Renegotiation of Trade Agreements and Firm Exporting Decisions: Evidence from the Impact of Brexit on UK Exports*

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Abstract

The renegotiation of a trade agreement introduces uncertainty into the economic environment. In June 2016 the British electorate unexpectedly voted to leave the European Union, introducing a new era in which the UK and EU began to renegotiate the terms of the UK-EU trading relationship. We exploit this natural experiment to estimate the impact of uncertainty associated with trade agreement re-negotiation on the export participation decision of firms in the UK. Starting from the Handley and Limão (2017) model of exporting under trade policy uncertainty, we derive testable predictions of firm entry into (exit from) a foreign market under an uncertain 'renegotiation regime'. Empirically, we develop measures of the trade policy uncertainty facing firms exporting from the UK to the EU after June 2016. Using the universe of UK export transactions at the firm and product level and cross-sectional variation in 'threat point' tariffs, we estimate that in 2016 over 5200 firms did not enter into exporting new products to the EU, whilst almost 4000 firms exited from exporting products to the EU. Entry (exit) in 2016 would have been 5.1% higher (4.3% lower) if firms exporting from the UK to the EU had not faced increased trade policy uncertainty after June 2016.

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1. Introduction

Nearly all global trade - 98.2% in 2016 – takes place under the import tariff commitments of the World Trade Organization (WTO). Regional trade agreements such as the European Union (EU) and the North American Free Trade Agreement (NAFTA) establish even more stringent tariff commitments which govern the 63% of EU exports to other EU members and the 50% of NAFTA exports to other NAFTA members.[1] While numerous studies have quantified the importance of multilateral and regional trade agreements in increasing trade,[2] more recent theoretical and empirical contributions (Limão and Maggi (2015), Handley and Limão (2015), and Handley and Limão (2017)) have emphasized that trade agreements increase trade between signatories not only by lowering tariffs but also by *reducing uncertainty over future tariff schedules.*

Although countries commit to future tariff rates when they sign trade agreements, renegotiations of tariff and other commitments have been routine over the last 60-70 years (Hoda, 2001). A common thread in post-war renegotiations has been that the threat point or fall back position is the status quo – tariffs would be kept at existing levels if negotiations were to collapse.[3] However, recent renegotiations including the Korea-US FTA in Spring 2018, the NAFTA renegotiation of 2017-2018, and the UK-EU post-Brexit trade relationship start from the position that tariffs could increase to levels above existing commitments if negotiations break down.

In this paper, we examine how firm participation in foreign markets changes under the renegotiation of an existing trade agreement. Among countries that are already in a free trade agreement or customs union, the switch to a 'renegotiation regime' creates uncertainty about the level of tariffs in the future and a non-zero risk of tariff increases.[4] In the Handley and Limão (2017) model of exporting under trade policy uncertainty, during a renegotiation in which tariff hikes are possible, two forces act upon a firm's entry decision: an increase in uncertainty about future tariff rates generates a pure risk effect which raises the real option value of waiting to enter foreign markets while the non-zero probability that higher 'threat point' tariffs could materialize if negotiations breakdown raises the mathematical expectation of future tariffs which, in turn, lowers the expected returns to entry.

The main contribution of this paper is to analyse how firm entry into and exit from foreign markets changes when existing tariff-free trading rights could be revoked under a trade agreement renegotiation. We present new evidence of the impact of a switch to a renegotiation regime in the context of Brexit, when the British public unexpectedly voted to leave the European Union in a referendum on 23rd June 2016. Using the EU's World Trade Organization schedule of tariff

[1] Source: *World Trade Statistical Review, 2017*, WTO.

[2] See for example Rose (2004) and Subramanian and Wei (2007) on the WTO; Baier and Bergstrand (2007), Egger, Larch, Staub, and Winkelmann (2011) and Limão (2016) on Free and Preferential Trade Agreements; and Head, Mayer, and Ries (2010) on colonial linkages.

[3] The theory of the optimal trade agreement design embeds this as an assumption (See Maggi and Staiger (2015)).

