Exporters and shocks: impact of the Brexit vote shock on bilateral exports to the UK*

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Abstract

This paper exploits the Brexit referendum as a quasi-natural experiment to investigate the effect of exchange rate and uncertainty shocks on export volumes, prices, entry and exit. We use transaction-level export data for the universe of exporters in Portugal. Using monthly observations on export quantity and price for products exported by the same firm to buyers in the UK and in other countries allows us to cleanly identify the differential response to the shock in the UK market. We find that exporters reduce the export volume and export price in the UK market after the referendum shock. We document heterogeneous responses to the shock across exporters. More productive, import-intensive and financially unconstrained exporters react to the shock by decreasing significantly more their export prices to the UK so that their export volumes decrease by less. We also find that goods with higher elasticity of substitution experienced a lower reduction in export price and a higher reduction in export volume. The effects of the shock are significantly larger for durable goods than for non-durable goods. The referendum shock also contributed to deter export entry to the UK market and reduce the probability of continuing to export in the UK.

Key Words: Brexit referendum, exchange rate pass-through, exchange rate shocks, exports, extensive margin of trade, financial constraints, intensive margin of trade, pricing-to-market, uncertainty.

JEL Classification Numbers: F14, F31, F32, F41.

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1 Introduction

Economists have long been interested in understanding and quantifying the effect of economic shocks, such as exchange rate movements and unforeseen policy shocks on international trade volumes, prices and firms' trade participation. The popular vote in the United Kingdom in June 2016 to leave the European Union (EU) constitutes one such shock, with potentially far-reaching economic implications, in particular for bilateral trade between the EU and the UK. The Brexit vote implied the likelihood of a large future shock to UK trade policy and trading costs, an immediate increase in policy uncertainty, and was given immediate and concrete form in a sharp, sudden and unanticipated plunge in the British pound exchange rate. In this paper, we examine the impact of the Brexit vote shock on bilateral exports to the UK.

On June 23, 2016, 51.9 percent of the UK voted in a referendum to leave the European Union. Until the results of the referendum were announced, the outcome of the vote was uncertain; exit poll results predicted 52 percent for 'Remain', and 48 percent for 'Leave'. But once the referendum result became known, the pound depreciated sharply against the euro and the U.S. dollar, plunging 10 percent to its lowest level in 31 years, as shown in Figure 1 below.[1]

We examine the ways in which exporters adjust to large shocks in the short run, using the referendum as a quasi-natural experiment. We identify the effects on export volumes, prices and participation using a difference-in-differences strategy, estimating the differential response to the shock for firms selling the same product in the UK and in other markets, accounting for countries' unobserved characteristics. This strategy has the advantage of cleanly identifying the overall effect of the Brexit vote on UK trade, without having to rely on proxies for various simultaneous elements of the shock, e.g., to the exchange rate, uncertainty and policy, which are difficult to disentangle and measure accurately.

Specifically, we analyze the response to the shock using uniquely disaggregated export data, at the firm-product-country-month level for the universe of exporters in Portugal. We have monthly observations on export value, quantity and unit values for firms exporting the same product - a CN 8-digit category (close to 10,000 distinct products) - to buyers in the UK and in other countries. Assuming that relative marginal cost is constant across markets within the same firm and product, this allows us to cleanly estimate the differential export price and volume effects in the UK market after the referendum shock. We use data from 2015 to 2017, and thus estimate the short-run effects of the shock.[2] We match the export data with firm-level characteristics, allowing us to construct measures of firm productivity, import intensity and financial constraints to estimate how responses to the shock differed across exporters.

[1] The depreciation of the pound proved to be persistent, and by the end of 2017 Sterling remained around 10 percent below its pre-referendum value.

[2] Existing studies show that firms adjust export prices quickly to exchange rate shocks, with most of the adjustment occurring within the first six months and levelling off soon after (e.g., Auer et al., 2020; Bonadio et al., 2020; Campa and Goldberg, 2005).

The setting we analyze is well-suited to studying the effects of the large and unanticipated Brexit shock on bilateral exports to the UK: in addition to the availability of exceptionally disaggregated data, the effects pertain to a significant trading relationship. The UK is the largest non-euro destination market for Portuguese exports, and the fourth largest market overall, following Spain, Germany and France.

We find that export volumes and (euro) prices to the UK decreased after the referendum, relative to exports of the same product by the same firm to other markets. As is common in the literature, the proxy for price is the unit value of a firm-product-country triple in a month. Using log differences relative to the same month in the previous year, our estimates show that the export price to the UK decreased by 2.5 percentage points after the referendum, relative to other markets. The export value response to the UK was a 5.5 percentage point relative reduction, on average after the shock. The same responses are observed also when we restrict the estimation to a sample of non-eurozone countries or to EU member states. Our finding of a reduction in export price to the UK market following the sudden depreciation of sterling, and consequent relative appreciation of the euro, suggests a degree of pricing-to-market.[3] Our results are robust to a battery of tests and estimation samples.

The richness of firm-level characteristics in our data allows us to estimate heterogeneous responses across exporters. We find that export prices fell by more and export volumes by less for the more productive exporters than for less productive ones after the Brexit shock. In particular, the estimates imply that a firm with mean total factor productivity (TFP) decreased its export price by 2.3 percentage points and its export value by 4.5 percentage points on average after the Brexit vote. In contrast, a firm with TFP one standard deviation above the mean reduced price by 5 percentage points but experienced a reduction in export value of just 2 percentage points. Although our estimates may capture factors other than just the impact of the exchange rate shock, these findings can be related to studies that document heterogeneous pass-through responses to exchange rate changes, with more productive firms absorbing more of exchange rate movements into their markups than less productive firms (e.g., Berman et al., 2012; Li et al., 2015).

An important feature in international trade is that large exporters tend to be simultaneously large importers, we take this into account to investigate the role of import intensity in firms' response to the Brexit shock. We find that more import-intensive exporters have significantly smaller response in terms of export volumes but significantly larger one in terms of their export price to the UK market after the shock. This finding is consistent with Amiti et al. (2014) who show that import-intensive exporters have lower exchange rate pass-through (ERPT) as

[3] Pricing-to-market (PTM) can arise in models with variable markups, where firms choose different prices for different destinations. Atkeson and Burstein (2008) provide a quantitative investigation of PTM. Fitzgerald and Haller (2014) estimate a significant price differential response to exchange rate movements for firms selling the same good in domestic and export markets.

they are able to set higher markups and change them in response to exchange rate shocks. This result is even clearer if we focus just on imports of intermediates from the UK.

We also analyze several other sources of heterogeneity and transmission channels for the response to the shock. Export price fell by more and quantity by less for goods with low elasticities of substitution and for consumer goods, suggesting that firms have more pricing power for differentiated goods or products with higher distribution costs. On the other hand, more substitutable goods, intermediate inputs, durable goods, firms which adjust their prices more frequently in normal times and those firms that face more financial or credit constraints experienced a significantly larger drop in export volumes.

Finally, we examine the impact of the shock on exporters' adjustment at the extensive margin of export participation. We investigate whether the Brexit shock contributed to deter entry to the UK export market for Portuguese firms or forced exits from the market. We find that the shock reduced the probability of firm export entry to the UK, relative to other markets. The probability of continuing to export to the UK was also reduced after the referendum.

Our paper is related to studies of the impact of trade shocks on exports prices, revenue, entry and exit (see e.g., Fitzgerald and Haller, 2018) and also to the literatures on exchange rate pass-through and pricing-to-market (e.g. Gopinath and Rigobon, 2008; Gopinath et al., 2010; Neiman, 2010; Berman et al., 2012; Amiti et al., 2014, and Li et al., 2015). Our paper is also related to a branch of studies on the effects of large exchange rate changes (see e.g., Burstein et al., 2005).

It is distinct from those literatures, however, in several respects. We analyze the Brexit referendum, a recent, unanticipated, large shock concerning a major currency and a significant trading relationship. We employ a difference-in-differences strategy to identify the differential effect of the referendum shock on exports to the UK relative to other markets. Also, the richness of firm-level information in our data allows us to estimate heterogeneous effects for different exporters, and the role of firms' import-intensity and credit constraints in the response to the shock. Moreover, we estimate the effects of the shock on export quantities and export participation in addition to export prices.

Our results have important policy implications for the adjustment to exchange rate shocks and increased uncertainty about trade policy, in particular at a time when the future trading relationship between the UK and the EU is still evolving. Our finding that exporters reduced their export prices and volumes to the UK market following the referendum shock suggests a reduction in profits for European firms, from a combination of lower markups and lower sales in the UK. On the other hand, the small magnitude of the effect on prices suggests that the bulk of the effect of the initial Brexit shock was passed-through to the UK users and consumers of Portuguese goods. This view is reinforced by the changes in the extensive margin, which reduced choice and competition in the UK.

The remainder of the paper is organized as follows. The next section discusses the institutional context in which the Brexit shock occurred and the conceptual framework for our empirical analysis. Section 3 describes the data used and the identification strategy. Section 4 presents and discusses the benchmark results on the effect of the quasi-natural experiment on export price, value and quantity. Section 5 investigates heterogeneous effects across firms and products, and Section 6 extensive margin effects. The last section concludes.

2 Institutional context and conceptual framework

2.1 Institutional context

This section briefly describes the macroeconomic context in the UK within which the exchange rate and uncertainty shocks associated with the Brexit vote occurred. In particular, we look at the exchange rate and economic activity in the UK before and after the referendum.

On June 23, 2016, 51.9 percent of those who voted in a UK referendum favoured British exit from the European Union (the process known as "Brexit"). The outcome of the referendum was unexpected. Until the results were announced, opinion polls, exit polls in the night of the vote, prediction markets and currency futures all forecast a small majority for the "remain" vote (see The Economist, 2016). The result of the vote hugely surprised the general public, politicians and markets. As a result, the British pound depreciated sharply and immediately, plunging 10 percent to its lowest level in over 30 years. The exchange rate change proved to be persistent, and by the end of 2017, the pound remained 10 percent below its pre-referendum value, as shown in Figure 1 below.

[FIGURE 1]

Importantly for this paper, the sudden and sharp exchange rate shock resulted from an unanticipated policy change and was not accompanied by changes in economic conditions that could affect the price or volume of Portuguese exports to the UK market. Figure A.1 in the appendix shows three main macroeconomic indicators for the UK economy: real GDP, retail sales index, and CPI inflation, as well as the Economic Policy Uncertainty index.[4] As shown in Figure A.1a, prior to the referendum the British economy was performing well, with real GDP growing at an average annualized rate of 2.4% in 2015, declining slightly to 1.9% in 2016 and 2017. GDP continued to grow on previous trends after the referendum, helped by robust consumer demand. Thus the Brexit referendum did not induce a significant economic downturn and the effects on GDP over the initial 18 months after the vote were limited.

[4] Data for panels (a)-(c) of Figure A.1 is from the UK's Office for National Statistics (ONS). The real GDP series is chained volume, seasonally adjusted; the retail sales index is all retail, percentage change on the previous three months, seasonally adjusted; and CPI inflation is the 12-month rate. Data for panel (d) is from Baker et al. (2016).

Figure A.1b shows that the Consumer Prices Index inflation in the UK had been low before the Brexit vote, averaging 0.2% in the twelve months leading up to the referendum. The sharp depreciation of sterling led to a significant increase in inflation, which averaged 1.7% over the twelve months after the referendum, and reached 3% by December 2017. Hobijn et al. (2019) show that the increase of inflation after Brexit was largely due to higher inflation rate of tradable goods and services, through imported products. Our study investigates how Portugal's export prices to the UK market changed after the sudden depreciation of the pound, and hence the extent of pass-through to destination prices in the UK.

Figure A.1c shows that retail sales continued to grow after the vote, contributing to the UK's economic growth in the initial period after the EU referendum. Retail sales actually jumped in July 2016 and continued to grow above previous trends in the following months, resulting in higher average growth in 2016 than in the previous year. Over the last six months of 2016 it was unclear when or how Brexit would occur and retail sales figures suggest that the referendum result had no significant immediate impact on consumer confidence. Retail sales growth slowed down in 2017, as prices rose and the Prime Minister announced in January 2017 that the UK would not remain in the EU Single Market.[5]

Figure A.1d plots the Economic Policy Uncertainty index for the UK. This is a general index of policy-related uncertainty that uses the number of news articles containing terms such as 'uncertain' or 'uncertainty', 'economic' or 'economy', as well as policy relevant terms, such as 'policy', 'tax', 'spending', 'regulation', 'Bank of England', 'budget', and 'deficit'. The figure shows that the index spiked in June 2016, the month of the referendum, and increased further in July; it subsequently declined but not back to 2015 levels.[6]

In sum, the large and sudden depreciation of sterling after the Brexit vote occurred in an otherwise stable macroeconomic environment. Moreover, the economic conditions in the UK did not change significantly in the 12 months post-referendum, during the sample period for our analysis. This contrasts strongly with the sudden exchange rate depreciation, shown in Figure 1, and the increased uncertainty, and given that reactions to the exchange rate typically occur fast, suggests a clean identification of the effects of the Brexit shocks.

