

The negative impact of disintegration on trade: the case of Brexit*

Juan de Lucio[†]

Raúl Mínguez[‡]

Asier Minondo[§]

Francisco Requena[¶]

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Abstract

Using firm-level export and import transactions and by applying an event study methodology, we quantify the impact of the UK's withdrawal from the EU's single market and customs union on Spain-UK trade flows. We find that Spanish exports and imports to the UK decreased by 24% and 27%, respectively, compared to the period before the Brexit referendum. The probability of Spanish exporters and importers starting a trade relationship with the UK decreased and the probability of ending one increased. Products subject to sanitary and phytosanitary measures, stringent rules of origin, and whose technical standards had not been harmonized before disintegration experienced a stronger decline in trade flows. Large firms faced a more severe decrease in exports than small ones after disintegration.

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Keywords: Brexit, trade costs, trade policy uncertainty, Spanish firms, rules of origin, European Union.

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[†]de Lucio: Universidad de Alcalá. Pza. San Diego, s/n, 28801, Alcalá de Henares (Spain). Email: juan.delucio@uah.es.

[‡]Mínguez: Cámara de Comercio de España and Universidad Antonio de Nebrija. Calle de Santa Cruz de Marcenado, 27, 28015, Madrid (Spain). Email: rminguez@nebrija.es.

[§]Minondo: Corresponding author. Deusto Business School, University of Deusto, Camino de Mundaiz 50, 20012 Donostia - San Sebastián (Spain). Email: aminondo@deusto.es

[¶]Requena: Department of Economic Structure, University of Valencia, Avda. dels Tarongers s/n, 46022 Valencia (Spain). Email: francisco.requena@uv.es

1 Introduction

Brexit is the most significant trade disintegration event that has occurred in recent times. On 1 January 2021, the United Kingdom (UK) withdrew from the European Union (EU)’s single market and customs union, and a new trade agreement between the UK and the EU came into effect: the Trade and Cooperation Agreement (TCA).

The TCA introduced no tariffs or quotas in the EU-UK trade if the products originated in any of these partners. However, the withdrawal of the UK from the EU’s single market and customs union generated new trade costs between these partners. Since customs must clear all transactions between Spain and the UK, there were new costs related to (i) procedures for recording trade transactions in customs; (ii) certification of rules of origin (RoO); (iii) compliance with the partner’s sanitary and phytosanitary measures; (iv) inspections on animals, plants, and food products; (v) compliance with the partners’ technical standards; (vi) higher transport costs due to the time spent waiting in customs for cargo and documents to be checked; and (vii) payment of the value-added tax (VAT) at customs for imported products.¹

We use the universe of Spanish firm-level export and import transactions to quantify the impact of the UK’s withdrawal from the EU’s single market and customs union on Spain-UK trade flows. Our identification strategy is to compare the difference of a firm’s exports of a particular product to the UK and another market (first difference) before the Brexit referendum and after the TCA was implemented (second difference). As explained by [Gasiorek and Tamberi \(2023\)](#), the last minute deal on TCA meant that firms could not anticipate the characteristics of the new EU-UK trade relationship. This enables us to consider the TCA as a quasi-natural experiment and interpret our estimates as causal.

We find that Spanish firm-level exports and imports to the UK decreased relative to the pre-referendum period, and relative to other partners, by 24% and 27%, respectively, after the TCA. Furthermore, the entry of Spanish exporters and importers into the UK decreased by 4% and 8%, respectively, and the probability of stopping an export and import relationship with a UK partner increased by 7% and 21%, respectively, after the TCA. These negative effects are magnified if entry and exit are measured at the firm-product level. The number of exported and imported products with the UK decreased by 12% and 31%, respectively, after the TCA.

Since our estimates control for variations in real GDP and real bilateral exchange rates, these results indicate that trade disintegration between the EU and the UK had a large negative impact on Spain-UK trade flows. We also find that the withdrawal of the

¹Before the TCA, since products were imported from other EU countries, the VAT was paid when a firm presented its VAT declarations to its domestic revenue agency. In the new regime, there is an additional cost because firms must advance VAT payments.

UK from the EU's single market and customs union had a much larger negative impact on trade flows than the previous two Brexit stages: 1) the period that spans from the Brexit referendum to the official Brexit, when the UK was still a member of the EU (23 June 2016-31 January 2020); and 2) the period that spans from the official Brexit to the TCA, where the UK was not member of the EU but was part of its single market and customs union (1 February 2020-31 December 2020). This result suggests that the uncertainty about the future trade policy between the EU and the UK during the first two Brexit stages had a much smaller negative effect on trade flows than the new trade costs that emerged after the TCA.

To understand the mechanisms that could explain the large decrease in the Spain-UK trade after the TCA we analyze heterogeneity across products and firms. The withdrawal of the UK from the EU's single market and customs union should raise trade costs in products subject to sanitary and phytosanitary measures (SPS), stringent rules of origin (RoO), and whose technical standards were not harmonized between the EU and the UK. Consistent with expectations, we find that Spanish imports from the UK decreased more after the TCA for SPS-intensive products. However, we did not find any difference in the impact of TCA on SPS-intensive products and the rest of the products in Spanish exports. This difference can be explained by the fact that EU authorities demanded certifications and introduced inspections on UK imports since the beginning of the TCA. In contrast, by the end of 2022, the UK had not yet introduced these controls on EU imports. The TCA had a stronger negative effect on the probability of starting importing a product from the UK if the product was subject to SPS. The effect of the TCA on the probability to stop importing from the UK was also larger if the product was subject to SPS.

We use the information contained in the TCA to build a product-level measure of the stringency of RoO in the EU-UK trade after 2020. As expected, we find that exports and imports decreased more in products that should comply with a more stringent RoO after the TCA. We also find that the negative impact of the TCA on the probability of starting an import relationship with the UK was stronger on products with stringent RoO. The negative effect of the TCA was particularly strong for Spanish exporters of non-harmonized products to the UK. However, there are no differences in the impact of the TCA between non-harmonized and harmonized products for imports. We find that the negative impact of the TCA on entry and exit was stronger for non-harmonized than for harmonized products both in exports and in imports.

In addition, we explore whether trade disintegration had heterogeneous effects between firms. We discover that the export revenue of large exporters decreased more after the TCA than the one of small exporters. This result suggests that, in the case of Brexit, the trade cost elasticity of large exporters was higher than that of small exporters. On

the contrary, we do not find any difference in the impact of the TCA on import revenue between small and large importers. Regarding the extensive margin, we find that small firms exhibit a larger probability to cease to trade with the UK than large firms after the TCA.

Our paper makes five contributions to the literature. First, we add to the literature on the trade effects of Brexit. Using firm-level data, [Fernandes and Winters \(2021\)](#) found that one year after the Brexit referendum, Portuguese firms decreased their exports to the UK by 5.5% relative to other countries. [Douch et al. \(2020\)](#) showed that British firms increased their exports to non-EU markets relative to EU markets in the 16 months following the Brexit referendum. [Crowley et al. \(2020\)](#) documented that British firms had a lower probability of introducing new products into the EU six months after the Brexit referendum if those products were more likely to experience a tariff increase in a hard Brexit scenario. We extend these analyses documenting the effect of the UK's withdrawal from the EU's single market and customs union on firms' intensive and extensive margins. As in the studies mentioned above, we find that the first stage of Brexit, characterized by trade policy uncertainty, had a negative effect on export flows and entry.² However, this effect is dwarfed by the one provoked by the implementation of the TCA. Using product-level data, [Freeman et al. \(2022\)](#) and [Gasiorek and Tamberi \(2023\)](#) conclude that the TCA had only a temporary negative effect on UK exports to the EU and a longer negative effect on UK imports from the EU. Using a different benchmark and a hybrid data set, [Kren and Lawless \(2022\)](#) found that the TCA had negative effects on both UK-to-EU and EU-to-UK trade. We explore the impact of TCA on firms, the economic units at which export and import decisions are taken. We show that the TCA had a strong negative effect on Spanish exports and imports to the UK.

Second, our paper contributes to the debate on the effects of trade policy uncertainty on trade flows. Using Portuguese firm-level data, [Handley and Limão \(2015\)](#) showed that the reduction in trade policy uncertainty due to the integration of Portugal into the European Economic Community (EEC) had a positive effect on firm's entry and exports to the EEC. Furthermore, this positive effect was greater than that accounted for by the actual reduction in tariffs. [Graziano et al. \(2020\)](#) documented that increases in the probability of Brexit reduced EU-UK exports and net export entry in the months preceding the Brexit referendum. We show that the increase in trade policy uncertainty has a much lower impact on firms' entry, exit, exports, and imports than the one provoked by new trade costs in a trade disintegration process.

Third, our paper is also related to the literature on the costs of non-Europe. [Mayer et al. \(2019\)](#) and [Felbermayr et al. \(2022\)](#) concluded that the disappearance of the EU's

²[Gutiérrez Chacón et al. \(2021\)](#) showed that the decrease in trade with the UK after the referendum was greater for Spanish firms more exposed to the UK market and facing a higher tariff in a hard Brexit scenario.

single market would be the largest contributor to the fall in trade in a non-EU scenario. Using microdata, we confirm that UK’s disengagement from EU’s single market had a large negative effect on firms’ extensive and intensive trade margins.

Fourth, we contribute to the novel literature on the response of small and large firms to a common trade shock. [Bricongne et al. \(2022\)](#) found that large French exporters were more sensitive to foreign demand shocks, such as those provoked by the Great Recession and Covid-19, than small exporters. We find that large exporters are also more sensitive to trade-cost shocks than small ones. However, we did not find any difference between large and small importers in trade-cost sensitivity.

Fifth, our work is also related to the literature that estimates the cost of using RoO in preferential trade agreements. Several studies conclude that the current system of trade restrictions associated with RoO should be simplified ([Cadot and De Melo, 2008](#)), and that the widespread and unconditional use of RoO is irrational since trade diversion is not usually profitable ([Felbermayr et al., 2019](#)). We show that exports and imports between Spain and the UK decreased more after the TCA in products with more stringent RoO. Since Spain and the UK have similar external tariffs, and there is, therefore, a low incentive for trade deflection, our result confirms that RoO introduce unnecessary trade costs.

The remainder of the paper is organized as follows. Section 2 provides a description of the firm-level data set used in the empirical analyses and presents the equations to estimate the effect of Brexit on Spanish trade flows with the UK. Section 3 presents the baseline results of the regression analyses on the impact of the withdrawal of the UK from the EU on the intensive and extensive margins of trade. This section comments on some further analyses to assess the robustness of our results. Section 4 explores whether the EU-UK trade disintegration had a heterogeneous impact on products and firms. The last section concludes.

