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NORTHERN IRELAND'S TRADE IN GOODS IN AN ERA OF BREXIT UNCERTAINTY: FIRM-LEVEL EVIDENCE*

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Abstract:
This paper uses firm-level data to examine the impact of Brexit uncertainty and the implementation of the Withdrawal agreement on the trading patterns of Northern Ireland's manufacturing, and wholesale and retail firms. There is some evidence that in the aftermath of the Withdrawal agreement the purchasing behaviour of the manufacturing firms shifted away from suppliers in Great Britain to suppliers in either Ireland or other parts of the EU. There appears to have been less of an impact on sales especially between the time of the Brexit referendum and actual Withdrawal. There is some evidence of a post-Withdrawal increase in sales to GB, especially for wholesale and retail, which may be indicative of the benefits of preferential dual-market access for NI firms. While overall measures of the regulatory burden arising from the post-Brexit trading arrangements were not found to exert a statistically significant effect on manufacturing trade activity, this does not apply to measures capturing third-party conformity assessment, which appear to have a negative post-Withdrawal impact on NI firms' trade with GB. These effects are primarily found to be larger for smaller firms, and non high-technology intensive firms as well as for the agri-food sector.

JEL codes: D22, F13, F14, F15

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Disclaimer. This is a working paper and represents research in progress. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. Any errors are attributable to the authors.

Keywords: Brexit uncertainty, firms, Northern Ireland, Non-tariff barriers

1. Introduction

The decision of the United Kingdom (UK) government to leave the European Union (EU) after the outcome of the June 2016 Referendum altered long-standing policies and governance arrangements for UK firms. The UK departure from an integrated trade bloc reversed a global trend towards greater integration witnessed throughout the previous quarter of a century or so. The complex nature of trade agreements and how they affect economic outcomes is emphasized in the work of Baier, Yotov and Zylkin (2019). The economic effects of joining a deep trade agreement have been the subject of detailed research and analysis (see Dhingra et al. (2018); Breinlich (2018); Mattoo, Rocha and Ruta (2020); and Breinlich *et al*. (2023)) but the effects of withdrawing from such an agreement are less well understood. The full extent of the UK policy changes are anticipated to exert impacts on the trading destinations, investment decisions, and the location of firms. The withdrawal from the deep Single Market agreements with the EU, which extended beyond tariff reduction arrangements to rules relating to market access and foreign service providers, creates the potential for economic disruption to supply chains, increased friction, and less stability in trading relationships.

Northern Ireland was generally viewed as a region of the United Kingdom most vulnerable to withdrawal from the EU given its output is most exposed to trading with the bloc (see Dhingra, Fry, Hale and Jia (2022)). This follows in part from its unique and historical relationship with the Republic of Ireland, its largest external trading partner and an EU member with which it shares a land border. The 1998 Good Friday Agreement (GFA), which is enshrined within an internationally-recognized treaty, ensures the absence of a hard border on the island of Ireland. Compliance with the provisions of the treaty led to the agreement of specific arrangements integral to the Brexit EU-UK Withdrawal agreement to ensure the key provisions of the GFA were safeguarded. These guarantees were originally introduced under the aegis of the Northern Ireland Protocol (NIP) in 2021, later amended under the Windsor Framework (2023).

The primary objective of the current research is to investigate if the trading sources and destinations of Northern Ireland firms have been affected by Brexit uncertainty since the 2016 referendum and, more recently, by the Withdrawal Agreement that took legislative effect on the 1st January 2021. This study exploits a unique firm-level dataset provided by the Northern

Ireland Statistics & Research Agency (NISRA). This comprises data covering the period from 2014 to 2022 drawn from various rounds of the Annual Business Inquiry (ABI), which is integrated with the Broad Economy Sales and Exports (BESES) data. This enables the trading destinations of Northern Irish firms to be identified: crucially, information on sales and purchases is reported separately for intra-UK (to/from Great Britain and Northern Ireland) and extra-UK transactions. Specifically, therefore, the study focuses on the purchases and sales of goods by manufacturing firms, and those operating in the retail and the wholesale sectors, to investigate how, if at all, the post-referendum Brexit era and the post-withdrawal period impacted firm-level trading behaviour, both within and outside the UK. In addition, the impact of various measures of potential (post referendum and pre-Withdrawal) and actual (post-Withdrawal) trade barriers affecting purchases and sales is examined using an array of indices reflecting the regulatory and administrative burdens of undertaking trade with the EU. These indices are primarily exploited to assess the effects of the regulatory burden on manufacturing firm-level purchases from Great Britain, i.e. those affected by the application of the NIP, and are also used to assess regulatory impacts on manufacturing sales to both Ireland and the rest of the EU.

The significant novelty of this paper is its use of firm-level data on purchases and sales rather than the more commonly used gravity-based approach that has exploited aggregate trade data to inform on the effects of Brexit and the withdrawal agreement (e.g., see Cudgin *et al*. (2017); Keogh (2019); and Brakman *et al*. (2021)). In so doing, we exploit a panel of firms contained within the ABI. The key findings of the paper are that the input purchases of both manufacturing and retail & wholesale sector firms from either within Northern Ireland or from Great Britain have flatlined since the Brexit referendum and the post-Withdrawal agreement. In contrast, there has been an increase in purchases from Ireland and the rest of the European Union. The sales destinations of Northern Ireland's firms do not appear to have been materially affected by either the referendum-induced uncertainty or the implementation of the Withdrawal Agreement from January 2021. In general, there is little empirical evidence that the regulatory burden facing Northern Ireland manufacturing firms associated with trading with Great Britain act as a significant constraint post-Withdrawal. However, measures of regulatory burden reflecting third-party assessment appear to have assumed a modest importance after the

implementation of the Withdrawal agreement and exerted a negative impact on NI purchases from GB.

The structure of the paper is now outlined. The next section provides some context within which the empirical analysis is situated. This is followed by a discussion of the data and a section detailing some descriptive patterns of Northern Ireland firm-level trading behaviour. A subsequent section details the econometric methodology, and this is followed by the empirical results. The penultimate section contains a discussion of the key findings, and a final section provides some concluding remarks.

2. Context

The UK, along with Ireland and Denmark, originally joined what was then the European Economic Community (EEC) in January 1973 leading to an increase to nine countries in the bloc's total membership. In June 1975 a referendum endorsed *ex post* the UK's decision to join. After more than 40 years of membership, the UK government announced a referendum on the unitary question of leaving the European Union, which took place in June 2016. The overall UK vote was 52% in favour of leaving the EU, but a majority of Northern Ireland voters (58%) expressed a preference to remain. The UK government invoked Article 50 of the Treaty of European Union on March 29th 2017 and withdrawal negotiations commenced in June 2017 with completion intended within two years. The Withdrawal agreement was eventually signed in January 2020 and, as a part it, the Northern Ireland Protocol (NIP) was agreed as a mechanism designed to protect the Good Friday Agreement (GFA).

Under the NIP, EU Single Market rules were to still to apply to goods made or moving into Northern Ireland, in contrast to all other regions of the UK. In addition, checks on goods moving from Great Britain to Northern Ireland were subject to customs' and regulatory checks. This required that a notional customs border was situated in the Irish Sea with checks applied at British seaports, rather than along the physical border with the EU. This was viewed as easier to manage administratively given Northern Ireland has only five commercial seaports, while the 500-kilometre border with the Republic of Ireland (i.e., the EU) is estimated to have over 200 crossing points. The introduction of the NIP was not without political controversy

and ultimately led to the collapse of Northern Ireland's locally elected administration in February 2022. The debate remains on-going with the Windsor Framework Agreement, finalized between the UK government and the EU Commission in March 2023, designed to mitigate what some regarded as the more perverse effects of the NIP. The agreement is designed to restore the smooth flow of trade within the UK's internal market through the introduction of conceptual 'red' and 'green' lanes for customs purposes for goods destined exclusively for use or consumption in Northern Ireland.

The negotiation period for the withdrawal of the UK from the EU was protracted and created a degree of uncertainty among firms operating within Northern Ireland. A significant part of the debate around the negotiations was linked to the status of Northern Ireland post-withdrawal. The significance of the debate is well beyond the economic size of the Northern Irish economy. It is one of the smallest within the UK's 12 ITL regions, and its productivity is well below that reported for the rest of the UK. Its manufacturing sector accounts for a modest 11% of total employment in the region and close to 15% of gross value added. The sector is now largely centred around the production of machinery equipment and high-tech electronic goods as well as food processing. It is reported by Manufacturing NI that about 90% of Northern Ireland's manufacturing firms are compliant with EU regulations. In contrast, Services remain among the most important sectoral employers within Northern Ireland with about one-third of those employed in public sector jobs. The wholesale and retail private sector make a significant contribution to the economy's overall services sector. As already noted, Northern Ireland's largest external trading market is the Republic of Ireland with which it has enjoyed substantial trade surpluses over the last decade or so. However, sales to and purchases from Great Britain by Northern Irish firms remain over three times that of its largest external trading partner.

It is important to distinguish two distinct periods for Northern Ireland firms over the period of the current analysis. The first relates to the period of uncertainty between the referendum itself but prior to the implementation of withdrawal agreement. This covers the period from June 2016 to December 2020 and is denoted here as the Brexit period. The second phase relates to the time after the completion of the Withdrawal Agreement from January 2021 onwards and primarily reflects the effects of the application of the NIP and the implementation of the Withdrawal agreement. Finally, Covid-19 added an additional layer of uncertainty for UK

firms with much of this concentrated in a period between April 2020 and early 2021. The nature of the foregoing timelines will inform the empirical analysis undertaken for this study.

3. Data

We exploit firm-level data provided by the Northern Ireland Statistics & Research Agency (NISRA). This comprises data drawn from various rounds of the Annual Business Inquiry (ABI) merged with data from the Broad Economy Sales and Exports (BESES) and covers the period from 2014 to 2022 (inclusive). As many firms feature multiple times in the annual surveys, the data are configured as a panel dataset enabling the use of a panel estimator in the subsequent empirical analysis.

The key outcome variables used are the monetary value of the firm's purchases of input goods from five separate geographical areas and the monetary value of the sale of goods to the same five destinations. The areas comprise Northern Ireland, Great Britain, the Republic of Ireland, the rest of the European Union, and the rest of the world. It is possible that a firm purchases goods from or sells to multiple areas concurrently within a given year. In addition to firm specific fixed effects (see below), the control variables include the number of workers employed by the firm, and a Covid-19 dummy variable equal to 1 for the year 2020 and 0 otherwise. The central policy variables are based on two key events that could potentially impact production and trading activity. The first is a dummy variable defined as 'BREXIT', which assumes a value of 1 for the years 2017 to 2020 (inclusive), and equals 0 otherwise. This variable captures the uncertain economic environment facing manufacturing firms after the June 2016 referendum. The second policy variable is defined as 'WITHDRAWAL' and equals 1 for 2021 and 2022 and 0 otherwise. This dummy variable reflects the impact of the implementation of the Withdrawal agreement that, as noted earlier, took legislative effect in January 2021. The reference or base group is provided throughout by the three relatively stable years covering 2014 to 2016 (inclusive). The implicit assumption here is that the uncertainty effects of the Brexit referendum did not crystalise in firm trading behaviour until 2017 onwards. The variables are described in more detail in Table 1 below with the overall summary statistics for trade in goods by area reported in Table A1 of the appendix.