2.2 Conceptual framework

This section discusses frameworks consistent with the effects of the Brexit shock on Portuguese firms' export price and quantity to the UK market, in particular, adjustment mechanisms related to exchange rate shocks and changes in policy uncertainty.

[5] The Prime Minister announced in October 2016 that the UK would proceed with Brexit and officially notified the EU of the intention to withdraw in March 2017.

[6] Existing studies examine additional impacts of the referendum on the UK economy, including trade and living standards (Dhingra et al., 2016a), foreign investment (Dhingra et al., 2016b), and immigration (Dhingra et al., 2016c).

In models of endogenous and variable markups, in which firms choose different prices for different destinations depending on local market conditions (pricing-to-market), domestic firms' export prices and quantities respond to a foreign currency depreciation. A vast literature documents an incomplete pass-through of exchange rate movements into destination prices. As shown in e.g., Dornbusch (1987), Krugman (1987), and Atkeson and Burstein (2008), when firms have market power they are able to absorb part of exchange rate movements in their markups, thus reducing the extent of pass-through. Similar results arise in e.g., Melitz and Ottaviano (2008) and Bergin and Feenstra (2001), which feature non-CES utility over a continuum of differentiated products. Incomplete pass-through into consumer prices also arises in models with local distribution costs (e.g., Burstein et al., 2003; Corsetti and Dedola, 2005).[7] Evidence on pricing-to-market supports the variable markup channel of incomplete pass-through (see Gopinath and Itskhoki, 2011; and Fitzgerald and Haller, 2014).

If exporters absorb part of a currency appreciation (such as the appreciation of the euro relative to the pound after Brexit) by lowering their export price, exchange rate pass-through into destination prices will be incomplete. Despite the fall in the producer price, the final price faced by consumers in the destination market (in the destination currency) still increases, generating a negative quantity response.[8] A combination of lower demand and lower export prices reduces exporters' revenue. An extensive margin effect can also arise as the reduction in export revenue may discourage entry and lead to more exits by the least productive exporters, who may find it unprofitable to continue serving the market.

We also investigate the heterogeneous reaction of Portuguese exporters to the Brexit vote shock. Variation in pass-through across heterogeneous firms can arise in the monopolistic competition model of Melitz and Ottaviano (2008), with high-performance (low-price) firms facing lower demand elasticity; and in Atkeson and Burstein (2008), where more productive firms have a larger market share in a sector and face lower demand elasticity. The prediction is that higher performance firms are able to absorb more of exchange rate movements in their markups and thus display lower ERPT (see also Berman et al., 2012). The heterogeneous responses of export prices to a currency appreciation generate heterogeneous responses of export volumes: the higher the reduction in export prices, the lower the reduction in export volumes.

Pass-through incompleteness can also be due to price stickiness in local currency in the short run. When prices are rigid, ERPT into destination price is complete if goods are priced in the exporter's currency and is zero if prices are set in the importer's currency. When prices adjust, there should be no difference, but even after they do, Gopinath et al. (2010) show

[7] Distribution costs paid in local currency are not affected by exchange rate movements and thus reduce exchange rate pass-through into consumer prices.

[8] There is evidence showing that the increase in inflation in the UK after Brexit was mostly due to increases in the prices of goods more exposed, directly or indirectly via inputs, to imports (Hobijn et al., 2019; Breinlich et al, 2017).

that there is still a large difference in pass-through, which is estimated at 0.84 for exports of goods priced in the producer's currency and at 0.25 for goods priced in the importer's currency. The latter authors show that the pricing-to-market and sticky price determinants of incomplete pass-through reinforce each other, with firms endogenously choosing the currency of pricing.

Increased uncertainty after the Brexit vote can be another channel for the effects on exports to the UK. Models of sunk investment costs predict that higher uncertainty reduces investment by increasing the value of waiting (Dixit, 1989; Bloom, 2014). This mechanism implies that trade policy uncertainty can lead to disintegration and deter exports (Handley and Limão, 2015; Carballo et al., 2018). The rise in uncertainty in the UK contributed to the sharp depreciation of sterling as markets incorporated expectations of trade barriers with the EU, and losses in earlier gains from trade and efficiency, in their valuation of the pound (see Gourinchas and Hale, 2017). Therefore, it is not possible to disentangle the separate effects of the simultaneous increase in uncertainty and the exchange rate shock after the vote.[9] The aim of our paper is to estimate the overall effect of the sudden shocks that followed the referendum (including the exchange rate and policy uncertainty) on exports and prices to the UK market.

3 Data description and identification strategy

3.1 Data description

Our empirical analysis is based on the Portuguese international trade customs data, collected by the National Statistics Office (INE), covering virtually the entire universe of monthly export and import transactions at the firm-product-country level. For this paper we use monthly data from July 2014 through to July 2017. For each transaction, the data contains information, among other, on export value (in euros) and physical quantities of each exported and imported product (close to 10,000 products) from/to each origin/destination country (over 200 countries), and transport mode (road, plane, rail, ocean, among other). Products are classified according to the Combined Nomenclature (CN) at the 8-digit level; the first 6 digits of the CN classification correspond to the international Harmonized System (HS) classification of products and the next two digits are country-specific. The availability of data at the CN8-digit level of product classification provides a very fine degree of disaggregation for the study of export prices and quantities.

Data for transactions with countries outside the EU are collected by the Customs System ("Extrastat"), which covers the universe of international trade transactions. Due to the removal of physical customs barriers within the EU from 1993, data for trade transactions with other EU

[9] Graziano et al. (2020) focus on the period prior to the referendum and find that increases in the probability of Brexit, measured by prediction markets for the outcome of the vote, reduced EU-UK bilateral export values and trade participation.

member states are collected through the "Intrastat" system, under which all firms are required to report information on all of their trade transactions, on a monthly basis, if the total volume of the firms' annual exports to (or imports from) the EU (declared on the VAT form) in the current year, the previous year, or two years before are above legally binding thresholds, applied to exports (imports) at the firm-level; while firms below the threshold are not precluded from reporting. The thresholds are set by each member country to ensure that at least 97 percent of the country's goods exports to the EU and 93 percent of imports are covered in the survey. For Portugal, the threshold for exports was set at 250,000 euros from 2010 (200,000 for imports).[10] The median firm-level exports exceeded 2.7 million euros in 2016.

The main dependent variables in our analysis are the log change in export value, quantity and price of a firm-country-product triple, relative to the same month in the previous year, covering twelve months of differenced data before and twelve months after the Brexit referendum. The quantity is reported in the data in terms of mass (weight). We proxy the export price by the unit value of a firm-product-country triple in a month, defined as the ratio between export value of the transaction and export quantity (in kilograms). The use of unit values to measure prices is a feature of the literature which has used customs data for analysis (e.g., Berman et al., 2012; Amiti et al., 2014; and Bonadio et al., 2020, among other). Despite the richness of detail of firm-level variables in our data, customs data has the usual drawback that prices of individual items are not observed. This is mitigated in our analysis by the very fine level of disaggregation, the firm-(CN8)product-country-month.

For about one third of our observations, in addition to weight, a "supplementary unit" is also reported, from which we can construct unit prices, as an alternative measure to unit values. These units are economically more relevant measures for the goods; for example, number of dresses, machines or cars, pairs of shoes, square meters of fabric, and as such, the unit prices are arguably more precise measures of prices (see also Bonadio et al., 2020).

We complement the International Trade data with census data on firms' balance-sheet information from the Enterprise Integrated Accounts System (SCIE), to estimate heterogeneous responses, and analyze transmission mechanisms. The data contains information on firms' sales, employment, industry, output, value added, different types of inputs, and location, among other. Using this information, we estimate total factor productivity and compute labor productivity at the firm-level to estimate heterogeneous effects of the shock across firms. We also construct measures of import intensity, using information on firm-level imports and total inputs purchased by a firm (sum of domestic and imported inputs). Since it is possible that some firms may import final goods in addition to just intermediate inputs, we identify imports of intermediate

[10] The Intrastat system is closely linked to the VAT system for intra-EU trade to ensure the completeness and quality of the statistical data. Eurostat regulation also ensures harmonization of methods and definitions for collection of international trade data for both the Intrastat and the Extrastat for compilation of data under both systems.

inputs using the UN Broad Economic Codes (BEC) and construct the measure of import intensity using imports of intermediate inputs only. We also obtain measures of firms' financial constraints.

Table A.1 in the appendix reports summary statistics for the variables used in our estimations, for the estimation samples. Table B.1 in the online appendix presents statistics for the top ten export destinations of Portugal. As shown, the UK is the largest non-euro destination market for Portuguese exports, and the fourth overall, accounting for over 7 percent of export value, following Spain, Germany and France, all eurozone members. Table B.2 in the online appendix presents aggregate statistics. The number of exporting firms in the sample was 22,519 in 2015 decreasing to 21,206 in 2016. An exporter exports on average 15 products to 4 destinations and mean exports per firm are 2 million euros.

3.2 Identification strategy

Our empirical analysis estimates how export prices, volume and export participation in the UK market reacted to the large shocks following the Brexit referendum. We adopt a reduced form strategy, which has the advantage of producing estimates that can be used to rationalize a variety of structural models.

To identify the effects of the shocks, we use the Brexit referendum as a quasi-natural experiment. Our identification is based on a difference-in-differences approach to estimate the differential effect of the referendum shock on Portuguese exports to the UK, relative to other countries. The sudden, large and unanticipated nature of the shock and the fact that it pertains to a major currency and a significant trading relationship, while being exogenous from the perspective of Portuguese exporters, makes it a uniquely suited experiment. In addition, economic conditions in the UK did not change significantly in the 12 months after the leave vote, mitigating potential confounders. The UK remained part of the EU and the single market, and only officially notified the EU of its intention to withdraw in March 2017. Our approach estimates the combined effect of various shocks, including the exchange rate and policy uncertainty, that followed the Brexit vote. This has the advantage of resulting in a clean identification that does not rely on measures to proxy for each of the shocks, some of which difficult to disentangle.

We use monthly observations on export quantity and price charged by Portuguese firms exporting the same product to buyers in the UK and in other countries. Assuming that relative marginal cost is constant across markets within the same firm-product pair, this allows a clean identification of the effect of the shocks on export price and volume in the UK market. We use log differenced dependent variables in our specifications, relative to the same month in the previous year, which thus account for cyclicality of exports and absorb firm-product-country unobserved characteristics. We estimate trend-adjusted difference-in-differences regressions, which allow for the possibility of different rates of change across countries.

The explanatory variable of main interest in our empirical specifications is the interaction term $Post_t \times GB_c$, where $Post$ is an indicator variable that takes the value 1 for all months after the referendum, and zero before, and GB is a dummy variable for exports to the United Kingdom. The interaction identifies the differential effect of the Brexit vote shocks on exports to the UK, relative to other countries. Our regressions control for firm-product-country fixed effects, which absorb any trends in export volume or price at the firm-product-country level, given the differenced equations.

The identifying assumption is that conditional on the set of controls, the regressor of interest, $Post_t \times GB_c$, is uncorrelated with the error term. As discussed above, the shock was unanticipated, and can be considered largely exogenous to Portuguese exporters. Figures B.1 and B.2 in the online appendix plot aggregate year-over-year monthly growth in exports and export unit values to the UK and the rest of the world.[11] Growth rates show considerable month-to-month fluctuation but there is no evidence of prior trends, supporting the identification assumption of similar trends between treatment and control groups before treatment. These simple figures do not, of course, account for firm, product or country characteristics and hide heterogeneity across export triples, but in our regression analysis we include a number of controls and exhaustive sets of fixed effects, which account, among other, for trends of an export triple. We also perform robustness checks, including placebo tests for treatment in countries other than the UK.[12]

4 Empirical analysis: benchmark results

4.1 Country-product level estimations

Before we turn to our firm-level analysis, in this section we start by estimating the effects of the EU referendum shock on exports and prices at the country-product-month level. We aggregate the data to exports of each CN 8-digit product to each country, in each month. Export price at the country-product-month level is computed as the trade-weighted average of log unit values at the firm-country-product-month across firms, using export quantity shares as weights. We then obtain log differences in export price, value and quantity from the same month in the previous year, for the period from July 2015 to July 2017. This results in a panel of monthly log differenced data for 6,918 unique CN8 products and 192 countries.[13] Year-over-year monthly changes for each month from July 2016 correspond to the treatment period, while those from July 2015 to June 2016 correspond to the pre-treatment period.

[11] For the unit values figure, we obtain weighted average ln unit values across firm-product-country triples, using export quantity shares as weights, and then year-over-year monthly changes.

[12] Although a difference-in-differences specification cannot account for potential spillovers, we show below that there is no evidence of spillover effects to control group countries, supporting the identification strategy.

[13] The estimation sample is smaller due to the unbalanced nature of the panel and the fact that estimation is based on continuing country-product pairs.