2 Data and specifications

Quarterly data on the universe of Spanish firms’ export and import transactions in goods were obtained from the Customs and Excise Department of the Spanish Tax Agency. The data set contains a firm identifier, export destination or import origin, the product’s combined-nomenclature eight-digits (CN 8-digit) classification, the value of the flow, and the traded quantities. Our data begin in the first quarter of 2014 and end in the fourth quarter of 2022.³ We eliminate transactions belonging to the Harmonized System 2-digit chapters 98 and 99. We also exclude transactions in energy-related products and

³We ensure a consistent concordance across the CN 8-digit products over time following [Van Beveren et al. \(2012\)](#).

gold because they can experience large variations in prices. To reduce noise in the data, we removed all trade transactions with a value below or equal to 10,000 euros.⁴ As explained below, the regression equations control for export destinations’ and import origins’ real GDP and real bilateral exchange rate. These pieces of information come from the Organization for Economic Co-operation and Development (OECD), the International Monetary Fund’s (IMF) International Financial Statistics, and the Federal Reserve Bank of St. Louis databases. Since quarterly real GDP and real bilateral exchange rate data were not available for all Spanish trade partners, the data set was reduced to 61 export destinations and import origins.⁵ They represent 78% and 71% of Spanish exports and imports in 2014 (the first year of our analysis period), respectively.⁶

The UK accounted for 7% of Spanish goods exports and occupied the top-4 position as a destination of Spanish exports in 2015, the year before the Brexit referendum. The UK was the top-6 supplier of Spain, accounting for 5% of its total imports of goods.⁷ There were 6,846 exporters to the UK and 6,117 importers from the UK in 2015, the year before the Brexit referendum. Table 1 presents some descriptive statistics on the median Spanish firm that traded with the UK in 2015. The median exporter to the UK exported 224 thousand euros to this country. The median importer from the UK imported 149 thousand euros from this country. The median exporter sold one product in the UK and the median importer purchased one product from the UK. The median exporter to the UK had 14 export destinations, and the median importer had eight supplier countries. The UK represented 9% of total exports for the median exporter. For the median importer, 10% of all its imports originated in the UK. In addition, for almost 20% of firms exporting to the UK, this market represented their main destination. For importers from the UK, this market was the main supplier for 25% of the firms.

As explained in the introductory section, we identify three Brexit stages. The first covers the period between the referendum and the official withdrawal of the UK from the EU: Post-referendum (2016Q3-2019Q4). During this stage, the UK was still a member of the EU, so there were no new trade costs in the Spain-UK trade. In this period, two major mechanisms could have affected trade flows between Spain and the UK, relative to those between Spain and other partners: trade policy uncertainty and the depreciation of the pound against the euro. Figure 1 plots the overall uncertainty index for the UK calculated by Ahir et al. (2022).⁸ It multiplied by three around the Brexit referendum

⁴As shown later, this threshold does not affect the conclusions of the empirical analyses.

⁵The countries included in the sample are listed in Table A.1 in the online Appendix A.

⁶Our final data set treats the UK as a single country. Since Northern Ireland remained in the EU’s single market for goods after the TCA came into force, statistics of trade flows with this territory use the Intrastat system, while the trade flows with the rest of the UK use the Extrastat system. However, our data set does not provide any information to identify Spanish flows with Northern Ireland or with the rest of the UK.

⁷Spain’s trade flows with Gibraltar are not included in Spain’s trade flows with the UK.

⁸The uncertainty index is calculated counting the number of times the term “uncertainty”, or vari-

Table 1: Descriptive statistics on the median Spanish firm trading with the UK, 2015

	Exporters	Importers
Value of flow with the UK (thousand euros)	224	149
Number of products traded with the UK	1	1
Number of foreign markets	14	8
Share of the UK in firm's total flow (%)	9	10

Note: Values correspond to the median trader. Source: authors' own calculations based on the Spanish Customs' database.

(23 June 2016). Although uncertainty declined during 2017, it rose again and reached a maximum just before the UK's official withdrawal from the EU (31 January 2020). As explained by [Handley and Limão \(2017\)](#), uncertainty about the conditions of a future trade relationship between the EU and the UK could have delayed firms' investments to increase their sales or purchases in the partner country, negatively affecting bilateral trade flows.

Figure 1 also plots the euro-pound exchange rate. The pound has been depreciating against the euro since the second quarter of 2015. The value of the pound relative to the euro experienced an additional 10% depreciation immediately after the referendum and continued to depreciate until the end of 2018. This depreciation could have negatively affected Spanish exports to the UK and favored Spanish imports from the UK.

The second stage covers the period between the official Brexit and the new trade agreement: Official (2020Q1-2020Q4). During this period, the UK was still a member of the EU's single market and customs union. Thus, no new trade costs have yet arisen between the EU and the UK. The level of uncertainty in the UK was reduced by more than half, and the exchange rate of the pound against the euro further depreciated.⁹

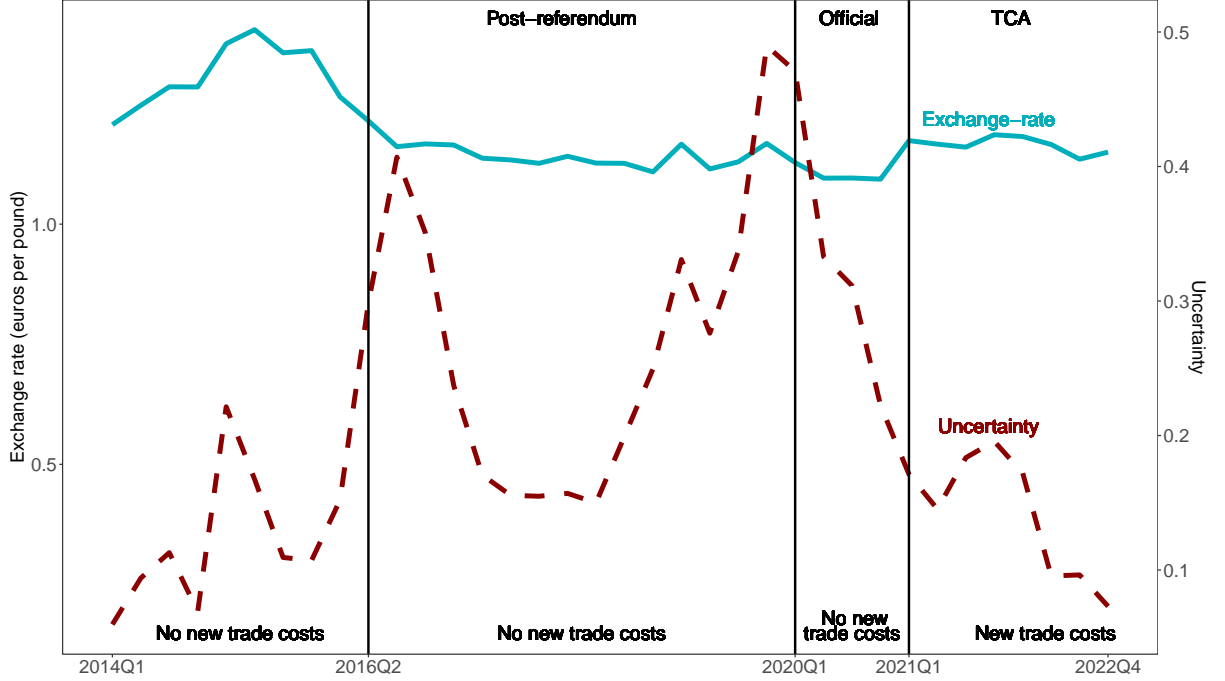
The third stage covers the implementation of the TCA (2021Q1-2022Q4). This agreement did not introduce tariffs or quotas in the EU-UK trade if products originated from any of these partners. However, it introduced new non-tariff measures in the UK-EU trade. During this stage, uncertainty in the UK decreased to pre-referendum levels and the exchange rate depreciated very mildly.

To identify the causal effect of the TCA, and the previous two Brexit stages, on Span-

ants of this term, appears in the Economist Intelligence Unit country reports. We select the three-quarter weighted moving average, the uncertainty index most preferred by the authors when working with country-level data. See also [Hassan et al. \(2020\)](#) for an alternative measure of Brexit-related uncertainty.

⁹Note that Official coincides with the period in which the most stringent confinement measures to arrest the spread of the Covid-19 virus were implemented. As explained below, our difference-in-differences methodology neutralizes the effect of these measures on trade flows.

Figure 1: Uncertainty in the UK, nominal exchange rate, and new trade costs during the three Brexit stages



Source: authors own elaboration using exchange rate data from the International Monetary Fund and uncertainty data from Tab 6 of the data set from [Ahir et al. \(2022\)](#).

ish firms' trade with the UK, we estimate the following difference-in-differences regression:

$$\ln x_{fkt} = \beta_1(UK_c \times PostReferendum_t) + \beta_2(UK_c \times Official_t) + \beta_3(UK_c \times TCA_t) + \alpha_1 \ln RER_{ct} + \alpha_2 \ln RGDP_{ct} + \gamma_{fkc} + \gamma_{fkt} + \epsilon_{fkt} \quad (1)$$

where x_{fkt} are exports by firm f of product k to country c at time t . UK_c is an indicator variable that turns one if the destination of exports is the UK. $PostReferendum_t$, $Official_t$, and TCA_t are indicator variables that turn one if t is between the third quarter of 2016 and the fourth quarter of 2019, the first quarter of 2020 and the fourth quarter of 2020, and the first quarter of 2021 or later, respectively. RER_{ct} is the real bilateral exchange rate between Spain and country c at time t .¹⁰ An increase in RER_{ct} means a real depreciation of the euro against the currency of country c . $RGDP_{ct}$ is the real GDP of country c at time t . γ_{fkc} is a firm \times product \times country fixed effect. It captures the permanent differences in a firm's export of product k across destinations, such as distance, speaking the same language, size of markets, or product-level preferences. γ_{fkt}

¹⁰It is defined as $RER_{ct} = NER_{ct} \frac{CPI_{ct}}{CPI_t}$, where NER_{ct} is the nominal exchange rate of the euro against the currency of country c at time t . It is measured as euros per unit of currency of c . CPI_{ct} and CPI_t are the consumer price index in c and Spain, respectively.

is a firm \times product \times time fixed effect that controls for the evolution of the marginal cost of manufacturing product k by firm f and any time-specific global supply and demand conditions that can affect exports of product k . ϵ_{fkt} is the disturbance term. After substituting the dependent variable for $\ln m_{fkt}$, we also use Equation (1) to analyze the impact of the TCA on Spanish imports from the UK.

Our key parameter is β_3 . It captures how the difference in firm f exports of product k between the UK and another destination (first difference) changed between the pre-referendum period and the UK's withdrawal from the EU's single market and customs union (second difference). The parameters β_1 and β_2 enable us to compare the effect of the first two Brexit stages, characterized by trade policy uncertainty, with that of the third stage, characterized by the emergence of new trade costs.

We also estimate a specification that includes interaction terms for each quarter included in the sample period (2014Q1-2022Q4):

$$\ln x_{fkt} = \sum_t \beta_t(UK_c \times D_t) + \alpha_1 \ln RER_{ct} + \alpha_2 \ln RGDP_{ct} + \gamma_{fkc} + \gamma_{fkt} + \epsilon_{fkt} \quad (2)$$

where D_t is an indicator variable that turns one if the analyzed quarter is t .