Table 1: Variable Description

Variable	Description
Outcome Variables	
Purchases_NI	The monetary value of goods purchased from Northern Ireland in pounds sterling
Purchases_GB	The monetary value of goods purchased from Great Britain in pounds sterling
Purchases_RoI	The monetary value of goods purchased from Republic of Ireland in pounds sterling
Purchases_EU	The monetary value of goods purchased from European Union in pounds sterling
Purchases_RoW	The monetary value of goods purchased from rest of the world in pounds sterling
Sales_NI	The monetary value of goods sold to Northern Ireland in pounds sterling
Sales _GB	The monetary value of goods sold to Great Britain in pounds sterling
Sales_RoI	The monetary value of goods sold to Republic of Ireland in pounds sterling
Sales _EU	The monetary value of goods sold to European Union in pounds sterling
Sales _RoW	The monetary value of goods sold to rest of the world in pounds sterling
Input Variables	
Log(Labour)	The log of the number of employees
Covid-19	=1 if the year is 2020; = 0 otherwise
BREXIT	=1 if the year is between 2017 to 2020 (inclusive); = 0 otherwise
WITHDRAWAL	=1 if the year is 2021 or 2022; = 0 otherwise

The requirement within the Single Market to comply and adhere to EU Regulations and Directives creates additional costs for firms and can act as a non-tariff barrier (NTB) to trade. Given the particular post-Brexit arrangements for Northern Ireland as the only UK territory remaining in the EU Single Market, we attempt to capture the impact of the regulatory barriers facing manufacturing firms when purchasing inputs from the rest of the UK (i.e. outside the Single Market) by using a set of recently developed regulatory intensity indices (RII) (see Clarke *et al*. (2025)). Machine learning and text-analysis tools are used on a core set of EU Regulations and Directives to extract information on obligations and requirements imposed on firms serving the EU Single Market. The index exploits 257 EU laws listed in the NIP with which manufacturing products sold in Northern Ireland, or shipped from Great Britain to Northern Ireland, are required to comply. The indices empirically capture the intensity of

regulation. Aside from using broader measures like the number of Regulations or Articles that apply to manufacturing products, regulatory indices are constructed on the basis of the number of non-synonym keywords in the documents across three dimensions, two of which are technical production requirements (capturing also product standards) and compliance. In addition, we also exploit a series of measures that capture the degree to which products are subject to independent third-party conformity assessment within the EU. This process, which uses an array of inspection, validation, and testing techniques, is designed to ensure a firm's product satisfies all necessary EU requirements and is generally targeted at those products considered either medium-risk or high-risk in terms of consumer safety.

The foregoing rules and procedures govern the manufacturing trade that crosses the UK-EU border, which under the original NIP agreement was situated in the Irish Sea. The rules are centred around key standards and procedures that the EU considers central to maintaining the integrity of the EU Single Market. Specifically, the current study is interested in ascertaining if Northern Ireland's manufacturing sector's purchases from Great Britain are particularly sensitive to these regulatory measures. We also investigate whether sales to Ireland and the rest of the EU exhibit sensitivity to such measures of administrative burden. It should be the case that firm trading activity with these latter two destinations is unaffected by this burden. However, even if the administrative costs are high, Northern Ireland firms must comply with Single Market rules anyway, in addition to the fact that NI firms are accustomed to trading with the Republic of Ireland.

It is acknowledged there are limitations to the construction of these regulatory measures in the current application. Both the ABI and BESES datasets are at firm level, while the regulatory index is constructed at the Harmonised System Products Classification 6-digit level (HS-6-digit, 2017 version). However, the detailed codes for products traded by firms in the ABI-BESES dataset are not recorded, though the industrial classification of firms is reported. The firm-level data contain information on the UK Standard Industrial Classification codes for firms in NI at the most detailed 5-digit level (SIC-5-digit, 2007 version). We concorded RII from the HS 6-digit product level to the SIC 4-digit industry level is two steps.[1] First, we used

[1] The industry level measure for the regulatory index is specified at the SIC-4-digit level rather than the SIC-5-digit level primarily because of the absence of a readily available concordance table between SIC-5 digit and HS-6 digit.

a concordance table constructed by the Department for Business and Trade (DBT) which concords between HS-6-digit (2017 version) and International Standard Industrial Classification (ISIC-Rev 4) at the 4-digit level. Next, we used a table supplied by the UN Statistical Division to concord the ISIC 4-digit to the SIC 4-digit level. Finally, we merge this with our firm-level data at the SIC four-digit level.

4. Descriptive Statistics on Northern Ireland's Trading Patterns

As a prelude to the econometric analysis, the ABI-BESES data are used to summarise the trading patterns of both the manufacturing, and the wholesale and retail sectors. Figure 1 provides pie charts of Northern Ireland's manufacturing firm purchases from the five defined geographical areas delineated across three distinct periods: pre-Brexit referendum; post-Brexit referendum but pre-Withdrawal Agreement; and post-Withdrawal Agreement. A comparison between the first and third of these charts provides some informative insights for the manufacturing sector. First, the share of purchases from supply sources based in Northern Ireland rose by about nine percentage points (from 41% to 50%) between the pre-Brexit referendum period and the post-Withdrawal Agreement period. Thus, the raw data potentially suggests that the uncertain environment facing manufacturing firms posed by Brexit encouraged firms to source more of their manufacturing inputs locally. This appears to be at the expense of sourcing from Great Britain where the contraction in the purchase shares is down from 30% to just over 22% (close to the nine percentage points for the same period of comparison). This alteration in shares may reflect a greater reluctance on the part of Great Britain manufacturing suppliers to service the Northern Ireland market given the additional bureaucratic costs incurred. Nevertheless, in the final post-withdrawal year of the data available, over 70% of Northern Ireland's manufacturing firms' purchases remain sourced from within the United Kingdom.

The patterns of change observed for the remaining three destinations appear less consequential with the share of purchases from the Republic of Ireland rising by a modest 1.4 percentage points (roughly a rise from just under seven to eight percent of total manufacturing firm purchases). The share purchased from the rest of the European Union contracted by three percentage points, while the shares sourced from the rest of the world remained stable.