We estimate the following specification:

$$\Delta \ln X_{cpt} = \beta(Post_t \times GB_c) + \gamma \pi_{ct} + \theta \Delta \ln RGDP_{ct} + \delta_{pt} + \delta_c + \epsilon_{cpt}, \quad (1)$$

where the dependent variable, $\Delta \ln X_{cpt}$, is the log difference in either the export price (in euro), export value or quantity, from the same month in the previous year for a country-product (cp) pair ($\ln X_{cpt} - \ln X_{cp,t-12}$). As discussed in Section 3, $Post$ is an indicator variable for all months after the referendum and GB is an indicator for exports to the UK. β is the coefficient of main interest, which captures the differential effect of the referendum shock on exports to the UK, relative to other destinations. The lower order terms of the $Post_t \times GB_c$ interaction are absorbed by the sets of fixed effects included. δ_{pt} represent product-time (year-month) fixed effects, which absorb trends at the product level, and the δ_c are a full set of country fixed effects that pick up trends at the country level in the differenced equation. The use of log differenced dependent variables eliminates time-invariant country-product characteristics. $\Delta \ln RGDP_{ct}$ is the log difference in quarterly real GDP of the importer, from the same quarter in the previous year.[14] π_t is the year-over-year monthly inflation of the destination country, using the consumer price index. ϵ_{cpt} is the mean-zero disturbance term. Standard errors are clustered by country to account for correlation of observations within a country, the level at which the Brexit shock treatment is assigned.

[TABLE 1]

The results from estimating Equation (1) are reported in Table 1. Data for quarterly GDP is available for a smaller set of countries, and since the results remain similar, we report results that do not include this variable. We obtain negative and statistically significant coefficients on the $Post \times GB$ interaction term, showing that growth in export value, quantity and unit values to the UK market were all reduced following the referendum. That is, as a result of the Brexit vote shock, the average growth in export volume and export price to the UK declines, relative to exports to other countries. The estimates suggest that export value to the UK has a roughly 7 percentage-point lower average growth after the referendum, relative to exports to other markets (column (1)), while there is a 5.6 percentage point fall in the growth rate of export quantity (column (2)). The log difference in export price to the UK is 1.8 percentage points smaller after the shock, on average, relative to the export price to other destinations (column (3)).[15] In column (4), we find no statistically significant effect on the number of exporters at the country-product level. We conduct a more detailed investigation of the entry and exit extensive margin effects in Section 6.

[14] Quarterly real GDP data is from the OECD.

[15] Since we use the trade-weighted average of prices across firms, the coefficient on export value will not equal the sum of coefficients on price and quantity for this analysis.

The results in this section suggest that Portuguese firms exporting to the UK adjusted their export price downwards after the Brexit vote and experienced lower export value and quantity growth in the UK market, relative to the control group countries. In Section 4.3 below we conduct the analysis at the firm-product-country level, for which prices are more precisely defined.

4.2 Firm-country level results

In this section, we perform the analysis at the firm-country level. This aggregates across products for a firm, despite potential product turnover; but since profit-maximizing firms are the economic unit of interest, it is relevant to assess how firms' exports to a country reacted to the shock. For this analysis, we collapse the Portuguese customs data to the firm-destination-month level for export value and quantity and obtain firm-destination-month prices by regressing ln unit value at the firm-product-country-month on firm-country-month and product (CN8) fixed effects. The estimated firm-country-month fixed effect is our measure of price at the firm-country-month level; it reflects the average price of a firm-country, clean of any product composition effects.[16]

We then obtain the dependent variables as the year-over-year growth (log difference from the same month in the previous year) in export value, quantity and unit value, for a firm-country. We also investigate whether the growth rate of firms' product scope, measured by the number of CN 8-digit products exported to a country, was affected by the shock. We estimate specifications of the form:

$$\Delta \ln X_{fct} = \beta(Post_t \times GB_c) + \gamma \pi_{ct} + \theta \Delta \ln RGDP_{ct} + \delta_{ft} + \delta_c + \epsilon_{fct} \tag{2}$$

We control for firm-time (δ_{ft}) and country (δ_c) fixed effects, which account for trends in exports and export prices at the firm-level and at the country-level, respectively, given the differenced equation. Time-invariant characteristics of a firm-country pair are absorbed in the differenced specification. We cluster the standard errors by country. The remaining variables are as described above.

Table 2 reports the results from estimating Equation (2). We find that firm-level export value, quantity and price to the UK market were all negatively affected by the Brexit vote, consistent with the results reported above. The estimates of the treatment interaction of interest, $Post \times GB$, which captures the differential effect of the shock on exports to UK, are negative and significant at the 1 percent level. The estimates imply a 6.6 percentage point lower export value and a 4.5 percentage point lower export quantity growth (columns (1) and (2)). In column (3), we find that the log change in export price is about 1.4 percentage points lower for exports

[16] The results remain robust to using trade-weighted average prices across products.

to the UK, relative to other markets. Column (4) shows that firms did not significantly change their export product scope, measured by the number of products exported to a country.

[TABLE 2]

The evidence from Table 2 shows that Portuguese firms reduced export values and prices to the UK market after the exchange rate and uncertainty shocks that followed the referendum. In the next section we present the main results of the paper, which consider the most detailed level in the customs data, the firm-product-country level.

4.3 Firm-product-country level results

In the previous sections we show that at the product-country and at the firm-country levels, the Brexit shock led to lower export growth and lower export prices to the UK. However, aggregate data can hide substantial heterogeneity across firms and products. Moreover, export prices are more precisely defined at the firm-product-country level. At that level of disaggregation we can also assume that relative marginal cost is constant, allowing us to cleanly identify the effect of the shock on export price in the UK market relative to that in other markets. Therefore, this section investigates the effects of the UK referendum shock using data at the finest level of disaggregation available.

As in previous sections, we estimate specifications with log differenced dependent variables to absorb unobserved characteristics of a firm-country-product triple, and to account for seasonality of exports. Estimation is based on continuing triples, exported both before and after the referendum. We estimate the specification:

$$\Delta \ln X_{fpct} = \beta(Post_t \times GB_c) + \gamma \pi_{ct} + \theta \Delta \ln RGDP_{ct} + \delta_{fpc} + \delta_t + \epsilon_{fpct} \tag{3}$$

where $\Delta \ln X_{fpct}$ is the change in log export value (exp), quantity (q) or unit value (uv) (the euro export price) of firm f, for product p, to destination c, relative to the same month in the previous year ($\ln X_{fpct} - \ln X_{fpc,t-12}$). As discussed above, the $Post \times GB$ term captures the overall differential effect of the large shocks in the UK market after the referendum. The δ_{fpc} are a full set of firm-product-country fixed effects that absorb trends in exports and prices at the firm-product-country level, given the differenced equation, and δ_t are time dummies. The effects are identified from differences before and after the referendum shock in the year-over-year monthly log changes in the UK, relative to other destinations. In alternative specifications, we include firm-country (δ_{fc}) and product-time fixed effects (δ_{pt}), which control for trends at the firm-country and at the product level.[17] The remaining variables are as defined above.

[17] The specification with firm-product-country and time fixed effects has the advantage of exploiting all variation within firm-product-destinations following the shocks.

[TABLE 3]

The results from estimating Equation (3) are presented in Table 3. We obtain a negative coefficient on the $Post_t \times GB_c$ interaction term for all dependent variables (significant at the 1 percent level), confirming that export value, quantity and unit value growth to the UK all declined after the Brexit referendum. The estimate in column (1) implies that export growth to the UK fell by 5.5 percentage points after the shock, while in column (2) we find that there is a 3 percentage-point drop in export quantity, relative to other markets. Export price to the UK market is also reduced, by 2.5 percentage points on average (column (3)). This is consistent with the finding in previous sections that Portuguese exporters adjust export prices to the UK downwards after the shock. The reduction in the value of exports to the UK, relative to other destinations, is due to both lower quantities and lower prices. The same conclusions hold in columns (4) to (6), which control for product-time and firm-country fixed effects, thus identifying the effects from variation within a product-month.

One interpretation for the reduction in export unit values is that Portuguese exporters reduced their markup in the UK market following the Brexit shock. This interpretation has been proposed in previous studies of the effect of exchange rate movements (e.g., Berman et al., 2012; Li et al., 2015). Since the change in price can be decomposed into a change in the markup and a change in marginal cost, another reason for the fall in export price would be a relative reduction in marginal cost of exports to the UK. However, it is reasonable to assume that relative marginal costs are constant for a firm-product across destination markets.[18] With incomplete exchange rate pass-through into destination prices, despite the reduction in the producer price, the depreciation of the pound - and consequent relative appreciation of the euro - still leads to an increase in the final price faced by consumers in the UK (denominated in pounds). Hence, export quantity responds negatively, consistent with our finding of a negative effect on export quantity.

Although our estimated response of export price to the Brexit shock is not directly comparable with ERPT estimates in the literature, if the effect of the shock was solely arising from the 10 percent depreciation of the pound (appreciation of the euro), the coefficient of 0.025 would imply an exchange rate pass-through to prices in the UK of 0.75 (=1−0.25), or 75 percent. Previous literature has documented incomplete pass-through of exchange rate movements into destination prices. Amiti et al. (2014) estimate an average pass-through of 0.8 using transaction-level data for Belgium. Using firm-level data, Chatterjee et al. (2013) report similar estimates, of 0.77, for Brazil, while Berman et al (2012) estimate pass-through at 0.92 for France. Estimating ERPT is not the main focus of this paper, but as a point of comparison,

[18] Our results remain similar if we include firm-product-time fixed effects, which control, among other, for marginal cost of a firm-product; but that specification has the disadvantage that it only exploits variation across destinations, excluding time variation for a firm-product-country after the shock.

Table B.3 in the online appendix reports results from regressing the log change in unit values and export quantity on the log change in nominal bilateral exchange rate ($\Delta \ln e_{ct}$).[19] In column (1) we find that in response to a 10 percent appreciation of the euro, export unit values fall by 1.36 percent, implying an average pass-through into destination currency prices of 0.86 in our data, which is close to estimates in previous literature. This is a slightly higher pass-through than the implied from the estimate in Table 3, suggesting a larger response of the euro export price to the Brexit shock. The quantity response estimate in column (2) of Table B.3 implies a 2.4 percent reduction.

Price stickiness in local currency could also result in a price change in euros. Our results could thus combine changes in the desired markup and mechanical changes from price stickiness in the destination currency.[20] We cannot decompose the two forces as currency of invoice information is not available for intra-EU trade, but aggregate data from Gopinath (2016) shows that in 2015, 82% of total Portugal's exports were priced in euros,[21] which would be consistent with the sort of pass-through we are observing. Moreover, Gopinath et al. (2010) show that the flexible price and local currency price channels of incomplete pass-through reinforce each other, with firms endogenously choosing the invoicing currency.

We also check the robustness of the price results to using "unit prices" as an alternative, potentially more precise measure of prices, as described in Section 3. This analysis is restricted to about one third of observations for which there is information on "supplementary units". The results are presented in Table B.4 in the online appendix. Compared to the baseline results with unit values for the full sample, the estimations based on unit prices remain robust, with somewhat larger estimates for the effects of the shock on export prices. The estimate implies a 4.3 percentage point lower price growth to the UK (4.6 percentage points when including firm-country and product-time fixed effects), relative to other countries.

We now assess the robustness of our results to different estimation samples, using different control groups. In Table 4, we estimate the same specifications as those reported in Table 3, but in columns (1) to (3), the sample is restricted to non-eurozone countries, thus comparing exports to the UK market with exports to other non-eurozone countries. The coefficients remain negative and statistically significant at the 1 percent level, and of similar magnitude, implying a 7 percentage-point lower growth in export value and a 2.5 percentage-point lower price to the UK market. Next, in columns (4) to (6) of Table 4, we restrict the sample to EU countries. This is a potentially cleaner comparison group, as export shares and patterns to the UK are more comparable to those for the remaining EU members, and their economies are also more similar

[19] Exchange rate is foreign currency per euro; hence an increase in the nominal exchange rate corresponds to a bilateral appreciation of the euro. Monthly exchange rates are from the International Monetary Fund.

[20] Vermeulen et al. (2012) show that 21% of producer prices are adjusted each month in the euroarea and that price decreases are frequent.

[21] 15% are priced in US dollars, and the remaining 3% in other, unspecified, currencies.

to the UK. We continue to find a negative and significant differential effect of the referendum shock on the price charged in the UK market, as well as on the value and quantity of exports to the UK. The magnitude of the effects also remains similar to those reported for the full sample of countries.

[TABLE 4]

Table B.5 in the online appendix shows that the results remain similar when we restrict the control group to EU members that are part of the eurozone (columns (1) to (3)). Since Portugal shares the euro with these countries, exports are not subject to exchange rate changes, allowing a clean identification of the effects of the sterling exchange rate shock. In columns (4) to (6) we use as another alternative comparison group the EU members that are not part of the eurozone.[22] The results remain largely robust, though some coefficients are less significant. However, EU-non-euro countries account for a small share of Portugal's exports, reducing the sample significantly. This group is also potentially less comparable to the UK; exports to e.g., Germany, France or the US are more comparable to those to the UK than are exports to Romania, Bulgaria or the two Nordic countries.