This flexible specification enables us to analyze the evolution of the difference between the exports of firm f of product k to the UK and another market in the second quarter of 2016 (first difference) relative to any other quarter included in the sample (second difference). We select 2016Q2 as the reference quarter, as the Brexit referendum took place at the end of that quarter (23 June 2016).

Finally, we analyze whether the UK-EU trade disintegration had an impact on the probability that a Spanish firm entered or exited the UK market. We analyze entry at the firm \times destination and the firm \times destination \times product levels. The specification to analyze the extensive margin of trade at the firm \times destination is defined as follows:

$$Y_{fct} = \beta_1(UK_c \times PostReferendum_t) + \beta_2(UK_c \times Official_t) + \beta_3(UK_c \times TCA_t) + \alpha_1 \ln RER_{ct} + \alpha_2 \ln RGDP_{ct} + \gamma_{ft} + \gamma_c + \epsilon_{fct} \quad (3)$$

where Y_{fct} turns one if firm f did not export to c at time $t - 1$ and exported to c at time t . The specification includes a firm \times time fixed effect and a destination fixed effect. The first controls for firm-level time-varying factors, such as marginal costs, which may facilitate a firm's entry into a new market. The second controls all time-invariant factors that make a destination easier or more difficult for a firm to enter. It is important to note that, for each quarter of the year and destination, the estimation sample only

includes the firms that did not export to destination c at time $t - 1$. The specification to analyze the extensive margin of trade at the firm-destination-product level is similar to Equation (3), adding the product subscript k to the dependent variable, the fixed effects, and the disturbance term.

After substituting for the dependent variable, the same equations are also used to analyze the impact of the TCA on import entry at the firm-destination and firm-destination-product levels. We also use a similar specification to analyze the exit of a firm from destination c . In this latter analysis, Y_{fct} turns one if firm f was exporting to c at $t - 1$ but did not export to c at t . The exit estimation sample only includes, for each destination and quarter of the year, the firms that were exporting at $t - 1$.

3 Baseline results

This section presents the baseline results on the impact of the withdrawal of the UK from the EU's single market and customs union on Spanish firms' exports and imports to the UK. First, we present the regression results for the intensive margin of trade and then comment on the estimates for the extensive margin of trade. The section ends with a discussion of some additional analyses to assess the robustness of our results.

3.1 Intensive margin of trade analyses

Table 2 presents the results of the impact of trade disintegration on Spanish firms' trade flows with the UK. Columns 1 to 3 present the estimates for exports and columns 4 to 6 the ones for imports. We cluster standard errors at the destination level.

Some scholars (e.g., [Fernandes and Winters \(2021\)](#)) consider that the nominal depreciation of the pound against the euro that happened right after the referendum should be considered as an effect of Brexit (see Figure 1). Hence, in column 1, instead of controlling for bilateral real exchange rates, we only control for price differences between Spain and the destination country, which we denote as *RelativeCPI*. In this specification, the impact on exports of the variation in the nominal euro-pound exchange rate that occurred between the pre-referendum period and the rest of Brexit stages will be captured by the Post-referendum, Official, and TCA coefficients.

As expected, column 1 shows that Spanish firms export more to destinations with a large GDP. However, surprisingly, we find that a rise in prices in the destination of Spanish exports, relative to Spanish prices, reduces the value of Spanish exports. The Post-referendum coefficient is negative and statistically significant: a Spanish firm's exports to the UK decreased, relative to other countries, by 3.5% ($[\exp(-0.036)-1]*100$) after the referendum. Our coefficient is in line with the result of [Fernandes and Winters](#)

Table 2: Impact of Brexit on Spanish firms' trade flows with the UK

	Exports			Imports		
	(1)	(2)	(3)	(4)	(5)	(6)
Post-referendum _{ct}	-0.036 ^a (0.008)	-0.017 ^c (0.009)	-0.016 ^c (0.009)	-0.046 ^a (0.007)	-0.057 ^a (0.015)	-0.057 ^a (0.014)
Official _{ct}	-0.027 ^b (0.012)	-0.009 (0.012)	-0.007 (0.012)	-0.051 ^c (0.027)	-0.059 ^c (0.032)	-0.058 ^c (0.032)
TCA _{ct}	-0.282 ^a (0.020)	-0.270 ^a (0.018)	-0.270 ^a (0.019)	-0.315 ^a (0.028)	-0.320 ^a (0.030)	-0.320 ^a (0.030)
ln Real GDP _{ct}	0.436 ^a (0.090)	0.427 ^a (0.087)	0.435 ^a (0.090)	0.506 ^a (0.129)	0.567 ^a (0.118)	0.573 ^a (0.121)
ln CPI _{ct}	-0.091 ^c (0.052)			0.225 ^a (0.059)		
ln Real exchange rate _{ct}		0.179 ^a (0.058)	0.184 ^a (0.058)		-0.135 (0.118)	-0.140 (0.117)
ln Uncertainty _{ct}			-0.002 (0.003)			-0.002 (0.004)
Observations	6771283	6771283	6771283	7555494	7555494	7555494
Adj.-R2	0.784	0.784	0.784	0.752	0.752	0.752
Firms	53546	53546	53546	76185	76185	76185
Countries	61	61	61	61	61	61
Products	7854	7854	7854	8220	8220	8220

Note: The dependent variable is the (log) value of exports in columns 1 to 3 and the (log) value of imports in columns 4 to 6. All estimations include a firm×country×product fixed effect, a firm×product×quarter fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

(2021) which uses Portuguese data and a post-referendum period that only covered the 12 months after the referendum.¹¹ The Official coefficient is also negative and statistically significant, but smaller in magnitude than the Post-referendum coefficient (-0.027). The TCA coefficient is negative, statistically significant, and large in absolute terms. According to this coefficient, firm-level exports to the UK after the TCA decreased by 24.6% ($[\exp(-0.282)-1]*100$) relative to the pre-referendum period. Our estimates indicate that the UK's withdrawal from the EU's single market and customs union had a much larger negative effect on Spanish exports to the UK than the British decision to leave the EU (Post-referendum) and the official separation of the UK from the EU (Official).

We introduce the real bilateral exchange rate in column 2 to neutralize the effect that the depreciation of the pound against the euro may have on Spanish exports. The real exchange rate coefficient has the expected positive sign: an increase in the Spanish real

¹¹Our specification differs from [Fernandes and Winters \(2021\)](#) in using export levels rather than year-to-year differences and applying more detailed fixed effects.

exchange rate (e.g., a real depreciation of the euro relative to other currencies) increases the value of Spanish exports. The Post-referendum coefficient remains negative and significant, but its point estimate is smaller, in absolute terms, than that reported in column 1. According to the new coefficient, the exports of a Spanish firm to the UK decreased, relative to its exports to other countries, by 1.7% ($[\exp(-0.017)-1]*100$) after the referendum. This result indicates that more than half of the reduction in Spanish exports to the UK during Post-referendum was explained by the nominal depreciation of the pound against the euro. The Official coefficient is statistically insignificant. However, as shown later, the zero value of this coefficient is explained by the surge in Spanish exports to the UK in the last quarter of 2020, in anticipation of the increase in trade costs due to the TCA in January 2021. If we removed the last quarter of 2020 from the sample, the Official coefficient would become negative, statistically significant, and similar in magnitude to the Post-referendum coefficient. Finally, the TCA coefficient remains negative, statistically significant, and large in absolute terms. According to this coefficient, firm-level exports to the UK after the new trade agreement was signed decreased by 23.7% ($[\exp(-0.270)-1]*100$) relative to the pre-referendum period.

In column 3 we introduce [Ahir et al.'s \(2022\)](#) country-level uncertainty index. The coefficient is statistically insignificant and its introduction in the regression equation alters minimally the rest of coefficients. This result is in line with [Freeman et al. \(2022\)](#), who argue that once a firm has paid the sunk costs of entering a foreign market, it will not substantially adjust its current behavior even if it anticipates a future increase in trade costs. Only when the trading costs materialize will the firm adjust its trade flows.

Columns 4 to 6 of Table 2 show the impact of Brexit on Spanish firm-level imports from the UK. The negative impact of Brexit on import flows became greater as the UK advanced along the three stages. Based on the estimates reported in column 4, during the post-referendum period, the value of imports decreased by 4.5%; during the Official period by 5.0%; and during the TCA period by 27.0%. These percentages increase when we control for bilateral real exchange rates (column 5): 5.5%, 5.7%, and 27.4% in the Post-referendum, Official, and TCA stages, respectively. Therefore, the depreciation of the pound against the euro moderated the negative impact of Brexit on imports. The results are minimally altered when we introduce the uncertainty index (column 6). Since uncertainty is statistically insignificant, we decided to eliminate this variable in the rest of the regressions.

Comparing the coefficients of the Brexit stages in column 6 with those in column 3, we observe that the magnitude of the effect is larger for imports than for exports. This difference is particularly salient in the first two Brexit stages. As explained later, this effect can be explained by the fact that imports from the UK were decreasing before the referendum. Hence, the Post-referendum and Official stages could be capturing this

downward trend. Furthermore, as shown later, the results for the first two stages are sensitive to the sample of countries used as a control group.

In summary, our results show that the TCA had a large negative effect on Spanish exports and imports to the UK. The first result is in line with [Freeman et al. \(2022\)](#), who found that TCA had a persistent negative effect on UK's imports from the EU. However, they showed that the negative effect of the TCA on UK exports to the EU may have been transitory, while we find that 2 years after the TCA the negative effect of Spanish imports from the UK remains.

