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Brexit and consumer food prices

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Brexit and consumer food prices: May 2023 update

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Brexit continues to affect the UK economy. The results in this report are updates to the original study of Bakker et al. (2022), showing that higher non-tariff barriers due to Brexit are affecting food price inflation and costing households in the UK. While the original paper used data up to January 2022, this report updates the dataset through to March 2023. The methodology is otherwise identical so for more details please consult the original paper (appended to this paper).

Key findings

- The UK has recently faced high inflationary pressure, and inflation rates for food and non-alcoholic beverages have reached a 45-year high.
- Between December 2019 and March 2023 food prices rose by almost 25 percentage points. Our analysis suggests that in the absence of Brexit this figure would be 8 percentage points (30%) lower.
- Figure 1 presents the results of the event study estimation (equation 1), showing the difference in prices between products more exposed to imports from the EU versus those less exposed over time. Before Brexit, these products had similar price trends. After Brexit, there has been a notable relative increase for more exposed products, which has continued into 2023.

Figure 1: EU Exposure and Food Prices

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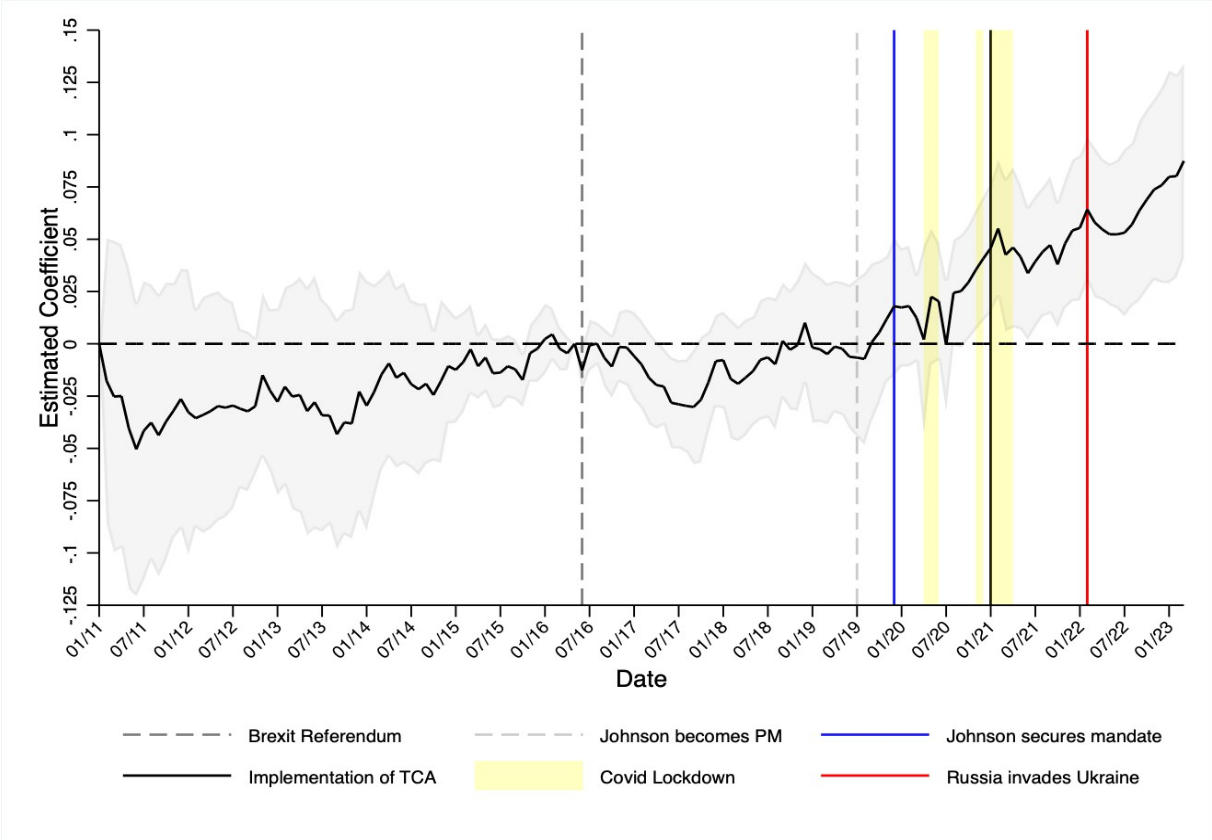

Notes: The figure presents price differences for food products more and less exposed to Brexit via EU import exposure. Specifically, the figure presents the estimates of $\widehat{\beta^k}$ from equation 1 and 95% confidence intervals based on the standard errors clustered at the product level.

- Between January 2022 and March 2023, the price of food products that were more exposed to Brexit (due to their reliance on imports from the EU before the referendum), increased by approximately 3.5 percentage points more than those that were not.
- These changes were entirely driven by products with high non-tariff barriers. Food products which fall into this category, such as meat and cheese imported from the EU, have seen price increases in the region of 10 percentage points higher relative to similar products which were not exposed to Brexit since January 2021, when the trade and co-operation (TCA) agreement began.
- The cost of Brexit to each household now stands at £250 when only considering the impacts on food since December 2019. This aggregates up to £6.95 billion overall for UK households.
- The observed price increases of products more exposed to Brexit are not correlated with macro events which could be associated with inflationary pressures such as Covid

lockdowns, or the Russian invasion of Ukraine. Furthermore, the fact that the results are driven entirely by products with high NTBs imported from the EU offers strong evidence that Brexit is the driving force behind these effects.

1. Data

We use detailed microdata on consumer prices matched with data on international trade flows of goods at the monthly level from January 2011 to March 2023.

Information on prices is obtained from the Office for National Statistics (ONS). We use the micro data collected by ONS every month on prices and expenditure weights, which it uses to construct the UK Consumer Price Index.

In addition to the matched price and trade data, we use information on ad-valorem tariff equivalent (AVE) estimates of non-tariff barriers collected from two sources. First, the World Bank provides ad-valorem equivalents (AVE) estimates for detailed HS6 product categories, these are only available unilaterally for the EU. Second, the Global Trade Analysis Project (GTAP) provides bilateral AVE estimates but at a much broader product classification (Bown, Kee, & Nicita, 2016). We use GTAP data on NTBs between EU and Canada because we believe that the UK-EU TCA is most similar to the EU-Canada Trade Agreement.

2. Empirical Strategy

The source of identifying variation in the analysis is the exposure of products to imports from the EU in the year before the Brexit referendum. For each product *i*, we compute the share of imports in 2015 that are from the EU, where imports is measured in quantity, defined as $\mathrm{M}_{\mathrm{i},2015}^{\mathrm{EU}}/\mathrm{M}_{\mathrm{i},2015}^{\mathrm{Total}}$.