In Table B.6, in the online appendix, we exclude from the sample observations in entry and exit periods for the firm, to account for potential selection issues caused by entry and exit, which could be a source of potential bias in the estimates. Firms could charge different prices or export different amounts in the period when they enter to or exit from exports. However, the results remain virtually unchanged for this sample. Our results are therefore robust to different estimation samples and control groups.

Our empirical specification is very demanding as we estimate trend-adjusted difference-in-differences regressions, which control for the possibility of differences in export and price growth trends at the firm-country-product level. But, Table A.2 in the appendix provides a further test of our identification. It estimates similar specifications as those reported in Table 3, but including interactions of the post-referendum dummy variable with indicators for exports to other destinations, rather than the UK. We include interactions for exports to France and Germany, two EU economies comparable to the UK and with similar export shares from Portugal, Denmark, which as the UK before Brexit, is part of the EU but not the euro-area, and the US, a non-EU country which is also one the main export destinations of Portugal. The estimates of the interaction terms identify differences, if any, in exports to these countries after the referendum shock, relative to the control group of countries, which excludes the UK. We find that the coefficients on the interaction terms of interest are generally statistically insignificant for these countries, supporting our identification of the effects of the Brexit shock on exports to

[22] This includes Denmark and Sweden, which opted out of the euro, as well as the countries of the last enlargement: Romania, Poland, Hungary, Bulgaria and Czech Republic, which had not met the convergence criteria to join.

the UK market.[23] These placebo specifications show that there are no positive and significant coefficients, confirming that there is no evidence of trade diversion, or spillover effects, to control group trading partners, supporting the identification strategy.

We also present event study evidence of the effects of the referendum shock over time, at each month. We estimate the following event study specification:

$$\Delta \ln X_{fpct} = \sum_{\tau} \beta_{\tau} (Month_{t,\tau} \times GB_c) + \gamma \pi_{ct} + \theta \Delta \ln RGDP_{ct} + \delta_{fpc} + \delta_t + \epsilon_{fpct} \qquad (4)$$

We include interactions of the GB_c indicator variable with a set of dummy variables for each month, relative to the referendum, where τ indexes months since the referendum, with a positive τ denoting the number of months since the referendum and a negative τ the number of months prior to the referendum; $Month_{t,\tau}$ takes the value one when month t is τ months since the referendum and zero otherwise. For example, β_0 estimates the differential effect of the shock on outcomes in the UK market in July 2016, while β_1 estimates the differential effect in August, the second post-referendum month. Each of the monthly coefficients β_0 to β_{12} is estimated relative to the omitted or reference category, which are the periods prior to the referendum (β_τ are thus zero by construction for negative values of τ). We assign an index of $\tau = -3$ to observations equal to or earlier than 3 months before the referendum. We include firm-product-country (δ_{fpc}) and time (δ_t) fixed effects.[24]

[FIGURE 2]

Figure 2 presents the event-study plots for unit values, export value and export quantity. We plot out the estimated coefficients β_τ over time, and 95 percent confidence bands. A negative β_τ coefficient means a lower value of the outcome in the UK market, relative to the pre-referendum period and to other countries. The results for unit values show that the coefficients become negative and statistically significant straight after the referendum (from July), suggesting that the price adjustment was fast, after a few weeks, consistent with existing literature. The effects remain significantly lower than pre-referendum for six consecutive months. The coefficients become less negative from January 2017, and eventually become insignificant almost a year after the shock. This is in line with findings that most of the price adjustment to exchange rate changes occurs within the first six months and levels off soon after (e.g., Auer et al., 2020; Bonadio et al., 2020; Gopinath et al., 2010).

The estimates for export value, plotted in the top right panel of Figure 2, show that there is a drop one month after the referendum, with a negative and significant coefficient estimate in July 2016. The differential effects are positive in the following two months, perhaps as firms adjust

[23] There is an exception of a small negative coefficient on unit values for Denmark.

[24] The results remain robust to including firm-country and product-time fixed effects. This event study specification is similar to that in Couture et al. (2020).

and try to shrug off the effect of the referendum result. However, the estimates become negative and statistically significant again from October 2016. Export growth to the UK market remains lower than before the referendum for the following eight consecutive months and is still bellow trend by the end of the sample period. This is suggestive of lasting effects of the referendum shock on exports to the UK. The results for export quantity, in the bottom panel of the figure, are similar to those for export value.[25]

In sum, the results in this section show that following the Brexit shock, Portuguese exporters reduced export price in the UK market, and experienced lower export value and quantity growth to the UK. Our findings are suggestive of some degree of pricing-to-market, where firms choose different prices for different destinations based on local market conditions.[26] Our results provide evidence of fast adjustment in export price, in the months after the Brexit shocks in the UK, while export volumes remained lower than pre-referendum for the duration of the sample period.

5 Heterogeneous results

5.1 Heterogeneous effects across firms

In the previous section, we have shown that following the referendum shock, Portuguese firms reduced average export and export price growth to the UK market. However, that does not imply that all exporters adjusted their price. Some firms may have more pricing power, and firms may have more pricing power for certain goods, such as differentiated goods. In this section, we investigate whether there are heterogeneous responses to the shock across firms and across products.

We start by investigating whether there is heterogeneity in the response of export prices and volumes to the Brexit referendum shock across exporters' performance distribution. A large body of literature, following the work by Melitz (2003), has documented substantial productivity heterogeneity across firms. As discussed in Section 2.2, models of endogenous and variable markups can also generate heterogeneous markup responses to exchange rate shocks across firms, and hence heterogeneous responses of export volumes (e.g., Melitz and Ottaviano, 2008; Atkeson and Burstein, 2008). This is because more productive firms face a lower demand elasticity and therefore are able to adjust their markups by more following exchange rate movements.

To investigate the heterogeneous response to the shocks according to exporters' performance, we estimate specifications of the change in log export price, value or quantity on the $Post_t \times GB_c$

[25] Figure B.3 in the online appendix plots coefficient estimates for every lead and lag relative to the referendum month, with April, the month before the referendum campaign started, as the reference period. We assign an index of $\tau = -9$ to all months equal or prior to 9 months before the vote. The coefficients for export prices oscillate before the referendum and only become negative and significant after the vote, showing that prices are lower in the UK after the referendum, relative to the reference month and other countries. Export value and quantity display a similar pattern as that discussed above.

[26] Our results are consistent Fitzgerald and Haller (2014) who find a significant price differential response to exchange rate movements for Irish firms selling the same good in domestic and export (UK) markets.

term interacted with a measure of firm performance:

$$\begin{aligned}\Delta \ln X_{fpct} &= \beta_1(Post_t \times GB_c) + \beta_2(Post_t \times GB_c \times \ln \varphi_f) + \beta_3(Post_t \times \ln \varphi_f) \\ &\quad + \theta \Delta \ln RGDP_{ct} + \gamma \pi_{ct} + \delta_{fpc} + \delta_t + \epsilon_{fpct} \end{aligned} \tag{5}$$

where φ_f is the performance measure, proxied by either total factor productivity (TFP), labor productivity or firm sales. We estimate TFP using the Levinsohn and Petrin (2003) approach, which uses intermediate inputs as a proxy to control for the correlation between input levels and unobserved firm-specific productivity.[27] Labor productivity is computed as value added per worker. We measure $\ln \varphi_f$ in 2015, prior to the Brexit vote, to avoid changes induced by the shock from biasing the estimates. The coefficient of main interest in Equation (5) is β_2, which captures the differential effect of the shock according to initial firm productivity. The lower-order terms of the triple interaction of interest ($Post_t \times GB_c \times \ln \varphi_f$) are explicitly included or absorbed by the fixed effects. The other variables in Equation (5) are as defined above.

Table 5 reports the results from estimating Equation (5). In columns (1) to (3) we present results using TFP to measure firm performance.[28] We find that while the estimates of β_1, on the $Post_t \times GB_c$ term, are negative for export value and quantity and are positive for unit values, those on its interaction with firms' TFP have the opposite sign: the estimated β_2 is positive for export value and quantity and it is negative for export price (all estimates are significant at the 1 percent level). That is, the reduction in log price following the Brexit shocks is larger for more productive firms than for less productive ones, while the reduction in export value and quantity is lower for the more productive exporters. These results suggest that higher performance firms absorb more of the shocks in their export prices, so that their export volumes are less sensitive.

[TABLE 5]

At the bottom of Table 5, we provide a quantitative assessment of the effects for firms with mean TFP level and for those with TFP one standard deviation above or below the mean. The estimates imply that a firm with average TFP experiences a 4.5 percentage-point drop in export value growth (column (1)) and a 2.3 percentage-point drop in export price (column (3)) in the UK market after the Brexit vote. In contrast, a firm with TFP one standard deviation above the mean reduces log price by 4.8 percentage points, but the reduction in export value is only 2 percentage points. A firm with TFP one standard deviation below the mean did not reduce price (the effect is a positive 0.25 percentage point change) but export value dropped by about 7 percentage points.

[27] The Levinsohn and Petrin estimator has the advantage that unlike Olley and Pakes' (1996), it does not suffer from the potential truncation bias induced by the requirement that firms have nonzero levels of investment.

[28] We trim the 1 percent tails of the distribution of the performance measures, to avoid outliers or measurement error, but the results remain similar if we include all observations.

In columns (4) to (6) of Table 5 we report results that use labor productivity as the measure of firm performance. The results remain similar: we continue to find that higher productivity firms reduce their export prices by more in response to the Brexit shocks, so that their export values fall by less, compared to lower performance firms. The estimates are also of the same magnitude as those based on TFP. Specifically, a one standard deviation higher labor productivity (from the mean level) implies that the price response is almost double, from a 2.5 to a 4.8 percentage point drop (column (6)), while the reduction in export growth is about half, from a 4.4 to a 2.1 percentage-point drop (column (4)). The effect of firm performance is therefore statistically significant as well as economically important. Finally, in columns (7) to (9) we report results using firm sales as the measure of performance. We continue to find that export unit values drop by significantly more while export volumes drop by less for higher performance firms.[29]

We also provide nonparametric evidence that the results in Table 5 are not driven by outliers or by the linear specification. To that end, we split the distribution of firm performance into four quartiles and define dummy variables for observations belonging to each quartile of the productivity distribution. We then estimate specifications similar to Equation (5), but interacting the $Post \times GB$ term with the performance quartile dummy variables. Table A.3 in the appendix presents the results for TFP in columns (1) to (3) and labour productivity in columns (4) to (6). The coefficient on the $Post \times GB$ term captures the effect for firms in the first quartile, the lowest performance bin, chosen as the reference group.[30] The results show that firms in the lowest productivity bin do not change their export price, suggesting that the least productive exporters fully pass on exchange rate movements to foreign consumers, but their export value and quantity are significantly reduced after the Brexit vote. The interactions for the top performing firms, in the third and fourth quartiles of productivity, are positive and significant for exports and are negative for unit values. This confirms that higher performance firms, in the top of the productivity distribution, tend to absorb more of the shocks in their prices so that their export volumes are less affected. Our results are consistent with theoretical predictions and empirical findings that more productive firms have more pricing power and change their markups by more in response to exchange rate movements than less productive firms (e.g., Berman et al., 2012; Chatterjee et al., 2013; Li et al., 2015).

An important feature in international trade is that large exporters tend to be simultaneously large importers, these firms may be more able to actively change their markup, thus affecting

[29] As discussed in the previous section, in addition to active changes in the desired markup, our results can also be at least partly due to changes induced by exchange rate changes if some prices are sticky in local currency. If large, more productive firms are more likely to price in sterling, the euro price would fall by more. Decomposing the two forces is beyond the scope of this paper. However, as shown in Gopinath et al. (2010), the two channels reinforce each other in the cross section of firms, with firms desiring low pass-through before prices adjust, endogenously choosing local currency pricing, which reduces short-run pass-through.

[30] All lower-order terms of the triple interactions not reported in the table are included explicitly or absorbed by the fixed effects.

the export price adjustment and the response of export volumes. We take this into account and investigate the role of import intensity in firms' response to the Brexit shock. To that end, we estimate a specification similar to Equation (5) but replacing φ_f by the firm's import intensity, measured by the share of imported inputs in total input purchases.[31] The results, presented in Table 6, show that firms with different import intensities have different responses to the Brexit vote shock. More import-intensive exporters experience a significantly lower drop in export value and quantity to the UK market, but have higher response in terms of their export price, although the coefficient for price is not statistically significant.[32]

[TABLE 6]

Particularly relevant to our analysis is the role of imported inputs from the UK on firms' responses to the Brexit shock. Large importers of intermediate inputs typically set high markups and change them in response to changes in marginal costs (see Amiti et al., 2014). If the share of imported inputs in production is high, a foreign depreciation may decrease firms' marginal cost of production through lower import costs, thus affecting the response of export prices. In columns (4) to (6) of Table 6, we explore the role of import intensity from the UK, computed as the share of imported inputs from the UK in a firms' total input imports. The estimates of the $Post \times GB$ term capture the effects for a firm with zero import intensity from the UK, the median in the sample. They are of similar magnitude as the benchmark estimates in Table 3, implying a 2 percentage point drop in unit values and a 5.7 (3.7) percentage-point reduction in export value (quantity).