Figure 1: Origin Market Shares for Purchases by Manufacturing Firms

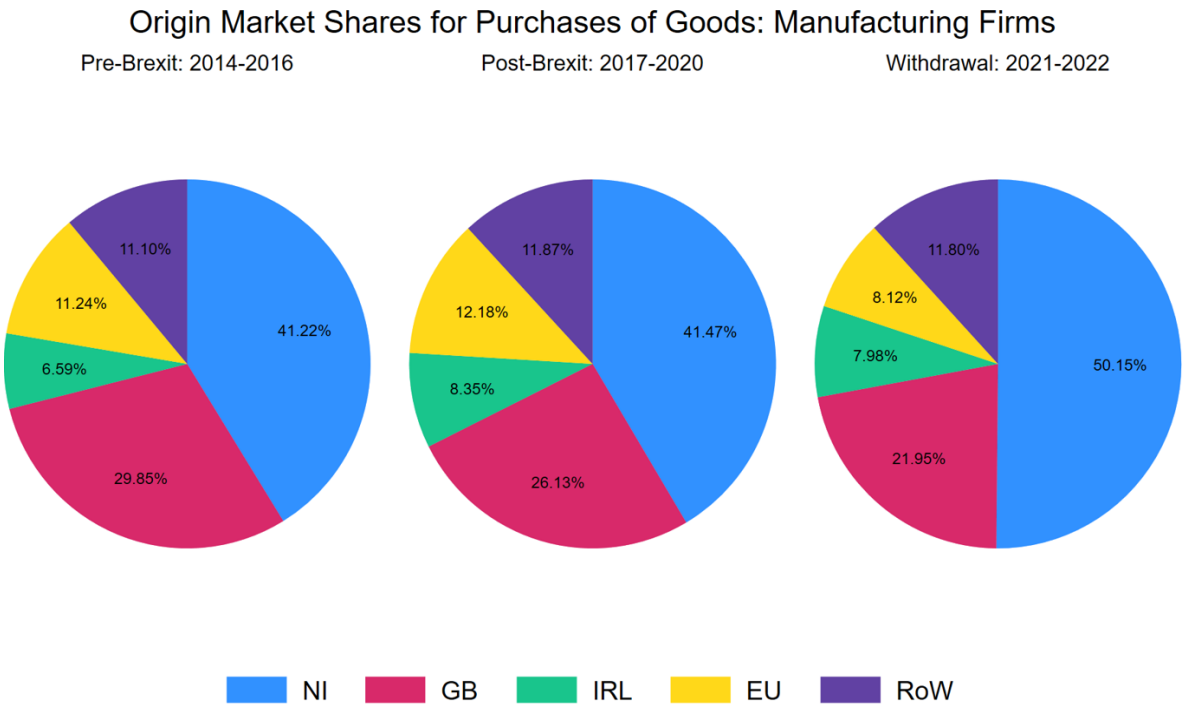

Figure 2: Destination Market Shares for Sales of Manufacturing Firms

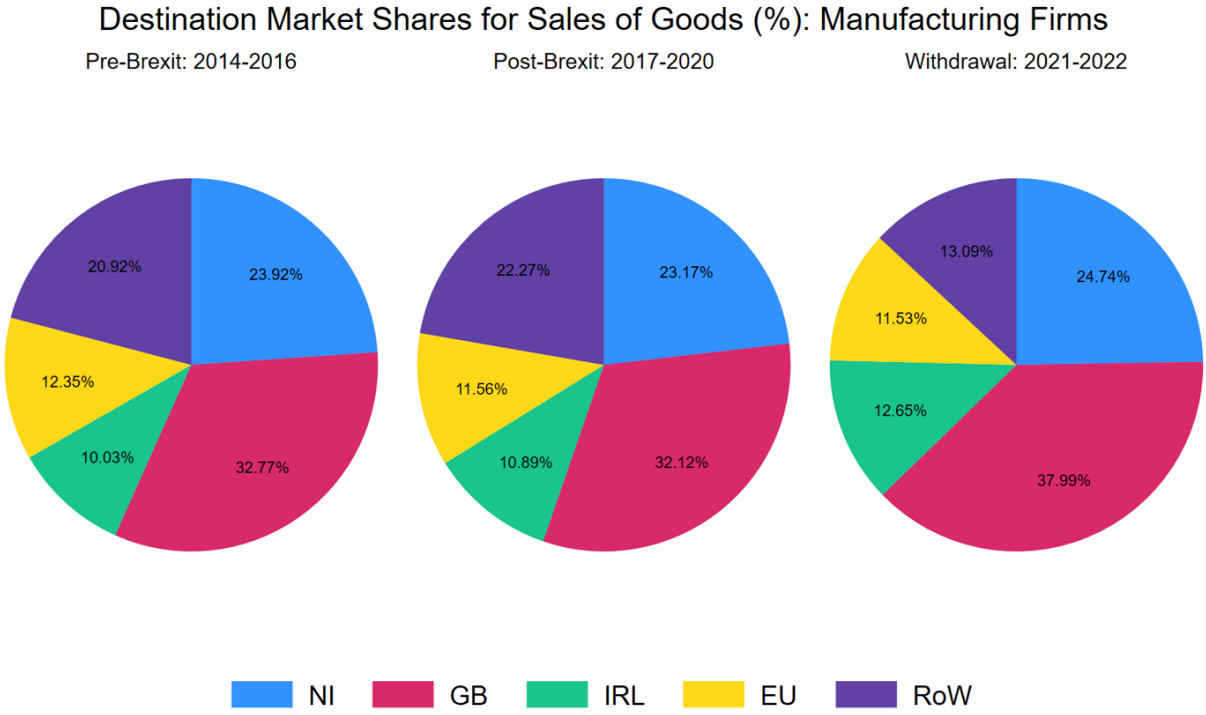

Figure 3: Origin Market Shares for Purchases by Wholesale & Retail Firms

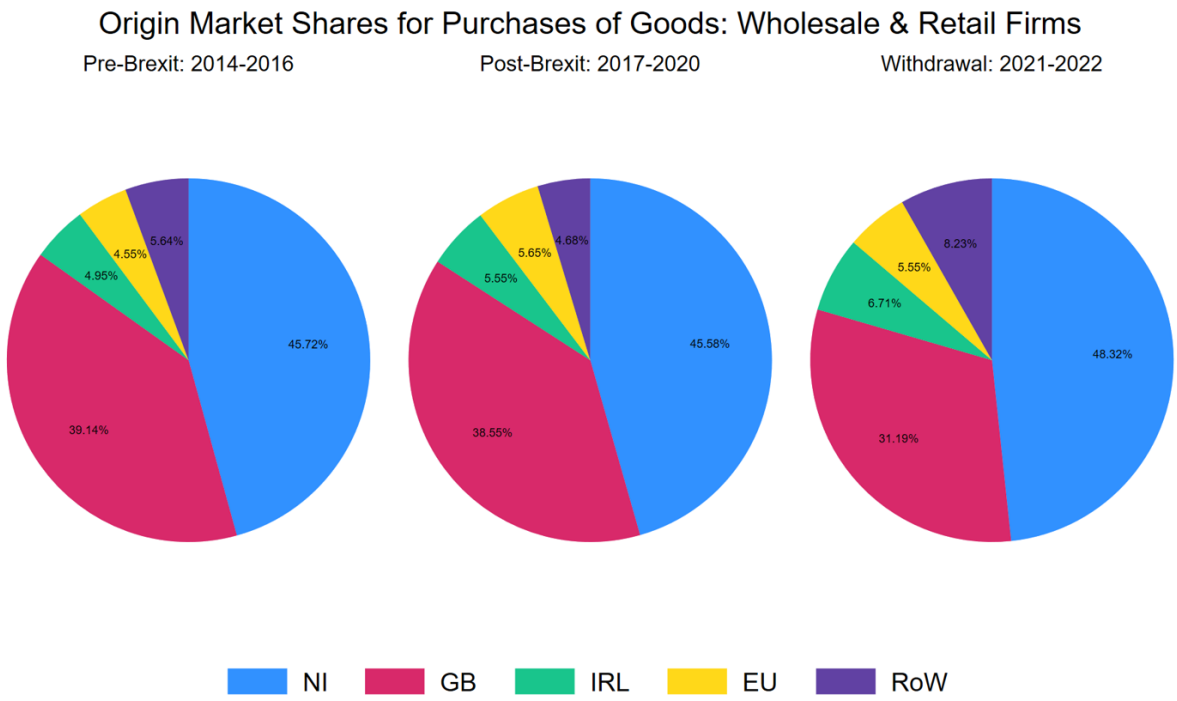

Figure 4: Destination Market Shares for Sales of Wholesale and Retail Firms

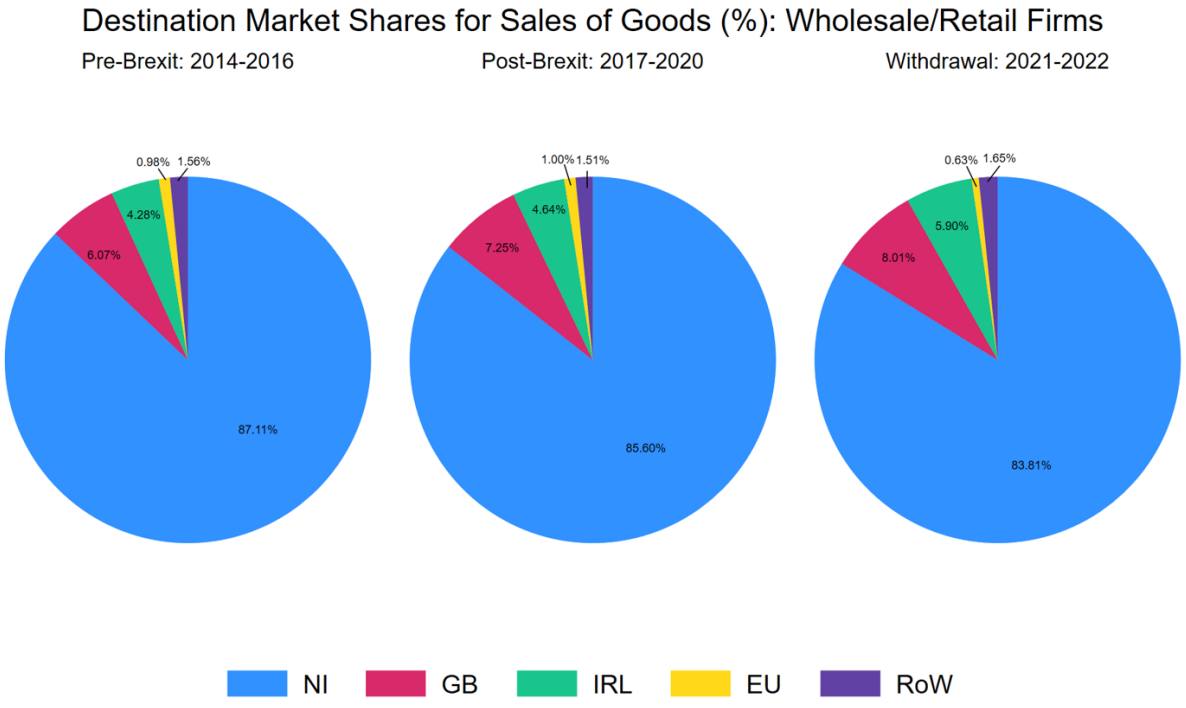

Figure 2 provides comparable pie charts for Northern Ireland's manufacturing firm sales to the five geographical areas across the same time periods. The pattern here suggests greater stability over time. In particular, the portion of sales by firms within Northern Ireland has largely remained stable between the pre-Brexit period and the post-withdrawal period, though the share of manufacturing sales to Great Britain increased slightly by three percentage points. Both markets account for well over one-half of all sales (roughly 63% in the post-withdrawal period). The share of manufacturing sales to the Republic of Ireland exhibited a modest increase of about two percentage points, while the share of sales to the rest of the European Union fell back slightly over the same period. The share of Northern Ireland's manufacturing firm sales to the rest of the world has exhibited a sharp contraction of about eight percentage points and this may reflect the sluggish growth in global markets post-pandemic. However, this destination comprises a modest one-tenth of all Northern Ireland's manufacturing sales in the post-withdrawal period.

Figures 3 and 4 replicate this descriptive analysis for firms in Northern Ireland's Wholesale and Retail sectors. Overall, over four-fifths of all purchases by firms within this sector originate within the United Kingdom (see Figure 3). In a comparison between the post-agreement period and the pre-Brexit referendum period, this share has contracted by about five percentage points. The remaining shares are all relatively small, though the share of inputs purchased from Ireland has increased by about 1.7 percentage points over the same period.

Figure 4 describes the shares of sales to the relevant destinations and, not surprisingly, approximately 84% is sold within Northern Ireland's domestic market. There is little evidence of a change in this share across the two periods of uncertainty (Brexit and the post-withdrawal agreement periods).

The descriptive analysis is now developed further by examining the firm-level average values of purchases and sales across these three discrete time periods. The average values are unconditional in that the zero values for firms feature. Table 2 reports the averages for the case of manufacturing. The entries in this table indicate that other than purchases from Ireland, there is limited statistical evidence of a change with trading partners between either the Brexit or post-withdrawal and the pre-Brexit periods. However, the estimates for the Republic of Ireland reveal that the average Northern Ireland manufacturing firm increased purchases from

south of the border by about £145,000 between the Brexit and the pre-Brexit periods, with statistical significance registered at the 10% level using a two-tailed test.

Table 2: Purchasing and Selling Values by Destination and Period for Manufacturing Firms (£'s 000)

	Pre-Brexit (1)	Post-Brexit Referendum but Pre-Withdrawal (2)	Post-Withdrawal (3)	Differences ($\widehat{\Delta}_1$) (2) – (1)	Differences ($\widehat{\Delta}_2$) (3) – (1)	Differences ($\widehat{\Delta}_3$) (3) – (2)
Northern Ireland:						
Purchases of Goods	2760.0 (224.0)	2912.5 (118.9)	3633.5 (320.0)	152.5 (253.6)	873.5*** (390.6)	721.0** (341.4)
Sales of Goods	2593.6 (180.5)	2709.2 (156.2)	2913.3 (200.1)	115.6 (238.7)	319.7 (269.5)	204.1 (253.8)
Great Britain:						
Purchases of Goods	1999.0 (200.9)	1835.4 (160.8)	1590.0 (153.5)	-163.6 (257.3)	-409.0 (252.8)	-245.4 (222.3)
Sales of Goods	3553.2 (350.8)	3755.0 (312.6)	4474.1 (488.8)	201.8 (469.9)	920.9 (601.7)	719.1 (580.2)
Ireland:						
Purchases of Goods	441.0 (43.1)	586.3 (62.6)	578.0 (92.6)	145.3* (76.0)	137.0 (102.1)	-8.3 (160.3)
Sales of Goods	1087.8 (82.4)	1273.0 (76.6)	1489.6 (129.8)	185.2 (112.5)	401.8*** (153.7)	216.6 (150.7)
European Union:						
Purchases of Goods	753.0 (81.4)	855.2 (91.9)	588.4 (66.3)	102.2 (122.8)	-164.6 (105.0)	-266.8*** (113.3)
Sales of Goods	1339.5 (170.7)	1351.2 (136.4)	1357.2 (186.5)	11.7 (218.5)	17.7 (252.8)	6.0 (231.1)
Rest of World:						
Purchases of Goods	743.0 (138.5)	833.5 (150.7)	854.6 (213.1)	90.5 (204.7)	111.6 (254.1)	21.1 (261.0)
Sales of Goods	2268.3 (364.9)	2603.7 (360.4)	1541.5 (250.9)	335.4 (364.9)	-726.9 (442.8)	-1062.2*** (439.1)

Notes: Standard errors are reported in parentheses; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests for the differences in means.

