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Abstract

Uncertainty over future tariff schedules and customs arrangements is a key factor in defying firms' participation in international markets. This paper investigates firm heterogeneity in the effects of trade policy uncertainty on the margins of trade, exploiting the Brexit process as a quasi-natural experiment and using transaction-level trade data for UK firms. Comparing UK trade flows to the EU and extra-EU countries, and the variations of product-specific tariff threats along firm size, our results show an overall reduction in UK-EU trade flows in respect with extra-EU markets, as uncertainty regarding future trade policies increased during the post-Brexit referendum negotiations. This is the result of two contemporaneous effects: a destruction of trade flows for smaller firms more exposed to uncertainty and potential tariffs, while a consolidation and diversion of trade flows, in particular towards more distant and emerging extra-EU markets, for larger firms. Falsification tests and alternative identification strategies corroborate the robustness of the main findings.

JEL Codes: F02, F13, F14, F15, F61, F68

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1 Introduction

Trade flows are highly dependent on the certainty of trade policies and the possibility of predicting future trade regimes, due to the high level of long-term investment required to plan future international operations. In this regard, economic and trade policy uncertainty surrounding future trade relationships with other countries could dampen export flows and other international activities of firms, by increasing the productivity cut-off at which firms find it profitable to engage in these activities. Thus the reduction of uncertainty over future tariff schedules and customs arrangements is a key factor in boosting firms' investment and participation in international markets (Handley & Limao 2015). This is even more important for smaller firms, which on average are less productive, incur in higher marginal costs compared to large firms, and lack the resources needed to quickly adjust their production in response to international shocks (Bernard et al. 2007, Mayer & Ottaviano 2008). These firms are also more exposed to trade risks, given their limited basket of traded goods and the over-reliance on geographically proximate markets (Altomonte et al. 2014, Shoag & Veuger 2016).

A growing body of literature has analysed the interaction between macro shocks and the related uncertainty with respect to economic growth, showing evidence that economic uncertainty could lead to reduced or delayed investment (Bloom 2009, 2014), damaged consumer confidence in businesses (Dominguez & Shapiro 2013, Baker et al. 2016*a*) and the reduction of trade participation and performance (Limão & Maggi 2015, Handley & Limăo 2017, Pierce & Schott 2016). In particular, recent studies have tried to disentangle the impact of policy uncertainty on international trade, providing theoretical predictions and empirical evidence on aggregate trade flows (Carballo et al. 2018, Graziano et al. 2020*b*,*a*), and on firms' export participation (Crowley et al. 2020). However, more evidence is needed in order to assess how uncertainty affects trade at a more granular level, in particular linking these studies with the body of literature looking at firms heterogeneity (Melitz n.d., Bernard et al. 2007).

In this study we seek to understand the effects of trade policy uncertainty on firms' export behaviour. In particular, we are interested in understanding whether uncertainty about future trade barriers can hold firms back from exporting to existing markets, with respect to trade flows towards other markets. To do so, we exploit the Brexit process as a quasi-natural experiment to assess whether the uncertainty about future trade relations between the UK and the EU has led UK firms to stop or divert their international trade flows to the EU in comparison with extra-EU countries. Using the UK HM Revenue & Customs (HMRC) Overseas Trade Statistics (OTS) database on quarterly transaction level data for the population of UK exporters during the 2012-2018 period, we test if policy uncertainty has disrupted UK exports towards EU destinations. We focus on this time period due to the high level of uncertainty experienced in the 2 years immediately after the Brexit referendum regarding the decision to formally start the process of exiting the EU, and the speculations around the possible future UK-EU trade arrangements, from some sort of Single Market and Custom Union membership to the "No-Deal" scenario (Bloom, Bunn, Chen, Mizen, Smietanka & Thwaites 2019). We focus in particular on the heterogeneous effects of trade uncertainty along the firms size distribution, investigating especially the behaviour of small and medium enterprises (SMEs), which are more exposed to policy uncertainty and the potential threat of tariff increases under a "no-deal" scenario.[1]

We seek to make several contributions to the literature. By using Brexit as a natural experiment, we are able to study the heterogeneous adjustments of firms' export

[1]In a no-deal scenario, the UK would immediately leave the European Union with no agreement about the divorce process and the future trade arrangements. In this case, the UK would leave the single market and customs union. Under a no-deal Brexit, there would be no time to bring in a UK-EU trade deal, and trade would initially have to be on MFN (most favoured nation) terms set by the World Trade Organization (WTO). According to the WTO Most Favoured Nation Clause, the country which is the recipient of trade policy treatment must nominally receive equal trade advantages, as the "most favoured nation", by the country granting such treatment (trade advantages include low tariffs or high import quotas). If this happens in the EU-UK case, tariffs will apply to most goods and border checks for goods would be applied.

strategies in relation to anticipated future trade barriers. This granular analysis allows us to carefully investigate novel dimensions of this effect. Our main contribution is a deepened understanding of the heterogeneous effects of trade policy uncertainty on exporters of different sizes with different resources and capabilities to react upon external shocks.

In particular, the effect of trade uncertainty could be exacerbated for smaller and less productive exporters, due to their reliance on exporting a limited range of goods, which are mostly traded only with geographically proximate markets (Altomonte et al. 2014, Shoag & Veuger 2016). A trade shock like Brexit, affecting the largest and closest export market, could have thus badly hit smaller businesses, in that they lack the resources to quickly adjust to the shock and diversify their export baskets. This then raises the productivity cut-off at which firms find it viable to export, thus pushing many smaller firms out of international markets (Melitz n.d., Crowley et al. 2020). This issue is particularly relevant, given that despite smaller exporters account for only a third of the UK total value of exports, they represent more than 95% of the total number of exporters in the UK, employing about 2.5 million workers (Mayer & Ottaviano 2008, HMRC 2020).

Our empirical analysis tests the two above-mentioned mechanisms along the distribution of exporters' size. First, we identify the heterogeneous effect across different product categories, based on the product-specific potential tariff threat under a no-deal scenario. It is reasonable to expect trade policy uncertainty affects businesses that primarily export products at higher risk of tariffs and non-tariff barriers (Crowley et al. 2020, Graziano et al. 2020*b*). Secondly, by comparing firm-level export flows to the EU and extra-EU destinations, we are able to disentangle the effect of uncertainty on firms' trade margins, considering both the extensive (number of products and markets) and the intensive margins (export values). This will allow us to identify the ways in which

the increased trade policy uncertainty has caused trade flows with the EU to cease, reduce or redirect towards extra-EU markets (Handley & Limão 2017, Graziano et al. 2020*b*).

Further, we account for the dynamic evolution of trade policy uncertainty, considering Brexit as a process rather than an event, and modelling the change in the perceived policy uncertainty from the time of the referendum announcement till the triggering of the formal Article 50 notice of withdrawal. Finally, we analyse the presence of asymmetric effects for UK exports and imports.

Our results show clear evidence of heterogeneous effects of trade policy uncertainty on UK exporters of different sizes. Micro exporters have experienced trade destruction due to Brexit, showing tendency to cease exporting towards EU markets. There is strong evidence of trade diversion among small and medium traders, significantly reducing exports towards the EU, but at the same time partially replacing these with more exports towards extra-EU markets. In contrast, larger exporters do not seem to be negatively affected by trade policy uncertainty, maintaining stable trade relationships with EU partners and further exploring extra-EU markets.

These heterogeneous effects are more pronounced for products that would face a potential increase in tariffs under a no-deal scenario, moving from a zero-tariff to a most-favoured nation (MFN) duty, such as agricultural products, chemicals, textiles and transport equipment. This results into a larger negative effect of trade policy uncertainty on micro and small exporters, which clustered most of their limited products baskets in the exports of products potentially facing higher trade barriers.

Further, trade diversion towards extra-EU markets has not been homogeneous, with medium and large exporters diverting prominently towards emerging economies, such

as the BRICS (Brazil, Russia, India, China and South Africa) and the Commonwealth countries, presumably because of their rapid economic growth, market potential and previous colonial and institutional ties. These effects were not only triggered by the referendum event, but consisted of an anticipatory effect pre-referendum (Douch & Edwards 2021*a*,*b*), which grew in magnitude after the surge in uncertainty following the triggering of Article 50 in March 2017 and the following snap general election. The results are robust to a battery of alternative econometric model specifications and estimation techniques and falsification exercises.

Our study is mainly related to three different strands of literature. First, the literature on the effects of policy uncertainty on economic performance; second, previous studies looking at the link between trade policies, trade destruction and diversion; finally to the literature focusing on heterogeneous effects of trade. Recent papers have highlighted the role played by less directly observable factors related to trade policies, such as expectations, anticipation and uncertainty. Freund & McLaren (1999) provide evidence that trade flows adjust in anticipation of trade agreements, as theoretically formalised by Handley & Limão (2017), distinguishing between the effect of anticipation and that of policy uncertainty (see also Lakatos & Nilsson (2017)). Regarding policy uncertainty, a study by Osnago et al. (2015) finds that the effect of trade policy uncertainty could be equivalent to a tariff increase, while other authors have also claimed that trade agreements play a major role in reducing policy uncertainty (Handley & Limao 2015, Carballo et al. 2018). Several papers have exploited the Brexit natural experiment to evaluate the effect on policy uncertainty on trade. For instance, Douch & Edwards (2021*a*) test the policy uncertainty effects of the Brexit announcement on UK exports and imports of goods, finding that UK aggregate exports have been lower than predicted for both UK-EU and the extra-EU trade flows. Similarly, Graziano et al. (2020*a*) model how the increased probability of a UK exit from the EU reduces bilateral export values and trade participation, finding heterogeneous effects of trade policy uncertainty across products, and asymmetric shocks between UK and EU exporters.

Closely related to this paper, Crowley et al. (2020) study the effect of renegotiating a trade agreement on firms' entry/exit decisions in export markets, using Brexit as a natural experiment and finding that export entry rate in 2016 would have been higher if UK firms exporting to the EU had not faced increased trade regulation uncertainty. Similarly, related studies looking at the effect of Brexit uncertainty on trade in services in the UK, have identified a significant negative impact both in terms of trade values and participation, heterogeneous across exported services (Ahmad et al. 2020, Douch & Edwards 2021*b*). More generally, previous studies have shown that the high uncertainty brought about by the Brexit process has affected investment and other business decisions, for example foreign direct investments (Dhingra et al. 2018, Breinlich et al. 2020), prompting firms to alter their plans and strategies (Bloom, Bunn, Chen, Mizen, Smietanka & Thwaites 2019)[2].

These adjustments may occur in changing export decisions, reconsidering the introduction of new products or in the exploration of new markets, thus leading not only to changes in export participation and total export volume, but also changes in the margins of trade, including products exported and the foreign market destinations. For instance, Graziano et al. (2020*b*) examine the Brexit uncertainty externalities beyond the UK-EU trade flows, estimating a negative trade-uncertainty elasticity between the UK and its extra-EU partners with preferential trade agreements in place that required renegotiation post-Brexit. This is linked to the established strand of literature investigating how trade policies can give rise to trade destruction and diversion, where trade flows diverge from the equilibrium of relative prices and quantities of varieties exported to different markets, due to the imposition of new trade policies (Frankel 1997). Trade

[2]A growing literature analyses the overall effect of Brexit-induced uncertainty on the UK economy. A first group of studies has modelled *ex-ante* the Brexit economic effect and its macroeconomic cost, predicting a reduction in trade and in GDP growth in multiple scenarios (Born et al. 2017, Dhingra et al. 2017, Sampson 2017). Secondly, several papers have analysed the first effects of the Brexit referendum, finding evidence of a reduction in UK living standards as a consequence of the related significant exchange rate shift (Kren 2017, Breinlich et al. 2017), of negative reactions to stock market fluctuations in certain industrial sectors (Ramiah et al. 2017), showing the impact on firms' financing decisions (Berg et al. 2019), and on their labour demand (Javorcik et al. 2019).

diversion occurs when the implementation of a trade policy causes trade to be diverted from one country to another third country, despite the equal treatment of the countries involved, where the original trade partner would be the low cost source of import or the preferred export destination, following comparative advantage or gravity models predictions (Clausing 2001). Most of the studies in this literature have mainly focused on the trade diversion effects of two different kinds of trade policies: preferential trade agreements (PTAs) (Clausing (2001); Romalis (2007), among others) and trade defence instruments, such as anti-dumping and anti-subsidies measures (Prusa 2001, Konings et al. 2001, Bown & Crowley 2007, Vandenbussche & Zanardi 2010, Egger & Nelson 2011, Cohen-Meidan 2013, Besedeš & Prusa 2013, Jabbour et al. 2019). Overall, these studies show how trade policies could lead to imperfect substitution across trade flows, increasing prices from equilibrium levels, and imposing significant externalities on the trade flows not directly targeted by trade policies.

What is less understood is the heterogeneous effect of trade policy uncertainty on exporters behaviour along several firms characteristics, and the underlying mechanisms at play. A large body of the literature pointed out that engaging in international markets can be expensive, and usually only the most productive firms can afford to do so (Melitz n.d., Bernard et al. 2007). Not exploiting economies of scale, trading costs represent a higher share of SMEs' export revenue, with the consequence that they are disproportionately affected by tariff and non-tariff barriers to trade (WTO 2016). In turn, SMEs also face considerable challenges in accessing finance for new investment, information, skills and technology (Fliess & Busquets 2006, Wagner 2012). Given these vulnerabilities, additional barriers to trade arising as a consequence of Brexit may reduce SMEs international competitiveness and their ability to face trade costs, hitting them harder than large firms. However, the repercussions of trade policy uncertainty along exporters size might not be limited to the entry/exit decision, but might affect their exporting strategies, pushing towards the rationalization of trade margins or towards the diversification of export baskets exploring new trade flows, based on their

productivity and resources. It is thus fundamental to shed a light on the heterogeneous effects that trade policy uncertainty might have on firms depending on their characteristics, in order to develop effective policy responses more targeted to the actual needs of small and and large exporters.

The rest of the paper is structured as follows. In the next section we summarise the Brexit process and present the context regarding our study. In Section 3 we present the data used and outline our methodological approach. Section 4 discusses the empirical results and presents robustness tests to verify the validity of our analysis. Section 5 concludes by suggesting related policy implications.

2 Brexit: A Trade Policy Uncertainty Case Study

This section outlines the Brexit process up to the ratification of the withdrawal agreement at the end of January 2020. The purpose of this account is to demonstrate the unpredictable nature of the Brexit referendum outcome and the fact that the consequences of Brexit for future trade relationships remained largely uncertain for year after after the referendum. The withdrawal process of the United Kingdom from the European Union, commonly known as Brexit, can be traced back to the 2015 UK General Election campaign, when the Conservative Prime Minister (PM) David Cameron announced an in-or-out referendum on EU membership, based on a renegotiated package of concessions, to take place before 2017. After winning the election in 2015 with a working majority, the Conservative government introduced the European Union Referendum Act to enable a referendum to be held in 2016, and started a negotiation process with the EU in order to reform the UK's EU membership, specifically regarding the protection of single market access for non-Eurozone countries, the reduction of "red tape" regulations, the exemption of Britain from aspirations to "ever-closer union", and the restriction of immigration to the UK from the rest of the EU.