Higher import intensity from the UK is associated with a larger fall in export price and a lower reduction in export quantity. In particular, for the mean firm import intensity from the UK, export price falls by 2.5 percentage points and quantity by 3 percentage-points, while firms one standard deviation above the mean reduce price by 4.3 percentage points but export quantity falls by only 1.4 percentage points after the shock. In contrast, firms one standard deviation below the mean adjust their price by just 0.7 percentage points while export volume falls by 5 percentage points.[33] These results suggest that imports of inputs from the UK are a channel for the adjustment of export prices, supporting a role for marginal cost changes through imported inputs. It can also suggest a potential role for value chain effects. However,

[31] Import intensity is measured in 2015, prior to the Brexit referendum, to avoid endogenous changes due to the shock. As discussed in Section 3, we identify imported intermediate inputs using the UN-BEC codes, and include only intermediate goods in the import intensity measure.

[32] These results are based on a smaller sample due to missing data for total input purchases (domestic and imported), which comes from the SCIE dataset.

[33] The results in Table 6 remain robust if we include TFP interactions with the $Post \times GB$ term, and lower order terms. The coefficients of the import intensity interactions are hardly affected by the inclusion of the additional interaction terms, confirming that accounting for TFP does not affect the import intensity estimates. The TFP interactions are also of similar size and significance as those in Table 5. These results are available upon request.

there is still a considerable differential effect after accounting for import intensity from the UK, suggesting active markup adjustment by firms exporting to the UK market.

Table A.4 in the appendix compares the performance of Portuguese domestic private and foreign owned firms, those with more than 50 percent of equity capital owned by domestic private or foreign investors, respectively. We find that foreign owned firms reduced their price by more than domestic firms after the shocks, 4 percentage points compared to 1.7, while domestic firms reduced export volumes by significantly more. This suggests that foreign owned firms are more able to adjust their price and engage in pricing-to-market after the shocks, thus offsetting more of the exchange rate change and experiencing a lower drop in exports.

We now investigate heterogeneous effects of the Brexit shock along a different dimension of firm heterogeneity: firms' financial constraints. A body of evidence has shown that availability of external finance affects firms' export activity (e.g., Amiti and Weinstein, 2011; Manova, 2013). Recent papers have also highlighted the role of firms' credit constraints on the effects of exchange rate movements (Strasser, 2013; Lin et al., 2018). We use sector-level measures of financial vulnerability widely employed in the literature, which has shown that firms in some industries are more financially dependent than others (Rajan and Zingales, 1998), while those in some sectors can pledge more tangible assets as collateral to access external funds (Braun, 2003). We thus use external finance dependence ($extfin$), measured as the share of capital expenditure not financed by internal cash flows from operations, and asset tangibility ($tang$), the share of net plant, property and equipment in total book value assets. These measures are widely considered intrinsic to an industry and exogenous for individual firms.[34] Following previous literature, we obtain the measures by computing average financial vulnerability at the firm-level and using the median value across firms in a 2-digit ISIC (rev 3.1) industry as the industry's measure of financial dependence.[35] We estimate a specification like Equation (5), interacting the treatment term, $Post \times GB$, with the financial vulnerability measures (fin).

[TABLE 7]

The results are reported in Table 7. In columns (1) to (3) we present results for external finance dependence. We find that firms in sectors that rely more on external finance reduce export price to the UK by more but the differential effect on export value or quantity is not statistically significant. Columns (4) to (6) report results for asset tangibility, an inverse measure of financial vulnerability since firms with more tangible assets are able to pledge more collateral to access external finance. Firms in financially less constrained sectors, with more tangible assets,

[34] The measures of financial dependence are constructed for manufacturing and services sectors only, excluding agriculture, fishing and mining. We verify that our main results across all firms, remain the same if we drop firms in these sectors.

[35] We compute the industry measures of financial vulnerability using balance sheet data for Portuguese firms. The measures are obtained for the period preceding the 2008-9 financial crisis, so that the effect of the financial crisis on firm behavior does not contaminate the measures.

reduced export value and quantity by less, the interaction with the tangibility measure is positive and significant, while the differential effect on export price is negative, though statistically insignificant. These results provide some evidence that firms in financially more constrained sectors have a more negative exposure of their export volumes to the shocks.

In sum, the results in this section show that there is a heterogeneous response to the Brexit shocks across firms, with more productive and more import-intensive exporters absorbing more of the exchange rate shock in their prices and thus experiencing a lower reduction in export volumes to the UK market. Firms with more asset tangibility also reduce export volume by less.

5.2 Heterogeneous effects across products

Next, we investigate whether the effects of the shock differ across goods. In particular, firms may have more pricing power for some goods, such as differentiated goods, with lower import demand elasticity. In the model of Atkeson and Burstein (2008), the export price and volume elasticities to exchange rate changes depend on the elasticity of substitution between goods and on the market share in the sector. Firms should absorb less exchange rate movements in their markups for goods with high elasticities of substitution. Therefore, we expect that the exporter's price of goods with high import demand elasticities should decrease by less in the UK market after the referendum.

To investigate this, we match the UK's import demand elasticity at the HS 3-digit tariff, estimated by Broda and Weinstein (2006), with the product exported by Portuguese firms, and interact the $Post \times GB$ term with the (log of the) elasticity of substitution ($BW\sigma$). The results, in columns (1) to (3) of Table 8, show that the coefficients have the expected sign and are statistically significant. Specifically, the estimate of the $Post \times GB \times BW\sigma$ term is positive for export price and negative for quantity, showing that export price to the UK is reduced by less while export volume decreases by more after the shock the higher the import demand elasticity of the good. For the mean log elasticity (0.92), the estimates imply a 2.5 percentage-point drop in export price and a 3 percentage-point drop in quantity, similar to the benchmark estimates of Table 3. These results are consistent with the hypothesis that firms are less able to adjust their price for more substitutable goods after the shocks, which thus experience a larger drop in exports.

[TABLE 8]

We assess the role of frequency of price adjustment on the impact of the shock in columns (4) to (6) of Table 8, as emphasized in Gopinath and Itskhoki (2010).[36] Following Berman et

[36] Gopinath and Itskhoki (2010) show that goods with a high frequency of price adjustment have higher pass-through than other goods. Theoretically, this arises because variable markups, which reduce pass-through, also

al. (2012), we proxy for how frequently firms adjust export prices by the variability in log unit values. We use the coefficient of variation of log monthly unit values (prior to the referendum), for a firm, and interact this measure with the main treatment interaction term, $Post \times GB$. Although this is an imperfect proxy for the frequency of price adjustment, the interaction term is positive and significant as expected, suggesting that firms that adjust prices more frequently change export price by less than other firms after the shocks. Importantly, accounting for this measure does not significantly change the baseline results; we continue to find that exporters decrease the price to the UK market after the shock by around 2.6 percentage points on average.

We also investigate whether there is a differential adjustment to the Brexit shock for different types of goods based on their end-use and durability. Models with variable markups and distribution costs (e.g., Corsetti and Dedola, 2005) predict that there is more PTM for goods with higher distribution costs.[37] Using data from Goldberg and Campa (2010) on distribution costs, Berman et al. (2012) show that distribution costs are higher for consumer goods than for intermediate goods, and that consumer goods display more PTM. Hence, we expect a larger drop in the prices of consumer goods after Brexit.

We classify each CN 8-digit product exported by Portuguese firms as a final consumer good or as an input, and as a durable or non-durable good, using the UN-BEC concordance.[38] We then estimate the effect of the shock on export price, value and quantity separately for intermediate inputs and consumer goods, as well as for durable and non-durable goods. The upper panel of Table 9 reports results for inputs in columns (1) to (3) and for consumption goods in columns (4) to (6). We find that the effect of the Brexit referendum shock on export prices is larger for consumer goods than for intermediate inputs. Specifically, while exporters of consumer goods decrease their price by 3 percentage points, exporters of inputs decrease their price by a lower 1.8 percentage points. This is consistent with the hypothesis that pricing-to-market is more pervasive for consumer goods than for intermediate goods. The results also show that, in line with the lower price adjustment, export volume falls significantly more for inputs than for consumer goods.

[TABLE 9]

The lower panel of Table 9 reports results for durable and for non-durable goods. The effect of the shock on export price is of the same order of magnitude for durable and non-durable goods, implying a roughly 3 percentage-point drop. However, while growth of durable goods'

reduce the curvature of the profit function, as a function of costs, reducing a firm's willingness to adjust prices. Therefore, we expect that firms with initially higher frequency of price adjustment, adjust their export price by less after the Brexit shock.

[37] This is because since distribution costs (paid in local currency) are not affected by exchange rate movements, higher distribution cost reduces the share of the consumer price that depends on the export price, contributing to lower exchange rate pass-through into consumer prices.

[38] We include both semi-durable and durable goods in the durable goods group.

export value and quantity dropped by 10 and 7.1 percentage points, respectively (significant at the 1 percent level), the effect is statistically insignificant for exports of non-durable goods. These findings can be rationalized in light of the literature on the dynamics of durable goods' expenditure over the business cycle (e.g., Engel and Wang, 2011; Leahy and Zeira, 2005). It has been shown that consumption of durable goods is highly volatile and procyclical, as households can postpone the decision to scrap and upgrade durable goods, such as cars, fridges, etc. A large fraction of international trade is in durable goods, which can thus experience larger fluctuations in response to shocks.[39] Our finding suggests that the increased uncertainty and weaker pound following the referendum may have induced consumers to postpone the replacement of durable goods, contributing to a larger drop in exports.[40]

In sum, this section shows that goods with a low elasticity of substitution and consumer goods experienced a larger drop in price, suggesting that firms have more pricing power for differentiated goods and products with higher distribution costs; as a result, their export volumes fell by less. On the other hand, more substitutable goods, inputs and durable goods experienced a significantly larger drop in export volume. This is consistent with the hypothesis that exports of goods for which substitutes are widely available and those for which consumption can be postponed are more affected by the shocks. However, despite cutting the data in a large variety of ways, the baseline conclusion that the sterling depreciation reduced Portuguese exports and export prices to the UK remains robust.

6 The Extensive Margin

This section investigates the differential effect of the shock on export participation in the UK market for Portuguese firms. In models with variable markups, a combination of lower markups and lower export sales following a currency appreciation results in a decrease in export profits. This in turn may lead to less entry and more exit of firms, who may find it unprofitable to serve the foreign market.

To investigate these extensive margin effects, we estimate specifications for the probability of firm f to export to destination c in period t (any product). Because firms may not export to a country every month due to lumpiness of trade, for this analysis to consistently estimate the effect of the referendum shock, we aggregate the data on firm-country level exports to half-yearly observations, from January to June and from July to December of each year. We want to assess whether the shocks deter entry to the UK market or encourage exits. We study the probability of entry to a new market for firms that are already exporting to at least one other

[39] Levchenko et al. (2009) find empirical evidence that trade in durable goods played an important role in explaining the collapse of US trade during the global financial crisis of 2008-9.

[40] This is consistent with reports from the UK automobile industry after the referendum that Brexit uncertainty and the weaker pound heavily impacted new car sales in the UK.

destination. We define the entry dependent variable of the regression as follows: $Entry_{fct} = 1$ if firm f was not exporting to country c in $t-1$ ($X_{fc,t-1} = 0$), but started exporting to c in t ($X_{fct} > 0$). To study the probability of entry, we set $Entry_{fct} = 0$ for all potential destination markets that were not served by firm f before ($X_{fc,t-1} = 0$) or in period t ($X_{fct} = 0$). Exporters that were already serving market c in $t-1$ are not included in the estimation. The variable is not defined in the first period, since we need information from the previous period's export status to define entry.

We also define two additional dependent variables: for the decision to continue on the export market, $Cont_{fct}$ takes the value 1 if the firm was exporting to market c in period $t-1$ ($X_{fc,t-1} > 0$) and continues to export in t ($X_{fct} > 0$) and takes the value zero if the firm exports in period $t-1$ but not in t. For the probability of exporting to country c in t, Exp_{fct}, takes the value 1 if the firm exports to c in period t and zero otherwise. We then estimate how the shock affects the probability of export participation in the UK market with the following specification:

$$Ext_{fct} = \beta(Post_t \times GB_c) + \ln X_{f,t-1} + \delta_c + \delta_t + \epsilon_{fct} \tag{6}$$

where the dependent variable, Ext_{fct}, can be $Entry_{fct}$, $Cont_{fct}$ or Exp_{fct}, as defined above. We control for the firms' lagged aggregate exports ($\ln X_{f,t-1}$) to account for the exporter's size, and include country (δ_c) and time (δ_t) fixed effects. Standard errors are clustered by country. As before, the coefficient of main interest is β, which captures the differential effect of the referendum shock on the probability of a firm entering, continuing or exporting in the UK market, relative to other destinations.