We estimate changes in consumer prices due to increases in trade costs introduced by Brexit. Our baseline event study strategy relates (the log of) consumer prices for product *p* with (the log of) exposure to EU imports in 2015. The equation is specified as:

$$\log(P_{it}) = \sum_{k \notin J}^{K} \beta^k \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \times \mathbb{1}t = k + \alpha_i + \tau_t + \varepsilon_{it} \quad (1)$$

where P_{it} is the mean consumer price of product i at time t, $\mathrm{M}_{\mathrm{i},2015}^{\mathrm{EU}}/\mathrm{M}_{\mathrm{i},2015}^{\mathrm{Total}}$ is the share of imports of product i from the EU in 2015 measured in quantity terms, α_i is a product fixed effect, τ_t is a time (month-year) fixed effect, ε_{it} is an error term, and J is the set of normalising periods in the event study (which traditionally only contained the period before treatment). Since some food prices may be very seasonal, we also estimate a version where we replace α_i with the product-month fixed effect $\alpha_i \times \gamma_m$.

In addition to the event study, we estimate the impact of increased trade barriers on consumer prices in a difference-in-differences framework. We define two post periods. The first post period covers the period after Prime Minister Johnson wins the General Election (Post_t^E) and the second post period is the period after the new trading arrangements are imposed under the TCA (Post_t^B). The difference-in-differences specification is defined as:

$$\begin{aligned} \log(P_{it}) = \beta^E \times \text{Post}_t^E \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \\ +\beta^B \times \text{Post}_t^B \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \\ +\alpha_i + \tau_t + \varepsilon_{it} \end{aligned} \quad (2)$$

We propose that the mechanism through which Brexit affected consumer prices was that the TCA increased NTBs faced by UK importers and this was in turn passed on, at least partially, to consumers. To test this mechanism, we add a further interaction in the difference-in-differences specification for the extent of NTBs for food product i. We define NTB_i to be a dummy variable that splits products into high (above median) and low (below median) values of their estimated NTB AVE, based on data from either GTAP or the World Bank. When estimating specification (3), if higher NTBs after Brexit drive the effects on prices, we expect estimated coefficient on the interactions with $1\{NTB_i > NTB^{p50}\}$ to be higher than on the interactions with $1\{NTB_i \leq NTB^{p50}\}$.

$$\begin{aligned} log\ (P_{it}) = {} & \beta_H^E \times \text{ Post}_t^E \times log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \times \mathbb{1}\{NTB_i > NTB^{p50}\} \\ & + \beta_L^E \times \text{ Post}_t^E \times log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \times \mathbb{1}\{NTB_i \leq NTB^{p50}\} \\ & + \beta_H^B \times \text{Post}_t^B \times log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \times \mathbb{1}\{NTB_i > NTB^{p50}\} \\ & + \beta_L^B \times \text{ Post}_t^B \times log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{\text{Total}}}\right) \times \mathbb{1}\{NTB_i \leq NTB^{p50}\} \\ & + \text{Post}_t^E \times NTB_i + \text{Post}_t^B \times NTB_i + \alpha_i + \tau_t + \varepsilon_{it} \end{aligned} \tag{3}$$

3. Results

Figure 1 presents the estimated coefficients and associated 95% confidence intervals from equation 1. We estimate the event study at the monthly level. As in the original paper, the results show we cannot reject parallel trends, during the untreated period, and in the lead up to, and following the implementation of the TCA food prices of more exposed products increased faster than those unexposed, and the trend has continued upwards over the proceeding years after implementation, suggesting that barriers to trade are continuing to impact consumer prices. As of March 2023, the difference is in the region of 8 percentage points.

The results of the difference-in-differences estimates from equation 2 are presented in Table 1.

Table 1: The effect of NTBs on prices

	(1) Log Price	(2) Log Price
Log EU Share × Post Brexit	0.0726***	0.0721***
	(0.0155)	(0.0157)
Log EU Share × Post Election	0.0368**	0.0364**
	(0.0172)	(0.0173)
Year-Month FE	Yes	Yes
Product FE	Yes	No
Product-Month FE	No	Yes
Observations	10220	10220
R^2	0.982	0.984

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the estimates of equation 2. Standard errors are clustered at the product level.

The results suggest that the average long run impacts between January 2021 and March 2023 now stand at approximately 7.3 percentage points, which is almost a 20% increase when compared to the original results up to January 2022 in Bakker et al. (2022).

Table 2: The effect of NTBs on prices

	(1) Log Price	(2) Log Price	(3) Log Price	(4) Log Price
Low NTB × Log EU Share × Post Brexit	-0.00732	-0.00901	0.0470	0.0451
	(0.0330)	(0.0331)	(0.0322)	(0.0323)
High NTB × Log EU Share × Post Brexit	0.0997***	0.0997***	0.0884***	0.0886***
	(0.0140)	(0.0140)	(0.0137)	(0.0137)
Low NTB × Log EU Share × Post Election	-0.0389	-0.0390	0.0108	0.00957
	(0.0259)	(0.0261)	(0.0281)	(0.0279)
High NTB × Log EU Share × Post Election	0.0646***	0.0640***	0.0550***	0.0551***
	(0.00929)	(0.00942)	(0.00973)	(0.00958)
Year-Month FE	Yes	Yes	Yes	Yes
Product FE	Yes	No	Yes	No
Product-Month FE	No	Yes	No	Yes
Observations	10220	10220	10220	10220
R^2	0.983	0.984	0.982	0.984
NTB Data Source	World Bank	World Bank	GTAP	GTAP

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the estimates of equation 3. Standard errors are clustered at the product level.

Table 2 presents the results from equation 3, testing the importance of NTBs in generating the observed price effects. Columns (1) and (2) classify products using the World Bank estimates for NTBs while columns (3) and (4) are based on GTAP. Our preferred specification uses the World Bank data as these are available at a more granular product level. As was the case in the original paper, all the action is coming from products with high NTB exposure. There is no statistically significant change in prices for products with low NTBs. This provides strong evidence in support of the mechanism that EU exporters and/or UK importers face higher costs due to the Brexit-induced rise in NTBs and pass at least part of these costs on to consumers through higher prices.

4. Welfare Calculation

To quantify the overall welfare effects of the rise in non-tariff barriers of food imports in the UK we introduce a simple partial equilibrium framework. UK consumers have quasi-linear preferences over "all other goods in the economy" (C) and food (F).

$$U = C + v(F) \tag{4}$$

where v fulfills the standard assumptions on utility functions: $\lim_{F\to 0} v'(F) = \infty$, $v' > 0$, $v'' < 0$.