After the outcome of the re-negotiations was announced in February 2016, the Prime Minister announced the date for the referendum,23rd June 2016, supporting as positive the outcome of the negotiations with the EU, and indicating his intention to campaign in favour of remaining in a reformed EU. This started a tense political campaign, "Remain" versus "Leave", open to either possible outcome, which led to growing uncertainty regarding the referendum outcome, the government's strategy vis-a-vis EU membership, and the country's position in the customs union. There were substantial variations in the opinion polls in the months immediately preceding the referendum, with large swings in the polls particularly around key events (Graziano et al. 2018), although the "Remain" side had maintained a relative margin ahead of the "Leave" campaign up to the day immediately before the referendum. On 23rd June 2016, the referendum delivered an outcome of 51.9% of British voters in favour of the UK leaving the European Union, against the predictions of opinion polls and experts.[3]

Although legally the referendum was non-binding, the government promised to implement the result. The PM David Cameron having campaigned to remain, resigned after the result, adding to the already mounting policy uncertainty. Following a leadership contest, the newly elected PM Theresa May formed a new government and started discussions to begin the process for the UK's withdrawal from the EU. Subsequently, the government initiated the official EU withdrawal process by triggering Article 50 of the EU Lisbon Treaty on 29th March 2017, meaning that the UK was due to leave the EU within two years unless this was extended. The purpose of the triggering was also to notify the European Council of the decision to "negotiate and conclude an agreement with the leaving State, setting out the arrangements for its withdrawal, taking

[3]Anecdotal evidence about the mismatch between expectations and actual results in the UK and elsewhere can be found in several newspaper articles published in the days following the Brexit referendum, such as in the New York Times (https://www.nytimes.com/2016/06/25/upshot/why-the-surprise-over-brexit-dont-blame-the-polls.html), on BBC News (https://www.bbc.co.uk/news/world-europe-46892422) or in the Economist (https://www.economist.com/graphic-detail/2016/06/24/who-said-brexit-was-a-surprise).

account of the framework for its future relationship with the Union".[4] This however has not been a linear process, given the polarised opinions between "Leave" and "Remain" supporters within the UK government, and the constitutional disputes between Parliament and Government about the procedure to be followed. Businesses and the rest of the country were in a state of increasing confusion and uncertainty about the future relationship with the EU for many months after the Brexit referendum (Bloom, Bunn, Chen, Mizen, Smietanka & Thwaites 2019).

Further, the negotiations with the EU did not start until the 19th June 2017, primarily because of the decision by the PM Theresa May in April to hold a snap general election to take place on the 8th of June, being confident of securing a fresh and stronger mandate for a new government with a larger majority to negotiate with the EU. However, the result of the election was the loss of a majority for the Conservative Party in the House of Commons, leading to a minority government, supported by the Democratic Unionist Party of Northern Ireland, which was pushing for a harder version of Brexit. The following political turmoil has provoked more uncertainty regarding the future relationship with the EU bloc. Even though the UK Parliament approved a Withdrawal Act in June 2018 and a draft withdrawal deal was agreed by the May government and the EU in November 2018, the UK Parliament failed to approve the Withdrawal Agreement several times before the 29th March 2019 deadline, with the exit date further extended first to 12th April and then to 31st October 2019, with the UK then obligated to hold European Parliament elections in May 2019. This succession of defeats of the government pushed the PM Theresa May to resign on 7th June, followed by Boris Johnson becoming Prime Minister on 24th July 2019. The change of government convinced the EU to re-open the negotiations on the Withdrawal Agreement, and on 17th October 2019 a revised withdrawal agreement was agreed between the parties, containing a new Northern Ireland Protocol, as well as other technical modifications.

[4]Consolidated version of the Treaty on European Union, Title VI - FINAL PROVISIONS, Article 50, OJ C 326, 26.10.2012: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12012M050.

In order to accommodate an early general election on the 12th December, a third extension was agreed to by the EU, with a new withdrawal deadline set for 31st January 2020. The election was focused mainly on "get Brexit done", and the Conservative Party won an 80-seat majority in parliament, giving an electoral mandate to the new Boris Johnson government to ratify the withdrawal agreement, which became law on the 23rd January 2020, and was ratified by the European Parliament and EU Council on the 29th January. On 31st January 2020 the United Kingdom's membership of the European Union ended after 47 years, starting with a transition period of 1 year. During the transition period, the two sides continued to negotiate a trade agreement, which was finally agreed after turbulent negotiations only on the 24th of December 2020, concluding the transitioning period on the 31st of December 2020. At the same time a new customs transitional arrangement started, limiting checks on trade between the EU, Northern Ireland and Great Britain until the 1st of July 2021. The new trade agreement provides tariff-free trade in goods, but only limited mutual market access in services, while still imposing significant non-tariff barriers to trade between the EU and the UK in terms of additional bureaucracy, different standards and phytosanitary requirements, etc.

This brief summary has highlighted how throughout the period since the Brexit referendum was announced firms had to face a high degree of uncertainty around future trade policies between the UK and the EU. Hence the unpredictable nature of the Brexit process provides an excellent opportunity to study the effects of policy uncertainty on firms trade diversion.

3 Data

The empirical analysis draws on the HMRC Overseas Trade Statistics (OTS) database containing the universe of above-threshold international trade transactions carried out

by UK firms.[5] The HMRC OTS database reports all manufacturing import and export monthly transactions between UK firms and the rest of the world, including information about the value and quantity of transactions, the HS 8-digit classification and the country of origin of imports or destination of exports. For the purposes of our analysis, we focus on export transactions during the period between January 2012 and December 2017, aggregated at the quarterly level to avoid the high volatility and fluctuations of monthly transactions, expanding up to December 2018 in further robustness tests.[6]

To analyse the heterogeneous effect of trade uncertainty on the destruction and diversion of trade flows following the Brexit referendum, we differentiate between export flows towards intra and extra-EU countries, calculating for each firm and quarter measures both of intensive and extensive margins of trade towards these two macro destinations. First, we measure the intensive trade margin as the total value of exports towards EU and extra-EU markets. Secondly, we build several measures of extensive trade margins, particularly focusing on the number of products exported and countries served, and the number of new products shipped and new destinations accessed both within and outside the EU.[7] Overall, we have detailed information about 339,493 quarterly export transactions carried out by more than 26,000 UK exporters during the period between 2012 and 2017[8].

[5]The dataset includes monthly records for all UK firms trading for more than £250,000 in a given year with other EU countries, and all transactions with extra-EU countries. Comparisons with official statistics indicate that the £250,000 threshold captures up to 98% of the total value of UK exports to the EU. As a robustness test, we have also limited the extra-EU transactions to be only for firms trading with a value of more than £250,000 in a year with extra-EU countries. Results are robust and available upon request.

[6]In order to carry out our analysis and to compare intra- and extra-EU export flows, we have performed several data management tasks. First, we have harmonized all the extra-EU trade flows to a unique trade term, the *Ex Works* (EXW) term, in order to make it comparable with the flows internal to the Customs Union. Secondly, we have aggregated the export flows at the firm, destination and HS 6-digit level, since the 6-digit codes are the most detailed definitions that are used as common standards across all countries. We also test the robustness of the key findings when observation frequencies are at monthly and semester level, as shown in Tables A.4 and A.5 in the Appendix.

[7]We define a product or destination as "new" if it appears in a firm's records for the first time since 1997, when the HMRC OTS database started.

[8]Table A.1 in the Appendix compares the summary statistics of different margins of trade flows to intra- and extra-EU destinations before and after the Brexit referendum. Most calculated trade

To detect possible evidence of exports diversion and destruction between EU and extra-EU across different trade margins over time we build double-difference measures, $\Delta ln(y_{iq})$, for all the trade margins y considered, where we compare the change in the growth of export flows to EU and to extra-EU markets (first difference) with respect to the same quarter one year earlier, $q-4$, (second difference) for each firm i and quarter q:

$$\Delta ln(y_{iq}) = \Delta ln(y_{iq}^{EU}) - \Delta ln(y_{iq}^{extra\text{-}EU}) \tag{1}$$

where the two terms $\Delta ln(y_{iq}^{EU})$ and $\Delta ln(y_{iq}^{extra\text{-}EU})$ represent the four-quarter logarithm difference for intra and extra-EU export flows of firm i at quarter q.[9] This design allows us to compare the post-referendum trade patterns with those in the same period a year earlier[10], and by comparing the yearly growth in export flows between flows affected (EU) or not affected (extra-EU) by the Brexit-related trade policy uncertainty in each quarter:[11]

$$\Delta ln(y_{iq}^{EU}) = ln(y_{iq}^{EU}) - ln(y_{iq-4}^{EU}) \tag{2}$$

$$\Delta ln(y_{iq}^{extra\text{-}EU}) = ln(y_{iq}^{extra\text{-}EU}) - ln(y_{iq-4}^{extra\text{-}EU}) \tag{3}$$

Figure 1 considers the dynamic evolution of these double-differences. First, it reports in the left-hand side diagram the average yearly growth in intra-EU and extra-EU export values for UK firms between quarters 2012-Q1 and 2017-Q4. Since the beginning of

margins for intra and extra-EU markets have increased in the post-Brexit referendum period, including the quarterly number of products and destinations both for existing products and for new products. However, total quarterly export value noticeably decreased in EU markets, while exports to extra-EU kept growing.

[9] As a robustness test, we have also considered only the sub-sample of exporters who export both to the EU and to extra-EU markets, in order to take into account the different thresholds used by HMRC, to include exporters trading with the EU and extra-EU markets. This exercise would also eliminate the potential selection bias of very small exporters exporting only to extra-EU markets. Results from using this alternative specification are quantitatively and statistically similar and are available upon request.

[10] We also use alternative specifications where we consider longer time differences -i.e. two years - obtaining consistent results.

[11] Refer to Appendix B for more details on how we identify the effect of trade uncertainty on the growth of trade margins.

the period examined, there has been a parallel downward trend in the growth of both intra and extra-EU exports by value between 2012-Q1 and 2015-Q4. However, after a sharp growth in both flows in Q1 2016 compared to one year earlier, the two trade flows have followed different growth rates after the Brexit referendum from Q3-2016 onward. This trend is more evident when focusing on the net double-difference between the two growth trends over the same time period presented in the diagram on the right-hand side. We can clearly observe that the difference between EU and extra-EU export growth has sharply increased after the Brexit referendum, when intra-EU exports value slowed down significantly.

[Figure 1 about here]

4 Methodology

In order to identify the heterogeneous effect of trade uncertainty on the destruction and diversion of export flows along the UK exporters size distribution, we start by estimating a benchmark specification employing a difference-in-difference strategy, by regressing the difference in the growth of trade margins between intra and extra-EU flows before and after the Brexit referendum:[12]

$$\Delta ln(y_{iq}) = \beta_0 + \beta_1 Brexit_q^D + \beta_2 Exp.Size_{it-1} + \beta_3 Brexit_q^D \times Exp.Size_{it-1} + \\ + \beta_4 ln(Size_{it-1}) + \beta_5 ln(y_{iq-4}) + \beta_6 \Delta(Ex.Rate_{iq}) + \gamma_i + \gamma q + \gamma_{pt} + \varepsilon_{it} \quad (4)$$

where $\Delta ln(y_{iq})$ represents the double-difference term, or the change in the growth of export margins to the EU in comparison with extra-EU markets in the same quarter

[12]The results tables in this paper report the estimates obtained by an OLS model, since the dependent variables are the double-log-difference of several trade margins. As a robustness test, we have replicated the results for the extensive margins specifications using Poisson maximum likelihood (PPML) and Negative Binomials models for counting double-differences. Results are robust and available upon request.

one year earlier, both in terms of intensive and extensive margins of trade. The variable $Brexit_q^D$ is a dummy, taking the value equal to 1 from Q3 2016 onward and 0 otherwise. $Exp.Size_{it-1}$ is a categorical variable classifying UK exporters as micro, small, medium or large based on the quartile distribution of their total exports in the previous year $(t-1)$. The main coefficient of interest will be β_3, capturing the heterogeneous effect of the Brexit induced uncertainty across the distribution of UK exporters' size.[13] This will allow us to analyse the heterogeneous reaction of exporters to external shocks and trade uncertainty, in particular for micro and small exporters, which usually rely on limited resources and capabilities, and are constrained in adjusting their production in response to international shocks, as they are heavily reliant on fewer and smaller trade flows to geographically proximate markets (Mayer & Ottaviano 2008, Shoag & Veuger 2016). We further proxy for the overall size and productivity of exporters by including the log value of firm i's total exports in the previous year $(ln(Size_{it-1}))$, assuming that large exporters usually tend to be highly productive large multi-product firms (Mayer & Ottaviano 2008).[14] We control as well for the lagged level of the dependent variable $(ln(y_{iq-4}))$ in the same quarter in the previous year.

In addition, we control for firms' exposure to exchange rate fluctuations $\Delta(Ex.Rate_{iq})$. The Brexit referendum might have affected trade flows not only through an increase in trade policy uncertainty, but also by stimulating sharp fluctuations in exchange rates between the GBP and other major foreign currencies. Immediately after the Brexit referendum, the Pound Sterling had a sharp depreciation by 15% against a trade weighted basket of currencies, and in particular vis-a-vis the Euro. This depreciation made foreign imported products more expensive, affecting inflation and living standards in the UK as demonstrated by Breinlich et al. (2017). However, it might have boosted UK

[13] In additional robustness tests we have interacted exporters size quartile with all control variables included in our specifications. Results are consistent and available upon request.

[14] As we analyse the OTS data, we do not have firm-size information in terms of employment or assets. We followed previous international trade studies to define size of trader by annual export value of a trader.

exporters' performance in international markets, by reducing the cost of their goods for foreign buyers. Thus, to disentangle this effect from the policy uncertainty one, we create a firm-level measure of exposure to exchange rate fluctuations given by the difference in the export share-weighted average exchange rate between the sterling and all the foreign quoted currencies included in the exporter's basket of exported goods before and after the Brexit Referedum, i.e. between quarters q and $q-4$:

$$\Delta(Ex.Rate_{iq}) = log\left(\frac{\sum_c w_{icq} ex_{cq}}{N_{iq}}\right) - log\left(\frac{\sum_c w_{icq-4} ex_{cq-4}}{N_{iq-4}}\right) \tag{5}$$

where ex_{cq} is the average exchange rate between British Sterling and currency c denominated in each trade transaction in quarter q, derived from the IMF monthly Exchange Rate Archives. Furthermore, w_{icq} is the share of export values denominated in currency c over the total exports of firm i in quarter q, while N_{iq} is the number of export transactions denominated in different currencies for firm i at time q.[15] Finally, we include firm (γ_i), quarter (γ_q), and product-year (γ_{pt}) fixed-effects in order to eliminate any residual firm-specific time-invariant unobservable variability, quarter-specific macro shocks, and any product-specific time trends which could bias our estimates[16].

Starting from this benchmark specification, we investigate two main channels through which the Brexit referendum might have affected UK exporters trade margins heterogeneously based on their size. First, we consider the heterogeneous effect across the different products that UK firms export, specifically based on the potential product-specific tariff threat under a no-deal scenario. In fact, not all products might be affected homogeneously by trade uncertainty, since for many products very little would change between the previous EU customs union regime and a new different trade agreement. In

[15]From the HMRC OTS database we know the denominated currency for all the extra-EU transactions. For the intra-EU transactions, we assume that the currency used is the Euro for Eurozone countries and the destination country local currency for all other non-Eurozone EU countries.