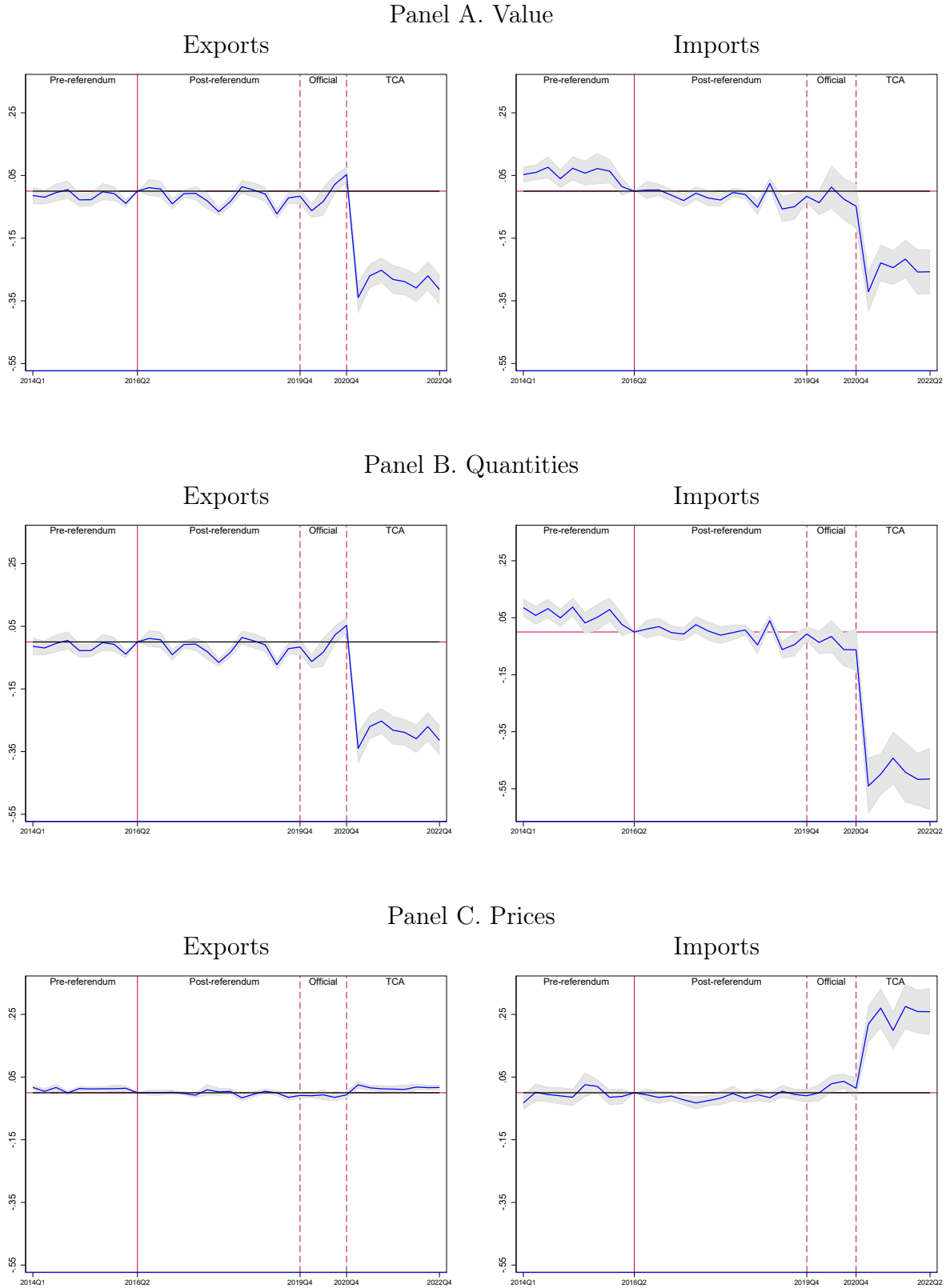
The Post-referendum, Official, and TCA coefficients reported in [Table 2](#) are stage averages. However, the impact of Brexit could be different throughout the stage. To explore this possibility, we estimate Equation (2). Furthermore, we decompose the effect of the three Brexit stages on trade value into quantity and price. Panels A, B, and C of [Figure 2](#) plot the quarterly UK interaction coefficient for value, quantity, and price, respectively. In addition to the point estimate, we draw the 95% confidence interval for each coefficient. The reference quarter is 2016Q2.

Panel A of [Figure 2](#) shows that before the Brexit referendum, the exports of Spanish firms to the UK were not statistically different, at 5%, from those to other countries. After the referendum, we observe a mild negative trend in the UK coefficient. However, there are many point estimates that are statistically not different from zero during this period. In the last quarter of 2020, when Brexit was already official, there is a substantial increase in the point estimate. This increase suggests that exporters were moving forward with their sales in anticipation of higher trade costs after the introduction of the TCA. There is a large drop in the point estimate in the first quarter of the TCA stage. Although the coefficients become less negative in the following quarters, their values are still much lower than in the previous Brexit stages. This indicates that the large decrease in exports to the UK after the TCA remained for at least the following seven quarters.

Spanish firm-level imports from the UK were slightly larger in the pre-referendum period relative to the quarter in which the referendum was held. Furthermore, imports began to decrease before the referendum took place. As mentioned above, this may explain the negative Post-referendum and Official coefficients reported in columns 4 to 6 of [Table 2](#). There is no increase in imports in the last quarter of 2020 in anticipation of higher trade costs after the TCA. There is a large drop in the point estimate in the quarter in which the TCA was implemented. The coefficients remain large and negative during the following quarters.

Exported quantities (panel B) follow a trend similar to the one of values (panel A). However, we observe a magnification in the drop of imported quantities during the TCA period. This is explained by the large increase in import prices after the TCA (panel C). Export prices are similar in the Pre-referendum, Post-referendum, and Official periods;

Figure 2: Spanish firm-level trade flows with the UK, relative to other countries, along the Brexit stages



Note: The figures report the point estimate and the 95% confidence interval of the quarter coefficients estimated in Equation (2). The excluded category is 2016-Q2.

however, they slightly increase after the TCA. In contrast, there was a large increase in import prices when the TCA was implemented. Since the import value includes cost, insurance, and freight (CIF), this result suggests that the increase in prices captures the increase in transportation and other logistic costs after the TCA. The fact that exports are measured FOB (free on board) and a potential complete pass-through of new export costs to export prices may explain why we do not observe any change in export prices after the TCA.

3.2 Extensive margin of trade analyses

This subsection analyzes whether the EU-UK trade disintegration had an impact on the probability that a Spanish firm would enter or exit the UK, and the number of products exported or imported from the UK.

UK’s disengagement from EU’s single market and customs union introduced a break in the series that recorded the number of Spanish exporters and importers to the UK. Since there are no border controls in the EU members’ trade, to quantify trade flows within the EU, firms must fill in a declaration each month, denominated Intrastat, which records all firms’ exports and imports with EU members. However, in the case of Spain, since 2015, only firms that have accumulated a value of exports (imports) with EU members of 400,000 euros in the current year or in the previous year must fill the Intrastat declaration. Once the UK leaves the EU’s single market and customs union, Spanish customs records all transactions above 1,000 euros with the UK. This leads to a large increase in the number of Spanish firms trading with the UK from 2021 onward: many firms that were absent from trade statistics before 2021 because they had no obligation to fill the Intrastat declaration appear now in customs records.¹² To address the break in the series, we performed entry and exit analyses with a sample of firms whose trade flows with the UK were recorded between 2014 and 2020.

We use Equation (3) to estimate the impact of each Brexit stage on Spanish firms’ entry and exit into the UK. Columns 1 to 4 of Table 3 report the estimates for entry and columns 5 to 8 for exit. We performed the analysis at the firm-destination level and at the firm-destination-product level. Spanish firms did not reduce their probability of entering the UK after the Brexit referendum relative to the pre-referendum period (column 1). During the Official period, there is an increase of 1.9 percentage points in the entry rate. As shown later, this rise is explained by Spanish firms moving forward their sales in the last quarter of 2020 to avoid the costs introduced by the new trade agreement. Finally, the entry rate decreases by 4.2 percentage points during the TCA period. In the case of

¹²Table A.2 in the online Appendix shows the number of Spanish firms that trade with the UK and the total value traded in the Customs database and our sample.

Table 3: Impact of Brexit on Spanish firms' entry and exit in the UK

	Entry				Exit			
	Firm-destination		Firm-destination-product		Firm-destination		Firm-destination-product	
	(1) Exports	(2) Imports	(3) Exports	(4) Imports	(5) Exports	(6) Imports	(7) Exports	(8) Imports
Post-referendum _{ct}	0.001 (0.002)	-0.008 ^b (0.004)	-0.000 (0.002)	-0.004 (0.005)	0.006 ^b (0.002)	0.010 ^b (0.005)	-0.000 (0.003)	-0.014 ^b (0.005)
Official _{ct}	0.019 ^a (0.003)	0.002 (0.004)	0.028 ^a (0.003)	0.022 ^b (0.008)	0.020 ^a (0.004)	0.006 (0.006)	-0.014 ^a (0.004)	-0.050 ^a (0.010)
TCA _{ct}	-0.042 ^a (0.004)	-0.136 ^a (0.007)	-0.123 ^a (0.009)	-0.300 ^a (0.023)	0.070 ^a (0.004)	0.205 ^a (0.010)	0.142 ^a (0.004)	0.277 ^a (0.012)
ln Real GDP _{ct}	0.050 ^a (0.014)	0.084 ^a (0.027)	0.055 ^a (0.017)	0.147 ^a (0.049)	-0.069 ^a (0.018)	-0.055 ^c (0.028)	-0.107 ^a (0.030)	-0.096 ^b (0.043)
ln Real exchange rate _{ct}	0.041 ^a (0.011)	-0.019 (0.022)	0.042 ^a (0.010)	-0.024 (0.023)	-0.040 ^a (0.015)	0.016 (0.012)	-0.040 ^b (0.016)	0.032 (0.027)
Observations	3959471	2137146	6070680	1891456	1860158	1035145	2796305	905227
Adj.-R2	0.045	0.000	0.129	0.014	0.121	0.009	0.278	0.062
Firms	16740	19296	16305	17073	16882	19531	16486	17358
Countries	61	61	61	61	61	61	61	61
Products			6099	6292			6108	6314

Note: In column 1 (2) the dependent variable turns one if firm f that did not export (import) to destination c at year-quarter $t - 1$ began exporting (importing) at t . In column 3 (4) the dependent variable turns one if firm f that did not export (import) product k to destination c at $t - 1$ began exporting (importing) product k at t . In column 5 (6) the dependent variable turns one if firm f that exported (imported) at $t - 1$ ceased to export (import) to destination c at t . In column 7 (8) the dependent variable turns one if firm f that exported (imported) product k to destination c at $t - 1$ ceased to export (import) product k at t . Estimations at the firm-destination level include firm \times time and destination fixed effects, and a constant. Estimations at the firm-destination-product level include firm \times country \times product and firm \times product \times quarter fixed effects, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

imports, the TCA led to a 13.6 percentage points decrease in the probability of starting to import from the UK (column 2). The negative effect of the TCA on the probability of entering the UK is magnified when the analysis is performed at the firm-destination-product level. In particular, a Spanish firm is 12.3 percentage points and 30.0 percentage points less likely to enter the UK market with a new product during the TCA period than during the pre-referendum period.

The probability of Spanish firms stopping exporting to the UK increased by 7.0 percentage points after the TCA (column 5). The probability of ceasing to import from the UK increased substantially after the TCA: 20.5 percentage points (column 6). The higher probability of exiting the UK market after the TCA is magnified when the analysis is performed at the firm-destination-product level. In particular, the probability of ceasing to export a given product to the UK increases by 14.2 percentage points after the TCA. Regarding imports, the probability of stopping importing a given product from the UK increases by 27.7 percentage points after the TCA.

To analyze how firms' entry and exit from the UK behaved along each Brexit stage, we estimate the entry and exit coefficients for each quarter included in our sample using an equation similar to (2). Figure 3 shows that there is a large decrease in entry and a large increase in exit once the TCA enters into force.