To calculate the welfare effects, we take a first-order approximation of $v(F)$ around the initial equilibrium, thus we treat demand for food products to be locally linear. Given Brexit can be represented by a negative supply shock, the loss of consumer surplus is given by the typical trapezium when prices move up a demand curve. In the absence of new estimates on demand effects, we assume the slope of the demand curve is consistent with that estimate in Bakker et al. (2022). Specifically, we calculate

$$\Delta \text{ Consumer surplus } = (\Delta P * Q_2) + \frac{(\Delta P * \Delta Q)}{2} \tag{5}$$

Combining data on the initial equilibrium from Bakker et al. (2022) and the new estimates on price changes, they imply that Brexit caused a welfare loss of £250 for the average household between December 2019 and March 2023, or £6.95 billion overall, when looking at its impact on the food market alone.

Further reading

Bakker, J., Datta, N., & De Lyon, J. (2022). Non-Tariff barriers and consumer prices: evidence from Brexit. *Centre for Economic Performance Discussion Paper 1888*.

Bown, C., Kee, L., & Nicita, A. (2016). Non-tariff measures and trade restrictiveness: Evidence from a new database. *GTAP Conference Paper*.

Non-tariff barriers and consumer prices: evidence from Brexit

J.D. Bakker, N. Datta, R. Davies and J. De Lyon (December, 2022).

Abstract
Non-Tariff Barriers (NTBs) are the main policy impediment to international trade, yet little is known about their pass-through to prices. This paper exploits the Brexit trade policy shock to quantify how NTBs affect consumer prices and welfare. The increase in NTBs raised prices by 6%, implying a pass-through of 50-80%. Based on a standard welfare framework, we show households lost £5.84bn, domestic producers gained £4.78bn, and £1.06bn was lost through deadweight loss. Due to differences in food expenditure shares, households in the lowest decile experience a 52% higher increase in the cost of living than households in the top decile.

Key words: Brexit, policy, shocks, wellbeing, welfare, cost of living, non-tariff barriers
JEL codes: E31; F13; F15; Q11

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1 Introduction

Following decades of successful tariffs reductions, the main policy barrier to trade is now non-tariff barriers (NTBs). For the European Union, the average ad-valorem equivalent NTB stood at 13.1% while the average tariff was just 1.8% in 2018. Despite their importance, there is little evidence on how NTBs affect consumers, mainly due to a lack of measurable variation and data limitations. This paper fills that gap by combining a novel dataset on consumer prices and trade with a unique, substantial and sudden increase in NTBs between major trading partners. We document significant impacts of NTBs onto consumer prices which translates into sizeable welfare effects, with low income households most affected.

In June 2016, the people of the UK voted to leave the European Union, a deep economic union with few internal trade barriers. After prolonged negotiations, the UK formally left the EU in January 2020, exiting the EU Single Market and Customs Union one year later. Since then, the EU-UK trading relationship has been governed by the Trade and Cooperation Agreement (TCA). The TCA ensures tariff and quota free trade but lacks provisions to deliver deep integration.

EU-UK trade is now subject to a customs and regulatory border, a sudden and immediate change that represents a unique rise in NTBs. In this paper, we exploit variation in the exposure of products to Brexit and NTBs, combined with detailed micro data on trade flows and consumer prices for food products in the UK, to study the pass-through of NTBs into consumer prices and the associated welfare effects.

We proceed in three steps. First, we show that UK food products that are more heavily imported from the EU experience larger price increases. This effect began to materialise from December 2019, when it became clear that the UK was going to leave the EU Single Market and the Customs Union, suggesting that firms anticipated and adjusted to expected future costs. We find that leaving the European Union increased the price of food products by 3% per year, leading to a 6% increase over a two-year period.

Second, to provide evidence on the underlying mechanism driving these price increases, we use data on NTBs from the World Bank and Global Trade Analysis Project (GTAP) which estimate ad-valorem equivalent (AVE) rate for each product. The regulations and standards that imported products are subject to varies across products. For example, fresh meat of bovine animals such as cattle, has a very high NTB AVE because it is subject to sanitary and phytosanitary checks and frozen sweetcorn has a high AVE due to technical barriers to trade, while vegetables such as onions, carrots, and broccoli have an AVE close to 0. We show that the price increases are entirely driven by food products with high non-tariff barriers to trade, with an implied pass-through rate between 50% and 88%. This high pass-through rate accounts for both, one-time setup costs (e.g. hiring specialist staff) to comply with the new regulations and the marginal cost of the NTBs (e.g. obtaining a sanitary certificate for each shipment).

Third, we introduce a simple theoretical framework that allows us to quantify the welfare effects of the observed changes in prices and quantities. The Brexit-induced rise in non-tariff barriers for food products caused sizeable welfare effects, with households losing £5.84bn (or £210 per household), domestic producers gaining £4.78bn, and a deadweight loss of £1.06bn over 2020-2021. This deadweight loss is considerably higher than the loss from an equivalent increase in tariffs as no government revenue is generated, and in the short run there are no domestic benefits from the increase in regulatory flexibility. Due to the differences in the food expenditure share between high and low income households, households in the lowest decile experience an increase in the cost of living that is 52% higher than a household in the top decile.

This paper contributes to several literatures, bridging the gap between the studies focusing on the pass-through of changes in trade cost into consumer prices and those which analyse the effects of non-tariff barriers (NTBs).

The recent literature on the pass through of tariffs into consumer prices finds consistently high pass-through rates. Using US antidumping tariffs on washing machines, Flaaen et al. (2020) find a tariff elasticity of consumer prices higher than 1 with estimates ranging from 108 to 225 percent. Studying the recent tariff hikes in the US, both Fajgelbaum et al. (2020) and Amiti et al. (2019) find evidence of complete pass through.

The estimates on the pass-through of exchange rate movements into consumer prices are more mixed. Most studies have found low pass-through rates (see Burstein and Gopinath (2014) for a review). However, Breinlich et al. (2022) find high rates of pass-through and cannot reject complete pass through of the Sterling depreciation following the Brexit vote into consumer prices. Similarly, Burstein et al. (2005) find high pass-through rates in various large devaluations. We add to this literature by providing the first evidence on the pass-through of rising non-tariff barriers into consumer prices.

In doing so, we relate to a small but growing literature that aims to quantify the role of non-tariff barriers for trade flows, such as Dhingra et al. (2021), who quantify the effects of deep trade agreements and Conconi et al. (2018) who study the effects of rules of origin.

In addition to deepening our understanding of the relationship between NTBs and consumer prices we contribute to the literature on the economics of international disintegration following Brexit. Most closely related to our work are Breinlich et al. (2022) who study the pass-through of the sterling depreciation into consumer prices and Freeman et al. (2022) that document the changes in trade flows following the implementation of the TCA. Additional studies include Costa et al. (2019) on nominal wages and worker training, Breinlich et al. (2020) on foreign direct investment and Bloom et al. (2019) on productivity and investment. Dhingra and Sampson (2022) summarise the literature on the economic effects of Brexit that materialised in the time between the referendum and the UK leaving the EU.