[16]For each firm we built a product dummy corresponding to the HS 2-digit category accounting for the largest share of its annual total exports.

order to model this, we follow the methodology proposed by Crowley et al. (2020) and measure the level of trade uncertainty faced by firms as the weighted average difference between the zero-tariff faced by products exported under the EU customs union regime and the tariff UK products would face if exported under WTO rules applying the EU Most-Favoured Nation (MFN) tariff, using data on EU MFN tariffs at the HS 8-digit level from the WB TRAINS database. Thus, we change our benchmark specification as follows, where $Tariff_{it-1}$ is a categorical variable differentiating between 4 levels of the overall firm export basket tariff threat in the previous year based on its quartile distribution (low potential tariff threat, medium-low, medium-high and a potential high threat):

$$\Delta ln(y_{iq}) = \beta_0 + \beta_1 Brexit_q^D + \beta_2 Tariff_{it-1} + \beta_3 Brexit_q^D \times Tariff_{it-1} + \\ + \beta_4 ln(Size_{it-1}) + \beta_5 ln(y_{iq-4}) + \beta_6 \Delta(Ex.Rate_{iq}) + \gamma_i + \gamma q + \gamma_{pt} + \varepsilon_{it} \quad (6)$$

[Figure 2 about here]

Figure 2 clearly illustrates that the exposure of UK exports to EU potential tariff threats is unevenly distributed across industries. The graph on the left shows that UK products would be potentially exposed to particularly high tariff threats from the EU in the agriculture and food industries, the textile and footwear sectors, and to medium-high level of tariff threats in chemicals, minerals and metals industries. Also around 30% of the products in the transport equipment manufacturing industry would face a very high risk of potential tariff threats. In addition, the diagram on the right shows that the potential tariff threat is not evenly distributed across UK exporters, but would particularly affect micro and small exporters, who are significantly more exposed to the potential tariff threat. Smaller exporters face disproportionately higher trade policy uncertainty and hence are more vulnerable for two reasons. First, micro and small exporters usually rely on very few exported products and would not be able to diversify their risk, as large multi-product firms would be able to do. Second, smaller exporters operate predominantly in mature manufacturing sectors, which are more prone to po-

tential tariff threats. Thus, moving from a zero-tariff regime to a MFN trade regime would have disproportionate effects on exporters of different sizes, and therefore disrupt the trade flows of micro and small exporters, possibly pushing them to cease exports to the EU or divert them towards alternative trade destinations.

Secondly, we investigate the heterogeneous effect of trade uncertainty on UK exporters by modelling Brexit as a dynamic process rather than a single event. As discussed in Section 2, the referendum result increased the likelihood of a change in trade regime, but the specific changes in policy and their timing remained uncertain for a long period. We argue that the perception of uncertainty about future trade relations between the UK and the EU has not been homogeneous during this period, but has dynamically evolved following the political decisions and strategies of the UK government at different points in time. For instance, Graziano et al. (2020*a*) have modelled how the increase in the probability of a UK exit from the EU has reduced bilateral export values and trade participation, using daily-frequency data on the variations in the average price of contracts predicting the referendum outcome. Therefore, we change our benchmark specification as follows, modelling $Brexit_q^E$ as a dynamic process hinged on three main events which significantly increased the likelihood of the UK leaving the EU: first, the announcement of the date of the referendum made by the PM in the first quarter of 2016 after the end of the re-negotiations with the EU; secondly, the Brexit referendum, taking place at the end of the second quarter in 2016; and finally the triggering of Article 50 made at the end of the first quarter of 2017, marking the beginning of the formal process of exiting the EU.

$$\begin{aligned}\Delta ln(y_{iq}) = \beta_0 + \beta_1 Brexit_q^E + \beta_2 Exp.Size_{it-1} + \beta_3 Brexit_q^E \times Exp.Size_{it-1} + \\ + \beta_4 ln(Size_{it-1}) + \beta_5 ln(y_{iq-4}) + \beta_6 \Delta(Ex.Rate_{iq}) + \gamma_i + \gamma q + \gamma_{pt} + \varepsilon_{it} \quad (7)\end{aligned}$$

These events have significantly affected the level of uncertainty in the UK surrounding Brexit. Several recent studies have tried to model this dynamic evolution of

uncertainty in an alternative way by making use of several uncertainty indices. We follow some of these approaches to show the correlation between these three events and uncertainty, and to overcome some of the challenges in defining and measuring uncertainty. We first make use of the Baker et al. (2016*b*) Economic Policy Uncertainty (EPU) index, proxying time-variant country-specific economic uncertainty based on the newspaper coverage of policy-related economic uncertainty, the number of national tax code provisions set to expire in future years, and the disagreement among economic forecasters. Secondly, to make sure we are capturing Brexit-related uncertainty, we use the Bank of England Brexit Uncertainty Index (BUI) developed by Bloom, Bunn, Chen, Mizen, Smietanka, Thwaites & Young (2019) based on the Decision Makers Panel survey of around 3,000 firms responding every month, and representing the share of firms which rate Brexit as one of the three highest drivers of uncertainty for their business. In addition, we follow Javorcik et al. (2019) by using indexes based on Google searches of specific keyword related to Brexit and trade arrangements. Google Trends provides public information on the Google searches of specific keyword combinations within a given country over time, offering an alternative way to gauge the degree of public concern surrounding Brexit and future trade policy. We use searches for the keywords combinations of "Brexit No-Deal" and "Brexit Tariffs", and the index represent the relative measure of searches in respect to the maximum observation. Figure 4 displays how these indices vary significantly over time, and how they are correlated with each other and the three main key Brexit events ($Brexit_q^E$) we previously considered in equation 7 to model Brexit uncertainty. It is possible to notice that according to most indicators uncertainty started to change significantly at the announcement of the referendum, before reaching high levels in Q3-2016 after the results of the referendum. Uncertainty remained high even after the trigger of Article 50, and started to increase again in 2018 when the possibility of not agreeing on a trade deal between the UK and the EU became increasingly likely. We thus change the previous specification as follows, replacing the Brexit dummy or categorical variables with a continuous variable, $Brexit_q^I$, in order to exploit the higher dynamic variance of these indexes at the quarter

level, and their ability to better capture Brexit and trade specific uncertainty:

$$\Delta ln(y_{iq}) = \beta_0 + \beta_1 Brexit_q^I + \beta_2 Exp.Size_{it-1} + \beta_3 Brexit_q^I \times Exp.Size_{it-1} + \\ + \beta_4 ln(Size_{it-1}) + \beta_5 ln(y_{iq-4}) + \beta_6 \Delta(Ex.Rate_{iq}) + \gamma_i + \gamma q + \gamma_{pt} + \varepsilon_{it} \quad (8)$$

[Figure 4 about here]

The last part of our analysis investigates then the heterogeneous impact of Brexit uncertainty on the exporting patterns of UK firms, based on their productivity and resources proxied by exports size. To do so, we first decompose our dependent variables into their two components, as highlighted by equation 1, thus estimating equation 4 separately for EU and extra-EU trade flows. This would help us to identify the source of the variation in the growth of export margins across the size of exporters, evidencing if it is driven by *diversion*, a drop in exports to the EU and a contemporaneous growth in exports to extra-EU markets, or *destruction*, a drop in exports to the EU while the growth in extra-EU exports remains stable.

Further, we attempt to identify patterns in the direction of diversion towards extra-EU markets, to analyse which markets are considered by UK exporters as potential key trade partners in a post-Brexit world. Following the baseline specification in equation 4, our dependent variables in this case will compare growth of exports to the EU with the growth of exports to specific groups of extra-EU countries. First, following the key principles of trade gravity models (Anderson & Van Wincoop 2003, Head & Mayer 2002, Head et al. 2010), we classify extra-EU countries based on the quartile distribution of average GDP per-capita. Secondly, we distinguish between 4 main groups of extra-EU destinations: (i) member states of the Commonwealth, with whom the UK maintains a privileged relation as the former colonizer[17], (ii) the BRICS group of

[17]The Commonwealth includes 53 extra-EU members across 4 continents: Botswana, Cameroon, Gambia, Ghana, Kenya, Kingdom of Swatini, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Seychelles, Sierra Leone, South Africa, Uganda, Tanzania, Zambia, Bangladesh,

emerging economies (Brazil, Russia, India, China and South Africa), (iii) the group of rich extra-EU countries part of the OECD[18], and (iv) the group of countries which had a Free Trade Agreement (FTA) in force with the EU in 2016 and did not automatically grant preferential access to UK exporters after the exit from the EU. In this way, we investigate where UK exports have been diverted to, trying to understand the role of the traditional gravity forces discussed in the literature in shaping uncertainty-induced diversion (Anderson & Van Wincoop 2003).

Similarly, we investigate whether potential diversion and destruction effects vary across EU destinations. There is a high degree of variation in the importance of the UK as a trading partner for different EU member states and vice-versa.[19] This could be reflected in a differential effect of Brexit uncertainty on the diversion and destruction of UK export flows towards the EU, in particular for smaller exporters who are usually more reliant on geographically and culturally proximate markets.

We develop further additional analysis and robustness tests to corroborate our results. First, we analyse the impact of Brexit uncertainty on UK imports, in a similar way as we do for exports. In fact, policy uncertainty might not have affected only UK exporters, but also other firms engaged in global value chains of production through importing intermediate goods from EU countries. Despite some previous evidence on

Brunei, India, Malaysia, Pakistan, Singapore, Sri Lanka, Antigua, Bahamas, Barbados, Belize, Canada, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St Kitts and Nevis, St Vincent and The Grenadines, Trinidad and Tobago, Australia, Fiji, Kiribati, Nauru, New Zealand, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

[18]This group includes the following extra-EU countries: Canada, Chile, Iceland, Israel, Japan, Korea, Mexico, New Zealand, Norway and the United States.

[19]Tables A.2 and A.3 in the Appendix report the relative importance of EU countries as trade partners to the UK and vice versa for 2015. In aggregate, the EU accounted for about 44% of total exports and 54% of UK total imports. However, the variation across EU countries is very large, where Germany, France, the Netherlands and Ireland account for more than 25% of total exports and imports, while Cyprus, Croatia and Slovenia are the least important markets for UK firms. On the contrary, the UK accounts for only 7% of total exports and 4% of total imports of the EU, but is for instance a key trading partner for Ireland, Germany, Belgium, the Netherlands, Cyprus and Malta, while representing marginal trade shares for many Central and Eastern European countries.

this topic (Ahmad et al. 2020, Graziano et al. 2020*b*), it is difficult to predict whether Brexit uncertainty affected imports in an analogous way to exports or if instead the effect was asymmetric. Thus, this analysis will provide initial empirical evidence on the differential impact of policy uncertainty on exports and imports across firms size.

In addition, we perform several robustness tests to check the validity of our main results. First, to make sure that our results are not picking up a more general trend taking place during the same period but completely unrelated to Brexit uncertainty, we perform several falsification exercises in which we fictionally and randomly assign the different Brexit treatments at different points in time between 2012 and the beginning of the Brexit process in 2016. We report in Table 4 representative results for one of these falsification tests, where the Brexit placebo treatment was set in Q3-2014[20].

Secondly, given the concern of possible omitted variable bias related to other product or country specific time-variant factors not currently accounted for in our main specifications, we develop an alternative identification strategy based on a panel dataset at the firm-transaction (product-county) and quarter level:

$$ln(y_{ipdq}) = \beta_0 + \beta_1 Brexit_q^D + \beta_2 EU_d + \beta_3 Exp.Size_{it-1} + \beta_4 Brexit_q^D \times EU_d \times Exp.Size_{it-1} + \\ + \beta_5 ln(Size_{it-1}) + \beta_6 ln(y_{ipdq-4}) + \beta_7 \Delta(Ex.Rate_{idq}) + \gamma_i + \gamma q + \gamma_{pd} + \gamma_{pt} + \gamma_{dt} + \varepsilon_{it} \tag{9}$$

In this specification, the dependent variable $ln(y_{ipdq})$ is the natural log of firm i transaction pd export value at quarter q. The main coefficient of interest will be β_4, capturing the heterogeneous effect of the post-Brexit referendum period ($Brexit_q^D$) on UK exports to EU countries (EU_d) across the distribution of UK exporters' size ($Exp.Size_{it-1}$). Similarly to the baseline specification, We further control for the exporter size ($ln(Size_{it-1})$), the lagged value of transaction exports ($ln(y_{ipdq-4})$) in the same quarter in the previous year, and firms' exposure to destination specific exchange

[20]Results of other placebo tests are consistent and available upon request.

rate fluctuations $\Delta(Ex.Rate_{idq})$. To control for residual sources of unobserved heterogeneity, we exploit the granularity of the data by including a wide range of fixed-effects. As in the baseline specification, we include firm (γ_i) and quarter (γ_q) fixed-effects; in addition we control for transaction level time invariant factors (γ_{pd}), product-year (γ_{pt}) and destination-year (γ_{dt}) time trends to eliminate any residual unobservable variability linked to product-specific or destination-specific dynamic shocks. This approach gives us the possibility of a much more stringent identification, however it prevents us from fully analyse the heterogeneous effects across exporters trade margins and the extent to which Brexit uncertainty caused trade destruction and diversion. We therefore use this methodology only as a robustness test. To further check the validity of our other main results, we employ a similar identification strategy looking at the number of products exported to each destination country, the heterogeneous effect along the potential tariff threat distribution, and the dynamic effect of Brexit uncertainty on UK exporters transactions values using different measures of uncertainty as previously discussed.

Finally, additional sensitivity tests replicate our baseline analysis using different data frequencies, initially exploiting as much as possible the granularity of the data at the monthly-level and then testing the noise of high-frequency data when collapsing the analysis to the semester level (Tables A.4 and A.5 in the Appendix). We also test the validity of the results by taking into account longer lags to calculate the growth rate in trade flows, considering up to 2 years' growth (Table A.6 in the Appendix). This is to make sure that our results are not driven by the specificity of the period of comparison, since uncertainty could have started before the actual Brexit referendum (Handley & Limão 2017), or previous periods might have been characterised by an export growth differential exceptionally positive towards the EU. In addition, we control that our results are not altered by a potential selection bias, since Brexit uncertainty have driven firms' entry and exit from the export markets as shown by Crowley et al. (2020). To this end, we examine whether the same effects are found when focusing only on firms that have always exported over the whole period, using a balanced panel

consisting only of these firms (Table A.7 in the Appendix). Finally, we check whether our results depend on the different number of countries that are within the EU relative to extra-EU countries, weighting the dependent variables by the total number of available destinations within and outside the EU (Table A.8 in the Appendix)[21].

5 Results

5.1 Baseline Results

Table 1 reports the results of our baseline model specified in equation 4, looking at the heterogeneous effect of Brexit uncertainty across the four quartiles of the size distribution of UK exporters, measured in terms of annual total exports. We use a fixed effect model with time, exporter and product-trend fixed effects to control for unobserved heterogeneity. A number of alternative trade margins are used as dependent variables, including the change in growth of firms' total export value, total number of products exported, total number of destinations served, the growth in the overall numbers of new products introduced and new destinations served.