[TABLE 10]

The results are reported in Table 10. Our specification is a linear probability model so coefficient estimates can be interpreted as average marginal effects.[41] In columns (1) to (3), we report results for the full sample of countries in the control group. We find that the interaction term of interest is negative and statistically significant for entry, showing that after the shock, Portuguese firms are less likely to start exporting to the UK, relative to other markets. In particular, the estimate implies that the probability of starting to export in the UK is 3.3 percentage points lower after the Brexit vote (column (1)). The estimates for the probability of exporting and remaining in the export market are statistically insignificant for this sample (columns (2) and (3)). In columns (4) to (6), we report results restricting the control group to EU countries, a more comparable group of destinations to the UK for Portuguese exports. The coefficients are negative and statistically significant at the 1 percent level for all dependent

[41] Similar to Bernard and Jensen (2004) and Fernandes and Tang (2014).

variables for this sample. The estimates show that after the shock, Portuguese firms are 4 percentage points less likely to enter the UK market, relative to the remaining countries of the European Union, and that existing exporters to the UK are 1 percentage point less likely to continue exporting there. In sum, the shock contributed to deter export entry in the UK market and reduce the probability of continuing to serve the market.[42]

7 Conclusion

This paper provides quasi-natural experimental evidence on the effects of the Brexit vote shock on export prices, quantities, entry and exit, using uniquely disaggregated export data, at the firm-product-country-month level, for the universe of exporters in Portugal. We identify the effects using a difference-in-differences strategy, estimating the differential response to the shocks for firms selling the same product in the UK and in other markets, accounting for countries' unobserved characteristics.

The large and unanticipated nature of the shock and the fact that it pertains to a major currency and a significant trading relationship makes it an exceptional setting for studying the effects of trade shocks on exports. The UK is the largest non-Euro destination market for Portuguese exports, and fourth market overall. Our empirical strategy has the advantage of cleanly identifying the overall effect of the Brexit vote on bilateral exports to the UK, without having to rely on individual proxies for each of the shocks that followed the referendum – e.g., exchange rate, financial markets, policy uncertainty and politics – some of which are difficult to measure accurately.

We find that export prices and export volumes to the UK decreased after the Brexit referendum shock. Our estimates show that the change in export price (in euros) to the UK decreased by 3 percentage points and export value by 6 percentage points on average. Our finding of a relative reduction in export price in the UK market is suggestive of a degree of pricing-to-market. Our results are robust to a battery of tests and different estimation samples.

The richness of firm-level characteristics in our data allows us to estimate heterogeneous responses across exporters and exported products. We find that more productive and import-intensive exporters adjust their export prices by more in response to the shock, so that their export volumes are less sensitive. In particular, a firm with average total factor productivity experienced a 2.3 percentage-point drop in price and a 4.5 percentage-point drop in export value after the Brexit vote. In contrast, a firm with TFP one standard deviation above the mean reduced price by 5 percentage points but experienced a lower reduction in export value of just

[42] Crowley et al. (2018), using data for the UK, find that after the Brexit vote, UK firms are also less likely to enter exports into EU countries and those exporting to the EU are more likely to exit. Exton and Rigo (2019) show that French firms are less likely to enter the UK export market and incumbent exporters are more likely to drop customers in the UK after Brexit.

2 percentage points. Firms that face fewer credit constraints also experience a lower reduction in exports.

We also find that export price fell by more and quantity by less for goods with low elasticities of substitution and for consumer goods, suggesting that firms have more pricing power for differentiated goods or products with higher distribution costs. On the other hand, more substitutable goods, inputs and durable goods experienced a significantly larger drop in export volumes. At the extensive margin of export participation, the Brexit shock contributed to deter entry to the UK market and reduce the probability of continuing to export to the UK.

Our results have important policy implications for the adjustment to the Brexit shock, in particular as the UK-EU trading relationship continues to evolve. Our finding that exporters reduce export prices and export volumes in the UK market following the referendum could imply a reduction in profits for European firms, from a combination of lower markups and lower sales, especially for less productive firms and goods with widely available substitutes. On the other hand, our estimates suggest a high degree of exchange rate pass-through into consumer prices in the UK after the shock, implying rising inflation and living costs.

8 References

1. Amiti, M. and D. Weinstein (2011). "Exports and financial shocks," Quarterly Journal of Economics, 126(4), 1841-1877.

2. Amiti, M., O. Itskhoki, and J. Konings (2014). "Importers, exporters, and exchange rate disconnect," The American Economic Review, 104, 1942-1978.

3. Atkeson, A., and A. Burstein, (2008). "Pricing-to-market, trade costs, and international relative prices," American Economic Review, 98, 1998-2031.

4. Auer, R., A. Burstein and S. Lein (2020). "Exchange rates and prices: Evidence from the 2015 Swiss franc appreciation," American Economic Review, forthcoming.

5. Baker, S., N. Bloom and S. Davis (2016). "Measuring economic policy uncertainty", Quarterly Journal of Economics, 131(4), 1593-1636.

6. Bergin, P., and R. Feenstra (2001). "Pricing-to-market, staggered contracts and real exchange rate persistence," Journal of International Economics, 54, 333-359.

7. Berman, N., P. Martin, and T. Mayer (2012). "How do different exporters react to exchange rate changes?" Quarterly Journal of Economics, 127, 437-492.

8. Bernard, A., and B. Jensen (2004). "Why some firms export," Review of Economics and Statistics, 86 (2), 561-569.

9. Bloom, N. (2014). "Fluctuations in uncertainty," Journal of Economic Perspectives 28(2), 153-176.

10. Bonadio, B., A. Fischer and P. Saure (2020). "The speed of exchange rate pass-through," Journal of the European Economic Association, 18(1), 506-538.

11. Braun, M. (2003), "Financial contractibility and asset hardness," University of California Los Angeles (Mimeo).

12. Broda, C., and D. Weinstein, (2006). "Globalization and the gains from variety," Quarterly Journal of Economics, 121, 541-585.

13. Breinlich, H., E. Leromain, D. Novy, and T. Sampson. (2017), "The Brexit vote, inflation and UK living standards," CEP Brexit paper no. 11.

14. Burstein, A., J. Neves, and S. Rebelo (2003). "Distribution costs and real exchange rate dynamics during Exchange-Rate-Based Stabilizations," Journal of Monetary Economics, 50, 1189–1214.

15. Burstein, A., M. Eichenbaum, and S. Rebelo (2005). "Large devaluations and the real exchange rate," Journal of Political Economy, 113 (4), 742-784.

16. Burstein, A. and G. Gopinath (2014). "International prices and exchange rates," Handbook of International Economics, 4, 391.

17. Campa, J., Goldberg, L. (2005). "Exchange rate pass through into import prices," Review of Economics and Statistics, 87 (4), 679-690.

18. Campa, J., Goldberg, L. (2010). "The sensitivity of CPI to exchange rates: distribution margins, imported inputs, and trade exposure," Review of Economics and Statistics, 92 (2), 392-407.

19. Carballo, J., K. Handley, and N. Limão (2018). "Economic and policy uncertainty: export dynamics and the value of agreements," NBER Working Paper 24368.

20. Chatterjee, A., Dix-Carneiro, R., Vichyanond, J. (2013). "Multi-product firms and exchange rate fluctuations," American Economic Journal Economic Policy 5 (2), 77-110.

21. Couture, V., B. Faber, Y. Gu, and L. Liu (2020). "Connecting the countryside via e-commerce: Evidence from China", American Economic Review: Insights, forthcoming.

22. Corsetti, G., and L. Dedola, (2005). "A Macroeconomic model of international price discrimination," Journal of International Economics, 67, 129-155.

23. Crowley, M., O. Exton and L. Han (2018). "Renegotiation of trade agreements and firm exporting decisions: evidence from the impact of Brexit on UK exports," mimeo, University of Cambridge.

24. Dhingra, S., G. Ottaviano, T. Sampson, and J. Van Reenen (2016a). "The consequences of Brexit for UK trade and living standards," CEP Brexit paper no. 02.

25. Dhingra, S., G. Ottaviano, T. Sampson, and J. Van Reenen (2016b). "The impact of Brexit on foreign investment in the UK," CEP Brexit paper no. 03.

26. Dhingra, S., G. Ottaviano, J. Van Reenen, and J. Wadsworth (2016c). "Brexit and the impact of immigration on the UK," CEP Brexit paper no. 05.

27. Dixit, Avinash (1989). "Entry and exit decisions under uncertainty," Journal of Political Economy, 97(3), 620-638.

28. Engel, C. and J. Wang (2011). "International trade in durable goods: understanding volatility, cyclicality, and elasticities." Journal of International Economics, 83 (1), 37-52.

29. Exton, O. and D. Rigo (2019). "The role of customer base in exporter dynamics," mimeo.

30. Fernandes, A. and H. Tang (2014). "Learning to export from neighbors," Journal of International Economics, 94, 67-84.

31. Fitzgerald, D. and S. Haller (2018) "Exporters and shocks," Journal of International Economics, 113, 154-171.

32. Fitzgerald, D. and S. Haller (2014) "Pricing-to-market: evidence from plant-level prices," Review of Economic Studies, 81(2), 761-786.

33. Gopinath, G. (2016). "The international price system," Jackson Hole Symposium Proceedings.

34. Gopinath, G. and R. Rigobon (2008). "Sticky borders," Quarterly Journal of Economics, 123(2), 531-575.

35. Gopinath, G., O. Itskhoki, and R. Rigobon (2010), "Currency choice and exchange rate pass-through," American Economic Review, 100, 304-336.

36. Gopinath, G., and O. Itskhoki (2011). "In search of real rigidities," NBER Macroeconomics Annual 2010, Vol. 25, ed. Daron Acemoglu and Michael Woodford, 261-309. Chicago: University of Chicago Press.

37. Gopinath, G., and O. Itskhoki, (2010). "Frequency of price adjustment and pass-through," Quarterly Journal of Economics, 125, 675-727.

38. Gourinchas, P. and G. Hale (2017). "Brexit: whither the pound?" Federal Reserve Bank of San Francisco, Economic Letter 2017-11.

39. Graziano, A., K. Handley, and N. Limão (2020). "Brexit uncertainty and trade disintegration," The Economic Journal, forthcoming.

40. Handley, K. and N. Limão (2015). "Trade and investment under policy uncertainty: Theory and Firm Evidence," American Economic Journal: Economic Policy 7 (4), 189-222.

41. Hobijn, B., F. Nechio, A. Shapiro. (2019). "Using Brexit to identify the nature of price rigidities," Federal Reserve Bank of San Francisco Working Paper 2019-13.

42. Leahy, J. and J. Zeira (2005). "The timing of purchases and aggregate fluctuations," Review of Economic Studies, 72(4), 1127–1151.

43. Levchenko, A., L. Lewis, and L. Tesar (2010). "The collapse of international trade during the 2008-2009 crisis: in search of the smoking gun." IMF Economic Review, 58 (2), 214-253.

44. Levinsohn, J. and A. Petrin (2003). "Estimating production functions using inputs to control for unobservables," Review of Economic Studies, 70(2), 317–342.

45. Li, H., H. Ma, and Y. Xu (2015). "How do exchange rate movements affect Chinese exports? - A firm-level investigation," Journal of International Economics, 97, 148-161.

46. Lin, S., K. Shi, and H. Ye (2018). "Exchange rate volatility and trade: The role of credit constraints," Review of Economic Dynamics 30, 203-222.

47. Manova, K. (2013). "Credit constraints, heterogeneous firms, and international trade," Review of Economic Studies, 80, 711-744.

48. Melitz, M. (2003). "The impact of trade on intra-industry reallocations and aggregate industry productivity," Econometrica 71 (6), 1695-1725.

49. Melitz, M., and G. Ottaviano (2008). "Market size, trade, and productivity," Review of Economic Studies, 75, 295-316.

50. Neiman, B. (2010). "Stickiness, synchronization, and passthrough in intrafirm trade prices," Journal of Monetary Economics, 2010, 57 (3), 295-308.

51. Olley, G. S. and A. Pakes (1996). "The dynamics of productivity in the telecommunications equipment industry," Econometrica 64, 1263–1297.

52. Rajan, R., and L. Zingales (1998). "Financial dependence and growth," American Economic Review, 88, 559-86.

53. Strasser, G. (2013). "Exchange rate pass-through and credit constraints," Journal of Monetary Economics, 60, 25-38.

54. The Economist (2016). "Who said Brexit was a surprise?" The Economist, June, 26, 2016.

55. Vermeulen, P., D. Dias, M. Dossche, E. Gautier, I. Hernando, R. Sabbatini and H. Stahl (2012). "Price setting in the Euro Area: Some stylized facts from individual producer price data," Journal of Money, Credit and Banking, 44(8), 1631-1650.