There was also a sharp increase in manufacturing sales to the Republic of Ireland in the post-withdrawal relative to the pre-Brexit period with the average increase per firm in the order of £400,000. There was also a statistically significant contraction of purchases from the European Union between the post-withdrawal and Brexit periods, and a sizeable contraction in the sales of goods to markets in the rest of the world over the same period. Nevertheless, the key stand-out estimates for purchases in Table 2 reveal a sharp increase in the value of purchases within Northern Ireland with the effects for both post-Brexit periods well determined statistically at the 5% level (or better).

We now compute a set of suggestive difference-in-difference estimates based on the raw data for the manufacturing sector. The primary focus of concern is around Northern Ireland firm-level purchases from British-based firms as these are most likely to be affected by the implementation of the NIP. The relevant estimates are reported in Table 3. Although the point estimates indicate the gap in the spend of the average Northern Ireland manufacturing firm between Great Britain and Northern Ireland sources reduced by £316,000 between the Brexit and the pre-Brexit periods, the difference-in-difference estimate is not found to be statistically different from zero. In contrast, the difference-in-difference estimate between the post-agreement period and the pre-Brexit period suggests a contraction in spend by manufacturing firms from GB relative to Northern Ireland by over £1 million, which is statistically significant. In addition, there is some statistical evidence that the gap in manufacturing purchases sourced from Great Britain relative to the Republic of Ireland has also contracted across the later period, though a similar pattern is not noted for the rest of the EU. No statistically significant reductions in goods' sales to British relative to Northern Ireland markets is detected, or in sales to British markets relative to all European Union markets in either the Brexit referendum period or post-withdrawal agreement period. This provides some tentative evidence of trade diversion within manufacturing when using the raw data with the Northern Irish market becoming relatively more important for the purchase of manufacturing firms' input goods. There is modest evidence of a contraction in manufacturing trading patterns with the region's largest external market (Republic of Ireland).

Table 3: Difference-in-Differences Estimates across Source & Destination Areas for Manufacturing Firms (£'s 000)

	Purchases	Sales
Brexit Period:		
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Northern\ Ireland}$	-316.1 (361.3)	86.2 (312.6)
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Ireland}$	-308.9 (268.3)	16.6 (483.2)
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{European\ Union}$	-265.8 (285.1)	190.1 (518.2)
Post-Withdrawal Agreement:		
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{Northern\ Ireland}$	-1282.5*** (465.3)	601.2 (659.3)
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{Ireland}$	-546.0** (272.6)	519.1 (621.0)
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{European\ Union}$	-344.4 (273.7)	903.2 (652.6)

Notes: Standard errors are reported in parentheses; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests for the differences in means.

A similar exercise is now conducted for the Wholesale and Retail sector with the differences across the three time periods reported in Table 4. In general, there does appear to have been sizeable and significant increases in both purchases and sales from within Northern Ireland during both the Brexit referendum and the post-withdrawal periods. In contrast, the purchase of inputs from British markets flatlined in the post-withdrawal period, though sales to this market have remained robust, and rose post-withdrawal. Both purchases from and sales to Ireland have exhibited a steady increase for this sector over the two later periods. In regards to other European Union markets, there is no statistical evidence for increased sales, though there was a statistically significant up-tick in purchases from this market in the Brexit pre-withdrawal period.

As noted in Table 5 using the difference-in-differences, there is no statistical evidence of a change in trading patterns for purchases across Northern Ireland's main trading destinations. In regards to sales, there is some evidence suggesting a growth in the importance of Northern Ireland relative to British markets, though the latter markets appear to have become more important than European Union markets in both the Brexit referendum and post-withdrawal periods.

Table 4: Purchasing and Selling Values by Destination for Wholesale & Retail Firms (£'s 000)

	Pre-Brexit (1)	Post-Brexit Referendum but Pre-Withdrawal (2)	Post-Withdrawal (3)	Differences ($\widehat{\Delta}_1$) (2) – (1)	Differences ($\widehat{\Delta}_2$) (3) – (1)	Differences ($\widehat{\Delta}_3$) (3) – (2)
Northern Ireland:						
Purchases of Goods	4850.2 (364.9)	6164.8 (421.7)	5808.7 (550.1)	1314.6*** (557.7)	958.5 (660.1)	-356.1 (693.1)
Sales of Goods	11726.0 (866.2)	15130.8 (1006.7)	13957.2 (1010.9)	3404.8*** (1328.1)	2231.2* (1331.2)	-1173.6 (1426.7)
Great Britain:						
Purchases of Goods	4152.4 (382.6)	5214.0 (470.5)	3749.9 (363.3)	1061.6* (606.4)	-402.5 (527.6)	-1464.1*** (594.4)
Sales of Goods	816.5 (116.3)	1282.1 (146.1)	1334.1 (215.3)	465.6*** (186.7)	517.6*** (244.7)	52.0 (260.2)
Ireland:						
Purchases of Goods	525.5 (62.6)	750.4 (78.4)	806.3 (97.0)	224.9*** (100.3)	280.8*** (115.4)	55.9 (124.7)
Sales of Goods	575.8 (76.8)	819.7 (72.9)	983.3 (136.2)	243.9*** (105.9)	407.5** (156.4)	163.6 (154.5)
European Union:						
Purchases of Goods	483.0 (68.6)	764.3 (103.2)	667.7 (87.6)	281.3*** (123.9)	184.7 (111.3)	-96.6 (135.4)
Sales of Goods	132.6 (25.3)	177.0 (47.6)	104.1 (27.1)	44.4 (53.9)	-28.5 (37.1)	-72.9 (54.8)
Rest of World:						
Purchases of Goods	598.4 (147.9)	632.6 (103.1)	989.8 (371.8)	34.2 (180.3)	391.4 (400.1)	357.2 (385.8)
Sales of Goods	210.6 (49.6)	266.1 (64.9)	274.9 (90.0)	55.5 (81.7)	64.3 (102.8)	-61.1 (110.0)

Notes: Standard errors are reported in parentheses; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests for the differences in means.

Table 5: Difference-in-Differences across Source & Destination Areas for Wholesale & Retail Firms (£'s 000)

	Purchases	Sales
Brexit Period:		
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Northern\ Ireland}$	-253.0 (823.9)	-2939.2*** (1341.2)
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Ireland}$	836.7 (614.6)	221.7 (214.6)
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{European\ Union}$	780.3 (618.9)	421.2*** (194.3)
Post-Withdrawal Agreement:		
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{Northern\ Ireland}$	-1361.0 (845.0)	-1713.6 (1353.5)
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{Ireland}$	-683.3 (540.1)	110.1 (290.4)
$\widehat{\Delta}_2^{Great\ Britain} - \widehat{\Delta}_2^{European\ Union}$	-587.2 (539.2)	546.1*** (247.5)

Notes: Standard errors are reported in parentheses; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests for the differences in means.

The foregoing descriptive analysis based on raw data reveals that the purchasing patterns of Northern Ireland's manufacturing firms with respect to Great Britain markets appear to have stagnated after the Brexit referendum and the subsequent withdrawal agreement. This is perhaps unsurprising as the NIP increased the regulatory and administrative costs incurred by British firms that have traditionally conducted business with enterprises in Northern Ireland. However, although it is extremely difficult to determine, the lack of any nominal growth in spend may reflect the influence of uncertainty with respect to British-based supply chains. In the absence of Brexit, it may be reasonable to anticipate some trend growth in the purchase of inputs from British sources over this period given the growth observed in other markets. The lack of such an effect may reflect the contribution of Brexit uncertainty. In contrast, the sales of goods by Northern Ireland's manufacturing firms appear less impeded given continued frictionless access to markets in Great Britain, the Republic of Ireland, and the rest of the European Union. A similar finding is detected for firms operating within the Wholesale and Retail sector.

It is important to stress that the foregoing findings relate to an examination of the raw data and ignore the role of firm-specific confounding factors. Therefore, the next phase of the empirical

analysis controls for a variety of potential confounders to investigate whether the uncertainty around the Brexit referendum and the implementation of the subsequent withdrawal agreement affected the monetary value of trade with different geographical areas given a potential for the emergence of higher trading costs associated with Brexit. The subsequent econometric modelling is intended to shed some further light on these issues.

5. Econometric Methodology

The econometric modelling used for the analysis is designed to cater for a specific feature of the firm-level outcome data available to us. Given the focus is on sales to or purchases from specific geographical areas (*viz*., Northern Ireland itself, Great Britain, the Republic of Ireland, the rest of the European Union, and the rest of the world), the outcome measure in some cases exhibits censorship at zero. Therefore, the use of OLS may lead to inconsistent estimates. The Poisson regression model has been extensively exploited in empirical trade gravity models to deal with this issue (see Santos Silva and Tenreyro (2006) and Correia, Guimarães and Zylkin (2020)). Santos Silva and Tenreyro (2006) demonstrate that under weak assumptions (notably that the gravity model contains the correct set of explanatory variables) the Poisson pseudo-maximum likelihood estimator provides consistent estimates of the original nonlinear model. In the current application, we formulate a firm-level fixed effects regression model (for either firm-level sales or purchases) as follows:

$$y_{it} = \alpha_i + \beta_1 \log(\text{labour}_{it}) + \beta_2 \text{Covid-19}_t + \gamma_1 \text{BREXIT}_t + \gamma_2 \text{WITHDRAWAL}_t + u_{it} \qquad [1]$$

where y_{it} denotes the value of purchases or sales from by firm *i* in year *t* from/to a certain origin/destination. The explanatory variables are defined as in the previous section, and α_i represents time-invariant firm-level fixed effects to control for firm-specific unobservable confounders. The above model is estimated for each of five separate source areas (for firm-level purchases) or destination areas (for firm-level sales). The analysis is undertaken separately for manufacturing firms, and then for retail and wholesale firms. The panel of firms is unbalanced. Estimation is undertaken using a high-dimensional fixed effects procedure (see Correia (2016)). Specifically, a Poisson pseudo-maximum likelihood (PPML) regression is used (see Correia, Guimares and Zylkin (2020)). The approach provides a feasible and computationally efficient estimator and exhibits a rapid asymptotic running time. It also

excludes 'singleton' panel observations from the analysis given their implication for the construction of the variance-covariance matrix. Robust standard errors, clustered at the firm-level, are used for inferential purposes.