[4] A literature on contract incompleteness in trade agreements (Horn, Maggi, and Staiger (2010)) has explored long-term incentives for parties, showing that institutional design can inhibit parties from reneging on commitments (Maggi and Staiger (2011)) and that renegotiation tends toward liberalization rather than protectionism (Maggi and Staiger (2015)) under a wide range of parameters.

commitments, we compile granular 'threat point' tariffs that British firms exporting to the EU would face if the renegotiation were to break down. We implement a generalized difference-in-difference strategy to estimate the impact of switch into a renegotiation regime on the growth in the number of UK firms entering (exiting) the EU market in in 2016 relative to 2015 (first difference) with different Harmonized System products (second difference) that face different threat point tariffs during the renegotiation period.[5]

Our results show that the switch to a renegotiation regime, characterized by substantial threat point tariffs for some products, decreases firm entry into and increases firm exit from exporting to the EU. The impact is largest for products facing higher threat point tariffs, suggesting that UK firms placed positive probability on the likelihood that negotiations could collapse and leave some firms facing substantially higher tariffs on exports to the EU. On average, across all products, a 1 percentage point increase in the threat point tariff decreases (increases) the growth rate of entry (exit) by 1.1 percentage point (0.5 percentage point). We explore possible non-linear responses with discrete categories of threat point tariffs and find that 'extreme' threat point tariffs of more than 15% ad valorem are associated with a 25.3 percentage point decline in the growth rate of entry while products with 'high' threat point tariffs from 10% up to 15% experience a decline in the growth rate of entry of 12.3 percentage point. We conduct a partial equilibrium aggregation exercise to calculate the number of missing entrants into (exiters from) the EU from the UK as a result of the switch to the renegotiation regime post-Brexit. This exercise estimates that 5,221 firms did not enter into exporting new products to the EU in 2016, whilst 3,850 firms exited from exporting products to the EU in 2016, in response to the uncertainty and tariff risk associated with renegotiation of the UK-EU trade agreement. Overall, entry into (exit from) the EU would have been 5.1% higher (4.3% lower) in 2016 relative to a counterfactual of zero tariffs on all products and no uncertainty about future tariff rates. While previous research has examined trade policy uncertainty (Handley and Limão (2015), Handley and Limão (2017), Pierce and Schott (2016), Crowley, Song, and Meng (2016)), ours provides the first empirical evidence on *increased uncertainty from renegotiation* of an agreement between freely trading partners. With declining support for globalization among many groups in society, more countries face the prospect of trade agreement re-negotiations and the uncertainty over policy that they bring.

We show that our findings are the result of the switch to the renegotiation regime and are not driven by product specific global demand shocks or supply chain disruption. We implement a generalized triple difference comparing entry and exit to the EU in 2016 relative to 2015 (first difference) across over 8500 products (second difference) relative to non-EU countries (third difference). The triple difference provides evidence that the impacts of the switch in trade policy regime are causally driven by the risk of future tariff increases. Estimates of the decline in the growth rate of entry for products with higher 'threat point' tariffs are larger in the triple difference specification relative to our baseline difference in difference over time and across products. This suggests that

[5]We apply the same methodology to half-year entry, comparing the growth of entry/exit in the second half of 2015 to entry/exit in the second half of 2016, in order to more precisely capture the timing of the switch into a renegotiation regime.

the phenomenon of trade deflection (Bown and Crowley, 2007) - in which firms shift export sales from destinations that have raised tariffs to those which have not - extends to the extensive margin with firms shying away from entry into destinations that might raise tariffs in favour of markets with more stable trade policy.

1.1. Related literature

This paper contributes to the growing empirical literature on the impacts of trade policy uncertainty on firm exporting decisions (Handley (2014), Handley and Limão (2015), Handley and Limão (2017), Pierce and Schott (2016), Crowley et al. (2016)). Handley and Limão (2015) develop a dynamic model of firm entry into export markets under trade policy uncertainty[6] and apply their model to Portugal's accession to the European Community in 1986. They show that the reduction in uncertainty accounted for a large proportion of the growth in Portuguese exporting entry and sales. Handley and Limão (2017) extend their model to incorporate investment for technological upgrading and general equilibrium effects in both the exporting and importing country. They use this model to show that the resolution of trade policy uncertainty when China acceded to the WTO in 2001 can explain one-third of Chinese export growth to the United States between 2002 and 2010. Pierce and Schott (2016) show this same reduction in trade policy uncertainty between China and the US led to declines in US manufacturing employment. Crowley et al. (2016) is the first paper to examine how an *increase* in trade policy uncertainty affects firm entry dynamics. This paper uses a panel of idiosyncratic product-level tariff scares facing Chinese exporters to identify a substantial decline in entry into foreign markets associated with the threat of tariff hikes.

Our paper is structured as follows: Section 2 describes the institutional framework of the Brexit referendum and derives empirical predictions of the impact of the switch to a renegotiation regime on firm exporting decisions; Section 3 outlines the empirical models for our analysis; section 4 introduces the data and measurement of the firm exporting decisions and tariff exposure; Section 5 presents the empirical results of the paper; Section 6 concludes.