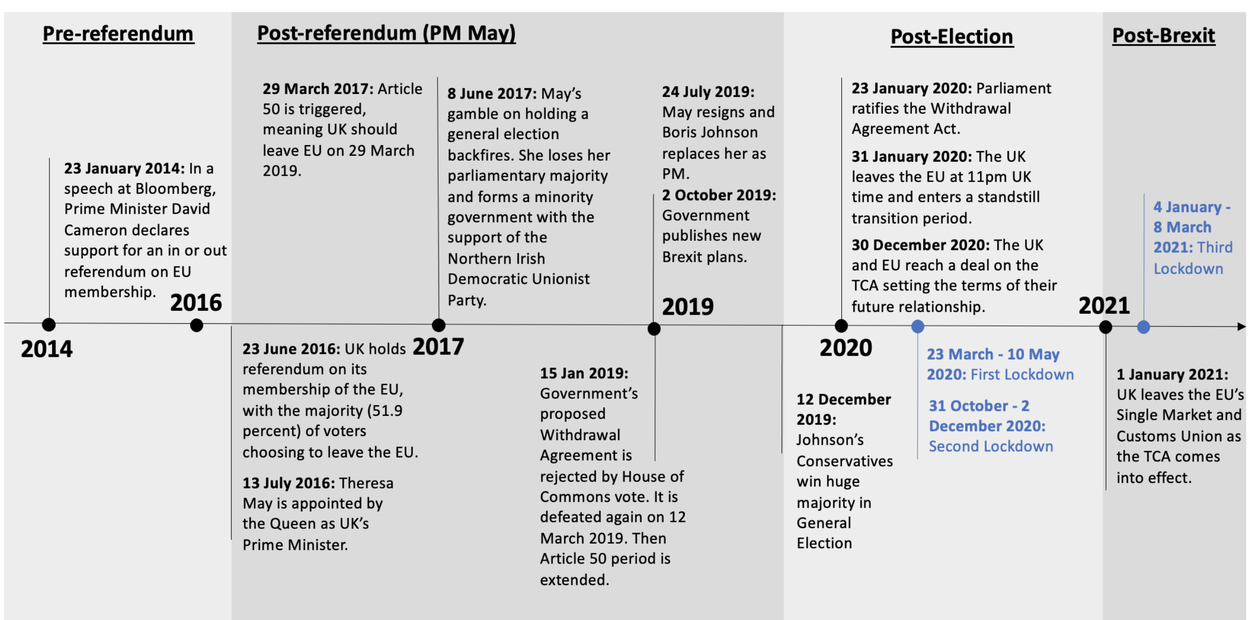
The remainder of this paper is structured as follows. Section 2 provides an overview of the timeline of the UK leaving the EU. Section 3 introduces the data and the empirical strategy while section 4 discusses the main results and section 5 concludes.

2 The Brexit Shock

The EU is one of the largest trading blocs in the world. It is also one of the deepest, going beyond the elimination of tariffs to include minimising NTBs via mutual recognition of standards, a common external tariff, and free movement of people and capital. Given the geographical proximity, the economic size of the bloc, and the reduction of trade barriers, it is not surprising that the UK became heavily integrated in the EU economy. In 2015, 53.4% of UK goods imports were from the European Union. For food products, the subject of this paper, the share was even higher, at 77.5%.

The UK unexpectedly voted to leave the EU in June 2016, but new trading relationships were not implemented until 2021. The period between the referendum and the eventual separation of the UK from the EU was politically and economically turbulent for the UK. Figure 1 provides a summary of key events.

Figure 1: Timeline of key Brexit events



Note: The figure presents the timeline of key Brexit events (black) and also includes UK specific dates for COVID "lockdowns" (blue).

Article 50, which stated that the UK would leave the EU within two years, was formally triggered on 29th March 2017. However, the negotiations on the future Brexit agreement proved difficult, complicated by weak parliamentary majorities and domestic disputes over the details of the type of Brexit agreement that should be pursued. An extension was requested in March 2019, with the leaving date postponed to October 2019. Twice in early 2019, the government's proposed Withdrawal Agreement which specified a "soft" Brexit (continued membership of the Customs Union), was rejected by the UK Parliament. This prompted, then Prime Minister, Theresa May to resign on 24th May 2019. A further extension was announced in October, with the new date proposed to be 31st January 2020.

Boris Johnson, who had actively campaigned to leave the EU in the lead-up to the referendum, replaced May as Prime Minister in July 2019. In October 2019, Johnson's government published its proposed Brexit deal and subsequently called a General Election for December 2020. The Conservative Party campaigned with its proposed Brexit deal and the slogan "Get Brexit Done". They won the election with a huge majority, therefore all-but-confirming that the UK would leave on 31st January 2020 with a "hard" Brexit - withdrawing membership of both the Customs Union and Single Market. The UK left the EU on 31st January 2020, beginning a Transition Period whereby current laws would remain in place until the end of 2020.[1]

The UK left the Single Market and Customs Union on 1st January 2021, marking the end of the transition period and the introduction of new relations outlined by the EU–UK Trade and Cooperation Agreement (TCA). Under the EU–UK TCA, goods continue to be traded without tariffs and quotas but the regulatory and customs framework for trade has changed, causing an increase in trade frictions. The new measures include comprehensive customs checks, rules of origin requirements, the need to prove regulatory compliance in each jurisdiction separately, sanitary and phytosanitary (SPS) measures for trade in animals and plants, and limitations on the freedom of movement for business travel, among other

[1]For more details, see Dhingra and Sampson (2022) and https://commonslibrary.parliament.uk/research-briefings/cbp-7960/

restrictions.

There provisions were phased in from January 2021 onwards. On the side of UK imports from the EU, full customs declarations were only required immediately for certain controlled goods, while other goods required only a simplified procedure. Similarly, some SPS checks were immediately imposed while others were delayed for a year or longer. All checks that are required by international conventions, excise duties, and licenses on high-risk goods were all imposed immediately.[2]

3 Data and Empirical Strategy

3.1 Data sources

We use detailed microdata on consumer prices matched with data on international trade flows of goods at the monthly level from January 2011 to January 2022.

Information on prices is obtained from the Office for National Statistics (ONS). We use the micro data collected by ONS every month on prices and expenditure weights, which it then uses to construct the UK Consumer Price Index.[3] We use the expenditure weights in the CPI data as a measure of expenditure by product, and compute quantity estimates by combining price and expenditure information.[4] We use data on UK import quantities (in kilograms) from 2015 by product-country from the UN Comtrade database at the HS 6 digit level to construct measures of EU trade exposure. Product descriptions are used to match the price and trade data at the product level. The match was conducted manually and independently by two researchers before a final match was constructed by harmonising the independently-conducted concordances.