[Table 1 about here]

What becomes immediately clear is that size matters. Table 1 shows that micro and small exporters have experienced the largest negative effect on the growth of all trade margins towards the EU vis-a-vis non-EU markets. Total export values growth for micro and small firms has decreased by 45% and 19% respectively as a result of the Brexit Referendum, while medium exporters have experienced a similar pattern but in a smaller magnitude. This is the case for other trade margins too. For growth in both products and destinations, micro, small and medium sized exporters have been most

[21] In other words, in deriving the Diff-in-Diff in the EU and the extra-EU we weight by 27 and 243 as the available destination in each market respectively, before calculating our net Diff-in-Diff ($\Delta ln(y_{it})$).

negatively affected by Brexit-related uncertainty. In contrast, large exporters increased export values towards EU markets more rapidly than to extra-EU destinations. In particular, although experiencing a negative impact on the growth of products exported and destinations served in the EU in comparison with extra-EU, large firms have enjoyed an acceleration in the growth of their export value. Combining the evidence, these findings suggest that large exporters might have substituted smaller exporters in serving the EU market, taking up their market shares.

Brexit uncertainty effects might be disproportionately larger for micro and small exporters because these firms are often financially constrained, and lack the capability to quickly adjust their production to economic shocks, relying heavily on fewer products and smaller volumes of trade flows to geographically and culturally proximate markets (Shoag & Veuger 2016). This finding has important policy implications. It sheds light on the type of exporters who are potentially more likely to be affected by uncertainty and hence might benefit more from public support. Future trade policies and support services should target mainly small-medium exporters, to help them overcome trade uncertainty which could overwhelmingly hinder their export performance, especially towards their traditional export markets.

Overall, the Brexit referendum has negatively affected both UK exporters' intensive and extensive margins of trade. This provides new evidence of the negative impact of Brexit on UK exports, beyond the typical ways of identifying the entry-exit probability for UK firms in relation to exporting, as highlighted in previous studies (Crowley et al. 2020). On average, UK traders have decreased their export values towards EU countries by 8.7% in comparison with non-EU countries in the post-Brexit referendum period. A back-of-envelope calculation reveals that the overall effect of trade destruction and diversion from the EU due to Brexit amounts to about £10.5bn. This is the magnitude of the aggregate net effect, considering both the positive effect for large firms and the

negative one for SMEs, thus indicating that the negative effect for small exporters must have been much larger.[22]

As previously discussed, Brexit uncertainty could have affected UK exporters differently according to their size because of the different products exported by these firms, and their relative product-specific potential threat of tariffs impositions under a "no-deal" scenario. We test this hypothesis by exploiting the difference in tariffs between the EU Customs Union zero-tariff regime and the EU tariff schedule under MFN-terms, as previously shown in the across-industries variation in Figure 2. Using data on MFN tariffs from the WTO, we report in Figure 3 the estimates of the effect of Brexit uncertainty on the change in growth of exports margins by level of risk of facing future potential tariffs from low (Q1) to high (Q4), as modelled in equation 6.[23]

[Figure 3 about here]

The results highlight a large and statistically significant effect, mostly in the middle-upper end of the distribution. This suggests that the negative impact of Brexit uncertainty previously observed is concentrated mostly in firms exporting products which might have faced potentially higher EU tariffs. This effect is especially pronounced in terms of the intensive margin, the export value, and also smaller extensive margins, the change in growth in the number of products exported and destinations served, for those

[22] We calculate this counterfactual export value using the average UK export volumes to both the EU and extra-EU in the pre-Brexit period, which account for about £151bn and £153bn, and the average annual growth of these flows of about -0.33% and -0.19%, respectively, and a deviation of about 8.73% as estimated and reported in Table 2. The details of the calculation are provided in Appendix B. The procedure implies some assumptions. First, we correct the pre-Brexit trade flows by adjusting for 1 year of the previous trend growth rates of about -0.33% and -0.14% respectively. We then adjust each trade flow for the estimated change of the post-Brexit dummy. These are used to produce a new total effect. Applying previous growth ratios to the new total trade flows, we obtain a counterfactual, where total trade has changed but the growth rate ratio has not. Finally, the shift is then found by comparing actual values with this counterfactual.

[23] In order to build a firm-level measure of exposure to potential tariff-threats, we have first calculated the difference for each product between the current customs union zero-tariff and the MFN tariff imposed by the EU on third countries outside the EU. We have then calculated the weighted average potential tariff by weighting the potential tariff increase for each product by its share in the firm's total export value.

products at the top-end of the potential tariffs threat distribution. When combining this analysis with the that of size heterogeneity, it also becomes evident that micro and small exporters are mostly affected because of the kind of products they export. The exposure to potential tariff threats is not evenly distributed across UK exporters, but it is particularly severe for micro and small exporters. SMEs usually rely on very few export transactions, mostly directed towards proximate and easily accessible traditional EU markets, and tend to export mostly mature manufacturing goods which are more exposed to potential tariff threats by the EU, such as agri-food products, textiles and footwear, chemicals and metal products. This is the evidence of a compounding effect of Brexit uncertainty on smaller firms, both because of the limited resources of smaller firms and because of their over-reliance on a limited number of products at high risk of tariffs exported mostly to proximate EU markets.

We carry on our analysis by investigating the heterogeneous effect of trade uncertainty on UK exporters, modelling Brexit as a dynamic process rather than a single event. The results above consider only the Brexit referendum shock as the main variable of interest. However, the perception of uncertainty about future trade relations between the UK and the EU has not been homogeneous since the announcement of the referendum, and has dynamically evolved with the political decisions and changes in the strategies of the UK Government at different points in time as shown in Figure 4. For this reason, following equation 7, in Figure 5 we first model the effect of Brexit on exports margins as a dynamic process hinged on three main events which have significantly increased the likelihood of the UK leaving the EU: the announcement of the referendum in Q1-2016, the Brexit referendum in Q3-2016, and the triggering of Article 50 in Q2-2017.

[Figures 4 and 5 about here]

We find that the Brexit referendum announcement did have an anticipatory impact on the value of exports to the EU, increasing almost 10% faster than exports to extra-

EU markets. We consider this as evidence of an anticipation effect by UK exporters and their EU trading partners, where firms might have anticipated their orders for existing trade flows in order to stockpile before the potential disruption and increase in uncertainty that a victory of the "Leave" campaign in the referendum might have caused (Handley & Limão 2017).

Next, we look at the effect of the results of the Brexit referendum, and find a negative but not statistically significant impact on the margins of exports towards the EU. However, when we turn to examine the effect of the triggering of Article 50 at the end of the first quarter in 2017, we find the strongest evidence of a reduction in exports margins growth for shipments towards the EU in comparison with extra-EU destinations. In fact, across all specifications these effects are consistent and seem stronger than the effects observed from the Brexit referendum. This evidence is in line with theoretical predictions from the previous trade policy uncertainty literature. In fact, while immediately after the referendum it was not clear if the UK Government would be following the indication of the referendum, and when the actual negotiations with the EU were still to start, the triggering of Article 50 confirmed that the UK would have to renegotiate its trade relationship with the rest of the EU, initially fixing the departure date for the 29th March 2019.

We further investigate the dynamic evolution of uncertainty over this period by using several time-variant uncertainty indices used in recent related literature - i.e. reported in Figure 4 - to estimate the heterogeneous effect of Brexit uncertainty on exporters following equation 8. Results in Table 2 report the results for two of these indexes, the Baker et al. (2016*b*) Economic Policy Uncertainty (EPU) and the "No-Deal" Google Trends index[24]. Similarly to the results reported in Table 1, our findings show that even when considering Brexit uncertainty as a dynamic process especially micro exporters

[24]Results using the BUI index and the Google Trends keywords combination for "Brexit Tariffs" are consistent and available from the authors upon request.

are the most negatively affected across all exports margins. These results are consistent when using both the EPU and the "No Deal" Google indexes. Contrary to previous findings, we do not observe any significant effect for small and medium exporters, while large exporters seem to profit from this period of uncertainty, as shown before in Table 1. These results further corroborate our main findings, illustrating how micro exporters are the most exposed to trade uncertainty, in particular when the likelihood of a "no-deal" scenario increased, which would have left smaller exporters struggling to cope with higher tariffs and an increased bureaucratic burden.

[Table 2 about here]

5.2 Uncertainty and Exports Diversion

What previous results establish is that UK exporters have experienced a significant decrease in the growth of export margins towards the EU in respect to extra-EU exports as a consequence of Brexit uncertainty. We have shown that this has affected not only the value of exports, but also the number of products exported and the number of EU markets served. In addition, our findings suggest that the impact of uncertainty has been heterogeneous, badly affecting in particular smaller exporters, while larger ones have experience a growth in terms of both the intensive and extensive margins of exports. However, these findings do not inform us if the effects are driven by a decrease in exports to the EU, an increase in extra-EU flows, or both. Disentangling these effects could help us to better understand whether the negative effect was driven by a diversion from the traditional EU market, or if instead it was simply the result of a destruction of exports flows due to an increase in the exporters' productivity cut-off. To capture the underlying trends of intra and extra-EU flows, net of fixed effects and control variables, we predict the resulting changes in the growth of key variables of interest separately for the two markets as previously explained.

[Figure 6 about here]

Figure 6 shows the evolution of export values, numbers of destination and of products separately for EU and extra-EU exports respectively, differentiating between exporters size. Across all three exports margins it is possible to notice a clear pattern. In particular, we identify effects of trade destruction for micro exporters, ceasing their exports towards EU markets and also significantly reducing the value of exports towards extra-EU markets. There is evidence instead that Brexit uncertainty has caused trade diversion for small and medium enterprises. Small exporters reduced significantly exports values, the number of products exported and of countries served in the EU, but at the same time they have partially replaced these with stronger exports towards extra-EU markets, in particular in the case of medium-sized exporters. On the contrary, larger exporters do not seem to be negatively affected by Brexit uncertainty, maintaining stable export relationships with EU partners, even significantly increasing the value of exports towards the EU, and further exploring extra-EU markets slightly increasing the number of products exported and of new extra-EU markets served. One reason for this may be due to the fact that large exporters might have more resources and skills to mitigate potential risks associated with Brexit uncertainty compared to smaller exporters, profiting from high-volatility periods, and possibly replacing smaller exporters to increase their market shares in the EU. These results identify an heterogeneous responses of UK exporters to the perceived potential threat of future trade barriers between the UK and the EU, with a reduction of export flows towards EU markets for smaller firms, perceived as riskier than before in comparison with extra-EU markets, for which instead the trade regimes have not changed, and are thus relatively less volatile and risky. Although affected by uncertainty, medium and large companies have the knowledge and resources needed to cope with these adversities. Nevertheless, small and micro size companies have suffered greatly from this uncertainty, experiencing a decline in export growth in their traditional markets, while struggling to diversify towards new extra-EU markets. Thus, uncertainty regarding potential future tariffs has led to a substantial drop in UK exporters performance, both in terms of new entry, as demonstrated in previous studies (Crowley et al. 2020), but also in terms of export

margins, as reported by our analysis. In addition, our results support the predictions of previous theoretical studies on the aggregate effect of policy uncertainty on trade relationships, disentangling the impact on different margins of trade (Limão & Maggi 2015, Handley & Limão 2017).

Clearly, the diversion from proximate, larger, and richer EU markets towards more distant, often smaller and less rich extra-EU markets for medium and large exporters is an intriguing pattern. This seems to contradict the theoretical predictions of the traditional trade gravity models, which argue for the role of distance and economic mass in shaping the direction and volume of trade flows (Anderson & Van Wincoop 2003, Head & Mayer 2002, Head et al. 2010). Thus, we further investigate the direction of exports diversion and seek to understand how Brexit uncertainty has shaken the traditional features of trade gravity models for large UK exporters. We start in Figure 7 by comparing the effect of Brexit uncertainty on the intra-EU exports margins with respect to groups of extra-EU countries based on their distribution of GDP per capita. Although the comparison is not as striking as before, both the intensive and extensive margins of trade towards EU countries have decreased in comparison with extra-EU countries in the third quartile of the distribution, that of upper-middle income countries, again mainly for micro and small firms.

[Figure 7 about here]

In addition, we take a closer look at four main groups of extra-EU destinations: Commonwealth countries, the BRICS group of emerging economies, the group of extra-EU OECD countries and the group of extra-EU countries with an FTA in place with the EU. As shown in Figure 8, we try to identify more precisely if the exports diversion has been more pronounced vis-a-vis specific groups of extra-EU countries. In addition, we also test whether UK exporters anticipate potential future trade agreements following the UK's departure from the EU, along with the announcement made by the UK Government about new trade negotiations with distant rich partners, some dynamic

emerging economies and other countries sharing cultural, institutional and former colonial ties[25].

[Figure 8 about here]

Figure 8 reports the results in relation to the distribution of UK exporters' size, trade margins and group of extra-EU countries. Only in the case of micro exporters we find different patterns of divergence across different groups of extra-EU destinations, where the divergence with respect to intra-EU flows is significantly larger for Commonwealth and BRICS countries, and to a lesser extent to the extra-EU OECD countries, in line with the existing macroeconomic evidence (Douch & Edwards 2021*a*). These results suggest that UK micro exporters have experienced a much larger decrease in exports to the EU in comparison with exports towards countries with former colonial and historical ties, or towards emerging economies where future market access potential could offset some of the current costs of trading. This may also reflect the impact of policies and campaigns of the UK Government intended to promote and support exporters to explore new rapidly growing extra-EU markets.

Finally, we investigate how policy uncertainty might have affected heterogeneously the export flows between the UK and specific EU member states. There is a high degree of heterogeneity in the significance of the UK as a trading partner for different EU member states, which could be reflected in differential effects of Brexit uncertainty on the diversion of UK exporters. The breakdown of these effects by different EU countries allows us to identify whether uncertainty mainly affects specific markets or it is a general trend across all the Single Market. In particular, the heterogeneous effect among EU destinations may reflect the strength of the links between these markets and

[25]For an overview of the future trade relationships envisaged by the UK Government after leaving the EU, refer to the House of Commons International Trade Committee report (https://publications.parliament.uk/pa/cm201719/cmselect/cmintrade/667/667.pdf), the Department for International Trade strategy (https://www.gov.uk/government/speeches/britains-place-in-the-global-trading-system), or some recent references in the academic debate (Hearne et al. 2019).

the UK, given that a high share of overall UK exports goes to Germany, the Netherlands, France, Ireland, Belgium and Italy as shown in Tables A.2 and A.3 in the Appendix.

[Figure 9 about here]

Figure 9 shows that Brexit uncertainty has reduced in particular the value of exports of UK SMEs going to secondary partners in the EU, such as Spain and Portugal, and many Central and Eastern European countries. The only main EU trade partner negatively affected in terms of value is France, which has experienced a decrease of imports from UK SMEs by around 10% in comparison to UK SMEs exports going to extra-EU markets. On the contrary, the effect of policy uncertainty on the number of products exported by UK SMEs towards EU member states in comparison to extra-EU markets has been much more evenly spread across EU countries. Again, France has been the country most affected among the main UK trade partners, but in general UK SMEs have experienced a decrease in the growth of products exported to all EU countries, with particularly high negative effects for products exported to Italy, Austria, Slovenia, Greece, Portugal, Belgium and Finland. What these results highlight is that policy uncertainty has had heterogeneous effects not only among firms but also across EU destinations, where UK exports flowing towards the main EU trade partners have been more resilient to policy uncertainty, though with the exception of exports to France.

5.3 Additional Results & Robustness Tests

We perform several additional analyses to complement and corroborate our main findings. First, as previously discussed, Brexit uncertainty might have affected not only UK exporters, but also firms engaged in global value chains of production importing intermediate goods. We hence analyse whether Brexit uncertainty has also affected import flows, and if there has been an asymmetric effect between the two trade flows.