As explained by multiproduct firm models, firms can reduce their product scope as a response to tougher competitive conditions in their trading partner (Eckel and Neary, 2010; Bernard et al., 2011; Mayer et al., 2014, 2021). We analyze whether the TCA had a negative impact on the number of products exported and imported by Spanish firms to the UK. We selected firms that traded more than one product with a country (multiproduct firms) in each of the pre-Brexit years (2014 and 2015) and continued trading, at least one product, with that country during the entire post-Brexit period. We estimate the following regression equation:

$$nprod_{fct} = \exp[\beta_1(UK_c \times PostReferendum_t) + \beta_2(UK_c \times Official_t) + \beta_3(UK_c \times TCA_t) + \alpha_1 \ln RER_{ct} + \alpha_2 \ln RGDP_{ct} + \gamma_{fc} + \gamma_{ft}] \epsilon_{fct} \quad (4)$$

where $nprod_{fct}$ is the number of products exported (imported) by firm f to country c in year-quarter t . Since the dependent variable is a count variable, we estimate the regression using a Poisson pseudomaximum likelihood estimator (Santos-Silva and Teneyro, 2010).¹³ Furthermore, this model enables the inclusion of quarterly observations in which the number of products traded with a country is zero. We cluster standard errors at the country level.

Table 4 presents the estimations. The TCA led to a reduction in the number of products traded by Spanish firms with the UK. In particular, the number of exported and imported products with the UK decreased by 12% and 31%, respectively [$1 - \exp(-.124)$ and $1 - \exp(-.369)$] relative to the pre-Brexit period. Interestingly, there was an increase in the number of exported products during the Post-referendum and Official periods, but a decrease in the number of imported products during the Official period.

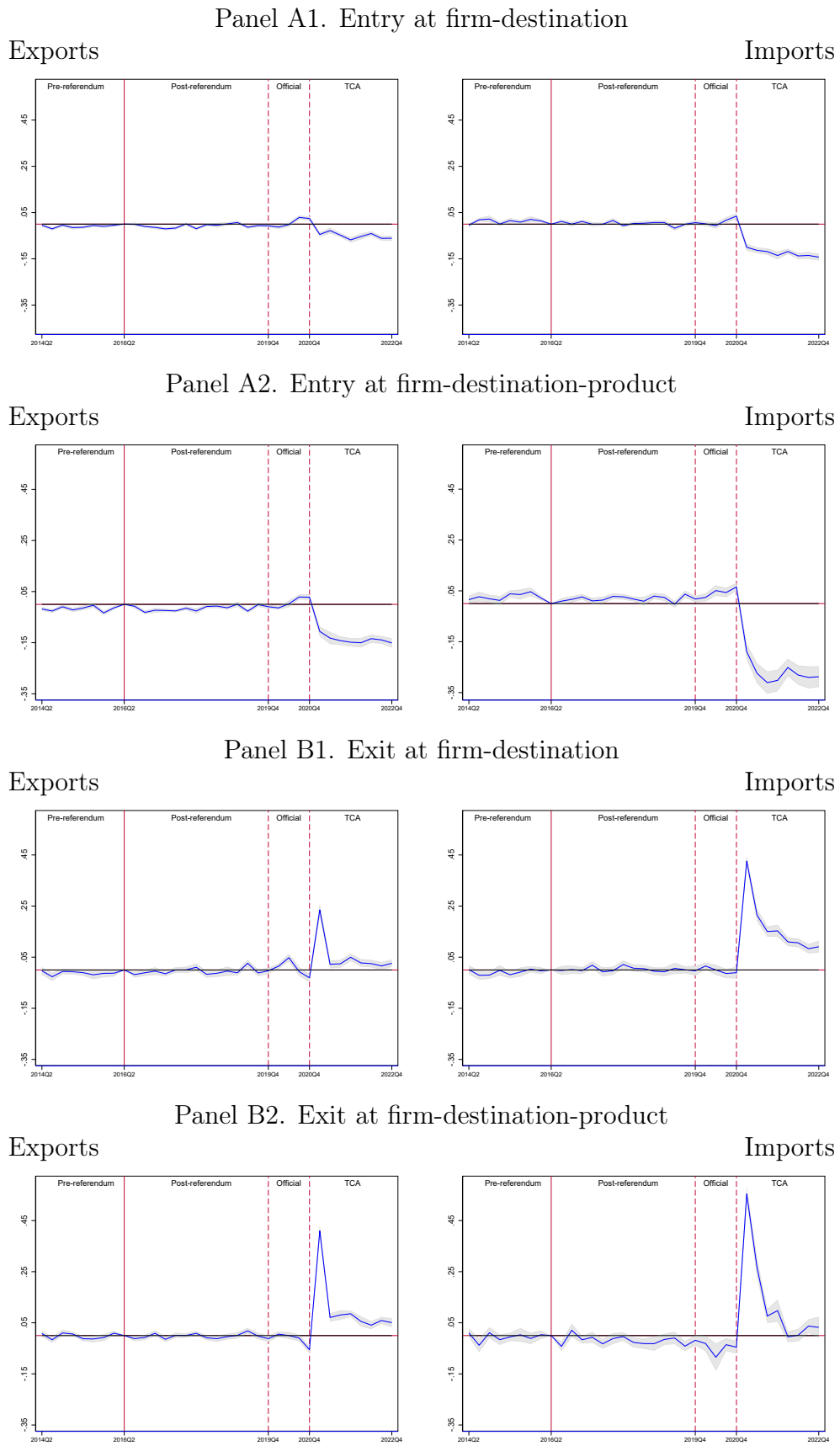
Panels A and B of Figure 4 present the evolution of the quarterly coefficients for the number of exported and imported products, respectively.

3.3 Robustness

We perform five additional exercises to assess the robustness of our baseline results. First, we present intensive and extensive margin of trade estimates for alternative control groups

¹³We use Stata's `ppmlhdf` command developed by Correia et al. (2020).

Figure 3: Spanish firms' entry and exit in the UK market

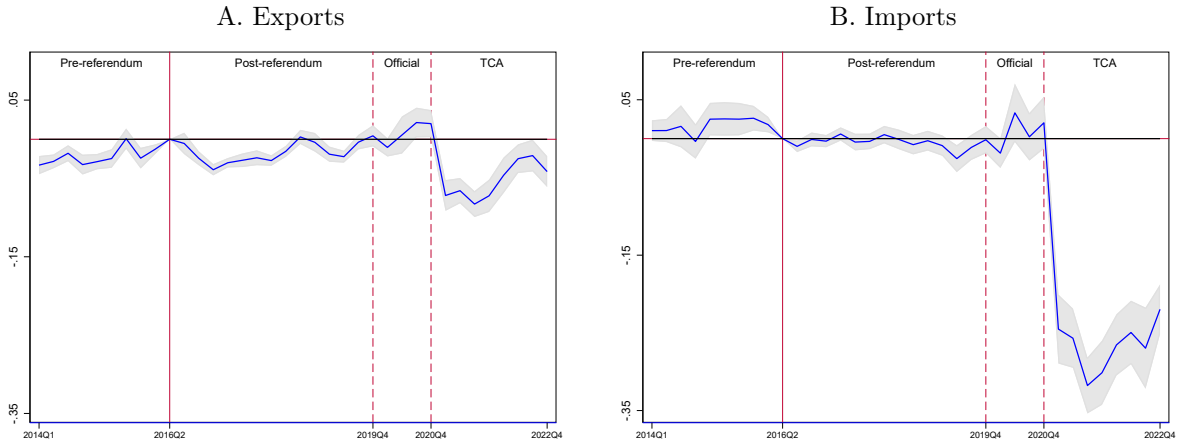


Note: The figures report the point estimate and the 95% confidence interval of the quarter coefficients estimated in Equation (1). The excluded category is 2016-Q2.

Table 4: Impact of Brexit on the number of products traded by Spanish firms with the UK

	(1)	(2)
	Exports	Imports
Post-referendum _{ct}	0.025 ^a (0.004)	-0.019 (0.014)
Official _{ct}	0.044 ^a (0.014)	-0.037 ^b (0.018)
TCA _{ct}	-0.124 ^a (0.013)	-0.369 ^a (0.019)
ln Real GDP _{ct}	0.150 (0.112)	0.472 ^a (0.088)
ln Real exchange rate _{ct}	0.180 ^a (0.039)	-0.117 ^c (0.065)
Observations	1013904	1047852
Pseudo-R2	0.601	0.652
Firms	8982	14409
Countries	139	108

Note: The dependent variable is the number of products exported and imported in columns 1 and 2, respectively. All estimations include a firm×country fixed effect, a firm×quarter fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

Figure 4: Number of products traded with the UK, relative to other countries, along the Brexit stages

Note: The figures report the point estimate and the 95% confidence interval of the quarter coefficients estimated with an equation similar to Equation (2). The excluded category is 2016-Q2.

in Tables A.3 to A.7 in the online Appendix A. In column 1 of Table A.3, we select EU countries as a control group. This enables us to compare the impact of the TCA relative to countries that remained within the EU's single market and customs union. In addition, most Spanish shipments to the EU and the UK are transported by road, so our estimates

will not be contaminated by the variation in the modes of transport between destinations.

The negative impact of the TCA on exports and imports is greater than in the baseline estimates. In columns 3 to 6 we divide the sample of EU countries among those that share the euro and those that keep their own currency. We find robust results for the negative impact of the TCA, although the magnitude of the effect is larger for euro countries than for non-euro countries, especially with regards to imports.

We do not find robust results for the Post-referendum and Official periods. For example, the Post-referendum period had a significant negative effect on exports and imports to the UK relative to other EU countries, but not relative to non-euro EU countries. The Official coefficient is only significant in the sample of non-euro countries. Tables A.4 to A.7 in the online Appendix A show that the TCA also led to a reduction in the probability of entering the UK and increased the probability of exiting the UK in the EU, euro, and the non-euro (EU) samples.

Second, we test whether results for the intensive margin are robust to using a Poisson pseudo-maximum likelihood estimator which addresses ordinary least squares (OLS) estimates' heteroskedasticity bias. Table A.8 in the online Appendix shows the results. The TCA coefficients remain negative and statistically significant. The point value of the TCA coefficient for exports is very similar to that reported in the baseline analysis (column 2 of Table 2). However, the point value for imports is lower in absolute terms than in the baseline analysis (column 5 of Table 2).

Third, we analyze whether results for the intensive margin of trade are robust to using a sample that only includes firms that exported to the UK in all the years covered in our database: 2014-2022. Column 1 of Table A.9 in the online Appendix shows that the first two Brexit stages had no impact on the revenue of regular exporters to the UK. On the contrary, the TCA had a large negative effect on exports. All Brexit stages had a negative effect on regular importers' purchases from the UK (column 2). The largest negative effect occurred when the TCA was implemented.