[2]For more detail, see https://www.instituteforgovernment.org.uk/explainers/future-relationship-gb-eu-border

[3]For more information see Davies (2021)

[4]Data for CPI weights is missing for some months (January to October 2017 and January to August 2019). We linearly impute data on the missing months. The results for price, quantity, and expenditure are very similar when estimated on the restricted sample without imputing.

In addition to the matched price and trade data we use information on ad-valorem tariff equivalent (AVE) estimates of non-tariff barriers collected from two sources. First, the World Bank provides ad-valorem equivalents (AVE) estimates for detailed HS6 product categories, but these are only available unilaterally for the EU. We assume that the imports to the UK from the EU can be proxied by the EU unilateral measure.[5] Second, the Global Trade Analysis Project (GTAP) provides bilateral AVE estimates but at a much broader product classification (Bown et al., 2016). We use GTAP data on NTBs between EU and Canada because we believe that the UK-EU TCA is most similar to the EU-Canada Trade Agreement.

We restrict our analysis to food products for several reasons. First, food products are precisely and narrowly defined in both the trade and price data, allowing for a detailed and accurate match. Second, they generally have few intermediate inputs meaning that we expect more easily estimateable pass-through and can measure it without making additional assumptions.[6] Third, food products have significant variation in NTBs (e.g. some products are subject to high NTBs as a result of SPS checks). As a result there is sufficient economic and statistical variation to identify the pass-through of NTBs into consumer prices. Fourth, food items are generally relatively homogenous and the food wholesale and retail sector in the UK is very competitive which allows us to abstract from various complications such as variable mark-ups.[7] Lastly, food products comprise an economically relevant share of expenditure, especially for poorer households.

The matched dataset contains 8,593 product-month observations for 70 unique food products covering January 2011 to January 2022. The average price of a product is £2.75.

[5]While the data is available at the 6 digit HS level, there are numerous missing values which cannot be estimated due to lack of precision, for these we accordingly aggregate to the 4 digit and 2 digit level where necessary.

[6]We focus only on the relationship between imports of final goods and consumer prices due to the highly aggregated nature of existing input-output tables.

[7]See, for example Competition Commission (April 2008) and Competition and Markets Authority (April 2015).

3.2 Empirical Strategy

The source of identifying variation in the analysis is the exposure of products to imports from the EU in the year before the Brexit referendum. For each product i, we compute the share of imports in 2015 that are from the EU, where imports is measured in quantity, defined as $M^{EU}_{i,2015}/M^{Total}_{i,2015}$.

The pattern of imports across countries is determined by global comparative advantage patterns, which are likely to be persistent over time. Products for which the UK was more reliant on imports from the EU before the Brexit referendum will be more exposed to future changes in trade costs. For these products, adjustment costs to sourcing from other countries are expected to be relatively high, meaning that we expect a significant increase in cost due to rising trade barriers, or expected trade barriers, that could be passed through into prices. The average EU import share is 0.76 and the standard deviation is 0.29. Some products, such as fresh pork, are only imported from the EU while others, such as frozen lamb, have an EU import share less than 0.1.

We estimate changes in consumer prices due to increases in trade costs introduced by Brexit. Our baseline event study strategy relates (the log of) consumer prices for product p with (the log of) exposure to EU imports in 2015. The equation is specified as:

$$\log(P_{it}) = \sum_{k \notin J}^{K} \beta^k \log\left(\frac{M^{EU}_{i,2015}}{M^{Total}_{i,2015}}\right) \times \mathbb{1}\{t = k\} + \alpha_i + \tau_t + \varepsilon_{it} \tag{1}$$

where P_{it} is the mean consumer price of product i at time t, $\frac{M^{EU}_{i,2015}}{M^{Total}_{i,2015}}$ is the share of imports of product i from the EU in 2015 measured in quantity terms, α_i is a product fixed effect, τ_t is a time (month-year) fixed effect, ε_{it} is an error term, and J is the set of normalising periods in the event study (which traditionally only contained the period before treatment). Since some food prices may be very seasonal, we also estimate a version where we replace α_i with the product-month fixed effect $\alpha_i \times \gamma_m$.

In addition to the event study, we estimate the impact of increased trade barriers on consumer prices in a difference-in-differences framework. We define two post periods. The first post period covers the period after Prime Minister Johnson wins the General Election, confirming a hard Brexit with no further delays. We label this period as Post-Election, and define the dummy variable $Post_t^E$ which equals 1 for months between (and including) December 2019 and December 2020, and 0 otherwise. The second post period is the period after the new trading arrangements are imposed under the TCA. We call this period Post-Brexit, defining the variable $Post_t^B$ to equal 1 in all months after and including January 2021, and 0 otherwise. The difference-in-differences specification is defined as:

$$
\begin{aligned}
\log(P_{it}) = \quad & \beta^E \times Post_t^E \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \\
& + \beta^B \times Post_t^B \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \\
& + \alpha_i + \tau_t + \varepsilon_{it}
\end{aligned} \tag{2}
$$

Recent econometric research has highlighted a number of issues with difference-in-differences estimators, particularly for settings with staggered treatment timing (Borusyak and Jaravel, 2017; Sun and Abraham, 2021; Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021). While our setting has simultaneous treatment, and thus doesn't suffer from many of the issues raised, we adopt two recommendations from Borusyak and Jaravel (2017). Firstly, in the event study, we normalise the pre-trends to two periods as recommended to deal with the under-identification problem they raise. Specifically, the set J in equation (1) contains both May 2016 and January 2011. Secondly, we calculate counterpart estimates to equation (2) using the dynamic treatment effects estimated in (1) to ensure transparency of the structure of weights across the dynamic treatment effects, for estimating the treatment effects β^E and β^B. These are averaged across the year-month effects in the relevant period (post Brexit, or post Election-pre Brexit) and are normalised against the entire pre period.

We propose that the mechanism through which Brexit affected consumer prices was that the TCA increased NTBs faced by UK importers. Producers and importers must adapt their products and procedures to adapt to new barriers, facing a potential increase in both fixed and variable costs of exporting. At least part of these new costs may be passed on to consumers, and the fixed costs are likely to have been incurred prior to the TCA but in the post election period.