In addition, and as already noted earlier, given regulation is a determinant of trade and production, a sub-theme of the research inquiry is centred around the impact of an array of regulatory indices for manufacturing firms discussed earlier in the previous section. The index is designed to capture the production requirements and bureaucratic costs associated with the Withdrawal Agreement on sales in Northern Ireland. Specifically, we will focus primarily on the effect of the regulatory intensity on the purchase of inputs from the Great Britain market post-withdrawal (given the NIP), and as a sub-theme on sales to the EU market separated into the Republic of Ireland and the rest of the EU.

If we define the index in general terms as RII, the following model is specified for the manufacturing firms to capture the effect of these regulatory and bureaucratic costs on firm-level trading patterns to and from Northern Ireland:

$$y_{it} = \alpha_i + \beta_1 \log(labour_{it}) + \beta_2 Covid\_19_t + \pi_0 RII_{it} + \gamma_1 BREXIT_t + \gamma_2 WITHDRAWAL_t + \pi_1 WITHDRAWAL_{it} \times RII_{jt} + v_{it} \quad [2]$$

where j represents the 4-digit SIC sector, which provides the variation in the regulatory intensity measure. The regulatory indices also vary across time. A PPML regression model is again used in the estimation of [2]. The estimated effect for π_1 provides the effects of regulatory intensity on manufacturing sales in the post-withdrawal period.[1]

6. Econometric Results

6.1. Brexit and Withdrawal Agreement Effects

The econometric estimates based on specification [1] are reported in Table 6. This table contains the key BREXIT and WITHDRAWAL estimates for the firm-level purchases of goods from five different geographical areas. As was the case for the summary statistics based on the raw data, once controls for firm size, Covid-19, and firm-level fixed effects are included in the

specification, manufacturing purchases from Great Britian exhibit no statistically significant change within either the Brexit referendum period of uncertainty or in the post-withdrawal agreement implementation years. In contrast, purchases from within Northern Ireland and from the Republic of Ireland register statistically significant increases. In general, these findings are resonant of the work of Flynn, Kren and Lawless (2021). There is also a statistically significant increase in purchases from countries outside the EU in the post-agreement periods relative to the three earliest years of the data.

Table 6: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms

	Northern Ireland	**Great Britain**	**Ireland**	**European Union**	**Rest of the World**
Ln(Labour)	0.2739***	1.0571***	0.8892***	0.6242	0.8902***
	(0.0993)	(0.2077)	(0.2987)	(0.4017)	(0.3333)
Covid-19	-0.0154	-0.1598*	-0.2386*	-0.2260***	-0.1129
	(0.0601)	(0.0889)	(0.1234)	(0.0772)	(0.1767)
BREXIT	0.1173**	-0.0473	0.3506***	0.1887*	0.1783
	(0.0506)	(0.0479)	(0.1298)	(0.1138)	(0.1225)
WITHDRAWAL	0.4295***	-0.0849	0.4168*	-0.0992	0.4498***
	(0.0986)	(0.1130)	(0.2355)	(0.1580)	(0.1664)
Pseudo-R^2	0.9326	0.9068	0.8356	0.8768	0.9282
Log Pseudo-L	-4846822	-4405115	-2441329	-2757724	-2288484
Fixed Effects	1,904	1,614	1,429	1,226	990
Singletons	544	1,636	2,393	3,521	4,901
Observations	10,632	9,541	8,783	7,655	6,275

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Attention now turns to the estimates for specification [1] based on the sales of manufacturing firms to the five geographical destinations reported in Table 7. There is evidence of a statistical increase in the average monetary values of firm-level manufacturing sales within Northern Ireland relative to the pre-Brexit referendum period. Manufacturing sales to Britain increased sharply in the post-withdrawal agreement implementation period, while the same was the case for the Republic of Ireland and the rest of the European Union.

Table 8 reports some suggestive difference-in-difference estimates based on the regression models reported in Tables 6 and 7 for manufacturing firm purchases and sales respectively.

Table 7: Sales of Goods by Destination Market by Northern Ireland Manufacturing Firms

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
Ln(Labour)	0.2081**	0.4985***	0.6410*	1.1624***	0.7006***
	(0.1027)	(0.1870)	(0.3289)	(0.2849)	(0.1673)
Covid-19	-0.1112*	0.0310	-0.0607	-0.0215	-0.1298
	(0.0579)	(0.0568)	(0.0535)	(0.0708)	(0.0858)
BREXIT	0.1052**	0.0574	0.1794***	0.0590	0.2531**
	(0.0483)	(0.0472)	(0.0673)	(0.0971)	(0.1229)
WITHDRAWAL	0.2176***	0.3667***	0.4084***	0.2465*	-0.0730
	(0.0803)	(0.0757)	(0.0862)	(0.1263)	(0.0902)
Pseudo-R^2	0.9229	0.9570	0.9212	0.9394	0.9692
Log Pseudo-L	-3210057	-3733759	-1924143	-2043550	-2001223
Fixed Effects	1,764	1,183	1,328	1,226	649
Singletons	660	3,566	4,690	6,415	6,728
Observations	9,895	6,989	7,865	4,140	3,827

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table 8: Difference-in-Differences Estimates across Source & Destination Areas for Manufacturing Firms (£'s 000)

	Purchases	Sales
Brexit Period:		
$\hat{\gamma}_1^{Great\ Britain} - \hat{\gamma}_1^{Northern\ Ireland}$	-0.1646***	-0.0478
	(0.0697)	(0.0675)
$\hat{\gamma}_1^{Great\ Britain} - \hat{\gamma}_1^{Ireland}$	-0.3979***	-0.1220
	(0.1384)	(0.0822)
$\hat{\gamma}_1^{Great\ Britain} - \hat{\gamma}_1^{European\ Union}$	-0.2360*	-0.0016
	(0.1235)	(0.1080)
Post-Withdrawal Agreement:		
$\hat{\gamma}_2^{Great\ Britain} - \hat{\gamma}_2^{Northern\ Ireland}$	-0.5144***	0.1491
	(0.1499)	(0.1104)
$\hat{\gamma}_2^{Great\ Britain} - \hat{\gamma}_2^{Ireland}$	-0.5017***	-0.0417
	(0.2612)	(0.1147)
$\hat{\gamma}_2^{Great\ Britain} - \hat{\gamma}_2^{European\ Union}$	0.0143	0.1202
	(0.1942)	(0.1472)

Notes: The difference-in-difference estimates are based on the differences between the relevant estimates in specification [1] for the separate source and destination areas (see Tables 6 and 9). ***, **, and * denote statistical significance at the 1%, 5% and 10% level using two tailed tests.

The statistically significant estimates reveal that during the post-withdrawal period, the gap in the value of purchases for the average Northern Ireland manufacturing firm between Great Britain and Northern Ireland and Great Britain and the Republic of Ireland contracted substantially relative to the base period. Although Great Britain remains the largest source

market for Northern Ireland's manufacturing firms, this suggests there is evidence that this historical advantage has exhibited some decline since the implementation of the withdrawal agreement. In contrast, there is no statistical evidence of a change in trading patterns along the sales dimension with respect to Northern Ireland, the Republic of Ireland or other European Union markets.[2]

Attention now turns to the purchases of firms in the wholesale and retail sector from these five separate destinations. Table 9 reports the key estimates and reveals no statistical evidence of an increase in the average value of firm-level purchases in the withdrawal period relative to the pre-Brexit period either from within Northern Ireland or Great Britian. In contrast, sizeable average increases are noticeable for the post-withdrawal period relative to the base period for the Republic of Ireland and the rest of the European Union. However, sales to all destinations other than to all European Union markets have exhibited a statistically significant increase in the withdrawal period relative to the pre-Brexit period (see Table 10).[3]

Table 9: Purchases of Goods by Market Origin by Northern Ireland Wholesale & Retail Firms

	Northern Ireland	**Great Britain**	**Ireland**	**European Union**	**Rest of the World**
Ln(Labour)	0.5146***	0.6827***	0.5103*	0.8213***	0.6962*
	(0.1302)	(0.1286)	(0.2977)	(0.2755)	(0.3670)
Covid-19	-0.1107**	-0.0792	-0.0460*	-0.0078	0.1667
	(0.0534)	(0.1173)	(0.1232)	(0.2095)	(0.2859)
BREXIT	0.0330	0.0063	0.1752	0.2738***	-0.2377
	(0.0390)	(0.0773)	(0.1244)	(0.0873)	(0.2357)
WITHDRAWAL	0.0998	-0.1738	0.3729**	0.3013*	0.5044***
	(0.0804)	(0.1232)	(0.1578)	(0.1720)	(0.1818)
Pseudo-R^2	0.9125	0.8828	0.8618	0.8444	0.8990
Log Pseudo-L	-9812033	-11435999	-2253316	-2463479	-2389441
Fixed Effects	2,067	1,706	1,244	1,026	784
Singletons	1,310	2,447	4,212	5,232	6,284
Observations	9,098	7,931	6,196	5,176	4,124

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table 10: Sales of Goods to Market Destinations by Northern Ireland Wholesale & Retail Firms

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
Ln(Labour)	0.6510***	0.1388	0.5379***	0.4453	0.8675**
	(0.0941)	(0.3403)	(0.1204)	(0.3741)	(0.4211)
Covid-19	0.0233	-0.3276***	-0.0904	-0.7638**	-0.1480
	(0.0557)	(0.1083)	(0.1473)	(0.3641)	(0.1571)
BREXIT	0.0238	0.3558*	0.1349	0.2838	0.1871
	(0.0206)	(0.2199)	(0.0988)	(0.2048)	(0.1234)
WITHDRAWAL	0.1067**	0.5564**	0.3394**	-0.3284*	0.3021*
	(0.0435)	(0.2457)	(0.0996)	(0.1609)	(0.1740)
Pseudo-R^2	0.9695	0.8891	0.9096	0.9130	0.9424
Log Pseudo-L	-6926525	-2698539	-1330814	-359206	-423351
Fixed Effects	2,083	811	1,068	406	338
Singletons	1,020	6,150	5,062	8,059	8,476
Observations	9,148	4,018	5,106	2,109	1,692

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table 11: Difference-in-Difference Estimates across Source & Destination Areas for Wholesale & Retail Firms

	Purchases	Sales
Brexit Period:		
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Northern\ Ireland}$	-0.0267	0.3328
	(0.0866)	(0.2209)
$\widehat{\Delta}_1^{Ireland} - \widehat{\Delta}_1^{Northern\ Ireland}$	0.1422	0.1111
	(0.1304)	(0.1009)
$\widehat{\Delta}_1^{European\ Union} - \widehat{\Delta}_1^{Northern\ Ireland}$	0.2408***	0.2600
	(0.0956)	(0.2058)
Post-Withdrawal Agreement:		
$\widehat{\Delta}_1^{Great\ Britain} - \widehat{\Delta}_1^{Northern\ Ireland}$	-0.2736*	0.4497**
	(0.1472)	(0.2495)
$\widehat{\Delta}_1^{Ireland} - \widehat{\Delta}_1^{Northern\ Ireland}$	0.2731	0.2327**
	(0.1771)	(0.1087)
$\widehat{\Delta}_1^{European\ Union} - \widehat{\Delta}_1^{Northern\ Ireland}$	0.2015	-0.4351***
	(0.1899)	(0.1667)

Notes: The difference-in-difference estimates are based on the differences between the relevant estimates in specification [1] for the separate source and destination areas (see Tables 9 and 10). ***, **, and * denote statistical significance at the 1%, 5% and 10% level using two tailed tests.