Fourth, coinciding with the entering into force of the TCA, the UK reduced the most favored nation (MFN) tariff on many products. This reduction made EU products less competitive relative to third-country products in the UK. Therefore, the large negative TCA coefficient for Spanish exports reported in the baseline analysis may be explained not only by the new trade costs introduced by the TCA, but also by the lower competitiveness of Spanish products in the UK market. To neutralize the effect of the change of the MFN tariff, we re-estimate the model using a sample of products whose MFN tariff did not change after 1 January 2021 (2,144 over 5,381 products).¹⁴ Column 3 of Table A.9 in the online Appendix shows that the TCA coefficient for Spanish exports, -0.353, is

¹⁴These products are evenly distributed across the HS chapters.

larger than the one estimated for the whole sample, -0.270 (column 2 of Table 2). These results suggest that the TCA coefficient reported in the baseline analysis was not biased downward due to the loss of competitiveness of Spanish exports caused by the reduction in the UK MFN tariff on third countries.

Fifth, our sample includes firms operating in different sectors: agriculture, mining, manufacturing, and wholesale. Manufacturing is the activity that accounts for most of the Spanish trade in goods. We assess whether results are robust to using a sample that only includes firms operating in this industry. To determine the activity of firms, we merge the Customs database with the SABI database from Bureau Van Dijk using the correspondence explained in [de Lucio et al. \(2018\)](#). SABI provides financial and accounting records of firms that deposited their accounts in the Spanish Business Register. In addition, it provides the 4-digit NACE classification of the economic activity of the firm. We select all firms whose economic activity lies between NACE codes 1000 and 3200. Due to statistical secrecy, we are only authorized to use the information of firms included in the Directorio de Empresas Exportadoras e Importadoras, a database constructed by Cámara de Comercio de España (Spanish Chamber of Commerce). The Directorio is a good representation of exporting and importing firms with more than 10 employees operating in the manufacturing sector. This reduces the number of firms that are present in the sample in any quarter between 2014Q1 to 2022Q4 from 53,546 to 7,355 in exports and from 76,185 to 6,677 in imports. However, these firms still account for 58% and 39% of all Spanish exports and imports, respectively. Table A.10 in the online Appendix A presents the results. They confirm that the TCA had a negative effect on the value of exports and imports, reduced the probability of Spanish firms of entering the UK, and increased the probability of Spanish firms stopping exporting to the UK.

Sixth, we use a 10,000 euro threshold to eliminate low-value transactions from our sample.¹⁵ This threshold could bias entry and exit estimations, since it may drop transactions with small partners or belonging to periods where traded values were low. We re-estimated all the baseline extensive margin specifications using a 1,500 euro instead of a 10,000 euro threshold.¹⁶ Table A.11 in the online Appendix presents the results. The point values of the TCA_{ct} coefficients are qualitatively and quantitatively similar to those obtained with the 10,000 euro threshold (Table 3).

¹⁵We selected the 10,000 euro threshold because it eliminated a large number of small-value transactions (43% and 42% of export and import transactions, respectively), while keeping most of the total value of exports and imports (99%).

¹⁶1,500 euro was the transaction value threshold used by Customs when providing us with this database.

4 Heterogeneity analyses

This section analyzes whether the EU-UK trade disintegration had heterogeneous effects on products and firms. This analysis will also allow us to understand the mechanisms that could explain the large decrease in the Spain-UK trade after the TCA.

4.1 Differences across products

Our previous analyses concluded that the TCA had a large negative effect on Spanish firm-level exports and imports to the UK. Our narrative is that the UK's withdrawal from the EU's single market and customs union generated new trade barriers in the EU-UK trade, leading to a decline in trade flows among these partners. We expect some of these new trade barriers to have a greater negative impact on some products than others.

Since the implementation of the TCA, the EU requested SPS, such as certificates and inspections, for animals, plants, and their products arriving from the UK. We expect these measures to increase the trade costs of Spanish importers of SPS products from the UK after the TCA. Although the UK had also planned to introduce SPS on EU imports, by the end of 2022 they were not required yet. We define an indicator variable, SPS, that turns one if a product is classified between Chapters 1 and 16 (both included) of the HS classification.¹⁷ We multiply the SPS variable by each Brexit stage interaction variable and add them to Equation (1).

Columns 1 and 2 of Table 5 present the results for the value of exports and imports, respectively. Although all regressions include logarithmic real GDP and logarithmic real bilateral exchange rate variables, to save space, their coefficients are not reported in the tables. The negative impact of the TCA on Spanish exports to the UK was similar for SPS and non-SPS products (column 1). This result is in line with expectations since the UK had not implemented any SPS after the TCA. In line with expectations, we discover that imports of SPS products from the UK were more negatively affected by the TCA than imports of non-SPS products (column 2). Specifically, while imports of non-SPS products decreased by 27% after the TCA, imports of SPS products decreased by 43%. This represents a 59% increase in the negative impact of the TCA on SPS products.

Column 3 shows that the negative impact of the TCA on the probability that a Spanish firm begins to export a product to the UK was not stronger for SPS products. However, column 4 concludes that the negative effect of the TCA on the probability of beginning to import from the UK was particularly strong for SPS products. Surprisingly, column 5 reports that the probability of ceasing exporting to the UK was lower for SPS products

¹⁷The animal, plants, and their products subjected to health certificates and controls are listed in EU Commission's Regulations 2019/2072 and 2021/632. Table A.12 in the online Appendix lists the description of the chapters that are subject to SPS measures.

Table 5: Impact of Brexit by products I: SPS

	Value		Entry		Exit	
	(1) Exports	(2) Imports	(3) Exports	(4) Imports	(5) Exports	(6) Imports
Post-referendum _{ct}	-0.008 (0.010)	-0.055 ^a (0.015)	-0.007 ^a (0.002)	-0.005 (0.005)	-0.002 (0.003)	-0.015 ^b (0.006)
Post-referendum _{ct} x SPS _k	-0.051 ^a (0.014)	-0.042 (0.034)	0.034 ^a (0.003)	0.004 (0.007)	0.009 ^c (0.005)	0.019 (0.015)
Official _{ct}	0.005 (0.011)	-0.056 (0.035)	0.027 ^a (0.003)	0.020 ^b (0.008)	-0.017 ^a (0.004)	-0.051 ^a (0.011)
Official _{ct} x SPS _k	-0.080 ^a (0.023)	-0.047 (0.063)	0.003 (0.005)	0.016 (0.013)	0.013 (0.009)	0.010 (0.022)
TCA _{ct}	-0.276 ^a (0.019)	-0.309 ^a (0.032)	-0.123 ^a (0.009)	-0.294 ^a (0.021)	0.146 ^a (0.004)	0.270 ^a (0.012)
TCA _{ct} x SPS _k	0.032 (0.025)	-0.256 ^a (0.085)	-0.000 (0.005)	-0.075 ^a (0.021)	-0.024 ^b (0.009)	0.133 ^a (0.033)
Observations	6771283	7555494	6070680	1891456	2796305	905227
Adj.-R2	0.784	0.752	0.129	0.014	0.278	0.062
Firms	53546	76185	16305	17073	16486	17358
Countries	61	61	61	61	61	61
Products	7854	8220	6099	6292	6108	6314

Note: The dependent variable is the (log) value of exports and imports in columns 1 and 2, respectively. In column 3 (4) the dependent variable turns one if firm f that did not export (import) product k to destination c at $t-1$ began exporting (importing) product k at t . In column 5 (6) the dependent variable turns one if firm f exported (imported) product k to destination c at $t-1$ ceased to export (import) product k at t . All estimations include a log real GDP and a log real bilateral exchange rate variable. In columns 1 and 2 estimations include a firm \times country \times product fixed effect, a firm \times product \times quarter fixed effect, and a constant. In columns 3 to 6, estimations include a firm \times product \times time fixed effect, a country \times product fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

after the TCA. However, and in line with expectations, we find that the probability of ceasing to import from the UK after the TCA was particularly large for SPS products.

Spanish firms exporting to the UK after the TCA should comply with the RoO to be exempted from tariffs. We expect the trade cost of a product subject to a stringent RoO to increase more after the TCA than that of a product subject to a light RoO. First, the costs of adapting the manufacturing process to comply with the RoO will be higher the stringent the RoO. Second, it is more likely that a firm will decide not to adapt the production process to comply with the RoO, and pay the tariff, if the RoO requirement is difficult to meet. Therefore, we expect the negative effect of the TCA on the Spanish-UK trade to be stronger in RoO-intensive products.

Using the information in the TCA, we built a product-level measure of RoO stringency.

The TCA uses ten different RoO categories.¹⁸ First, we identify the RoO applied to each 6-digit HS product. Second, following a methodology similar to [Estevadeordal \(2000\)](#), we rank the stringency of the RoO categories from bottom to top. Third, we define the RoO stringency of a product as the ranking of the RoO category applied to that product.¹⁹

The RoO stringency index ranges from 0 to 8.5. The median stringency level is 4. There are 219 products of 5,393 whose RoO index is zero, that is, they are not subject to RoO. 37% of total Spanish exports to the UK in 2019 corresponds to products that had a stringency index above the median in 2019. This percentage decreased to 35% in 2021. 25% of total Spanish imports from the UK corresponds to products that had a stringency index above the median in 2019. This percentage decreased to 23% in 2021.

We define an indicator variable that turns one if the stringency of the RoO is above the median. As above, we extend Equation 1 multiplying the high-RoO dummy by each Brexit stage interaction variable. As expected, we find that products with more stringent RoO experienced a greater decline in exports and imports after the TCA (columns 1 and 2 of Table 6). In particular, the decrease in exports and imports of high-RoO products after the TCA was 29% and 19% larger, respectively, than that of low-RoO products. The negative impact of the TCA on the probability of starting to export or import a product from the UK was stronger for high-RoO products (columns 3 and 4). However, the impact of the TCA on the probability of ceasing to export or import a product from the UK was similar for high-RoO and low-RoO products.

The EU follows two strategies to ensure that product standards do not introduce unjustified barriers to trade between member countries. In some products, EU members use the same standards; that is, standards are harmonized. In the remaining products, the EU relies on mutual recognition: if it is legal to sell a product in a member state, then it is also legal to sell that product in another member state. The TCA does not include a mutual recognition clause. Therefore, we expect the costs of trade after the TCA to increase more in products that relied on the mutual recognition principle than in products whose technical standards were already harmonized between the EU and the UK. In the former scheme, firms have to incur new costs to ensure that their products comply with the technical standards of their trading partner. In the latter scheme, there are no new compliance costs.

We use [European Commission’s \(2017\)](#) which in Annex Table 8.2 classifies manufacturing industries as harmonized or non-harmonized.²⁰ We expand Equation (1) by

¹⁸See online Appendix B for a detailed description of each RoO category, the construction of the index, and some additional statistics.

¹⁹Interested readers can download a Stata file with the RoO stringency index for each HS 6-digit product from <https://paginaspersonales.deusto.es/aminondo/Research.htm>.

²⁰Products in [European Commission \(2017\)](#) are defined using the 4-digit NACE classification. We use a crosswalk obtained from Eurostat Ramon to match this classification with the HS classification used by Spanish Customs.