To test this mechanism, we add a further interaction in the difference-in-differences specification for the extent of NTBs for food product i. We define NTB_i to be a dummy variable that splits products into high (above median) and low (below median) values of their estimated NTB AVE, based on data from either GTAP or the World Bank.[8] When estimating specification (3), if higher NTBs after Brexit drive the effects on prices, we expect estimated coefficient on the interactions with $\mathbb{1}\{NTB_i > NTB^{p50}\}$ to be higher than on the interactions with $\mathbb{1}\{NTB_i \leq NTB^{p50}\}$.

$$\begin{aligned}
\log(P_{it}) = \quad & \beta_H^E \times Post_t^E \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \times \mathbb{1}\{NTB_i > NTB^{p50}\} \\
& + \beta_L^E \times Post_t^E \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \times \mathbb{1}\{NTB_i \leq NTB^{p50}\} \\
& + \beta_H^B \times Post_t^B \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \times \mathbb{1}\{NTB_i > NTB^{p50}\} \\
& + \beta_L^B \times Post_t^B \times \log\left(\frac{M_{i,2015}^{EU}}{M_{i,2015}^{Total}}\right) \times \mathbb{1}\{NTB_i \leq NTB^{p50}\} \\
& + Post_t^E \times NTB_i + Post_t^B \times NTB_i + \alpha_i + \tau_t + \varepsilon_{it}
\end{aligned} \tag{3}$$

[8] We choose to use only the ordinal information in the NTB variable, as it is notoriously difficult to estimate the AVE of NTBs implying the presence of a lot of noise variable, and because there are some unrealistically large outliers with values well above 100%.

In our final empirical exercise, we estimate equation (2) changing the dependent variable to quantity and total expenditure (in logs) to help inform welfare effects as documented in section 4.3. The weight variable in the ONS data gives the expenditure share of each product. We define quantity as the expenditure weight divided by the price.

Identification of the impact of new trade barriers imposed by Brexit on consumer prices relies on two assumptions. First, we require that trends in consumer prices are unrelated to exposure to EU imports in the absence of Brexit. The event study estimates show this to be the case in the pre-period. Second, we require that factors correlated with both the timing of Brexit and the pre-period share of imports from the EU are not correlated with changes in consumer prices.

Possible violations of the second include the striking of new strategic trade agreements by the UK government or, conversely, the inability to roll over existing trade agreements the UK had through the EU with non-EU countries. In practice, the UK was able to negotiate to roll over with 63 of the 70 countries that it had trade agreements with as a member of the Customs Union. Additionally, since Brexit, the UK has signed only three new trade agreements but none had entered into force in our sample period and the earliest was signed in the last month of our sample period.[9]

Another factor of concern is the Covid-19 pandemic and associated lockdowns, which has disrupted global production and consumption of food products. We control for aggregate macroeconomic conditions with the year-month fixed effect, but if the impacts of Covid-19 on prices is correlated with the EU import share then this would impact the estimates of the βs. The event study shows that the estimates of β^k are uncorrelated with key Covid-19 outbreaks and lockdowns in the UK.[10]

[9] Agreements with Australia and New Zealand were signed in December 2021 and February 2022, respectively, while a digital trade agreement was signed with Singapore in February 2022 (Webb, 2022).

[10] Our sample period stops before Russia's invasion of Ukraine, which also affected food supply chains.

4 Results

4.1 The impact of Brexit on prices

Figure 2 presents the estimated coefficients and associated 95% confidence intervals from equation 1. We estimate the event study at the monthly level but aggregate estimated coefficients to the quarterly level (specifically the plot presents $\beta^q = \frac{1}{3}\sum_{k\in q}\beta^k$).

There is no evidence of differential pre-trends in prices of products more exposed to increased trade barriers from Brexit. There is a clear trend break after the UK left the EU and implemented the TCA with higher trade costs. From quarter one of 2021 onwards, products that were more reliant on EU imports had significantly higher consumer prices than products that were less reliant, suggesting that higher trade barriers from Brexit increased costs which were passed on to consumers.

The event study estimates also show that there was a trend break after the 2019 General Election. At this point, it was clear that the UK would leave the Customs Union and Single Market. Therefore, firms would be expecting higher trade costs and making investments into conforming to future trade barriers. The evidence suggests that they immediately began to pass this on to consumers. The estimated coefficients are not statistically significant when aggregated to the quarter but are statistically significant in the difference-in-differences specification, the results of which are shown in Table 1.

There is a notable *fall* in relative prices of goods more exposed to the EU following the outcome of the referendum. This is likely driven by the sharp depreciation of the pound that followed the unexpected vote to the leave the EU. The pound depreciated relatively less against the Euro and other EU currencies than most other currencies (Costa et al., 2019). Therefore, the relative price increase through the depreciation was more for non-EU imports than for EU imports, causing the relative fall in consumer prices for EU imports of food seen in Figure 2.[11]

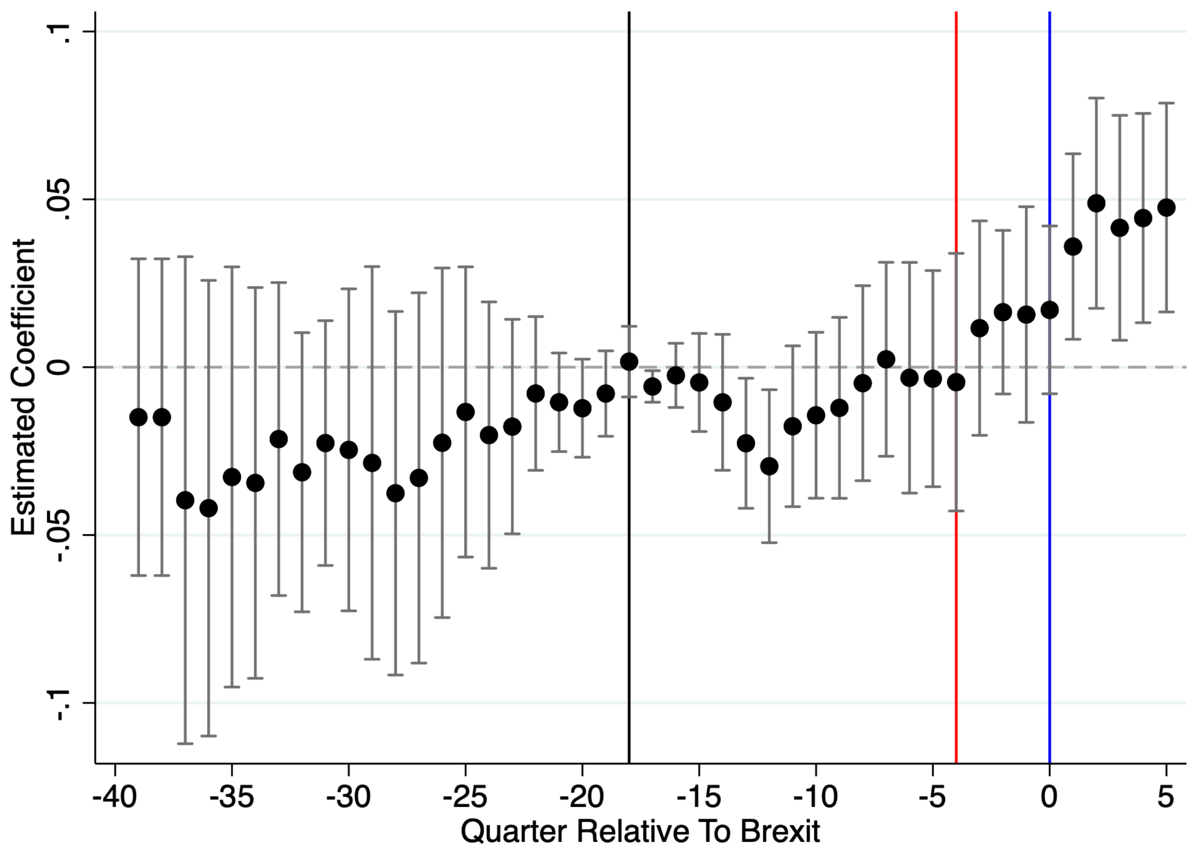
The timing of the relative changes in prices of products more exposed to imports from the EU is uncorrelated with key Covid-19 outbreaks and associated lockdowns. First, there is step increase in average prices of products more exposed to the EU in December 2019, before the Covid-19 outbreak had become a concern. Second, throughout 2020 and 2021, there is no correlation between Covid-19 outbreaks and lockdowns with the relative changes in prices of products with greater EU exposure. For example, in the UK, the first lockdown was imposed on 26th March 2020 and was eased in June 2020, while the second national lockdown only covered November 2020.