9 Tables

Table 1: Aggregate effects, country-product(CN8) level estimations

	(1)	(2)	(3)	(4)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(no. firms)
$Post_t \times GB_c$	-0.0713***	-0.0557***	-0.0175***	0.00659
	(0.00882)	(0.00945)	(0.00564)	(0.00534)
δ_{pt} fixed effects	yes	yes	yes	yes
δ_c fixed effects	yes	yes	yes	yes
Observations	612452	612452	612452	612452
R-squared	.162	.162	.167	.156

Observations are by product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. Column (1) reports results for export value, column (2) for export quantity, column (3) for unit values, and column (4) for the number of firms. All columns include product-month (δ_{pt}) and country fixed effects (δ_c). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 2: Firm-country level estimations

	(1)	(2)	(3)	(4)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(no. prod)
$Post_t \times GB_c$	-0.0659***	-0.0452***	-0.0139***	0.000109
	(0.0105)	(0.0112)	(0.00353)	(0.00532)
δ_{ft} fixed effects	yes	yes	yes	yes
δ_c fixed effects	yes	yes	yes	yes
Observations	377263	377263	377263	377263
R-squared	.225	.232	.292	.25

Observations are by firm-country-month. A constant term and foreign country inflation, using the consumer price index, are always included. All columns also include firm-month (δ_{ft}) and country fixed effects (δ_c). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 3: Firm-country-product(CN8) level, benchmark estimations

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
$Post_t \times GB_c$	-0.0551***	-0.0300***	-0.0251***	-0.0564***	-0.0365***	-0.0199***
	(0.00810)	(0.0113)	(0.00471)	(0.00962)	(0.0115)	(0.00390)
δ_{fpc} fixed effects	yes	yes	yes			
δ_t fixed effects	yes	yes	yes			
δ_{pt} fixed effects				yes	yes	yes
δ_{fc} fixed effects				yes	yes	yes
Observations	966878	966878	966878	976474	976474	976474
R-squared	.164	.169	.188	.15	.154	.173

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. δ_{fpc} are firm-product-country fixed effects, which absorb trends by firm-product-country, and δ_t are time dummies; δ_{pt} and δ_{fc} are product-time and firm-country fixed effects, respectively. Robust standard errors, clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 4: Firm-country-product(CN8) level, non-eurozone and EU samples

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Sample:		Non-eurozone			EU	
$Post_t \times GB_c$	-0.0699***	-0.0447***	-0.0252***	-0.0477***	-0.0235**	-0.0242***
	(0.0136)	(0.0135)	(0.00666)	(0.00718)	(0.0106)	(0.00524)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	325071	325071	325071	772929	772929	772929
R-squared	.174	.177	.194	.158	.164	.184
Sample:		Non-eurozone			EU	
$Post_t \times GB_c$	-0.0749***	-0.0513***	-0.0237***	-0.0462***	-0.0259**	-0.0203***
	(0.0113)	(0.0106)	(0.00532)	(0.00876)	(0.0108)	(0.00457)
δ_{pt} fixed effects	yes	yes	yes	yes	yes	yes
δ_{fc} fixed effects	yes	yes	yes	yes	yes	yes
Observations	325595	325595	325595	762394	762394	762394
R-squared	.208	.209	.223	.161	.167	.195

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. δ_{fpc} are firm-product-country fixed effects and δ_t are time dummies; δ_{pt} and δ_{fc} are product-time and firm-country fixed effects, respectively. Robust standard errors, clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 5: Heterogeneous responses to the Brexit vote shock, firm-country-product level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Performance measure (φ):	Total factor productivity			Labor productivity			Sales		
$Post_t \times GB_c$	-0.184***	-0.308***	0.124***	-0.416***	-0.773***	0.358***	-0.300***	-0.351***	0.0509**
	(0.0326)	(0.0376)	(0.0140)	(0.0982)	(0.103)	(0.0410)	(0.0739)	(0.0724)	(0.0218)
$Post_t \times GB_c \times \ln \varphi_f$	0.0583***	0.120***	-0.0614***	0.0358***	0.0725***	-0.0368***	0.0156***	0.0201***	-0.00450***
	(0.0127)	(0.0136)	(0.00524)	(0.00947)	(0.0101)	(0.00406)	(0.00443)	(0.00412)	(0.00139)
$Post_t \times \ln \varphi_f$	0.0125	-0.00295	0.0154***	0.0272***	0.0123	0.0149***	-0.00837*	-0.00630	-0.00206
	(0.0127)	(0.0136)	(0.00524)	(0.00956)	(0.0102)	(0.00405)	(0.00445)	(0.00415)	(0.00138)
				Quantification: effect for					
mean firm performance	-4.48	-2.15	-2.26	-4.35	-1.87	-2.49	-4.64	-2.43	-2.22
mean + 1 s.d. performance	-2.10	2.75	-4.76	-2.09	2.71	-4.81	-2.07	0.89	-2.97
mean - 1 s.d. performance	-6.86	-7.04	0.25	-6.61	-6.45	-0.16	-7.22	-5.75	-1.48
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	901486	901486	901486	914689	914689	914689	905759	905759	905759
R-squared	.162	.166	.186	.162	.166	.186	.163	.168	.188

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. All columns also include a full set of firm-product-country fixed effects (δ_{fpc}) as well as time fixed effects (δ_t). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 6: The role of imported inputs

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Import intensity (*impsh*):	Overall import intensity			Import intensity from UK		
$Post_t \times GB_c$	-0.0947***	-0.0830***	-0.0117***	-0.0574***	-0.0371***	-0.0203***
	(0.00960)	(0.0115)	(0.00374)	(0.00809)	(0.0102)	(0.00394)
$Post_t \times GB_c \times impsh_f$	0.104***	0.117***	-0.0126	-0.0010	0.237**	-0.238***
	(0.0221)	(0.0243)	(0.0105)	(0.0654)	(0.0977)	(0.0561)
$Post_t \times impsh_f$	-0.0444**	-0.0730***	0.0285***	0.139**	-0.0452	0.184***
	(0.0219)	(0.0242)	(0.0105)	(0.0654)	(0.0977)	(0.0561)
			Quantification: effect for			
mean import share	-6.83	-5.33	-1.49	-5.74	-3.24	-2.50
mean + 1 s.d. import share	-3.79	-1.91	-1.86	-5.75	-1.44	-4.31
mean - 1 s.d. import share	-9.86	-8.74	-1.12	-5.73	-5.05	-0.68
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	656399	656399	656399	962671	962671	962671
R-squared	.157	.16	.175	.163	.168	.188

Observations are by firm-product-country-month. A product is a CN 8-digit category. Overall import intensity is the share of imported inputs in total input purchases. Import intensity from the UK is measured by the share of imported inputs from the UK in total input imports. A constant term and foreign country inflation, using the consumer price index, are always included. All columns also include a full set of firm-product-country fixed effects (δ_{fpc}) as well as time fixed effects (δ_t). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 7: The role of credit constraints

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Fin. Vulnerability (fin):		EXTFIN			TANG	
$Post_t \times GB_c$	-0.0578***	-0.0418***	-0.0160***	-0.129***	-0.104***	-0.0245***
	(0.00778)	(0.00925)	(0.00553)	(0.0260)	(0.0300)	(0.00797)
$Post_t \times GB_c \times fin$	-0.00296	0.0255	-0.0285***	0.392***	0.406***	-0.0139
	(0.0228)	(0.0204)	(0.00615)	(0.135)	(0.139)	(0.0316)
$Post_t \times fin$	0.0118	0.0134	-0.00158	0.427***	0.264*	0.162***
	(0.0229)	(0.0205)	(0.00616)	(0.133)	(0.138)	(0.0317)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	925747	925747	925747	925747	925747	925747
R-squared	.164	.169	.188	.164	.169	.188

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation are always included. All columns also include a full set of firm-product-country fixed effects (δ_{fpc}) and time effects (δ_t). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 8: Demand elasticity and price volatility

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Interaction:	Demand elasticity			Price volatility		
$Post_t \times GB_c$	-0.0451***	-0.00179	-0.0433***	-0.0560***	-0.0305***	-0.0255***
	(0.0144)	(0.0165)	(0.00515)	(0.00802)	(0.0112)	(0.00470)
$Post_t \times GB_c \times BW\sigma$	-0.0106	-0.0308***	0.0202***			
	(0.0116)	(0.0116)	(0.00511)			
$Post_t \times BW\sigma$	0.00539	0.0132	-0.00779			
	(0.0116)	(0.0116)	(0.00510)			
$Post_t \times GB_c \times CV \ln uv$				0.00001	-0.00004	0.00005***
				(0.00006)	(0.00007)	(0.00002)
$Post_t \times CV \ln uv$				0.0001*	0.000106	-0.000002
				(0.00006)	(0.0000668)	(0.00002)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	964147	964147	964147	966803	966803	966803
R-squared	.164	.169	.188	.164	.169	.188

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation are always included. $BW\sigma$ is Broda and Weinstein (2006) import demand elasticity and $CV\ln uv$ is the coefficient of variation of ln monthly unit values. All columns include firm-product-country fixed effects (δ_{fpc}) and time effects (δ_t). Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 9: Goods type

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Goods type:		Inputs			Consumption goods	
$Post_t \times GB_c$	-0.0533***	-0.0352***	-0.0181***	-0.0486***	-0.0187	-0.0299***
	(0.00843)	(0.00752)	(0.00517)	(0.0151)	(0.0195)	(0.00588)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	386249	386249	386249	527702	527702	527702
R-squared	.168	.173	.185	.162	.165	.193
Goods type:		Durable goods			Non-durable goods	
$Post_t \times GB_c$	-0.100***	-0.0708***	-0.0295***	-0.00227	0.0283*	-0.0306***
	(0.0198)	(0.0242)	(0.00633)	(0.0121)	(0.0166)	(0.00812)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	260529	260529	260529	267173	267173	267173
R-squared	.163	.165	.19	.16	.166	.196

Observations are by firm-product-country-month. A product is a CN 8-digit category. We use the UN-BEC to classify each CN8 product exported as an input or consumer good, and as durable or non-durable good. A constant term and foreign country inflation are always included. All columns also include firm-product-country (δ_{fpc}) and time (δ_t) fixed effects. Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table 10: Extensive margin

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Pr(Enter)	Pr(Exp)	Pr(Cont)	Pr(Enter)	Pr(Exp)	Pr(Cont)
Sample:		Full sample			EU sample	
$Post_t \times GB_c$	-0.0334***	-0.00292	0.00679	-0.0400***	-0.0130***	-0.00899***
	(0.00838)	(0.00412)	(0.00661)	(0.00831)	(0.00216)	(0.00266)
ln(firm exports)$_{t-1}$	0.0103***	0.0279***	0.0463***	0.0165***	0.0421***	0.0571***
	(0.000881)	(0.00131)	(0.00185)	(0.000681)	(0.00122)	(0.00172)
δ_c fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	131013	663000	417620	47256	245725	193005
R-squared	.0306	.0796	.154	.0807	.115	.183

The dependent variable in columns (1) and (4) is the probability that firm f starts exporting to country c in period t; in columns (2) and (5) it is the probability for firm j to export to destination c in period t, and in columns (3) and (6) the probability of a firm continuing to export to market c in t. Observations are by firm-country-time. Monthly data are aggregated to half-yearly observations, for the first and second six-month periods in each year for a firm-country. Country and time fixed effects are always included. A constant term is also included in all specifications. Robust standard errors clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