In particular, we might expect an analogous response by UK importers due to the uncertainty surrounding future trade relations.

[Table 3 about here]

By replicating the previous analysis of the export effect of the Brexit-induced uncertainty on imports among UK importers of different sizes, we find a significant negative effect in particular for micro and small importers, as shown in Table 3. The uncertainty has reduced intra-EU imports on average by 6.5% after the Brexit referendum in comparison with extra-EU imports. The effect is similar to total exports, although much larger in magnitude, and we also find similar patterns across other trade margins. For instance, there has been on average a 1.7% decrease in the number of products imported from the EU in comparison with extra-EU markets since the referendum result, but no significant effect in terms of the number of countries of origin. This suggests that smaller firms, exporting, importing or both, react more strongly to the mounting uncertainty about the post-Brexit trade regime, presumably because of their vulnerability facing looming risks. While the negative effect has been much stronger for micro and small firms in terms of imports rather than exports, there has been a positive effect in terms of values of imports for large firms. This could have been driven by large firms stockpiling as trade uncertainty increased, while micro and small firms have seen their limited import flows based on a few products lines disrupted by the uncertainty about Brexit.

We then perform several sensitivity tests to check the robustness of our main findings[26]. First, we check that our results do not pick up a more general trend taking place during the same period but completely unrelated to the Brexit uncertainty. In

[26]See the Appendix for additional robustness tests replicating our baseline analysis using different data frequencies (Tables A.4 and A.5), longer lags to calculate the growth rate in trade flows (Table A.6), focusing only on firms that have always exported over the whole period (Table A.7), or weighting the dependent variables by the total number of available destinations within and outside the EU (Table A.8).

order to do so, we perform several falsification tests in which we fictionally and randomly assign the different Brexit treatments at different points in time between 2012 and the beginning of the Brexit process in 2016. Acemoglu et al. (2016) highlight the requirement of a falsification test when considering a treated group and a control group in a difference-in-difference framework. In Table 4 we report the results of one of these placebo tests, showing no significant estimates of trade destruction or diversion effects of policy uncertainty when setting the Brexit referendum in June 2014 for example, corroborating with our main findings.[27]

[Table 4 about here]

Secondly, given the concern of possible omitted variable bias related to other product or country specific time-variant factors not currently accounted for in our main specifications, we develop an alternative identification strategy based on a panel dataset at the firm-transaction (product-county) and quarter level as shown in equation 9, where the dependent variable is the transaction export value in each quarter. This approach gives us the possibility of a much more stringent identification by controlling for transaction level time invariant factors, product and destination time trends to eliminate any residual unobservable variability.

[Tables 5 and 6 about here]

Results in column 1 of Table 5 corroborate our main findings, showing evidence of a negative effect of Brexit uncertainty on the value of exports to the EU in particular for micro and small exporters, while larger exporters experience a positive increase in the value of exports to the EU. To further check the validity of our other main results, in column 2 we employ a similar identification strategy looking at the number of products exported to each destination country, finding again a negative effect of uncertainty, but

[27] We have randomly assigned the Brexit shock to various points in time before Q1-2012 and Q1-2016, always estimating insignificant effects. Results of these additional tests are available from the authors upon request.

only for micro exporters. Column 3 instead replicates the results shown in Figure 3, differentiating between products at higher or lower exposure to potential tariff using this alternative methodology. Again, these results are consistent with our main findings, identifying stronger negative effects of Brexit uncertainty on exports transaction values in particular for products which might face higher tariffs under a MFN scenario. Finally, in Table 6 we replicate the results presented in Table 1 looking at the dynamic effect of Brexit uncertainty on UK exporters transactions values using different indexes of uncertainty as previously discussed. Results in columns 1, 3, 4 and 5 are consistent with our main findings, showing an overall negative effect of the dynamic Brexit uncertainty on UK export transactions values to the EU. In addition, in column 2 we perform an additional falsification exercise, where we use as a measure of Brexit uncertainty the ratio between the UK and the US EPU indexes. This in fact should only marginally affect trade flows between the UK and the EU. In addition, the US experienced high levels of uncertainty over the same period, with the unexpected election of Donald Trump as President, and the following trade war with China. As a matter of fact, the effect of this UK/US specific uncertainty measure is not significant to explain changes in export transactions values between the UK and the EU. This further corroborates the robustness of our findings, and highlights how it was the specific Brexit-induced uncertainty that has affected UK exports to the EU.

6 Conclusions

Building on the current literature on the consequences of trade policy uncertainty, this study finds strong and robust evidence of the significant impact of trade policy uncertainty induced by Brexit on UK firms' exports. In particular, using a natural experiment this paper provides new insights on the type of firms that are more exposed to these uncertainties. In fact, contrary to the previous literature that assumed homogeneous effects across firms, we show that firm size matters in the capacity of absorbing

macroeconomic shocks. This heterogeneity can be explained by the different types of products that firms export and their tariff threat. Indeed, smaller firms tend to have a large share of their export basket at a high risk of potential tariffs under a "no-deal" scenario. Using Brexit as a quasi-natural experiment and analysing a period of particularly high policy uncertainty, we show how the anticipation of potential future trade barriers has had a significant heterogeneous impact on firms' exporting and importing decisions, even before the final implementation of Brexit. This highlights the fact that uncertainties may dampen cross border activity for smaller and less productive firms, due to their reliance on the exports of a limited range of goods, which are mostly traded only with geographically proximate markets, leading in turn to an increase in the productivity cut-off point at which firms engage in cross border activity. In particular our results show that micro and small exporters have seen the largest negative effect on the growth of all trade margins towards the EU vis-a-vis non-EU markets, while large firms gained some market share. This highlights a trade destruction for micro firms towards EU countries, partially offset by a trade diversion for SMEs toward distant extra-EU countries. These results hold also when we model Brexit related uncertainty as a dynamic process rather than as an event, and when performing falsification tests and alternative identification strategies. This finding has important policy implications. It sheds light on the type of exporters who are potentially more likely to be affected by uncertainty and hence might benefit more from public support. Future trade policies and support services should target mainly small-medium exporters, to help them overcome trade uncertainty which could overwhelmingly hinder their export performance, especially towards their traditional export markets.

In addition, this study provides new evidence about the mechanisms through which policy uncertainty affects trade, enriching the existing literature on firms' entry-exit export patterns. The evidence suggests that the Brexit-induced trade policy uncertainty had negative effects on the UK-EU trade both in terms of intensive and extensive margins. UK firms, and in particular smaller firms, traded less with EU partners over the

examined period, in terms of volumes, varieties of products and market destinations and increased their exports towards far away extra-EU countries. Not surprisingly, these effects are more pronounced for new traded products and new market destinations. This marks a clear overall picture of trade destruction and diversion.

The implications of these findings have considerable economic significance. The uncertainty induced by Brexit has proved to have a forceful impact. Redirecting from nearby, larger and similar trading partners to further away, smaller and relatively poorer markets implies that, ceteris paribus, UK firms are likely to face higher costs, increasing sunk costs of pursuing new markets and higher transport costs, reduced profits when dealing with less mature consumer markets, and potentially linked to lower opportunities to learn-by-exporting to less developed markets. This would weaken firms' competitiveness in a highly competitive international market. In the longer term, diverting from the advanced supply chain networks in the EU Single Market will have a severe and long-lasting effect in particular on smaller UK firms, affecting in turn jobs, productivity and economic growth.

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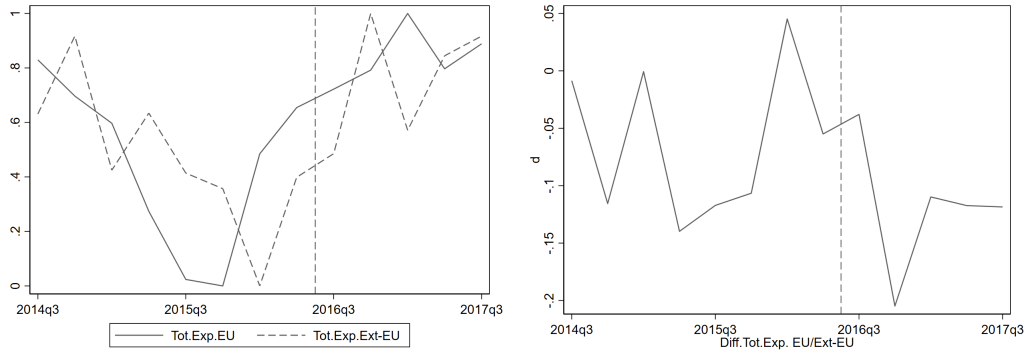
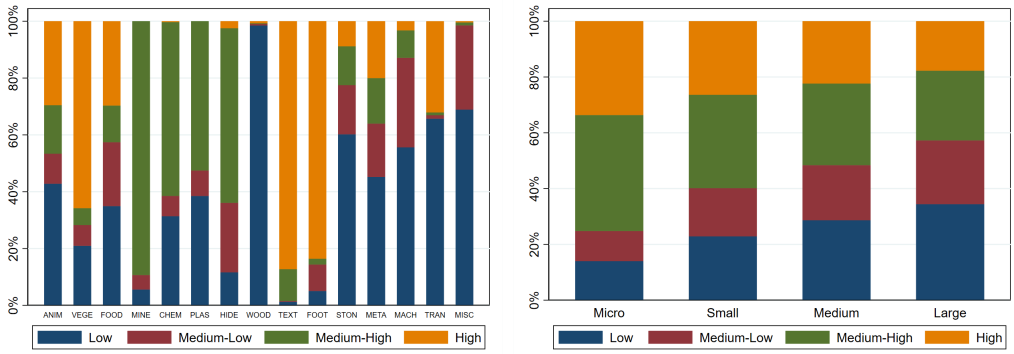
Tables and Figures

Figure 1: Quarterly growth in UK total exports towards EU and extra-EU markets



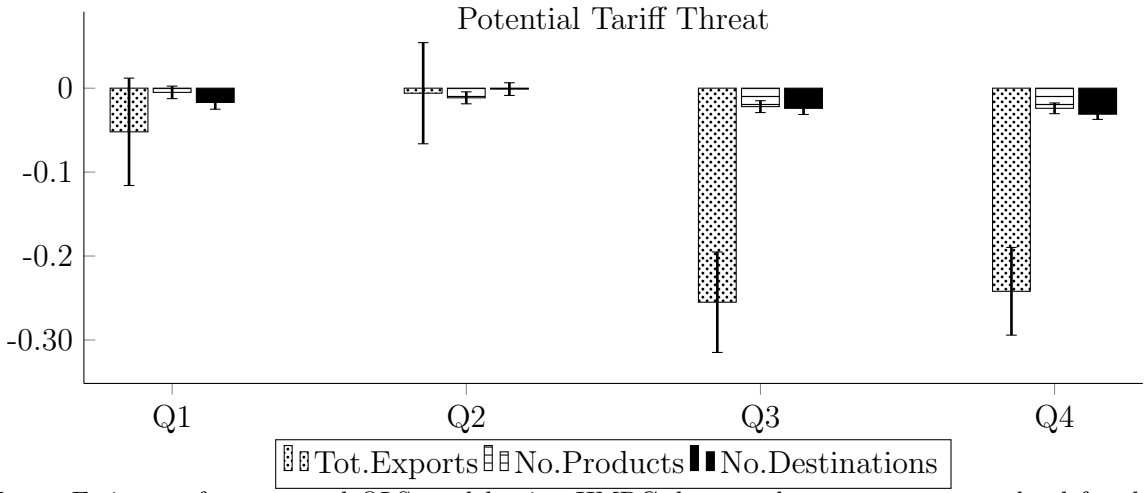
Note: Elaboration at the quarter-level based on the HMRC OTS database. The diagram on the left-hand side compares the average yearly growth in intra-EU and extra-EU exports flows for UK firms for each quarter between 2012-Q1 and 2018-Q4. The diagram on the right-hand side shows the difference between the two growth trends over the same time period.

Figure 2: Tariff exposure across product categories and exporters size.



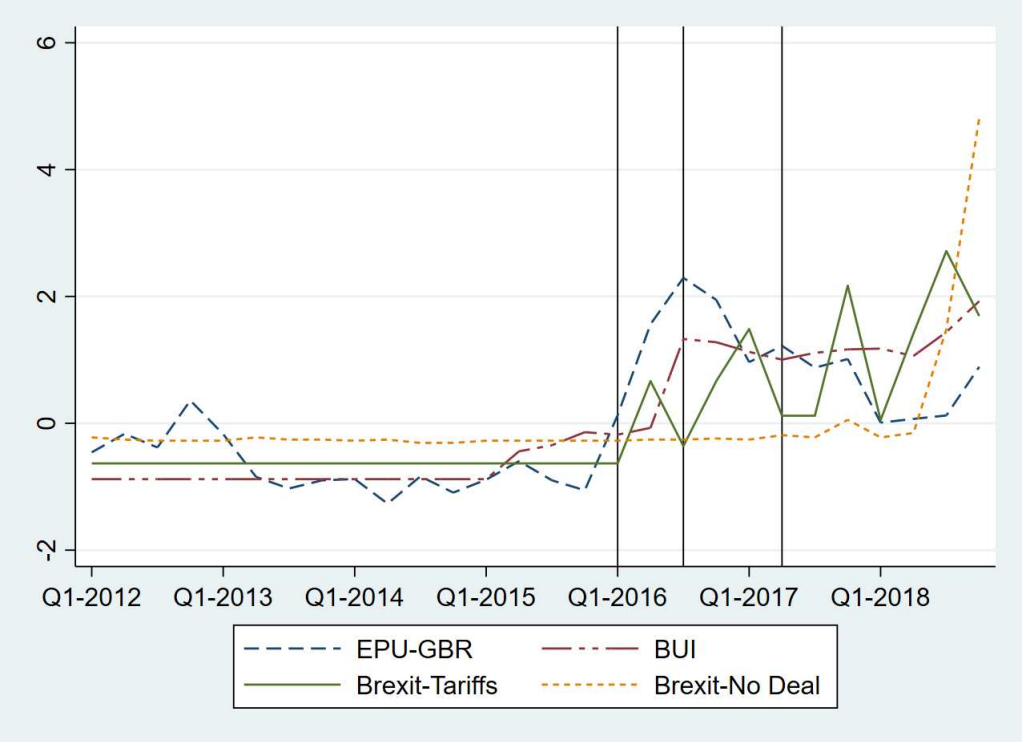
Note: Elaboration at the quarter-level based on the HMRC OTS database for the year 2015. Data on MFN tariff schedule for the EU obtained from the WB TRAINS database. Potential tariff threat measured as the difference between the zero-tariff faced by products exported under the EU custom union regime and the tariff UK products would face if exported under WTO rules applying the EU Most-Favoured Nation (MFN) tariff. Low potential tariff-threat, medium-low, medium-high and high threat categories based on the 4 quartiles of the tariff threats distribution. Exporter size categories based on the quartile distribution of firms annual total exports.

Figure 3: Heterogeneous effect of Brexit uncertainty on UK exporters trade margins across quartile distribution of potential tariff threat.



Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. Fixed-effects and control variables included as previously indicated. Potential tariff threats measured as the quartile distribution of the difference between the zero-tariff faced by products exported under the EU custom union regime and the tariff UK products would face if exported under WTO rules applying the EU Most-Favoured Nation (MFN) tariff, from low potential tariff-threat (Q1) to high threat (Q4). 95% confidence interval reported for each estimate.