The results of the difference-in-differences estimates from equation 2 are presented in Table 1. The estimated coefficient on the interaction with the post-Brexit variable suggests that a doubling of the share of imports from the EU in the pre-period is associated with a 6.16% higher consumer price after the TCA was introduced relative to before December 2019. In the period after the General Election and before the introduction of the TCA, a doubling of the EU share of imports is associated with a 3.64% higher consumer price. The results are similar when including a product-month fixed effect to control for product-specific seasonality or just a product fixed effect. The estimates of $\hat{\beta^E}$ and $\hat{\beta^B}$ when estimated by using equal weighting of the dynamic treatment effects, as discussed in 3.2, are very similar. Specifically the coefficients are 0.038 (.019) and 0.066 (.022), respectively (standard errors in parantheses).

Given the mean EU import share for food products is 0.75, a back-of-the-envelope calculation implies that a product with full EU import exposure would experience 4.9% more inflation in 2020 and 8.1% higher inflation over 2020 and 2021 in comparison to a product with no

[11] This is consistent with the findings by Breinlich et al. (2022), who show that products with higher import shares experienced a relative increase in prices as a result of the depreciation caused by the referendum.

Figure 2: The impact of Brexit on consumer prices: event study estimates



Notes: This figure presents the estimates of equation 1 aggregated to the quarterly level by $\beta^q = \frac{1}{3}\sum_{k\in q}\beta^k$ and 95% confidence intervals based on standard errors clustered at the product level. Estimates are normalised against May 2016 and Jan 2011. The vertical lines indicate the timing of the referendum to leave the EU in June 2016 (black), the UK general election in December 2019 (red), and implementation of the TCA in January 2021.

EU import exposure.[12] Thus, Brexit increased average food prices by approximately 3% annually in 2020 and 2021.

We provide additional robustness checks in the Online Appendix. The results are very similar when excluding the period after the Brexit referendum which was characterised by significant price changes due to the sterling depreciation which could bias our results (see Table 1 in the Online Appendix). The results are also robust to specifying the treatment variable as

[12]As the point estimate relates to an elasticity one calculate the semi-elasticity accordigly: $0.0365 = \frac{\%\Delta\ Price}{\%\Delta\ Exposure} = \frac{\Delta Price}{\Delta Exposure}\frac{Exposure}{Price}$, substituting in $\overline{Exposure} = 0.75$ and rearranging gives $\frac{\%\Delta\ Price}{\%\ Exposure} = 0.0365/0.75 = 0.049$.

the level of the share instead of the log of the share (see Figure 1 for the event study and Table 2 for the difference-in-differences estimates in the Online Appendix).[13]

Table 1: The impact of Brexit on consumer prices: difference-in-differences estimates

	(1) Log Price	(2) Log Price
Log EU Share × Post Brexit	0.0616***	0.0613***
	(0.0187)	(0.0189)
Log EU Share × Post Election	0.0364**	0.0355**
	(0.0159)	(0.0160)
Year-Month FE	Yes	Yes
Product FE	Yes	No
Product-Month FE	No	Yes
Observations	8593	8593
R^2	0.987	0.989

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the estimates of equation 2. Standard errors are clustered at the product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2 The passthrough of trade barriers to prices

Table 2 presents the results from equation (3), testing the importance of NTBs in generating the observed price effects. Columns (1) and (2) classify products using the World Bank estimates for NTBs while columns (3) and (4) are based on GTAP. Our preferred specification uses the World Bank data as these are available at a more granular product level.

Across specifications, the rise in consumer prices associated with Brexit is driven only by products with high NTBs. There is no statistically significant change in prices for products with low NTBs. This provides strong evidence in support of the mechanism that EU exporters and/or UK importers face higher costs due to the Brexit-induced rise in NTBs and pass at least part of these costs on to consumers through higher prices.

We calculate the implied pass-through of the ad-valorem equivalent (AVE) NTBs to consumer

[13]The implied economic effects across the two specifications are very similar but the estimates are more precisely estimated when using log-exposure, suggesting it may be a better approximation of the underlying relationship.

Table 2: The effect of NTBs on prices

	(1) Log Price	(2) Log Price	(3) Log Price	(4) Log Price
Low NTB × Log EU Share × Post Brexit	-0.0268	-0.0282	0.0343	0.0327
	(0.0325)	(0.0327)	(0.0312)	(0.0312)
High NTB × Log EU Share × Post Brexit	0.0887^{***}	0.0890^{***}	0.0845^{***}	0.0848^{***}
	(0.0110)	(0.0110)	(0.00931)	(0.00927)
Low NTB × Log EU Share × Post Election	-0.0343	-0.0354	0.0152	0.0137
	(0.0236)	(0.0237)	(0.0267)	(0.0265)
High NTB × Log EU Share × Post Election	0.0619^{***}	0.0610^{***}	0.0525^{***}	0.0520^{***}
	(0.00892)	(0.00900)	(0.00905)	(0.00906)
Year-Month FE	Yes	Yes	Yes	Yes
Product FE	Yes	No	Yes	No
Product-Month FE	No	Yes	No	Yes
Observations	8593	8593	8593	8593
R^2	0.987	0.989	0.987	0.989
NTB Data Source	World Bank	World Bank	GTAP	GTAP