Table 6: Impact of Brexit by products II: Rules of origin

	Value		Entry		Exit	
	(1) Exports	(2) Imports	(3) Exports	(4) Imports	(5) Exports	(6) Imports
Post-referendum _{ct}	-0.037 ^a (0.009)	-0.060 ^a (0.015)	-0.006 ^b (0.002)	0.000 (0.005)	0.001 (0.003)	-0.011 ^c (0.006)
Post-referendum _{ct} x High-RoO _k	0.038 ^a (0.011)	0.018 (0.017)	0.012 ^a (0.002)	-0.013 ^a (0.004)	-0.002 (0.003)	-0.010 (0.008)
Official _{ct}	-0.038 ^a (0.012)	-0.058 ^c (0.032)	0.028 ^a (0.003)	0.026 ^a (0.009)	-0.011 ^b (0.004)	-0.039 ^a (0.012)
Official _{ct} x High-RoO _k	0.059 ^a (0.019)	0.008 (0.023)	-0.001 (0.003)	-0.012 (0.008)	-0.006 (0.005)	-0.040 ^a (0.014)
TCA _{ct}	-0.238 ^a (0.016)	-0.302 ^a (0.033)	-0.113 ^a (0.009)	-0.283 ^a (0.021)	0.143 ^a (0.005)	0.279 ^a (0.014)
TCA _{ct} x High-RoO _k	-0.075 ^a (0.020)	-0.065 ^c (0.035)	-0.022 ^a (0.003)	-0.050 ^a (0.009)	0.000 (0.006)	-0.010 (0.017)
Observations	6771283	7555494	6070680	1891456	2796305	905227
Adj.-R2	0.785	0.752	0.130	0.014	0.278	0.062
Firms	53379	76015	16266	17034	16447	17316
Countries	61	61	61	61	61	61
Products	7851	8219	6097	6289	6100	6302

Note: The dependent variable is the (log) value of exports and imports in columns 1 and 2, respectively. In column 3 (4) the dependent variable turns one if firm f that did not export (import) product k to destination c at $t-1$ began exporting (importing) product k at t . In column 5 (6) the dependent variable turns one if firm f exported (imported) product k to destination c at $t-1$ ceased to export (import) product k at t . All estimations include a log real GDP and a log real bilateral exchange rate variable. In columns 1 and 2 estimations include a firm \times country \times product fixed effect, a firm \times product \times quarter fixed effect, and a constant. In columns 3 to 6, estimations include a firm \times product \times time fixed effect, a country \times product fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

multiplying each Brexit stage by a dummy variable that turns one if the product was not harmonized before the TCA. Table 7 presents the estimates. We find that the negative impact of TCA on Spanish exports to the UK was stronger for non-harmonized than harmonized manufactures (column 1). However, the negative impact of the TCA on Spanish imports from the UK was similar on non-harmonized and harmonized manufactures (column 2). The decrease in entry into the UK after the TCA was stronger for non-harmonized than harmonized manufactures both in exports and imports (columns 3 and 4). The probability of stopping exporting or importing a product from the UK after the TCA was also stronger for non-harmonized than harmonized manufacturers (columns 5 and 6). To sum up, the results indicate that manufactures whose technical standards had not been harmonized before the withdrawal of the UK from the EU's sin-

gle market experienced, in most cases, a larger decrease in the intensive and extensive margins of trade after the TCA than manufactures using harmonized standards.

Table 7: Impact of Brexit by products III: Harmonized vs. non-harmonized

	Value		Entry		Exit	
	(1) Exports	(2) Imports	(3) Exports	(4) Imports	(5) Exports	(6) Imports
Post-referendum _{ct}	-0.022 ^b (0.009)	-0.072 ^a (0.016)	-0.008 ^a (0.002)	-0.003 (0.006)	0.004 (0.003)	-0.018 ^a (0.006)
Post-referendum _{ct} x Non-Harmonized _k	0.023 ^b (0.010)	0.054 ^a (0.012)	0.012 ^a (0.003)	-0.011 (0.007)	-0.015 ^a (0.004)	0.003 (0.007)
Official _{ct}	-0.029 ^b (0.013)	-0.053 (0.033)	0.018 ^a (0.003)	0.023 ^b (0.010)	0.001 (0.004)	-0.039 ^a (0.008)
Official _{ct} x Non-Harmonized _k	0.076 ^a (0.023)	-0.014 (0.020)	0.034 ^a (0.004)	-0.019 (0.012)	-0.044 ^a (0.009)	-0.060 ^a (0.017)
TCA _{ct}	-0.206 ^a (0.014)	-0.320 ^a (0.034)	-0.107 ^a (0.010)	-0.286 ^a (0.021)	0.121 ^a (0.004)	0.243 ^a (0.010)
TCA _{ct} x Non-Harmonized _k	-0.238 ^a (0.029)	0.060 (0.045)	-0.059 ^a (0.005)	-0.054 ^a (0.011)	0.081 ^a (0.005)	0.155 ^a (0.020)
Observations	6771283	7555494	6070680	1891456	2796305	905227
Adj.-R2	0.789	0.751	0.121	0.011	0.265	0.057
Firms	47069	71893	16266	17034	16447	17316
Countries	61	61	61	61	61	61
Products	7161	7488	6097	6289	6100	6302

Note: The dependent variable is the (log) value of exports and imports in columns 1 and 2, respectively. In column 3 (4) the dependent variable turns one if firm f that did not export (import) product k to destination c at $t-1$ began exporting (importing) product k at t . In column 5 (6) the dependent variable turns one if firm f exported (imported) product k to destination c at $t-1$ ceased to export (import) product k at t . All estimations include a log real GDP and a log real bilateral exchange rate variable. In columns 1 and 2 estimations include a firm \times country \times product fixed effect, a firm \times product \times quarter fixed effect, and a constant. In columns 3 to 6, estimations include a firm \times product \times time fixed effect, a country \times product fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

Finally, a potential major change in technical standards was the introduction of the UK Conformity Assessed (UKCA) mark for products to be placed in the UK (except Northern Ireland). UKCA was intended to be required for a set of products similar to those regulated by CE marking. However, when this paper was written, the UK had indefinitely postponed the compulsory use of the UKCA mark.²¹

²¹See <https://www.gov.uk/guidance/using-the-ukca-marking>.

4.2 Differences across firms

This subsection explores whether the impact of the EU-UK trade disintegration was heterogeneous between firms. First, we analyze whether the effect of Brexit was similar for small and large traders. We identify a firm as a large trader if its exports (imports) with all countries in 2015, the year before the Brexit referendum, were above the median. We extend equation (1) interacting each Brexit stage with a high-trader dummy.

The standard model of trade with firm heterogeneity, [Melitz \(2003\)](#), predicts that a rise in trade costs leads to the same relative reduction in export (import) revenue for small and large firms, if firms continue to operate in the foreign market. In addition, the reduction in revenue will make it more difficult for firms to obtain the profits needed to cover the costs of operating in a foreign market. Since small firms are closer to this break-even point, they are more likely to exit and less likely to enter a foreign market after an increase in trade costs than large firms.

Table 8 presents the results. The Post-referendum and Official stages had similar effects on small and large exporters (column 1). However, the negative effect of the TCA was stronger for large than for small exporters. Whereas the TCA reduced the export revenue of small exporters in the UK by 12.6%, the export revenue of large exporters decreased by 24.1%. Our finding is in line with [Fitzgerald and Haller \(2018\)](#) who found that the revenue of large Irish exporters was more sensitive to tariffs than that of small ones. It is also in line with [Bricongne et al. \(2022\)](#), who discovered that large French exporters were more sensitive to the negative demand shock generated by Covid-19 than small firms.

To confirm this argument, we identify four categories of traders: (i) traders below or equal to the median; (ii) traders above the median and equal or below the 75th percentile; (iii) traders above the 75th percentile and equal or below the 90th percentile; and (iv) traders above the 90th percentile. The left-hand side of panel A of Figure 5 plots the interaction coefficient of each firm size category with the TCA coefficient. The reference category is the group of firms below or equal to the median (the point estimate equals zero). The coefficient becomes more negative as the size of an exporter increases, confirming the positive relationship between the elasticity of export revenue to trade costs and the size of the exporter.

The impact of the TCA on imports was similar for large and small firms (column 2 of Table 8). The right-hand side of Panel A of Figure 5 shows that the 95% intervals of all coefficients include the zero value. This confirms that the negative impact of the TCA on imports was similar for all size categories.

Next, we analyze whether the impact of the TCA on entry and exit was similar for small and large traders. The TCA reduced the probability of starting exporting to the