Figure 4: Quarterly changes in Brexit uncertainty indexes 2012-2018.



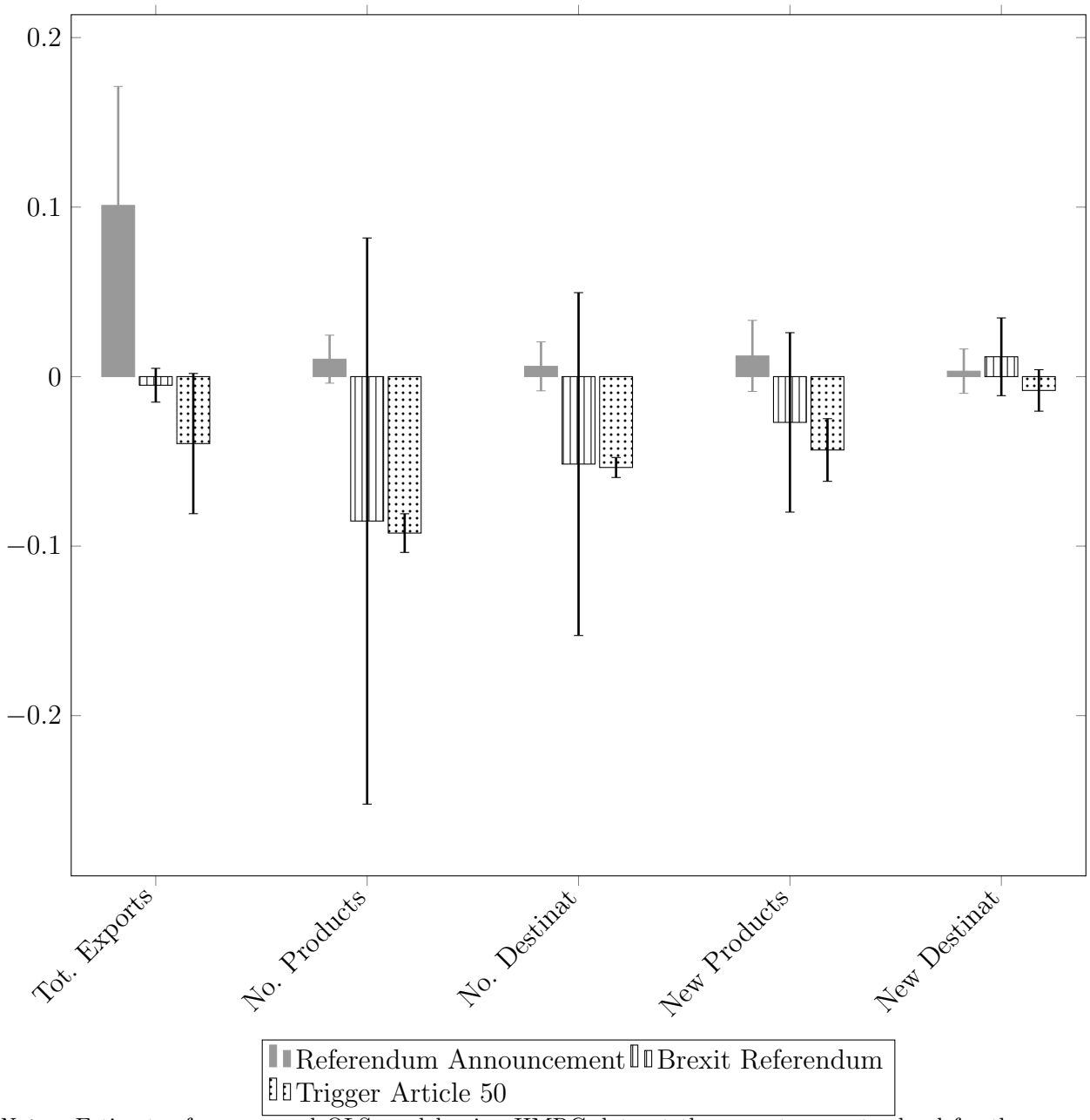
Note: Time series of the Economic Policy Uncertainty (EPU) index (Baker et al. 2016*b*), the Bank of England Brexit Uncertainty Index (BUI) (Bloom, Bunn, Chen, Mizen, Smietanka, Thwaites & Young 2019), and the Google Trends indexes for "Brexit No-Deal" and "Brexit Tariffs" keywords searches for each quarter between 2012-Q1 and 2018-Q4. Reference lines indicate the referendum announcement in Q1-2016, the Brexit referendum in Q3-2016, and the trigger of Article 50 in Q2-2017.

Table 1: Heterogeneous effect of Brexit uncertainty on trade margins across UK exporters' size distribution

Quarterly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
$Brexit_q^D \times$ Micro Exp.	-0.457***	-0.0356***	-0.0454***	-0.0552***	-0.0321***
	(0.0543)	(0.00658)	(0.00569)	(0.00781)	(0.00350)
$Brexit_q^D \times$ Small Exp.	-0.189***	-0.0266***	-0.0261***	-0.0517***	-0.0313***
	(0.0341)	(0.00597)	(0.00444)	(0.00926)	(0.00376)
$Brexit_q^D \times$ Medium Exp.	-0.0730***	-0.0238***	-0.0291***	-0.0505***	-0.0244***
	(0.0275)	(0.00493)	(0.00427)	(0.00564)	(0.00431)
$Brexit_q^D \times$ Large Exp.	0.261***	-0.0184***	-0.0184***	-0.0393***	-0.00855*
	(0.0432)	(0.00556)	(0.00671)	(0.00875)	(0.00479)
L.Dep.Variable	-0.936***	-0.896***	-0.919***	-1.008***	-1.038***
	(0.00843)	(0.00540)	(0.00617)	(0.00300)	(0.00180)
L.Exporter Size	-0.0802***	-0.00409***	-0.00230**	-0.00893***	-0.00717***
	(0.0163)	(0.00152)	(0.00109)	(0.00189)	(0.000757)
Ex. Rate Exposure	-0.0593**	0.00727*	0.00939*	-0.0281***	-0.00534
	(0.0285)	(0.00393)	(0.00493)	(0.00377)	(0.00427)
Observations	339,493	339,493	339,493	339,493	339,493
R-squared	0.504	0.569	0.536	0.516	0.551
No. Exporters	26,051	26,051	26,051	26,051	26,051
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Product-Trend	Y	Y	Y	Y	Y

Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated. Exporters size based on quartile distribution of firms total annual export value.

Figure 5: Dynamic evolution of the effect of Brexit uncertainty on UK exporters trade margins.



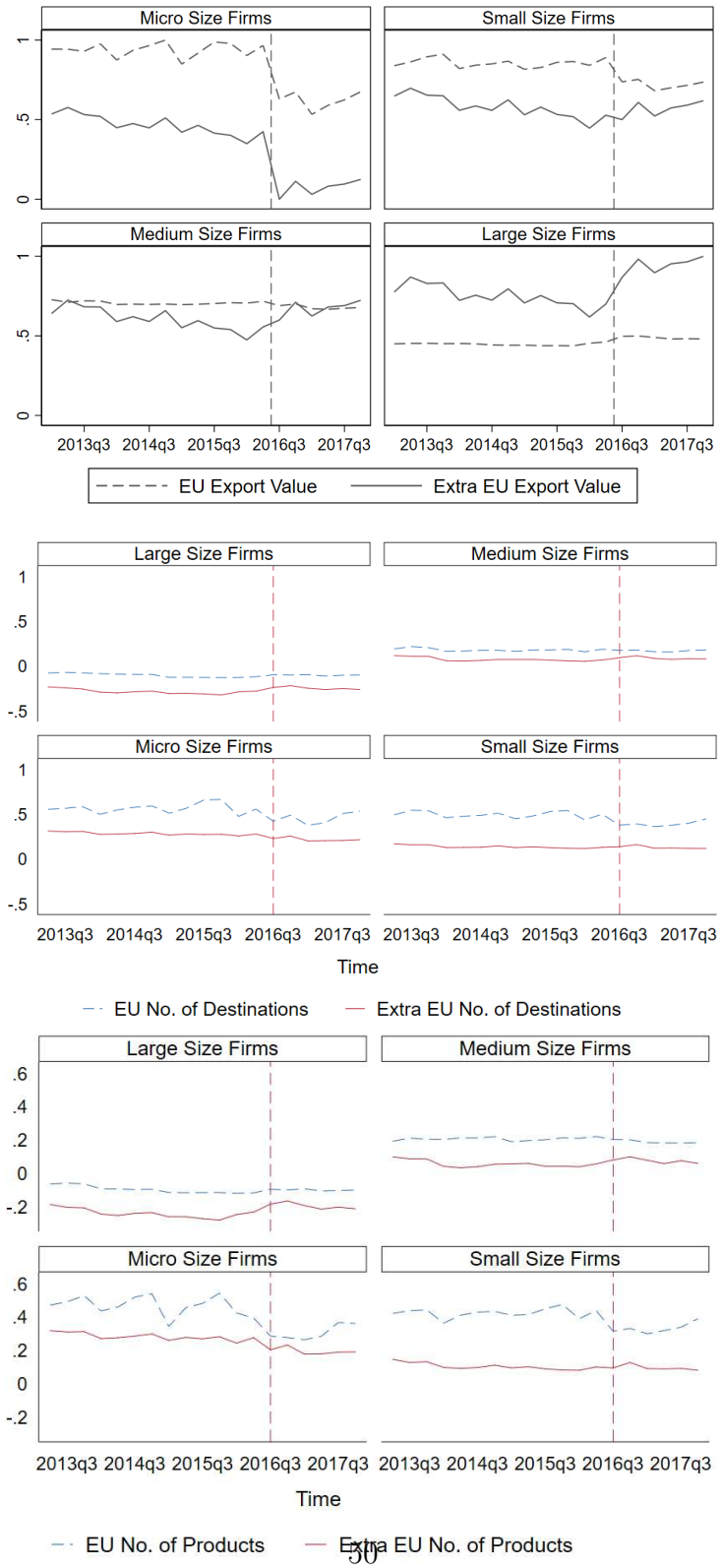
Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. 95% confidence interval reported for each estimate. Referendum announcement in Q1-2016, Brexit Referendum in Q3-2016, Trigger of Article 50 in Q2-2017.

Table 2: Heterogeneous effect of Brexit uncertainty on trade margins across UK exporters' size distribution - Dynamic evolution of Economic Policy Uncertainty (EPU) and "No-Deal" Google Trends indexes.

	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
EPU × Micro Exp.	-0.207***	-0.0507***	-0.0360***	-0.0469***	-0.0114
	(0.0705)	(0.00941)	(0.00808)	(0.0121)	(0.00770)
EPU × Small Exp.	0.000872	0.00829	0.0102	0.00749	-0.00936
	(0.0712)	(0.00886)	(0.00964)	(0.0112)	(0.00753)
EPU × Medium Exp.	0.0214	0.0121	0.00821	0.0130	-0.00614
	(0.0715)	(0.00938)	(0.00800)	(0.0120)	(0.00613)
EPU × Large Exp.	0.00368	0.0317***	0.0205***	0.0249	0.00143
	(0.0661)	(0.00880)	(0.00743)	(0.0153)	(0.00660)
No-Deal × Micro Exp.	-0.0516***	-0.0122***	-0.0118***	-0.0718***	-0.0124***
	(0.0105)	(0.00178)	(0.00168)	(0.00380)	(0.00200)
No-Deal × Small Exp.	-0.00689	-0.00450	-0.00106	-0.00436	-0.00114
	(0.0287)	(0.00436)	(0.00551)	(0.00468)	(0.00295)
No-Deal × Medium Exp.	-0.0188	-0.00401	-0.000456	-0.000989	0.00414
	(0.0362)	(0.00549)	(0.00492)	(0.00438)	(0.00393)
No-Deal × Large Exp.	0.00133	-0.00327	-0.000655	0.00113	0.0126***
	(0.0366)	(0.00545)	(0.00508)	(0.00520)	(0.00400)
Observations	339,493	339,493	339,493	339,493	339,493
R-squared	0.503	0.569	0.536	0.516	0.551
No. Exporters	26,051	26,051	26,051	26,051	26,051
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Product-Trend	Y	Y	Y	Y	Y

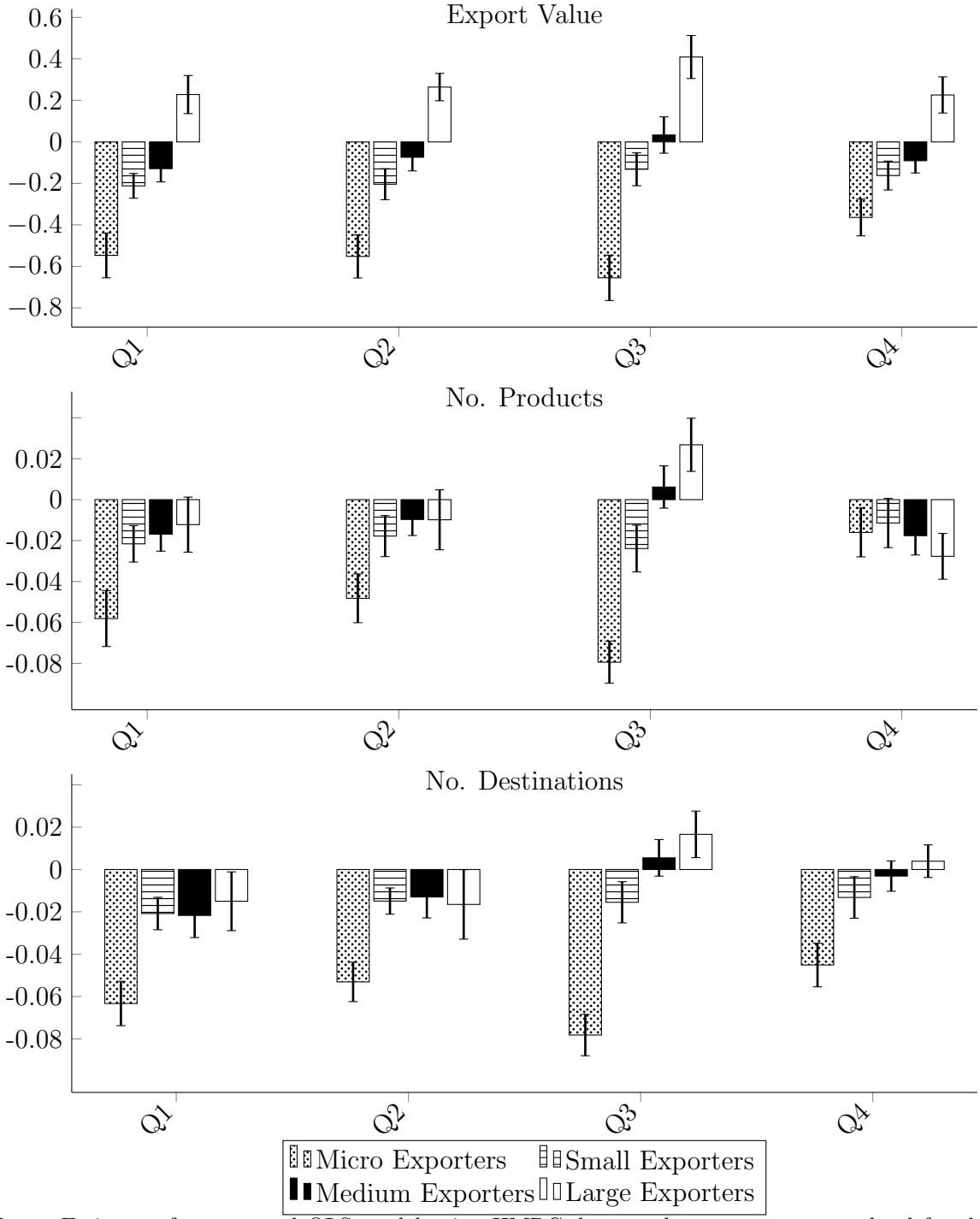
Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated. Exporters size based on quartile distribution of firms total annual export value.