Table 11 reports an illustrative set of difference-in-difference estimates for the wholesale and retail sector. These reveal that in terms of inputs, Northern Irish firms purchased less from sources in mainland Britain in the withdrawal relative to the base period. There is no statistical

evidence of a similar effect with respect to EU markets. In terms of sales, British markets have increased in their importance for this sector over the same period of comparison particularly relative to both Ireland but also other EU markets.

6.2. Regulatory Burden Effects

We now explore the impact of regulatory intensity (or burden) on the pattern of sales for Northern Ireland manufacturing firms. The estimates are based on specification [2]. The first measure is a Regulations count, while the second is based on the number of articles in the Regulations applying to the industry of a firm. The sum of the key words for each Regulation is then used to inform indices for Technical Requirements and Compliance. The greater the number of non-synonym key words featured in the Regulations, the greater is the assumed regulatory burden facing firms. Each regression model is estimated separately using the different regulatory indices. The key focus here is centred around the interaction between the regulatory indices and the WITHDRAWAL dummy variable.

Table 12 reports the estimates for manufacturing purchases from Great Britain, the supply source most affected by the NIP, using four different forms of regulatory index (viz., the number of regulations, the number of articles, the count of key words for Technical Requirements, and the count of key words for Compliance). The impact pre-withdrawal of the regulatory indices based on the number of regulations, Technical Requirements and Compliance are found to be negative and statistically significant, but there is little evidence of a differential effect for these in the post-withdrawal period.[4] A set of comparable estimates for the regulatory index based on Conformity Assessment are reported in Table 13. Three separate measures for Conformity are used given the type of assessment that products must undergo can imply substantially different burdens for firms. Specifically, we single out requirements specific to third-party conformity assessment as opposed to in-house assessment. We therefore use the following indices: the number of regulations requiring that the assessment is undertaken by third parties, the count of key words for conformity assessment procedures (including both in-house and third-party assessment), and a dummy variable for the presence of provisions in the regulations for third-party conformity. This dummy variable delineates the 4-digit SIC sectors on which third party assessment is imposed from those sectors where no this is not imposed. The estimates reveal statistically significant negative effects for the latter two of these

measures on manufacturing purchases from Great British markets in the post-withdrawal period.[5]

Table 12: Purchases of Goods from Great Britain by Northern Ireland Manufacturing Firms with Regulatory Indices

	Great Britain (1)	**Great Britain (2)**	**Great Britain (3)**	**Great Britain (4)**
Ln(Labour)	1.0128***	1.0138***	1.0098***	1.0171***
	(0.2013)	(0.2039)	(0.2018)	(0.2033)
Covid-19	-0.1471*	-0.1649*	-0.1441	-0.1489*
	(0.0906)	(0.0856)	(0.0903)	(0.0904)
BREXIT	-0.0552	-0.0456	-0.0564	-0.0663
	(0.0516)	(0.0490)	(0.0525)	(0.0537)
WITHDRAWAL	-0.2411*	-0.2714**	-0.2392*	-0.2422*
	(0.1322)	(0.1275)	(0.1308)	(0.1477)
Reg_Index	-0.0418**	-0.0001	-0.0129**	-0.0107*
	(0.0204)	(0.0005)	(0.0059)	(0.0055)
WITHDRAWAL× Reg_Index	0.0175	0.0006*	0.0060	0.0058
	(0.0118)	(0.0003)	(0.0046)	(0.0058)
Pseudo-R^2	0.9078	0.9081	0.9077	0.9076
Log Pseudo-L	-4356804	-4343181	-4361180	-4367799
Fixed Effects	1,614	1,614	1,614	1,614
Singletons	1,636	1,636	1,636	1,636
Observations	9,541	9,541	9,541	9,541

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) is number of regulations; (2) is number of articles; (3) count of non-synonym key words for Technical Requirements; (4) count of non-synonym key words for compliance.

As an additional exercise, due to the onerous nature of food safety regulation in the EU (agri-food is one of the most intensely regulated sectors, also according to the RII measures – see Clarke et al, 2025), and the importance of agri-food in Northern Ireland, we undertook an analysis for the food and beverages manufacturing sector alone. Again, there was little statistical evidence that the purchases of this sub-sector by Northern Ireland firms were affected by most measures of regulatory intensity in the implementation of the post-withdrawal agreement (see Table A10 of Appendix I). However, again, the provisions within the regulations associated with third-party conformity appear to matter for this sub-sector and acted to reduce purchases in the post-withdrawal period relative to the pre-Brexit period (see Table A11 of Appendix I).

Table 13: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms with Regulatory Indices on Third-Party Conformity

	Great Britain (1)	Great Britain (2)	Great Britain (3)
Ln(Labour)	1.0013***	0.9918***	1.0180***
	(0.1939)	(0.1965)	(0.1986)
Covid-19	-0.1665*	-0.1580*	-0.1634*
	(0.0871)	(0.0871)	(0.0885)
BREXIT	0.0044	-0.0029	-0.0509
	(0.0496)	(0.0496)	(0.0458)
WITHDRAWAL	0.1763	0.2216	0.1430
	(0.1413)	(0.1413)	(0.1580)
Reg_Index	-0.1453**	-0.0390	-0.1320
	(0.0458)	(0.0141)	(0.3795)
WITHDRAWAL× Reg_Index	-0.1006	-0.0346*	-0.4743*
	(0.0632)	(0.0183)	(0.2684)
Pseudo-R^2	0.9098	0.9100	0.9083
Log Pseudo-L	-4261194	-4250098	-4334627
Fixed Effects	1,614	1,614	1,614
Singletons	1,636	1,636	1,636
Observations	9,541	9,541	9,541

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) is number of regulations related to third parties; (2) count of non-synonym key words for third party conformity; (3) dummy for third party conformity.

As a complementary exercise, we integrate the analysis of firm-level purchases from the Great Britain market with sales to the EU markets. The purpose of this exercise is to determine if the supply chain constraints on manufacturing firms sourcing inputs from Great Britain has impacted their sales behaviour to the Republic of Ireland and other EU member country markets. We augmented specification [2] by including a control for a firm's share of purchases of inputs from the Great Britain market. This share is then interacted with the WITHDRAWAL dummy, and subsequently with the regulatory indices. Table A8 of Appendix I reports the relevant estimates for the case of the Republic of Ireland. There is no evidence that the share of input purchases from Great Britain adversely affected manufacturing sales to Ireland in the wake of the withdrawal agreement or through an increased regulatory burden. Table A9 in the same appendix replicates the exercise for sales to the other EU markets. In contrast to the case for Ireland, there is some very mild counter-intuitive statistical evidence that regulatory intensity, as mediated though the British supply chain channel, increased manufacturing firm sales to the EU market in the immediate post-withdrawal period.

Finally, we explored whether the greater degree of policy uncertainty post the Brexit referendum but prior to the implementation of the withdrawal agreement impacted the trading behaviour of Northern Ireland's manufacturing firms. This was explored by interacting the regulatory intensity measures with the BREXIT dummy in specification [2]. However, none of the estimated interactive effects were found to be statistically significant at the 5% level or better and are thus not reported in this paper here.

6.3. Effects by selected subsamples: firm size and high-tech manufacturing firms

In order to explore the possible heterogeneity of the preceding either across firm size or by product characteristics, we turn to whether the impacts of the Withdrawal Agreement, with and without the additional effects of the regulatory burden introduced by the NIP, differ between large and small firms, and between low- and high-tech industries. These results are presented in Tables A1-A6 in Appendix 1.

Table A1 and Table A3 report our estimates of the differential impact on large relative to small firms of the Withdrawal Agreement on, respectively, purchases and sales. Interestingly, both the impact on purchases and sales are driven by small firms (i.e. those with less than 50 employees), with the differential effect estimated for large firms being largely statistically insignificant. This suggests, therefore, that it was small firms who needed to make greater adjustments to their supply-chain operations to deal with the post-Brexit trading arrangements. Large producers, that could possibly rely or a larger (or wider) network of suppliers, or for which could absorb more easily the adjustment costs, reported no change in their trading behaviour.

Table A5 reports on the differential effect by size group of the indices for Conformity Assessment requirements. Here we see that the trade deterring impact of third-party conformity assessment, as picked up by the binary variable denoting the presence of such requirements, is found disproportionately for large firms. This a somewhat unexpected finding, as one could conjecture that testing and certification costs affect operations of small producers more than those of large firms. However, it is possible that this finding is driven by compositional effects: conformity assessment requirements, and third party assessment in particular, are imposed

predominantly on advanced manufacturing and machinery industries, which possibly feature a larger share of large producers as opposed to other industries (e.g. food and beverage). This is a hypothesis that merits further future investigation.

Table A2, A4 and A6 estimate the differential impact of the Withdrawal Agreement, and the incidence of third party conformity assessments, on firms in high- versus low-tech industries. Here we find that it's low-tech manufacturers to be driving the post-withdrawal trade adjustments (Table A2 and Table A4). Again, we believe this is a sensible characterization of our empirical findings, suggesting that low-tech producers are those whose supply-chain operations were re-oriented towards the domestic (NI) and EU markets, and away from GB. In terms of the effects of conformity assessment, we do not find a statistically significant difference between high- and low-tech producers, but the pattern of the estimated coefficients suggests larger impacts for high-tech firms. Without wanting to over-interpret these results, due to the lack of significance, we believe this can possibly be driven again by the composition of the industries most exposed to this particular regulatory burden.

7. Discussion

The purchasing behaviour of firms offers insights on the source and nature of their supply chains. There is a suggestion that the NIP mostly affected those Northern Ireland firms' supply chains located in Britain. The raw data appeared to provide corroboration for this in revealing for Northern Ireland manufacturing firms some evidence of a contraction in the share of purchases drawn both from suppliers in Great Britain post-withdrawal and Ireland, which was offset by a corresponding increase in the share sourced from local suppliers in Northern Ireland. These effects remain intact once we introduce into our modelling controls for firm-level fixed effects, Covid-19, and firm size. In contrast, purchases from EU suppliers have exhibited a stable pattern in the withdrawal period relative to the pre-Brexit period. Taken together these two findings suggest that the region's manufacturing firms are spending less with British (and Irish) suppliers in the post-withdrawal agreement period than in the pre-Brexit period, though it is acknowledged suppliers from the former jurisdiction remain the largest source of inputs for such firms. This may reflect the role of the NIP with the region's manufacturing firms anticipating greater costs associated with sourcing from Great Britain.