Table 8: Impact of Brexit on small and large traders

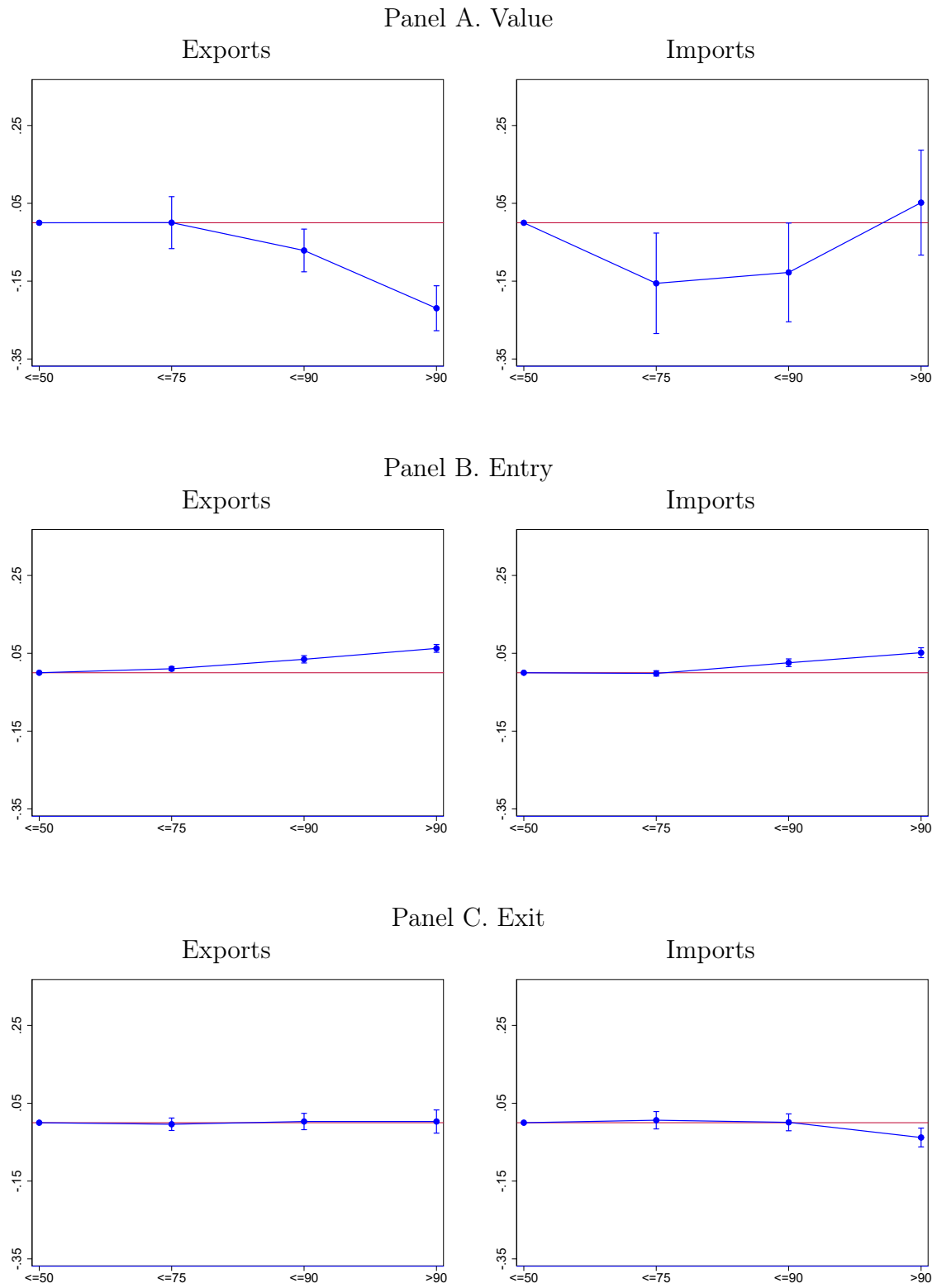
	Value		Entry		Exit	
	(1)	(2)	(3)	(4)	(5)	(6)
	Exports	Imports	Exports	Imports	Exports	Imports
Post-referendum _{ct}	-0.056 ^b (0.028)	-0.042 (0.034)	-0.021 ^a (0.004)	-0.008 ^c (0.005)	0.003 (0.008)	0.010 (0.007)
Post-referendum _{ct} x Large trader _f	0.040 (0.029)	-0.016 (0.031)	0.039 ^a (0.004)	-0.002 (0.003)	0.004 (0.011)	0.000 (0.006)
Official _{ct}	-0.019 (0.030)	-0.065 (0.051)	0.008 ^b (0.004)	-0.012 ^b (0.005)	0.024 ^b (0.009)	0.025 ^a (0.009)
Official _{ct} x Large trader _f	0.013 (0.031)	0.009 (0.042)	0.008 ^b (0.004)	0.003 (0.004)	-0.003 (0.012)	-0.017 ^b (0.009)
TCA _{ct}	-0.135 ^a (0.036)	-0.396 ^a (0.059)	-0.051 ^a (0.004)	-0.143 ^a (0.008)	0.066 ^a (0.008)	0.212 ^a (0.012)
TCA _{ct} x Large trader _f	-0.141 ^a (0.030)	0.076 (0.062)	0.024 ^a (0.003)	0.018 ^a (0.004)	0.000 (0.010)	-0.009 (0.011)
Observations	6376934	7012862	3805147	2036018	1791160	989071
Adj.-R2	0.784	0.751	0.040	-0.003	0.118	0.006
Firms	37735	50236	14609	16089	14647	16189
Countries	61	61	61	61	61	61
nprod	7792	8171				

Note: The dependent variable is the (log) value of exports and imports in columns 1 and 2, respectively. In column 3 (column 4) the dependent variable turns one if firm f that did not export (import) at $t - 1$ began exporting (importing) at t . In column 5 (column 6) the dependent variable turns one if firm f exported (imported) at $t - 1$ ceased to export (import) at t . All estimations include a log real GDP and a log real bilateral exchange rate variable. In columns 1 and 2 estimations include a firm \times country \times product fixed effect, a firm \times time fixed effect, and a constant. In columns 3 to 6, estimations include a firm \times time fixed effect, a country fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

UK particularly for small firms (column 3 of Table 8). The left-hand side of panel B of Figure 5 shows that the entry coefficients become higher as the size of the firm increases. The probability of starting to import from the UK after the TCA is also lower for small importers (column 4) and the difference in the probability of entry between small and large firms increases as firms become bigger (right-hand side figure of panel B of Figure 5). We find no difference between small and large exporters in the probability of exiting the UK after the TCA. However, the right-side figure of panel C of Figure 5 shows that the probability of leaving the UK after the TCA was lower for the largest importers (>90 percentile).

Second, we analyze whether the impact of trade disintegration was greater for high-

Figure 5: Impact of the TCA on trade value by firm size



Note: The figures report the point estimate and the 95% confidence interval of the $UK_j \times TCA_t \times Dfirmsize_f$ coefficient estimated with an extension of Equation (1). Firms whose total exports (imports) are equal to or below the median is the reference category.

productivity traders than for low-productivity ones. We define a firm as highly productive if its total factor productivity (TFP) in 2015, the year before the Brexit referendum, was above the median TFP. As before, we enlarge Equation (1) interacting the high-TFP dummy variable with each Brexit stage.

We estimate TFP using the [Levinsohn and Petrin’s \(2003\)](#) approach. It employs a Cobb-Douglas gross output production function that uses intermediate inputs as a proxy to control the correlation between input levels and unobserved firm-specific productivity.²² Variables to estimate the production function (revenue, employment, tangible assets, and intermediate inputs) are obtained from the Bureau van Dick SABI database. The nominal values are deflated using the industrial price index obtained from the Spanish National Statistics (2010=100). We eliminate observations with negative output or a revenue smaller than the value of intermediate inputs.

As explained above, we can only merge a subsample of firms included in SABI with those recorded by Spanish Customs. These are manufacturing firms with 10 or more employees. The data set covers manufacturing firms with complete data for at least 4 years over the period 2010-2019. The production function is estimated separately for each four-digit NACE manufacturing industry.

Table 9 shows that the negative impact of the TCA on the value of exports was larger for high-TFP firms than for low-TFP ones (column 1). However, we find that the negative impact of the TCA on imports was similar for high and low-TFP firms (column 2). These results are in line with those presented in Table 8. The probability of starting to export to the UK decreased more for high-TFP firms than low-TFP firms after the TCA (column 3). There were no differences between low-TFP and high-TFP firms in the impact of the TCA on import entry (column 4). Finally, we find that high-TFP firms had a greater probability of stopping exporting and importing to the UK.

We analyze whether these results are robust to using productivity measures calculated with alternative methodologies. First, Table A.13 in the online Appendix presents the results using the [Akerberg et al.’s \(2015\)](#) productivity measure. The results are qualitatively similar to those using the [Levinsohn and Petrin’s \(2003\)](#) TFP measure. Second, Table A.14 in the online Appendix presents the results using the [Gandhi et al.’s \(2020\)](#) productivity measure.²³ There are some differences with respect to the estimates using the [Levinsohn and Petrin’s \(2003\)](#) TFP measure. First, we find that the negative impact of the TCA on import value is now stronger for high-productivity importers. Second, the negative impact of the TCA on entry is not stronger for high-productivity exporters. Finally, the impact of the TCA on exit is similar for low-productivity and high-productivity

²²The production function is estimated using Stata’s `prodest` module.

²³We use Stata’s `prodest` module to estimate [Akerberg et al.’s \(2015\)](#) TFP and R’s `gnrprod` package to estimate [Gandhi et al.’s \(2020\)](#) total productivity.

Table 9: Impact of Brexit on low and high-productive manufacturers

	Value		Entry		Exit	
	(1)	(2)	(3)	(4)	(5)	(6)
	Exports	Imports	Exports	Imports	Exports	Imports
Post-referendum _{ct}	-0.038 ^a (0.009)	-0.020 (0.019)	-0.000 (0.003)	0.012 ^a (0.004)	0.000 (0.004)	-0.004 (0.008)
Post-referendum _{ct} x High-TFP _f	0.004 (0.005)	-0.079 ^a (0.020)	-0.000 (0.002)	-0.023 ^a (0.004)	0.009 ^b (0.004)	0.034 ^a (0.007)
Official _{ct}	-0.112 ^a (0.012)	-0.020 (0.034)	0.003 (0.004)	0.016 ^a (0.006)	0.023 ^a (0.006)	0.022 ^b (0.009)
Official _{ct} x High-TFP _f	0.043 ^a (0.012)	-0.094 ^a (0.018)	0.012 ^a (0.004)	-0.026 ^a (0.004)	0.014 ^b (0.006)	-0.005 (0.014)
TCA _{ct}	-0.166 ^a (0.014)	-0.210 ^a (0.057)	-0.027 ^a (0.004)	-0.097 ^a (0.005)	0.036 ^a (0.005)	0.146 ^a (0.008)
TCA _{ct} x High-TFP _f	-0.047 ^a (0.013)	-0.066 (0.040)	-0.010 ^a (0.004)	-0.000 (0.004)	0.017 ^a (0.006)	0.015 ^b (0.007)
Observations	2918426	2173944	1876411	720358	969583	363629
Adj.-R2	0.791	0.758	0.032	0.002	0.104	0.007
Firms	7355	6677	5007	3852	5010	3856
Countries	61	61	61	61	61	61
Products	6587	7210				

Note: The dependent variable is the (log) value of exports and imports in columns 1 and 2, respectively. In column 3 (column 4) the dependent variable turns one if firm f that did not export (import) at $t - 1$ began exporting (importing) at t . In column 5 (column 6) the dependent variable turns one if firm f exported (imported) at $t - 1$ ceased to export (import) at t . All estimations include a log real GDP and a log real bilateral exchange rate variable. In columns 1 and 2 estimations include a firm \times country \times product fixed effect, a firm \times time fixed effect, and a constant. In columns 3 to 6, estimations include a firm \times time fixed effect, a country fixed effect, and a constant. Standard errors clustered at the country level are in parentheses. a, b, and c: statistically significant at 1%, 5%, and 10%, respectively.

importers.

5 Conclusion

The UK is the only country that has left the EU and has withdrawn from its single market and customs union. This paper has analyzed the impact of this transition from a deep to a lower-level integration on Spanish firm-level trade with the UK.

We use the universe of firm-level export and import transactions for Spanish firms at a quarterly frequency. Applying an event study methodology, we compare the difference

of a firm’s export (import) of a particular product between the UK and another market before Brexit and after the UK’s withdrawal from the EU’s single market and customs union. We find that trade disintegration led to a large negative effect on trade flows: exports and imports decreased by 24% and 27%, respectively. Furthermore, Spanish firms reduced their probability of entering the UK and increased their probability of exiting the UK after the trade disintegration. Spanish firms also reduced the number of products traded with the UK after the TCA.

Products more affected by SPS, more stringent rules of origin, and whose technical standards had not been harmonized experienced a larger decrease in trade after the new trade agreement between the EU and the UK entered into force. We find that the export revenue of large exporters was more negatively affected by trade disintegration than that of small exporters. However, we observed no difference in the impact on the intensive margin of trade between small and large importers.

Our paper shows that trade disintegration has a large negative effect on trade flows. Furthermore, these negative effects occur even if previously integrated partners reach a new trade agreement that includes no tariffs or quotas. This result demonstrates the need for deep integration to maximize the benefits of international trade.

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