Figure 6: Heterogeneous effect of Brexit uncertainty on the quarterly growth of UK exporters trade margins towards EU and extra-EU markets across UK exporters' size distribution.



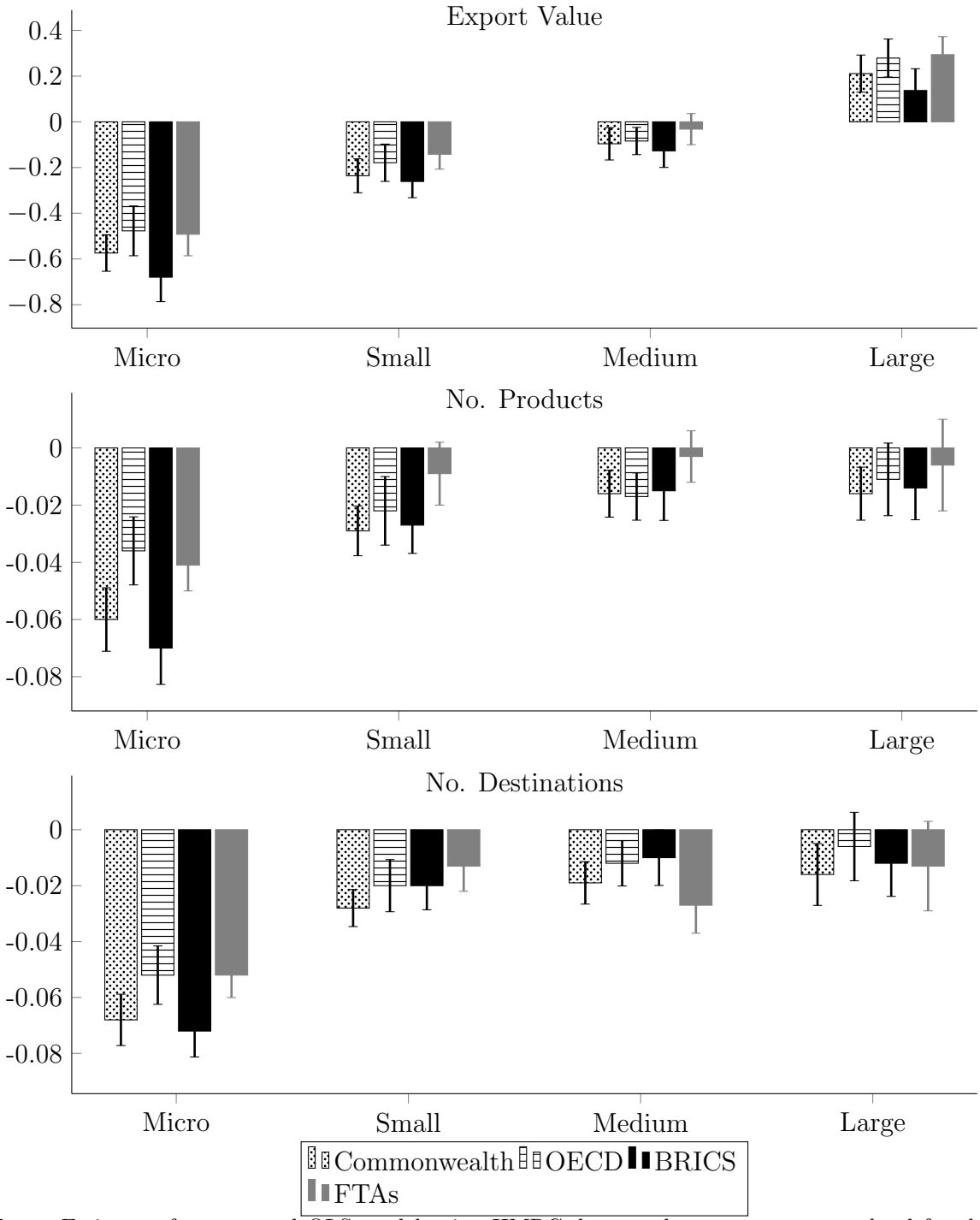
Note: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. The figures show the firms average quarterly growth in intra-EU and extra-EU exports flows separately, conditional on firm-product-quarter fixed effects, product time trend, and exchange rate exposure. Exporters size based on quartile distribution of firms total annual export value.

Figure 7: Heterogeneous effect of Brexit uncertainty on the diversion of UK exporters trade margins by extra-EU GDP-per-capita countries distribution across UK exporters' size distribution.



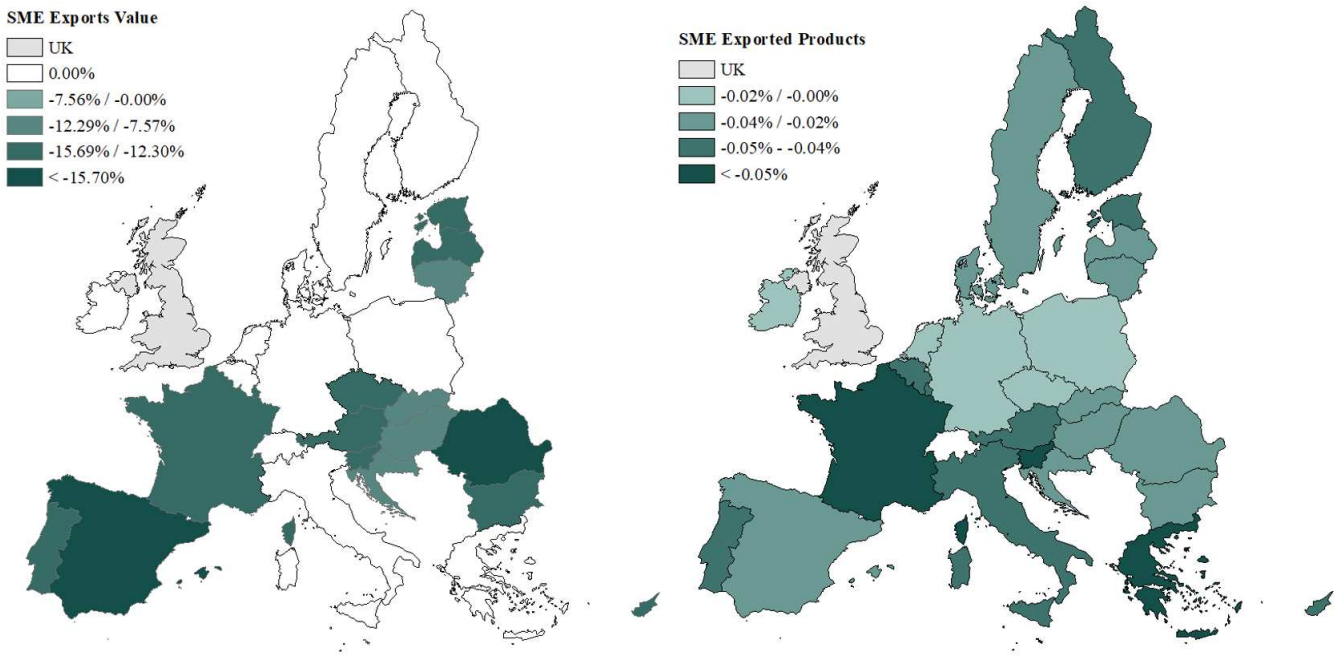
Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. 95% confidence interval reported for each estimate. Exporters size based on quartile distribution of firms total annual export value. Extra-EU countries GDP-per-capita quartile distribution from lowest (Q1) to highest (Q4) based on CEPII Gravity database.

Figure 8: Heterogeneous effect of Brexit uncertainty on the diversion of UK exporters trade margins by extra-EU groups of countries across UK exporters' size distribution.



Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. 95% confidence interval reported for each estimate. Exporters size based on quartile distribution of firms total annual export value.

Figure 9: Effect of Brexit uncertainty on the diversion of total exports and number of exported products from single EU Member States with respect to extra-EU markets for micro, small and medium UK exporters.



Note: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level. Exporters size based on quartile distribution of firms total annual export value. The estimation controls for the effect of firm-product-quarter fixed effects and product-trend as well as the exchange rate exposure. Figures show the estimated coefficients statistically significant at the 5% level for flows to each EU member state in respect to extra-EU markets.

Table 3: Heterogeneous effect of Brexit uncertainty on UK importers trade margins across UK importers' size distribution.

Quarterly	(1) Tot. Imports	(2) No. Products	(3) No. Destinat.	(4) New Products	(5) New Destinat.
Micro Exporters	-0.773***	-0.0747***	-0.0317***	-0.0988***	-0.0124**
	(0.0932)	(0.00939)	(0.00823)	(0.00975)	(0.00494)
Small Exporters	-0.234***	-0.0163**	-0.00989*	-0.0623***	-0.00697*
	(0.0394)	(0.00728)	(0.00522)	(0.0129)	(0.00414)
Medium Exporters	-0.0504	-0.00308	0.00505	-0.0354***	-0.00861
	(0.0368)	(0.00646)	(0.00660)	(0.00702)	(0.00523)
Large Exporters	0.619***	0.0149	0.00890	-0.00818	-0.00145
	(0.0814)	(0.00982)	(0.00641)	(0.0119)	(0.00511)
Observations	234,041	234,041	234,041	234,041	234,041
R-squared	0.506	0.519	0.525	0.517	0.542
No. Importers	19,501	19,501	19,501	19,501	19,501
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Product-Trend	Y	Y	Y	Y	Y

Notes: Estimates from a panel OLS model using HMRC data at the importer-quarter level for the period 2012-2018. Robust standard errors clustered at the importer level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated. Importers size based on quartile distribution of firms total annual import value.

Table 4: Effect of Brexit uncertainty on UK exporters trade margins: Placebo test.

Quarterly	(1) Tot. Exports	(2) No. Products	(3) No. Destinat.	(4) New Products	(5) New Destinat.
Brexit Referndum	-0.458	0.0297	0.113	-0.0705	-0.0179
	(0.762)	(0.122)	(0.104)	(0.130)	(0.100)
Observations	202,542	202,542	202,542	202,542	202,542
R-squared	0.552	0.670	0.609	0.542	0.558
No. Exporters	22,529	22,529	22,529	22,529	22,529
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y

Notes: Estimates from a panel OLS model using HMRC data at the exporter-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated. Brexit placebo treatment set in Q3-2014 rather than in Q3-2016.

Table 5: Heterogeneous effect of Brexit uncertainty on UK exporters trade margins across exporters size distribution and potential tariff thret distribution: Diff-in-diff transaction-level panel.

	(1) Tot.Exports	(2) No.Products		(3) Tot.Exports
Micro Exporters	-0.105***	-0.0295***	High Tariffs	-0.0832***
	(0.00343)	(0.00183)		(0.00351)
Small Exporters	-0.0520***	0.0134***	Medium-High Tariffs	-0.0513***
	(0.00312)	(0.00228)		(0.00299)
Medium Exporters	-0.00284	0.0101***	Medium-Low Tariffs	-0.0128***
	(0.00315)	(0.00266)		(0.00269)
Large Exporters	0.0278***	0.00368	Low Tariffs	0.0216***
	(0.00320)	(0.00383)		(0.00305)
Observations	13,220,942	3,941,648	Observations	13,220,942
R-squared	0.841	0.853	R-squared	0.865
Quarter FE	Y	Y	Quarter FE	Y
Trader FE	Y	Y	Trader FE	Y
Transaction FE	Y	Y	Transaction FE	Y
Product-Year FE	Y	Y	Product-Year FE	Y
Destination-Year FE	Y	Y	Destination-Year FE	Y

Notes: Estimates from a panel OLS model using HMRC data at the exporter-product-destination-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter-product-destination level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated.

Table 6: Dynamic effect of Brexit uncertainty on UK exporters trade value using different uncertainty indexes: Diff-in-diff transaction-level panel.

	(1) EPU GBR/EUR	(2) EPU GBR/USA	(3) BUI	(4) Google "No Deal"	(5) Google "Tariffs"
Uncertainty Index	-0.0494***	-0.00513	-0.00723***	-0.00521***	-0.00601***
	(0.00438)	(0.00525)	(0.00114)	(0.00174)	(0.00136)
Observations	13,220,933	13,220,933	13,220,933	13,220,933	13,220,933
R-squared	0.842	0.842	0.842	0.842	0.842
Quarter FE	Y	Y	Y	Y	Y
Trader FE	Y	Y	Y	Y	Y
Transaction FE	Y	Y	Y	Y	Y
Product-Year FE	Y	Y	Y	Y	Y
Destination-Year FE	Y	Y	Y	Y	Y

Notes: Estimates from a panel OLS model using HMRC data at the exporter-product-destination-quarter level for the period 2012-2018. Robust standard errors clustered at the exporter-product-destination level reported in parenthesis. Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed-effects and control variables included as indicated. *EPU GBR/EUR* is the ratio between the EPU index for the UK and the average EPU index for major EU economies; *EPU GBR/USA* is the ratio between the EPU index for the UK and the average EPU index for the US; *BUI* is the Bank of England Brexit Uncertainty Index estimated by Bloom, Bunn, Chen, Mizen, Smietanka, Thwaites & Young (2019); *Google No-Deal* is the Google Trends statistic for the search of keywords "Brexit No-Deal" on Google in the UK; *Google Tariffs* is the Google Trends statistic for the search of keywords "Brexit Tariffs" on Google in the UK.

A Appendix A

Table A.1: UK firms export margins to intra and extra-EU destinations before and after the Brexit referendum.

	Pre-Brexit		Post-Brexit	
	mean	sd	mean	sd
Intra EU Exports				
Growth in Tot. Exports	-0.334	1.831	0.0488	1.491
Tot. Exports (£m)	31.110	2,186	24.050	2,344
No. Transactions	105.5	1,684	115.5	1,611
No. Products	13.71	69.91	14.95	71.51
No. Destinations	7.803	6.376	8.027	6.611
New Transactions	3.999	22.68	4.729	27.83
New Products	0.719	3.611	0.899	4.239
New Destinations	0.154	0.506	0.131	0.472
Extra EU Exports				
Growth in Tot. Exports	-0.144	3.100	0.124	2.991
Tot. Exports (£m)	1.313	26.500	1.351	24.340
No. Transactions	20.87	147.6	21.83	150.5
No. Products	6.729	30.00	6.987	30.43
No. Destinations	6.281	8.124	6.259	8.072
New Transactions	4.030	18.66	4.246	17.97
New Products	1.915	2.142	2.005	2.910
New Destinations	1.226	0.606	1.210	0.581
Annual Tot. Exports EU&extraEU (£m)	121.6	6,830	103	6,630
Annual Tot. Exports extraEU (£m)	5.142	101	5.191	91.310
Annual Tot. Exports EU (£m)	116.5	6,826	97.8	6,627

Note: Statistics at the quarter-level based on the HMRC OTS database for the period 2012-Q1 to 2018-Q4. Variables reported in levels. Total exports expressed in million of pounds. Pre-Brexit considers the period between 2012-Q1 and 2016-Q2, pots-Brexit referendum between 2016-Q3 and 2018-Q4.