There is no evidence that the value of Northern Ireland's manufacturing sales within the UK (or to markets beyond) have been adversely affected by either Brexit uncertainty or the implementation of the withdrawal agreement. This is to be anticipated as there are no restrictions or administrative regulations facing Northern Irish firms to either the UK or all EU markets. Furthermore, the share of manufacturing inputs purchased from Great Britain exerts no impact on manufacturing firm sales to European Union markets (including Ireland).

The finding of an increase in sales to substantially all destinations can also be rationalized with reference to what in the policy world has been termed "dual market access" for Northern Irish firms. Dual market access is defined as "the free movement of goods from Northern Ireland to Great Britain and the European Union".[6] This is unique condition arising for firms in Northern Ireland due to Brexit, and consists in them having better access to the EU market, relative to firms in the rest of the UK, and better access to the UK market, relative to EU firms. This dual advantage in accessing both the EU and the UK market could have resulted in an increase in firms' activity in Northern Ireland and a corresponding higher level of sales relative to the pre-Brexit period.

The impact of the regulatory intensity index does not suggest that, over the Brexit period, when there was significant uncertainty about the evolving nature of trading relationships with the European Union, there is evidence of a reduction in manufacturing sales to either Ireland or other EU destinations. Nevertheless, during the withdrawal period the provisions associated with third party conformity appear to have impacted manufacturing purchases from British markets. The nature and degree of this clearly merits further and more detailed investigation. However, the share of purchases of Northern Irish manufacturing firms from British markets, where some degree of regulatory burden appears to be present, does not appear to have deterred their sales to European Union markets (including Ireland).

There is a suggestion, which is well-documented in the media, that the NIP has exerted a greater effect on the supply chains of Northern Ireland's wholesalers and retailers. There is some systematic evidence supporting this view as the set of industries that appear most affected by the NIP operate within this sector. This sector has witnessed a contraction in purchases from

Great Britain in the post-withdrawal period. This has been off-set by increased purchases from the Republic of Ireland, the European Union, and the rest of the world. Given the regulatory burden faced by firms in Britain due to the NIP immediately after the implementation of the Withdrawal Agreement, this empirical finding is viewed as plausible. We will have to await the availability of more recent data to establish if some of these adverse effects have been mitigated by the provisions contained within the recently agreed Windsor Framework Agreement. However, the evidence reported here also confirms the British market as remaining the most significant market for the sales of this sector.

Finally, a set of auxiliary exercises reveal two additional results. First, small firms in low-tech industries are those that felt the impact of the new trading arrangement the most. Changes in purchases and sales, along the pattern described above, are predominantly driven by firms with less than 50 employees, and firms in low-tech manufacturing. The costs of dealing with the post-referendum uncertainty, as well as complying with the new NIP requirements, might have resulted in a diversion of their activities away from GB, and spurred them to find easier supply-chain links in the Republic of Ireland. Second, the trade dampening impact of third-party conformity assessment is mostly evident for large and high-tech firms. Here we believe that it is likely to be the industry composition in terms of firm size, coupled with the inherent higher complexity of the goods produced by sectors most exposed to more demanding (i.e. costly) testing and certification of their products, to explain this finding.

8. Concluding Remarks

The decision of the UK government to leave the European Union and withdraw from the deep trading relations developed since joining the bloc in 1973 created policy uncertainty that directly affected UK firms. Some of these effects are centred around trading and investment decisions. The study by Bloom *et al*. (2018) reported that 40% of UK firms considered Brexit one of their top three uncertainties. In the immediate aftermath of the referendum, these concerns were articulated in terms of the timing of exit and whether it would be orderly in nature. It was inevitable that these concerns were voiced more strongly in trade-related industries. Firms based in Northern Ireland were confronted with an additional set of uncertainties around the status of the region within both the EU and the UK, which the NIP was originally designed to address.

The research undertaken in this study investigated if the uncertain business environment created over the Brexit and post-withdrawal periods impacted trading patterns of Northern Ireland's firms along the dimension of market choice for both their input purchasing and sales. In contrast to recent studies examining the impact of Brexit on trade using aggregate trade data with gravity models (e.g., Pisani and Vergara Caffarelli (2018), Campos and Timini (2019), Kren and Lawless (2022), Freeman *et al*. (2022), Du and Shepotylo (2022), Du *et al*. (2022), and Springford (2022)), this study exploits firm-level data. This provides a novel and innovative dimension to our study and strongly distinguishes it from much of the existing literature on this topic to date, where aggregate rather than firm-level data is routinely used. The empirical focus is restricted primarily to Northern Ireland's manufacturing firms but those in the wholesale and retail sector are also the subject of assessment. The empirical analysis was undertaken over the period from 2014 to 2022, which covered the key events of policy interest (i.e., Brexit uncertainty post-referendum and the implementation of the withdrawal agreement). There is some evidence that, in the aftermath of the withdrawal agreement, the purchasing behaviour of manufacturing firms shifted away from suppliers in Britain to those either in Ireland or other parts of the EU. In contrast, the trend in sales appear largely unaffected by either Brexit uncertainty or the implementation of the withdrawal agreement. A similar pattern is detected for firms within the wholesale and retail sector, though the magnitude of the effects appears larger. Overall, measures of regulatory intensity were not found to exert a statistically significant effect on manufacturing trade activity, though there is some evidence that the provisions associated with third-party conformity might directly affect trading with British-based supply chains. This finding is viewed as intuitive but represents an issue that merits further and deeper investigation in the current context.

It is arguable that the change in trading patterns observed with respect to firm-level purchases may reflect what would have occurred even in the absence of the uncertainty created by Brexit and the implementation of the withdrawal agreement. However, we believe this is unlikely. Nevertheless, we argue the analysis can only be further under-pinned with the availability of more recent data when the nature and workings of the withdrawal and Windsor Framework agreements have had more time in which to settle.

Endnotes

1. The econometric modelling also allowed for variation in the regulatory intensity effects over the Brexit referendum period of uncertainty. These are discussed below.

2. Table A1 in the Appendix reveals no evidence of a differential withdrawal effect in terms of manufacturing purchases from four of the five broadly defined markets for larger firms (i.e., those employing over 50 workers). The exception is provided by EU markets, where there is statistical evidence of a contraction in manufacturing sales post-withdrawal agreement. Table A2 reveals no evidence of a contraction across any of the five markets for the more high-tech manufacturing industries (viz., manufacturing two-digit SIC codes 19, 20, 21,26 & 27). There is also no evidence of any withdrawal effects across these two dimensions for manufacturing sales (see Tables A3 and A4 of the Appendix).

3. There is no evidence of size effects for the retail and wholesale sector in regards to purchases though evidence that larger firms are selling more to the Ireland market but less to other European Union markets post-withdrawal (see Table A9 of the Appendix). Furthermore, sales of Northern Irish firms operating in the retail and wholesale sectors to all European Union markets (including Ireland) are unaffected by the share of inputs sourced in British markets.

4. However, the effect for the number of articles in the post-withdrawal period is found to be statistically significant, though exhibiting a counter-intuitive positive sign.

5. These estimated effects appear to be more concentrated among the larger firms (those employing over 50 workers) but are not present for the more high-tech industries (see Tables A5 and A6 of the Appendix).

6. Peter Curran, Head of Dual Market Access, Invert Northern Ireland.

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APPENDIX I

Table A1: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms by Employment Size

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
WITHDRAWAL	0.3338*** (0.0603)	0.0713 (0.0963)	0.3190** (0.1491)	0.2592 (0.1634)	0.2885* (0.1625)
WITHDRAWAL×Large	0.1172 (0.1062)	-0.1781 (0.1628)	0.1159 (0.2647)	-0.4021* (0.2491)	0.1790 (0.2290)
Pseudo-R^2	0.9327	0.9069	0.8357	0.8772	0.9283
Log Pseudo-L	-4840315	-4399445	-2440316	-2747353	-2286315
Fixed Effects	1,904	1,614	1,429	1,226	990
Singletons	544	1,636	2,393	3,521	4,901
Observations	10,632	9,541	8,783	7,655	6,275

Notes: Other controls as in Table1; Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table A2: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms by High Tech industries

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
WITHDRAWAL	0.4209*** (0.0961)	-0.0801 (0.1238)	0.4578* (0.2606)	-0.3044 (0.1628)	0.4628** (0.1959)
WITHDRAWAL×HI_TECH	0.0906 (0.2995)	-0.0230 (0.0967)	-0.3395 (0.4475)	-0.0727 (0.2183)	0.1131 (0.4535)
Pseudo-R^2	0.9327	0.9068	0.8365	0.8809	0.9281
Log Pseudo-L	-4841467	-4404206	-2428301	-2664999	-22880655
Fixed Effects	1,904	1,614	1,429	1,226	990
Singletons	544	1,636	2,393	3,521	4,901
Observations	10,632	9,541	8,783	7,655	6,275

Notes: Other controls as in Table 1; Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table A3: Sales of Goods by Destination Market by Northern Ireland Manufacturing Firms by Size

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
WITHDRAWAL	0.3120*** (0.0460)	0.2767 (0.1285)	0.4349*** (0.0889)	0.0833 (0.1166)	0.1373 (0.1180)
WITHDRAWAL×Large	-0.1467 (0.0751)	0.0992 (0.1371)	-0.0320 (0.0932)	0.1736 (0.1499)	-0.2206 (0.1463)
Pseudo-R^2	0.9293	0.9570	0.9212	0.9395	0.9283
Log Pseudo-L	-3197345	-3730824	-1923950	-2041396	-2286315
Fixed Effects	1,764	1,183	1,328	695	649
Singletons	660	3,566	2,691	6,415	6,728
Observations	9,896	6,990	8,783	4,141	3,828

Notes: Other controls as in Table 5; robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table A4: Sales of Goods by Destination Market by Northern Ireland Manufacturing Firms by High Tech industries

	Northern Ireland	Great Britain	Ireland	European Union	Rest of the World
WITHDRAWAL	0.3120*** (0.0460)	0.2767 (0.1285)	0.4349*** (0.0889)	0.0833 (0.1166)	0.1373 (0.1180)
WITHDRAWAL×HI_TECH	-0.1467 (0.0751)	0.0992 (0.1371)	-0.0320 (0.0932)	0.1736 (0.1499)	-0.2206 (0.1463)
Pseudo-R^2	0.9293	0.9570	0.9212	0.9395	0.9283
Log Pseudo-L	-3197345	-3730824	-1923950	-2041396	-2286315
Fixed Effects	1,764	1,183	1,328	695	649
Singletons	660	3,566	2,691	6,415	6,728
Observations	9,896	6,990	8,783	4,141	3,828

Notes: Other controls as in Table 5; robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel.