10 Figures

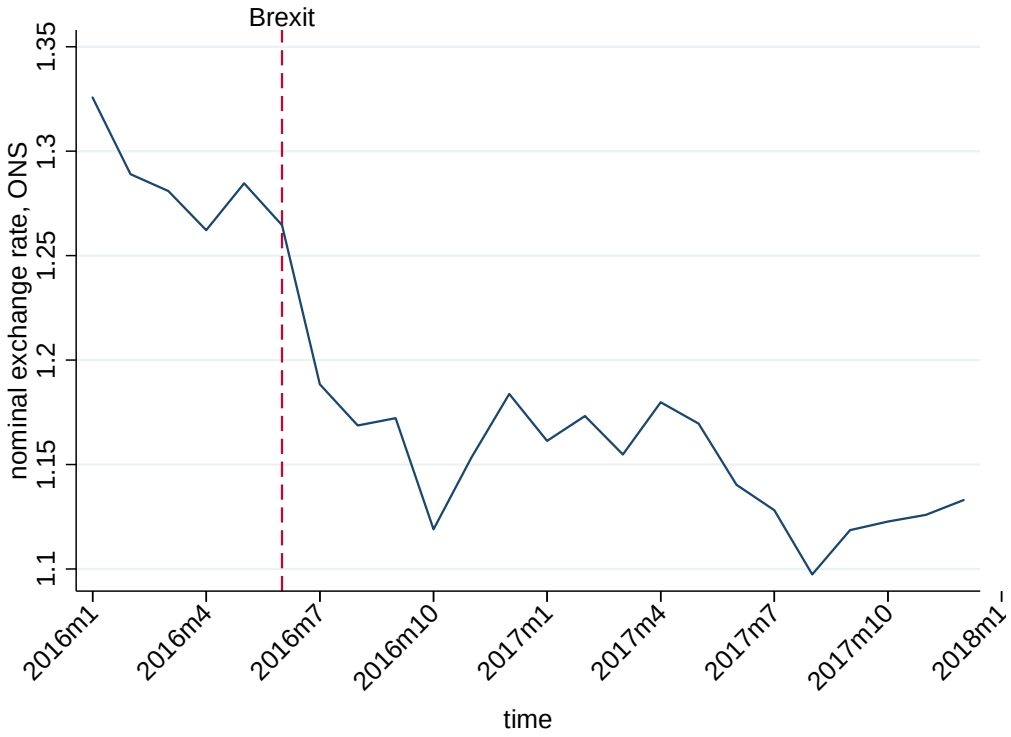

Figure 1: Sterling euro nominal exchange rate, ONS

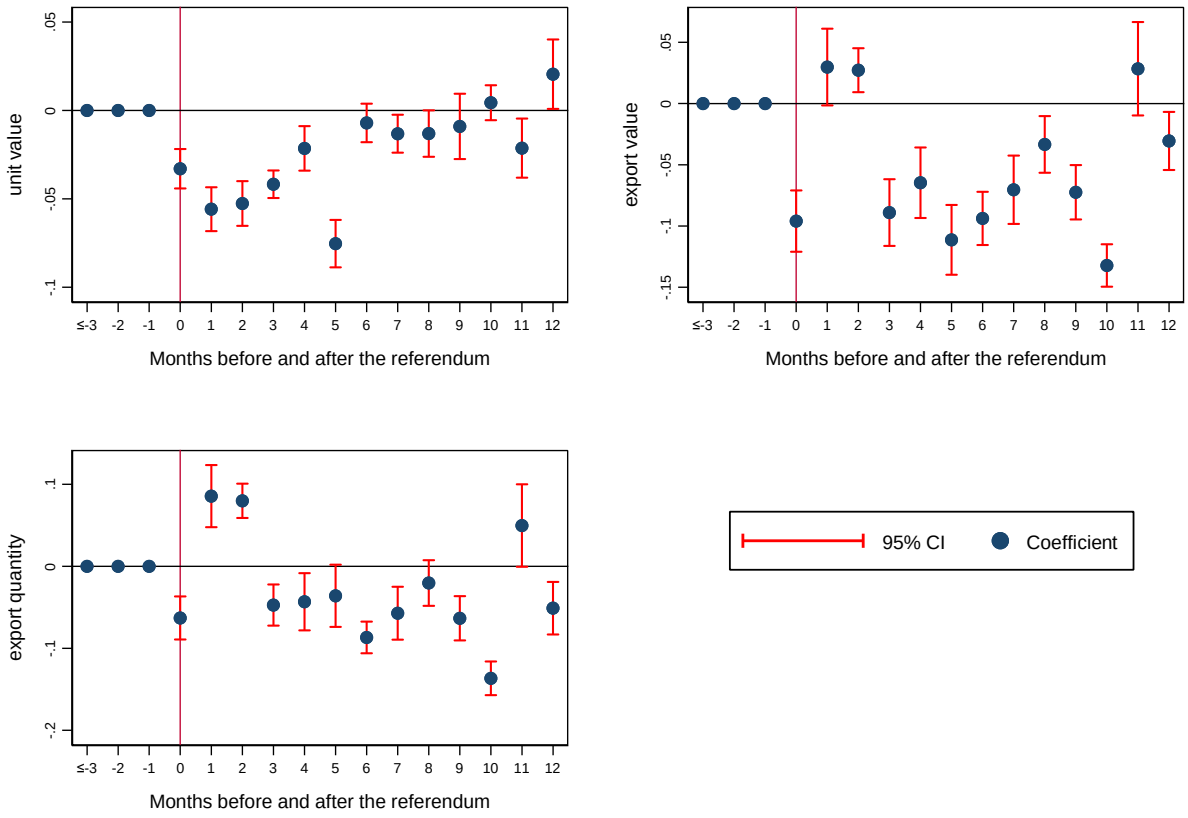

Figure 2: Effect of the Brexit referendum shock over time

A Appendix

Table A.1: Summary statistics

	No. Obs	Mean	Median	Std. dev	P10	P90
Product-country level						
Δ ln(export value)	727370	0.03572	0.03095	1.87145	-2.04767	2.12012
Δ ln(export quantity)	727370	0.02270	0.01930	2.08957	-2.29299	2.32004
Δ ln(unit value)	727370	0.01122	0.00211	0.99751	-0.93285	0.96527
Δ ln(no. firms)	727370	0.01706	0.00000	0.50702	-0.69315	0.69315
Firm-country level						
Δ ln(export value)	486187	0.02091	0.02456	1.47796	-1.52925	1.56152
Δ ln(export quantity)	486187	0.00386	0.00984	1.69028	-1.69364	1.69236
Δ ln(unit value)	486187	0.01416	0.00193	0.70385	-0.61889	0.65375
Δ ln(no. products)	486187	0.01338	0.00000	0.57974	-0.69315	0.69315
Firm-product-country level						
Δ ln(export value)	1093309	0.02540	0.02045	1.54168	-1.68425	1.72934
Δ ln(export quantity)	1093309	0.01980	0.00206	1.66800	-1.81036	1.85015
Δ ln(unit value)	1093309	0.00561	0.00048	0.73913	-0.60946	0.62266
Δ ln(unit price)	358931	0.01030	0.00413	0.57641	-0.46044	0.48083
Firm variables						
ln(tfp)	1013667	2.38754	2.35996	0.40793	1.92741	2.91279
ln(value added/worker)	1029897	10.40435	10.32144	0.63167	9.68480	11.16181
ln(sales)	1025967	16.25396	16.21121	1.64967	14.09011	18.58268
Import intensity overall	731481	0.25401	0.11824	0.29179	0.00000	0.71807
Import intensity from the UK	1088398	0.01966	0.00000	0.07624	0.00000	0.04309
C.V. ln unit values	1092861	1.79678	0.34668	8.68740	0.10418	1.10796
Product variables						
Broda&Weinstein (2006) elasticity of substitution	1089184	0.91683	0.83781	0.42792	0.45139	1.36613
Sector financial characteristics						
EXTFIN	1046032	0.26754	0.08252	0.36148	-0.11440	0.70071
TANG	1046032	0.15112	0.14296	0.07451	0.08455	0.23293

Own calculations based on Portuguese firm-level international trade data, from the National Statistics Office. Statistics are for the estimation samples.

Table A.2: Placebo - other countries, firm-country-product(CN8) level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Δln(q)	Δln(uv)	Δln(q)	Δln(uv)	Δln(q)	Δln(uv)	Δln(q)	Δln(uv)
$Post \times FR$	0.00927	0.00266						
	(0.0171)	(0.00424)						
$Post \times DE$			-0.000631	-0.00102				
			(0.0107)	(0.00377)				
$Post \times US$					-0.0261*	-0.00772		
					(0.0140)	(0.00479)		
$Post \times DK$							0.00967	-0.0181***
							(0.0141)	(0.00429)
δ_{pt} fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
δ_{fc} fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	911186	911186	911186	911186	911186	911186	911186	911186
R-squared	.159	.177	.159	.177	.159	.177	.159	.177

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. δ_{pt} and δ_{fc} are product-time and firm-country fixed effects, respectively. The table includes interactions for exports to France, Germany, US and Denmark. The UK is excluded from the sample for this table. Robust standard errors, clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table A.3: Heterogeneous responses, by quartiles of firm performance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Performance measure (φ):	Total factor productivity			Labor productivity		
$Post \times GB$	-0.0905***	-0.0996***	0.00907*	-0.0914***	-0.0897***	-0.00163
	(0.0128)	(0.0127)	(0.00533)	(0.0133)	(0.0151)	(0.00829)
$Post \times GB \times 2nd$ perf. quartile	0.0393**	0.0725***	-0.0332***	-0.00910	0.0193	-0.0284***
	(0.0166)	(0.0166)	(0.00457)	(0.0176)	(0.0172)	(0.00812)
$Post \times GB \times 3rd$ perf. quartile	0.0470***	0.0994***	-0.0524***	0.135***	0.155***	-0.0201**
	(0.0151)	(0.0161)	(0.0134)	(0.0207)	(0.0185)	(0.00933)
$Post \times GB \times 4th$ perf. quartile	0.0916***	0.130***	-0.0381***	0.0547***	0.0925***	-0.0379***
	(0.0176)	(0.0165)	(0.00824)	(0.0167)	(0.0154)	(0.00772)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	901486	901486	901486	914689	914689	914689
R-squared	.162	.166	.186	.162	.166	.186

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. δ_{fpc} are firm-product-country fixed effects and δ_t are time dummies. Robust standard errors, clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

Table A.4: The role of firm ownership

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Δln(exp)	Δln(q)	Δln(uv)	Δln(exp)	Δln(q)	Δln(uv)
Sample:	Domestic private			Foreign affiliates		
$Post \times GB$	-0.0521***	-0.0351***	-0.0170***	-0.0328*	0.00905	-0.0418***
	(0.00792)	(0.00884)	(0.00354)	(0.0168)	(0.0251)	(0.0103)
δ_{fpc} fixed effects	yes	yes	yes	yes	yes	yes
δ_t fixed effects	yes	yes	yes	yes	yes	yes
Observations	741323	741323	741323	149353	149353	149353
R-squared	.16	.164	.188	.176	.183	.181

Observations are by firm-product-country-month. A product is a CN 8-digit category. A constant term and foreign country inflation, using the consumer price index, are always included. All columns also include a full set of firm-product-country fixed effects (δ_{fpc}) and time fixed effects (δ_t). Robust standard errors, clustered by country are reported in parenthesis. *p<0.1; ** p<0.05; ***p<0.01.

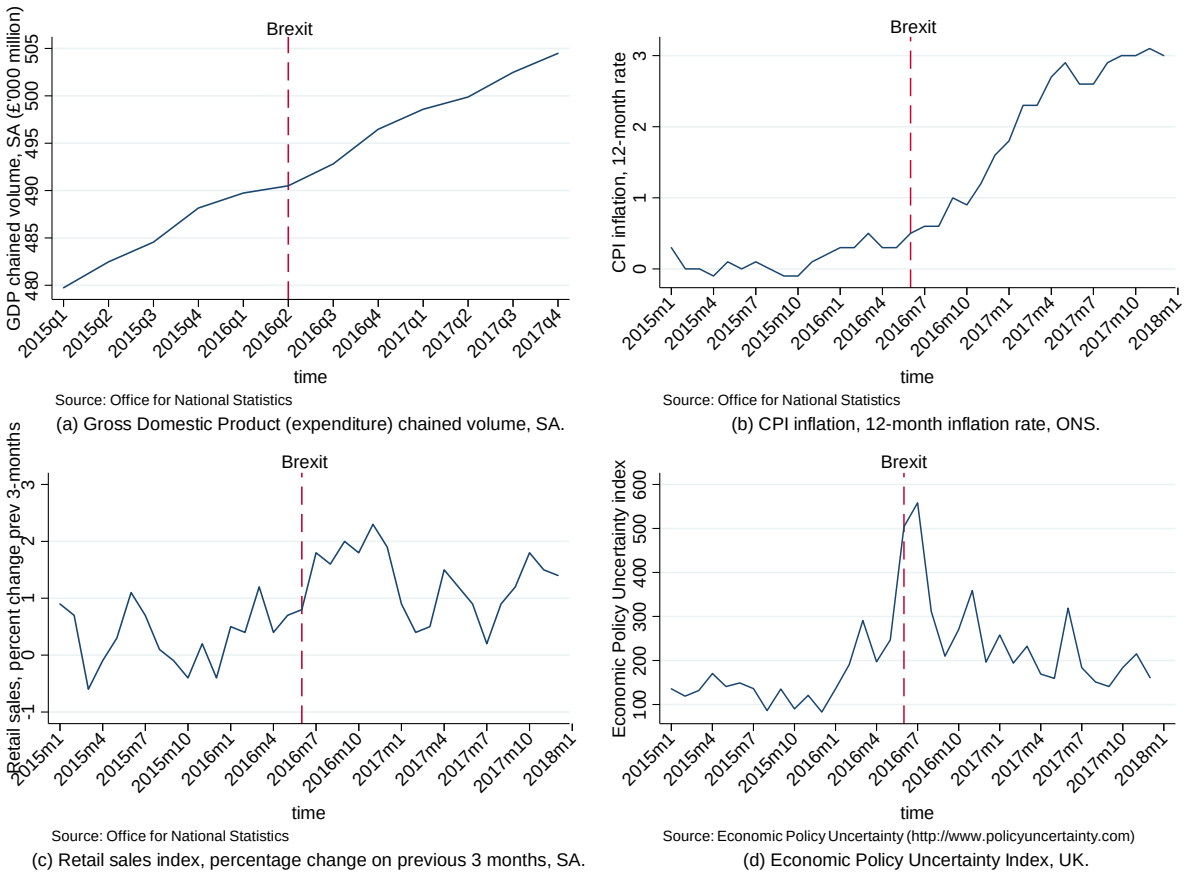

Figure A.1: UK GDP, inflation, retail sales and uncertainty index