Table A.2: UK share of trade with the EU-27 countries in 2015.

	Imports				Exports		
Partner	Value($B)	Share(%)	Rank	Partner	Value($M)	Share (%)	rank
Germany	94,350	14.969	1	Germany	46,630	10	1
Netherlands	47,550	7.544	2	France	27,280	5.849	2
France	38,700	6.141	3	Netherlands	26,460	5.674	3
Belgium	31,400	4.98	4	Ireland	25,500	5.468	4
Italy	25,060	3.975	5	Belgium	17,720	3.799	5
Spain	21,610	3.428	6	Spain	13,540	2.903	6
Ireland	19,180	3.043	7	Italy	12,870	2.760	7
Poland	12,430	1.972	8	Sweden	6,747	1.447	8
Sweden	10,450	1.657	9	Poland	5,538	1.187	9
Czechia	7,445	1.181	10	Denmark	3,534	0.758	10
Denmark	5,308	0.842	11	Czechia	2,999	0.643	11
Austria	4,692	0.744	12	Austria	2,454	0.5265	12
Hungary	3,860	0.612	13	Finland	2,055	0.441	13
Portugal	3,594	0.570	14	Hungary	1,951	0.418	14
Finland	3,136	0.497	15	Portugal	1,911	0.4093	15
Slovakia	3,060	0.485	16	Romania	1,508	0.323	16
Romania	2,373	0.376	17	Greece	1,355	0.291	17
Lithuania	1,188	0.188	18	Slovakia	675	0.145	18
Greece	1,095	0.173	19	Malta	575	0.123	19
Luxembourg	742	0.117	20	Cyprus	567	0.122	20
Latvia	737	0.116	21	Bulgaria	531	0.114	21
Bulgaria	564	0.089	22	Lithuania	412	0.089	22
Slovenia	497	0.078	23	Estonia	335	0.072	23
Estonia	289	0.046	24	Luxembourg	335	0.072	24
Malta	278	0.044	25	Latvia	329	0.071	25
Cyprus	239	0.038	26	Slovenia	308	0.066	26
Croatia	145	0.023	27	Croatia	211	0.045	27
EU 27 Total		53.94				43.81	

Note: Statistics at the annual-level based on the UN COMTRADE database for 2015. Variables reported in levels. Total exports expressed in millions of dollars and total imports in billions of dollars. We present the share and the rank of bilateral trade of 27 EU countries with the UK

Table A.3: Share of EU-27 countries trade with the UK in 2015.

	Imports				Exports		
Reporter	Value($B)	Share(%)	Rank	Reporter	Value($M)	Share(%)	Rank
Ireland	18.76	24.109	1	Ireland	15,320	12.287	1
Cyprus	0.6	8.402	2	Netherlands	38,780	8.868	2
Malta	0.46	6.848	3	Belgium	35,150	8.838	3
Sweden	7.66	5.536	4	Germany	98,360	7.403	4
Netherlands	20.6	5.233	5	Spain	20,260	7.283	5
Belgium	18.74	5.0516	6	France	35,000	7.086	6
Spain	13.97	4.574	7	Sweden	9,777	6.983	7
Denmark	3.86	4.518	8	Poland	13,240	6.809	8
Germany	41.94	3.965	9	Portugal	3,722	6.761	9
France	21.62	3.838	10	Denmark	5,481	5.792	10
Portugal	2.1	3.137	11	Italy	24,780	5.423	11
Finland	1.87	3.102	12	Czechia	8,372	5.325	12
Lithuania	0.83	2.952	13	Slovakia	3,923	5.232	13
Estonia	0.46	2.938	14	Latvia	602	5.168	14
Italy	12.07	2.936	15	Finland	2,895	4.851	15
Greece	1.33	2.811	16	Lithuania	1,136	4.470	16
Poland	5.05	2.663	17	Romania	2,642	4.358	17
Romania	1.74	2.484	18	Greece	1,201	4.244	18
Czechia	3.02	2.145	19	Cyprus	142	4.219	19
Hungary	1.71	1.885	20	Hungary	3,910	3.898	20
Bulgaria	0.53	1.824	21	Luxembourg	486	3.853	21
Latvia	0.26	1.813	22	Malta	140	3.584	22
Austria	2.61	1.761	23	Austria	4,431	3.050	23
Slovenia	0.44	1.712	24	Estonia	362	2.604	24
Luxembourg	0.31	1.599	25	Bulgaria	651	2.522	25
Slovakia	0.83	1.131	26	Slovenia	593	2.231	26
Croatia	0.23	1.127	27	Croatia	231	1.801	27
EU Average		3.97				5.97	

Note: Statistics at the annual-level based on the UN COMTRADE database for 2015. Variables reported in levels. Total exports expressed in millions of dollars and total imports in billions of dollars. We present the share and the rank of bilateral trade of 27 EU countries with the UK.

Table A.4: The Effect of Brexit Shock on the Population of Exporters, Monthly Diff-in-Diff

Monthly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
Brexit Referendum	-0.632***	-0.0566***	-0.107***	-0.0510***	-0.0234***
	(0.0350)	(0.00586)	(0.00510)	(0.00501)	(0.00266)
Observations	938,260	938,260	938,260	938,260	938,260
R-squared	0.482	0.441	0.462	0.510	0.563
No. Exporters	25,590	25,590	25,590	25,590	25,590
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y

Notes: This table reports the overall effect of the Brexit referendum shock on a number of exporter variables. That is, we investigate the effect on total export value, total number of products, total number of destinations served, new products and new destinations. Here we consider our dependent variable, $\Delta ln(y_{it})$, on a monthly basis by using monthly transaction rather than quarterly aggregates. The results highlight trade diversion towards extra-EU markets.

Table A.5: The Effect of Brexit Shock on the Population of Exporters, Semesterly Diff-in-Diff

Semesterly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
Brexit Referendum	-0.131***	-0.0300***	-0.0296***	-0.0600***	-0.0398***
	(0.0232)	(0.00357)	(0.00367)	(0.00672)	(0.00415)
Observations	177,903	177,903	177,903	177,903	177,903
R-squared	0.521	0.611	0.579	0.550	0.563
No. Exporters	26,387	26,387	26,387	26,387	26,387
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y

Notes: This table reports the overall effect of the Brexit referendum shock on a number of exporter variables. That is, we investigate the effect on total export value, total number of products, total number of destinations served, new products and new destinations. Here we consider our dependent variable, $\Delta ln(y_{it})$, on a semester basis by aggregating transaction level information. The results highlight trade diversion towards extra-EU markets.

Table A.6: The Effect of Brexit Shock on the Population of Exporters, 2 years Diff-in-Diff

Quarterly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
Brexit Referendum	-0.103***	-0.0259***	-0.0324***	-0.0108**	-0.0192***
	(0.0285)	(0.00511)	(0.00473)	(0.00474)	(0.00429)
Observations	248,903	248,903	248,903	248,903	248,903
R-squared	0.550	0.641	0.599	0.534	0.566
No. Exporters	21,597	21,597	21,597	21,597	21,597
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y

Notes: This table reports the overall effect of the Brexit referendum shock on a number of exporter variables. That is, we investigate the effect on total export value, total number of products, total number of destinations served, new products and new destinations. Furthermore, these variable consider 8 quarters lag in the dependent variable. That is, when constructing our dependent variable, $\Delta ln(y_{it})$, we account for a longer control period. The results highlight trade diversion towards extra-EU markets.

Table A.7: Effect of Brexit dynamic process policy uncertainty on the trade margins of UK Exporters: Always Exporters

Quarterly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
Brexit Referendum	0.000447	-0.000155**	-0.000270***	-0.00131***	-0.000393***
	(0.000439)	(6.44e-05)	(0.000101)	(0.000182)	(0.000108)
Observations	270,823	270,823	270,823	270,823	270,823
R-squared	0.615	0.514	0.480	0.515	0.551
No. Exporters	17,282	17,282	17,282	17,282	17,282
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Product-Trend	Y	Y	Y	Y	Y

Notes: This table reports the overall effect of the Brexit referendum shock on a number of exporter variables. In particular we investigate the effect of policy uncertainty restricting our sample to firms who when they enter export activity do not exit. That is, we investigate the effect on total export value, total number of products, total number of destinations served, new products and new destinations. We include a number of fixed effects to control for unobserved characteristics.

Table A.8: Heterogeneous effect of Brexit related uncertainty on trade margins across UK exporters' size distribution - share of total number of countries

Quarterly	(1)	(2)	(3)	(4)	(5)
	Tot. Exports	No. Products	No. Destinat.	New Products	New Destinat.
Micro Exporters	-0.0227***	-0.00204***	-0.00221***	-0.00233***	-0.000756***
	(0.00116)	(0.000143)	(0.000156)	(0.000157)	(0.000109)
Small Exporters	-0.00294***	-0.000212	-0.000129	-0.00145***	-0.000679***
	(0.000582)	(0.000133)	(0.000136)	(0.000187)	(9.74e-05)
Medium Exporters	0.00524***	0.000575***	0.000460***	-0.000926***	-0.000544***
	(0.000570)	(9.70e-05)	(0.000135)	(0.000177)	(0.000102)
Large Exporters	0.0165***	0.000703***	0.000309*	-0.000441	-0.000437***
	(0.00114)	(0.000153)	(0.000157)	(0.000310)	(0.000108)
Observations	339,493	339,493	339,493	339,493	339,493
R-squared	0.607	0.513	0.484	0.525	0.576
No. Importers	26,051	26,051	26,051	26,051	26,051
Control Variables	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Exporter FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Product-Trend	Y	Y	Y	Y	Y

Notes: This table reports the overall effect of the Brexit referendum shock on a number of exporter variables. That is, we investigate the effect on total export value, total number of products, total number of destinations, new products and new destinations. We include a number of fixed effects to control for unobserved characteristics. Furthermore, we break down this effect by firm size (annual import values category). Here we weight our EU diff-in-diff variables by 27 countries and the extra-EU by 243 countries, before we calculate a net Diff-in-Diff between the two.

B Modelling the impact of policy uncertainty on the growth of trade margins

The purpose of this section is to provide more details on the way we identify the impact of policy uncertainty on the growth of trade margins, and estimate its magnitude for UK firms' trade destruction and diversion. We start by setting up the observed UK trade flows to the EU and extra-EU in the pre-Brexit period as $ln(y_0^{eu})$ and $ln(y_0^{neu})$, where y_0^{eu} and y_0^{neu} represent the observed trade flows (i.e. export values) to the EU and extra-EU markets prior to the Brexit referendum. These flows have natural growth rates, defined as g^{eu} and g^{neu}, which help to define the trade flows in period $t+1$, in the absence of any macroeconomic shock, as:

$$ln(y_1^{eu}) = g^{eu} + ln(y_0^{eu}) \tag{10}$$

and

$$ln(y_1^{neu}) = g^{neu} + ln(y_0^{neu}). \tag{11}$$

Hence, the first Diff-in-Diff specification takes the following form, to capture what would have happened without the policy uncertainty shock:

$$dln(y^{eu}) = ln(y_1^{eu}) - ln(y_0^{eu})$$

and

$$dln(y^{neu}) = ln(y_1^{neu}) - ln(y_0^{neu}),$$

which enable us to define the relative change in export growth to the EU compared to extra-EU markets as the following:

$$\Delta ln(y) = dln(y^{eu}) - dln(y^{neu}).$$

In the presence of a policy uncertainty shock (eg. Brexit), the trade flows in Eq. 10 and Eq. 11 in period $t+1$ will take the following form:

$$ln(y_{1a}^{eu}) = g^{eu} + b_1^{eu} + ln(y_0^{eu}), \tag{12}$$

$$ln(y_{1a}^{neu}) = g^{neu} + b_1^{neu} + ln(y_0^{neu}), \tag{13}$$

where b_1^{eu} and b_1^{neu} represent the change in the estimated growth of trade flows in each market following the policy uncertainty shock.

Thus, we can derive a new set of Diff-in-Diff specifications incorporating the policy uncertainty shock as follows:

$$dln(y_{1a}^{eu}) = ln(y_{1a}^{eu}) - ln(y_0^{eu})$$

and

$$dln(y_{1a}^{neu}) = ln(y_{1a}^{neu}) - ln(y_0^{neu}),$$

and the double difference as:

$$\Delta ln(y_{1a}) = dln(y_{1a}^{eu}) - dln(y_{1a}^{neu}).$$

which can also be defined as:

$$\Delta ln(y_{1a}) = \Delta ln(y) - B, \tag{14}$$

where:

$$B = b_1^{neu} - b_1^{eu}.$$

We can now decompose the policy uncertainty effect on the changes in export growth

into a change in exports following a "natural" trend, and a shift in export growth due to the policy uncertainty shock. This is needed in order to build a counterfactual for the changes in total export growth for both markets. In other words, we adjust the natural trends in export growth for the estimated shifts due to the policy uncertainty. By applying previous EU/extra-EU shares of total trade to the actual trade flows, we obtain a counterfactual scenario where total trade has changed, but the EU/extra EU ratio has not. Then, the shift due to policy uncertainty is found by comparing actual trade flows values with this counterfactual.

Mathematically, trade flow without a policy uncertainty shift would be:

$$y_1^{eu} = e^{lny_1^{eu}} \text{ and } y_1^{neu} = e^{lny_1^{neu}}$$

for the EU and extra-EU respectively. On the other hand, with a policy uncertainty shock this would be:

$$y_{1a}^{eu} = e^{lny_{1a}^{eu}} \text{ and } y_{1a}^{neu} = e^{lny_{1a}^{neu}}$$

Therefore, the overall total trade would be $TotTrade_1 = y_1^{eu} + y_1^{neu}$ in case of no shift and $Tot\,Trade_{1a} = y_{1a}^{eu} + y_{1a}^{neu}$ in case of a shift.

We can then define the value of total exports to the EU and extra-EU in the case of no shift as follows:

$$y_s^{eu} = Tot\,Trade_{1a}(y_1^{eu}/Tot\,Trade_1)$$

and

$$y_s^{neu} = Tot\,Trade_{1a} - y_s^{eu}.$$

Thus the corresponding shift due to policy uncertainty is defined as:

$$EU_{shift} = y_{1a}^{eu} - y_{s}^{eu} \tag{15}$$

$$extra\ EU_{shift} = y_{1a}^{neu} - y_{s}^{neu} \tag{16}$$

Using Eq. 16 and Eq. 15 we can then calculate the magnitude of the policy uncertainty effect on total exports. From the summary statistics, we assume the pre-shock average growth rate g^{eu} and g^{neu} as the "natural" growth rates, -0.33% and -0.14%, for the intra and extra-EU respectively, and the average values of trade in the pre-Brexit period (2012-2015) to be £151bn and £153bn for EU and extra-EU respectively. Then, using the estimated Brexit coefficient on aggregate across all firms (-8.7%), we are able to calculate the overall effect of the Brexit-related policy uncertainty on total exports to be worth about £10.45bn. This is the aggregate effect, considering both the positive effect for large firms and the negative one for SMEs, thus indicating that the negative effect for small exporters must have been much larger.