Table A5: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms with Regulatory Indices on Third-Party Conformity

	Great Britain (1)	**Great Britain (2)**	**Great Britain (3)**
WITHDRAWAL	0.0510	0.0481	-0.0540
	(0.1000)	(0.0999)	(0.0979)
Reg_Index	-0.1488**	-0.0406**	-0.1654
	(0.0455)	(0.0139)	(0.3830)
WITHDRAWAL× Reg_Index	0.0396*	0.0117*	0.2438
	(0.0218)	(0.0060)	(0.1941)
WITHDRAWAL× Large	0.1388	0.1993	0.2304
	(0.1855)	(0.1876)	(0.2009)
WITHDRAWAL× Reg_Index×Large	-0.1544**	-0.0520**	-0.8380**
	(0.0705)	(0.0204)	(0.3647)
Pseudo-R^2	0.9103	0.9107	0.9089
Log Pseudo-L	-4239286	-422112	-4302239
Fixed Effects	1,614	1,614	1,614
Singletons	1,636	1,636	1,636
Observations	9,541	9,541	9,541

Notes: Other controls as in Table 3; Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) is number of regulations related to third parties; (2) count of non-synonym key words for third party conformity; (3) dummy for third part conformity.

Table A6: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Firms with Regulatory Indices on Third-Party Conformity & High Tech Industries

	Great Britain (1)	**Great Britain (2)**	**Great Britain (3)**
WITHDRAWAL	0.1598	0.2134	0.1211
	(0.1491)	(0.1550)	(0.1674)
Reg_Index	-0.1474**	-0.0406**	-0.1411
	(0.0453)	(0.0141)	(0.3810)
WITHDRAWAL× Reg_Index	-0.0988	-0.0365*	-0.4408
	(0.0724)	(0.0550)	(0.3055)
WITHDRAWAL× HI_TECH	0.2377	0.1875	0.3621
	(0.4369)	(0.4324)	(0.4940)
WITHDRAWAL× Reg_Index×HI_TECH	-0.0390	0.0013	-0.4568
	(0.1234)	(0.0335)	(0.6214)
Pseudo-R^2	0.9099	0.9102	0.9084
Log Pseudo-L	-4256715	-4242785	-4328143
Fixed Effects	1,614	1,614	1,614
Singletons	1,636	1,636	1,636
Observations	9,541	9,541	9,541

Notes: Other controls as in Table 3; Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) is number of regulations related to third parties; (2) count of non-synonym key words for third party conformity; (3) dummy for third part conformity.

Table A7: Sales of Goods by Northern Ireland Manufacturing Firms to Ireland

	(1)	(2)	(3)	(4)
Ln(Labour)	0.6462*	0.6459*	0.6397*	0.6359*
	(0.3313)	(0.3328)	(0.3347)	(0.3401)
Covid-19	-0.0661	-0.0664	-0.0748	-0.0755
	(0.0531)	(0.0532)	(0.0532)	(0.0534)
BREXIT	0.1779***	0.1778***	0.1882***	0.1906***
	(0.0671)	(0.0671)	(0.0649)	(0.0644)
WITHDRAWAL	0.4010***	0.3936***	0.3919***	0.4031***
	(0.0859)	(0.1090)	(0.1084)	(0.1009)
GB Purchase Share	-0.2460	-0.2546	-0.2494	-0.2337
	(0.1673)	(0.1672)	(0.1677)	(0.1592)
GB Purchase Share×WITHDRAWAL	⸸	0.0301	0.0355	0.1993
		(0.2314)	(0.2323)	(0.3533)
Number of Regulations	⸸	⸸	0.0097	0.0112
			(0.0091)	(0.0100)
GB Purchase Share× Number of Regulations ×WITHDRAWAL	⸸	⸸	⸸	-0.0184
				(0.0198)
Pseudo-R^2	0.9216	0.9216	0.9217	0.9219
Log Pseudo-L	-1912516	-1912464	-1909983	-1905668
Fixed Effects	1,324	1,324	1,324	1,324
Singletons	2,639	2,639	2,639	2,639
Observations	7,833	7,833	7,833	7,833

Notes: ***, **, and * denote statistical significance at the 1%, 5% and 10% level using two tailed tests.

Table A8: Sales of Goods by Northern Ireland Manufacturing Firms to the EU

	(1)	(2)	(3)	(4)
Ln(Labour)	1.1619***	1.1448***	1.1536***	1.1230***
	(0.2892)	(0.2884)	(0.2872)	(0.2720)
Covid-19	-0.0205	-0.0174	-0.0218	-0.0213
	(0.0734)	(0.0746)	(0.0744)	(0.0743)
BREXIT	0.0600	0.0636	0.0655	0.0661
	(0.0981)	(0.0984)	(0.0989)	(0.0991)
WITHDRAWAL	0.2487**	0.3246*	0.3213	0.3106
	(0.1230)	(0.1970)	(0.1990)	(0.2006)
GB Purchase Share	0.0231	0.1053	0.1195	0.0946
	(0.2826)	(0.3356)	(0.3308)	(0.3345)
GB Purchase Share×WITHDRAWAL	⸸	-0.3676	-0.3733	-0.7374
		(0.5228)	(0.5182)	(0.5499)
Number of Regulations	⸸	⸸	0.0200	0.0192
			(0.0224)	(0.0224)
GB Purchase Share× Number of Regulations ×WITHDRAWAL	⸸	⸸	⸸	0.0523*
				(0.0311)
Pseudo-R^2	0.9393	0.9394	0.9396	0.9399
Log Pseudo-L	-2042554	-2037039	-2032024	-2022765
Fixed Effects	693	693	693	693
Singletons	6,355	6,355	6,355	6,355
Observations	4,118	4,118	4,118	4,118

Notes: ***, **, and * denote statistical significance at the 1%, 5% and 10% level using two tailed tests.

Table A9: Purchases of Goods from Great Britain by Northern Ireland Manufacturing Food & Beverages Firms with Regulatory Indices

	Great Britain (1)	**Great Britain (2)**	**Great Britain (3)**	**Great Britain (4)**
Ln(Labour)	0.9134	0.8171***	0.8968*	0.8948*
	(0.5738)	(0.5308)	(0.5531)	(0.2033)
Covid-19	-0.0681	-0.0788	-0.0279	-0.0409
	(0.2226)	(0.2250)	(0.2405)	(0.2345)
BREXIT	-0.0618	-0.0080	-0.1547	-0.1902
	(0.1435)	(0.1097)	(0.1822)	(0.2043)
WITHDRAWAL	2.4493**	0.3009	2.1424	2.1391**
	(1.4317)	(0.9884)	(1.3454)	(1.0522)
Reg_Index	-0.0129	0.0001	-0.0118	-0.0106
	(0.0269)	(0.0004)	(0.0111)	(0.0106)
WITHDRAWAL× Reg_Index	-0.0939*	0.0000	-0.0294	-0.0361**
	(0.0559)	(0.0013)	(0.0194)	(0.0184)
Pseudo-R^2	0.8649	0.8605	0.8634	0.8635
Log Pseudo-L	-1316184	-1358659	-1331151	-1330168
Fixed Effects	268	268	268	268
Singletons	287	287	287	287
Observations	1,638	1,638	1,638	1,638

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) is number of regulations; (2) is number of articles; (3) count of non-synonym key words for Technical Requirements; (4) count of non-synonym key words for compliance.

Table A10: Purchases of Goods by Market Origin by Northern Ireland Manufacturing Food & Beverages Firms with Regulatory Indices on Third-Party Conformity

	Great Britain (2)
Ln(Labour)	0.8934*
	(0.5424)
Covid-19	0.0311
	(0.2399)
BREXIT	0.0246
	(0.1097)
WITHDRAWAL	2.7138
	(1.1362)
Reg_Index	-0.1936*
	(0.1017)
WITHDRAWAL× Reg_Index	-2.5640**
	(1.0451)
Pseudo-R^2	0.9100
Log Pseudo-L	-4250098
Fixed Effects	268
Singletons	287
Observations	1,638

Notes: Robust standard errors clustered by firm; ***, **, * denotes statistical significance at the 1%, 5% and 10% levels using two-tailed tests; 'Singletons' represents the number of singleton observations dropped from the panel; (1) count of non-synonym key words for third party conformity.

APPENDIX II

Table AII_1: Summary Statistics for Outcome Variables for Goods (£'s 000)

	Northern Ireland	**Great Britain**	**Ireland**	**Other EU**	**Rest of the World**
Manufacturing:					
Purchases	3052.0 (139.2)	1822.4 (101.3)	539.4 (38.5)	754.6 (50.1)	811.1 (95.5)
Sales	2726.3 (101.7)	3878.4 (214.5)	1271.7 (53.6)	1349.1 (92.6)	2225.8 (203.1)
Wholesale & Retail					
Purchases	5591.7 (250.4)	4467.4 (247.3)	680.6 (44.9)	636.8 (51.9)	706.1 (112.4)
Sales	13588.6 (562.0)	1122.1 (88.1)	768.6 (51.8)	143.1 (21.8)	247.7 (38.0)

Notes: The sample size for manufacturing goods' purchases is 11,199 and for manufacturing goods' sales is 10,577; the sample size for whole & retail goods' purchases is 10,427 and for wholesale retail goods' sales is 10,183. The averages are unconditional and include zeroes. The standard errors are reported in parentheses.

Table AII_2: Two-digit Manufacturing and Wholesale & Retail Industry Codes

Variable	Description
Manufacturing	
Division Code 10	Manufacture of Food
Division Code 11	Manufacture of Beverages
Division Code 12	Manufacture of tobacco products
Division Code 13	Manufacture of Textiles
Division Code 14	Manufacture of Wearing Apparel
Division Code 15	Manufacture Leather & Related Products
Division Code 16	Manufacture of Wood and Wood Products & Cork Materials
Division Code 17	Manufacture of Paper & Paper Products
Division Code 18	Printing & Reproduction of Recorded Media
Division Code 19	Manufacture of coke and refined petroleum products
Division Code 20	Manufacture of Chemical & Chemical Products
Division Code 21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
Division Code 22	Manufacture of Rubber & Rubber Products
Division Code 23	Manufacture of Other Non-Metallic Mineral Products
Division Code 24	Manufacture of Basic Metals
Division Code 25	Manufacture of Fabricated Metal Products (except machinery)
Division Code 26	Manufacture of Computer; electronic & optical products
Division Code 27	Manufacture of electrical equipment
Division Code 28	Manufacture of Machinery & Equipment (nec)
Division Code 29	Manufacture of Motor Vehicles; trailers & semi-trailers
Division Code 30	Manufacture of other transport equipment
Division Code 31	Manufacture of Furniture
Division Code 32	Other Manufacturing
Division Code 33	Repair and installation of machinery and equipment
Wholesale & Retail	
Division Code 45	Wholesale & Retail Trade of motor vehicles & motorcycles
Division Code 46	Wholesale Trade excluding motor vehicles & motorcycles
Division Code 47	Retail Trade excluding motor vehicles & motorcycles