis_mean	0.001	0.001	<0.001	1.000
HGVt_PLcs_crisis_mean	0.338	0.388	0.234	0.500
DHGVf_IE_crisis_0.05	0.363	0.363	0.221	-0.500
DHGVf_PL_crisis_0.05	0.388	0.388	0.234	-0.500
DHGVf_IEcs_crisis_0.05	0.100	0.178	0.087	0.750
DHGVf_PLcs_crisis_0.05	0.667	0.667	0.447	0.286
DHGVt_IE_crisis_0.05	1.000	1.000	0.553	-0.138
DHGVt_PL_crisis_0.05	1.000	1.000	0.556	-0.125
DHGVt_IEcs_crisis_0.05	0.423	0.657	0.332	0.400
DHGVt_PLcs_crisis_0.05	1.000	1.000	0.561	0.129

Source: *Own elaboration.*

In the case of Polish hauliers, considerable adverse effect of Brexit was identified for cross-trade transport from the United Kingdom, where their market share had been particularly high prior to Brexit. The strong positive values of the Yule's Q coefficient further confirmed the strength of the impact on these types of transport.

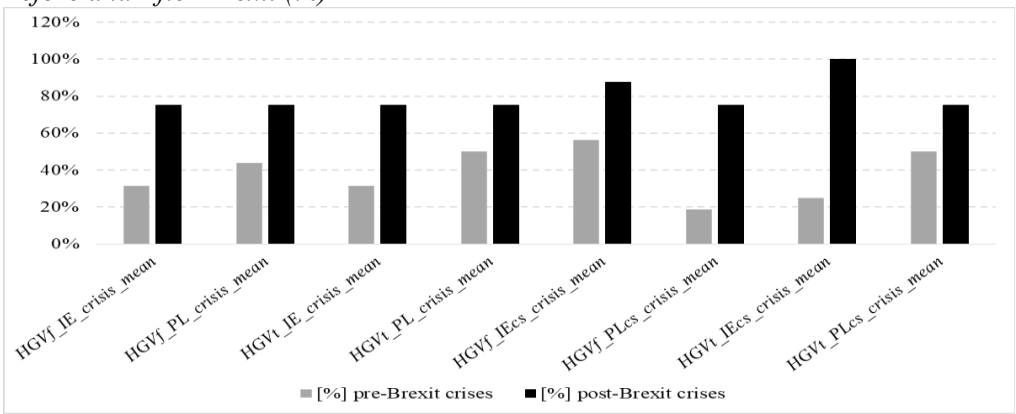
For Irish hauliers, the negative impact of Brexit was reflected not only in statistically significant changes in volume but also in the need to reorganise operational activities. A study by Paraskevadakis and Ifeoluwa (2022) highlights that Irish hauliers faced not only increased administrative and staffing challenges following Brexit, but also insufficient institutional support, which exacerbated the operational

[4] *The exact p-value is defined as the permutation probability; further details can be found, among others, in the work of Mehta and Patel (2011).*

disruptions triggered by the new border regime.

Based on data from the contingency tables used in the tests, the frequency of 'crisis' events was determined for each period (before and after Brexit).

Figure 3. *Frequency of Crisis Episodes in UK-Related Road Freight Transport Before and After Brexit (%)*



Source: *Own elaboration.*

The results of this study are consistent with industry views, the Irish Road Haulage Association (2023) reported that the effects of Brexit have had a lasting and destabilising impact on hauliers' operations, forming part of a broader restructuring of the transport market and supply chains between Ireland and the United Kingdom.

The results are supported by assessments from the Polish transport sector and institutional reports. These sources point to operational disruptions, longer transit times, and increased freight rates resulting from customs procedures and driver shortages (Kłak, Zadworny, and Madej, 2023; TC Kancelaria Prawna, 2024). Independent analyses confirm this trend, highlighting above-average cost increases on UK–EU routes compared to the European market as a whole (Ti, Upply, and IRU, 2022).

The demonstrated negative impact of Brexit on freight transport, particularly in the area of cross-trade to and from the United Kingdom, was also associated with limited driver availability, as highlighted in industry reports. New visa requirements and regulatory barriers to employing EU nationals led to staff shortages and increased operational costs, further exacerbating delivery challenges (Maroszyk, 2024; STAN_TRANS, 2024).

According to IRU, prior to Brexit, around 4.4 million trucks moved annually between the EU and the UK, of which 500,000 trips were carried out by Polish hauliers (Beresnevičius, 2021; Świeboda, 2021). Following Brexit, the number of

transport operations decreased by one-third, and many companies withdrew from the UK market (TC Kancelaria Prawna, 2024). This trend intensified further in 2024 (Maroszyk, 2024).