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the estimates of equation 3. Standard errors are clustered at the product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

prices using the difference in the estimated coefficients $(\hat{\beta^B_H} - \hat{\beta^B_L})$ and the difference in the average AVE NTB of the high and low group $(\overline{NTB_H} - \overline{NTB_L})$. Specifically the pass through ρ is given by:

$$\rho = \frac{\hat{\beta^B_H} - \hat{\beta^B_L}}{\overline{NTB_H} - \overline{NTB_L}} \tag{4}$$

The calculated pass-through is sensitive to a few products with very large NTBs. Our preferred specification truncates the distribution of NTBs at the 95th percentile which yields a pass-through of 75%. If we instead winsorize the NTB distribution at the 95th percentile we get a pass-through of 50% while a pass-through calculation based on the median rather than the mean yields a pass-through of NTBs into prices of 83%. Overall, we conclude that there was high but imperfect pass-through of NTBs into prices.

4.3 Price, quantity, and expenditure adjustments

Table 3 presents estimates from our baseline difference-in-difference specification 2 but looking at the impacts on quantity and expenditure. The estimates suggest a sizeable, precisely estimated fall in quantity consumed and total expenditure of products that were more exposed to Brexit.

Table 3: The impact of Brexit on consumer prices, quantity, and expenditure

	(1) Log Quantity	(2) Log Quantity	(3) Log Expenditure	(4) Log Expenditure
Log EU Share × Post Brexit	-0.158***	-0.158***	-0.0959**	-0.0965**
	(0.0301)	(0.0300)	(0.0341)	(0.0341)
Log EU Share × Post Election	-0.104***	-0.103***	-0.0671*	-0.0677*
	(0.0281)	(0.0282)	(0.0322)	(0.0323)
Year-Month FE	Yes	Yes	Yes	Yes
Product FE	Yes	No	Yes	No
Product-Month FE	No	Yes	No	Yes
Observations	8433	8433	8433	8433
R^2	0.964	0.965	0.955	0.955

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the estimates of equation 2 for different outcome variables on a sample that is consistent across variables. Standard errors are clustered at the product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To quantify the overall welfare effects of the rise in non-tariff barriers of food imports in the UK we introduce a simple partial equilibrium framework. UK consumers have quasi-linear preferences over "all other goods in the economy" (C) and food (F).

$$U = C + v(F) \tag{5}$$

where v fullfills the standard assumptions on utility functions: $lim_{F\to 0} = \infty$, $v' > 0$, $v'' < 0$. This allows us to abstract from income effects as well as changes in non-food sectors and given the low income elasticity of food as a composite product is a reasonable approximation given the empirical estimates for the UK (Tiffin and Tiffin, 1999 and Dogbe and Revoredo-Giha, 2021).

To calculate the welfare effects, we take a first-order approximation of $v(F)$ around the initial equilibrium, thus we treat demand for food products to be locally linear. As we assume quasi-linear utility the following welfare calculation corresponds to an equivalent variation, compensating variation and consumer surplus. Given Brexit can be represented by a negative supply shock, the loss of consumer surplus is given by the typical trapezium when prices move up the demand curve from P_1 to P_2 and quantity shifts in from Q_1 to Q_2.([14] Specifically

$$\Delta \text{Consumer surplus} = (\Delta P * Q_2) + \frac{(\Delta P * \Delta Q)}{2} \tag{6}$$

Combining data on the initial equilibrium (P_1 and Q_1)[15] with our reduced form estimates of the impacts on price and quantity imply that Brexit caused a welfare loss of £210 ($246) for the average household over two years, or £5.84 billion overall, when looking at its impact on the food market alone. Since poorer households spend a larger fraction of their income on food, these effects are unequally distributed across the income distribution. Specifically, the increase in the cost of living is 52% higher for a household in the lowest decile of the income distribution compared to a household in the top decile.[16]

Domestic producers on the other hand benefit from the price increases. There is no statistically significant difference in the impact of Brexit on total imports and consumption (see Table 3 in the online appendix), suggesting that the domestic supply curve is highly inelastic in the short run, which is in line with reports by industry insiders (see Bakker et al. (2020) for a more detailed discussion). The producer surplus is given by the price change and the inital quantity ($\Delta P \times Q_1$) which is equal to £172 per household or £4.78 billion.[17] The implied dead weight loss of the rise in non-tariff barriers for food is therefore £42 per household, or £1.06 billion. Note that this dead weight loss is significantly larger compared

[14] I.e. area A + B + C in figure 2 in the Online Appendix

[15] P_1 = £2.69 average price of food, Q_1 = 1423.7 items of food, %ΔP = 0.06, %ΔQ = -0.16.

[16] It is a 0.7% increase for the top decile and a 1.1% increase for the bottom one.

[17] I.e. area B + C in figure 2 in the Online Appendix

to an equivalent rise in tariffs, as tariffs would generate government revenue while NTBs do not.[18] If the NTBs had raised standards for consumers then the amount of deadweight loss would be reduced but, at least in the short run, regulations have remained very similar and the increase in barriers is frictional and administrative.

5 Conclusion

The UK inflation rate rose well above 10% in mid-2022, a higher rate than any time since the 1970s. Many factors, affecting both supply and demand for goods and services, are involved. This paper shows that one factor contributing to high inflation has been the rise in non-tariff barriers for trade with the EU.

In leaving the EU the UK swapped a deep trade relationship with few impediments to trade for a shallow one where tariffs are eliminated but a wide range of checks, forms and steps are required before goods can cross the border.[19] This paper shows that such non-tariff barriers are economically significant. Food items which were more intensively imported from the EU had higher inflation after the TCA. This was driven entirely by products with the biggest increases in NTBs. Firms faced higher costs, and passed most of these on to consumers: over the two years to the end of 2021, Brexit increased food prices by around 6% overall.

The policy implications are stark: NTBs are an important impediment to trade that should be a first-order concern, at least on par with tariffs, for policy makers interested in low consumer prices. Unlike tariffs, NTBs do not generate government revenue and are therefore prone to generating larger deadweight loss, unless they increase welfare by raising the quality of imported goods. Internationally, policy has moved in the direction of protectionism in recent years. Our study shows that those seeking to protect household budgets by delivering

[18] For non-tariff barriers the DWL is equal to area B + C while for an equivalent raise in ad-valorem tariffs it would just be area C in figure 2 in the Online Appendix

[19] The trade costs of Brexit have been set out by numerous food and trade bodies: on milk, see Agriculture and Horticulture Development Board (2021); on meat see British Meat Producers Association (2021). For business in general see Confederation of British Industry (2022).

low prices should be wary of non-tariff measures.

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