In summary, the differences between Polish and Irish hauliers concern not only the scale of changes in transport volumes but also the operational context in which companies operated after Brexit. Both Poland's industry reports and qualitative research conducted in Ireland highlight similar challenges, increased administrative burdens, driver shortages, delays, and regulatory uncertainty.

The differences observed in the statistical data are more likely to be attributable to variations in market structure. Polish transport companies operate more frequently on a larger scale and have a stronger competitive position in international transport, whereas Irish companies, being more focused on the British market, were more vulnerable to disruptions resulting from unilateral regulatory changes.

It should also be noted that other external factors (e.g., changes in the economic cycle, disruptions of the supply chain during the pandemic) may have influenced the observed changes. However, the consistency of the quantitative results with industry reports and qualitative research allows the identification of Brexit as the key factor driving changes in road freight transport to and from the UK, with a high degree of probability.

5. Conclusions

An analysis of the transport volumes indicates that:

1. Among the bilateral flows to and from the UK, the most pronounced downward trend was recorded in freight transported from the United Kingdom to Ireland by Irish hauliers (HGVt_IE), which declined by 38% between Q3 2019 and Q4 2022;

2. Brexit, in particular, caused adverse changes in cross-trade transport — in the case of Ireland, this concerns transport to the United Kingdom (HGVt_PLcs), where the average volume fell from 64 kt before Brexit to 35 kt after Brexit; in the case of Poland, it refers to transport from the United Kingdom (HGVf_PLcs), with the average volume declining from 680 kt before Brexit to 490 kt after Brexit;

3. The quarterly dynamics of transport operations carried out by Polish hauliers showed greater variability than those of Irish companies. However, it cannot be clearly concluded that this increased volatility emerged after Brexit. The absence of a relationship between Brexit and the percentage change in transport volumes is confirmed by the results of the Fisher and Likelihood Ratio tests.

The analysis of the frequency of crises shows that:

4. The likelihood ratio and Fisher's exact test confirmed the relationship between Brexit and negative changes in the international transport, which were particularly evident in the case of transit transport to the United Kingdom carried out by Irish hauliers. The percentage of observations classified as crisis-related in this category increased from 25% before Brexit to 100% after 1 January 2021;

5. A similar, though somewhat weaker, effect was also observed in other cross-trade categories, particularly for transport from the UK conducted by Polish companies, where the share of crisis cases rose from 19% before Brexit to 75% after Brexit. This may indicate the persistence of operational difficulties and market disruptions in international road freight transport following the withdrawal of the United Kingdom from the EU.

The aforementioned conclusions indicate that operational difficulties and disruptions in the international road freight transport market are likely to persist following the United Kingdom's withdrawal from the European Union.

The authors hope that this article not only contributes empirical evidence to the debate on the association between Brexit and the European transport sector but also highlights the importance of selecting appropriate statistical tools to analyse complex economic phenomena, particularly when working with small samples.

6. Limitations and Future Research

The authors of the study acknowledge its limitations, which concomitantly offer opportunities for further analysis. The study does not address the challenge of structurally modelling freight volumes in relation to cost, structural and organisational factors (e.g., such as transport costs, number of registered carriers or customs clearance times) or import and export volumes.

It should be noted that significance tests based on discrete probabilities are conservative; they rarely reject individual comparisons, and p-values tend to be too high (Berry and Armitage, 1995). This occurs because the average significance level when the null hypothesis is true always exceeds 0.5. The choice between Fisher's exact test and other tests like the chi-square test often involves a trade-off between conservatism and power.

While Fisher's test is more conservative and may be less powerful in some cases (especially when the sample size is large), it also provides a more precise p-value, especially when dealing with small sample sizes or low expected cell counts. Furthermore, this conservatism can be advantageous in some situations, as it reduces the risk of false positives.

However, it also means that a true association might be missed if the test is too conservative. One way to reduce this conservatism while continuing to use exact small-sample probability distributions is to apply the mid-p-value approach (Lancaster, 1949; 1961).

Further limitations arise from the nature of the available data. Three main aspects can be identified: a short time horizon, a limited set of explanatory variables, and a high degree of aggregation.

It is recommended that future research be conducted over a longer time frame, including data from before the Brexit referendum, with the preferred approach being an analysis based on micro-level data from individual transport companies. Similar studies should also be conducted for other EU countries active in the road transport market to identify specific patterns and additional prospects for market development.

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