2. Institutional framework: The Brexit referendum

Changes to the level or likelihood of a country's future tariff schedule represent a switch in the trade policy regime. The Brexit vote initiated a 'renegotiation regime' - a period of heightened uncertainty about future tariff rates between the UK and EU characterized by a change in the probabilities over the sets of possible future tariff schedules. In this section, we briefly outline the Handley and Limão (2017) heterogeneous firm model of firm exporting decisions under trade policy uncertainty which provides the framework for our analysis.

[6] This model builds upon an earlier macro literature on the impacts of uncertainty (Bernanke, 1983; Dixit, 1989; Bloom, Bond, and Van Reenen, 2007; Bloom, 2009).

2.1. Renegotiation regime following the Brexit referendum

On 23rd June 2016 the British electorate voted by a 52-48 margin to leave the European Union.[7] The outcome surprised many; betting markets had placed the likelihood of a 'leave' outcome at around 30% for most of the preceding year (See Figure 1.) Post- June 2016, firms exporting from the UK to the EU faced two possible future trade policy scenarios with clearly defined tariff schedules: in the most liberal possible tariff scenario the UK would retain tariff free access to the EU Customs Union; in the most restrictive, or 'threat point', tariff scenario the UK would trade with the EU under the EU's WTO tariff schedule.

2.2. Theoretical model

Handley and Limão (2017) develop a model where consumers have preferences over a homogeneous good and differentiated products h, all of which are freely traded on world markets. Consumers have constant elasticity of substitution preferences over varieties v within each product h with $\sigma > 1$. CES aggregate demand for variety v is $q_v = E_h P_h^{\sigma-1} p_v^{-\sigma}$, where p_v is the consumer price and $P_h = \left(\int_{v \in \Omega_h} (p_v)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$ is the CES price index for the set of all varieties in product h, Ω_h. E_h is the aggregate demand shifter representing the total expenditure on the differentiated product h in a country. Consumer prices p_v include an ad valorem tariff $\tau_h \geq 1$, such that exporters receive p_v/τ_h per unit of good sold, whilst domestic producers face no taxes.

Firms produce using a technology with constant marginal cost of production, c. In the differentiated goods sector there is a continuum of monopolistically competitive firms each producing a variety v with heterogeneous productivity $1/c$. Firms within a product h draw their productivity from the same distribution $G_h(c)$. Productivity in each product is drawn from a Pareto distribution bounded below at $1/c_h$: $G_h(c) = (c/c_h)^{\kappa}$ where it is assumed that $\kappa > \sigma - 1$. Firms also face an ad valorem (iceberg) export cost $d_h \geq 1$. Firms set p_v to maximize operating profit taking aggregate market conditions as given and correctly anticipating the equilibrium.

The per-period profits of an exporting firm, $\pi(\tau_{sh}, c)$, are a function of the state-contingent tariff on its product, h. Firms enter into exporting if entry in the given state s maximizes the firm's expected discounted profits $\Pi_e(\tau_{sh}, c)$ net a sunk entry cost, K_h, given the state-contingent tariff schedule τ_{sh}. Firms discount the future at rate $\beta = (1-\delta)(1+r) < 1$, a composite of a probability of an exogenous death shock δ and a pure time preference factor R.

We assume that Britain is a small exporting country to the European Union, such that changes in British exports have a negligible effect on EU aggregate variables, E_h and P_h across all products.[8] Thus, with CES demand, the economic conditons facing an exporter of h –i .e., the aggregate expenditure on h, E_h, its price level, P_h, and the foreign state-contingent tariff, τ_{sh} – can be summarized by the state variable, a_{sh}, where $a_{sh} = (\tau_{sh}\sigma)^{-\sigma}((\sigma-1)P_h/d_h)^{\sigma-1}E_h$.

[7] The UK had been a member of the EU/European Economic Community since 1973.

[8] Handley and Limão (2017) highlight that this assumption is not necessary for the qualitative nature of the empirical predictions, but simplifies the theoretical framework.

2.2.1. Firm exporting decisions under certain trade policy

When future trade policy is known and given by τ_h, firms enter if their cost is below the threshold cost, $c_h^{certain}$. Handley and Limão (2017) show that the threshold is identified at the marginal firm where the discounted value of profits exactly equals the sunk cost to enter into exporting:

$$\frac{\pi(\tau_h, c_h^{certain})}{1-\beta} = K_h \iff c_h^{certain} = \left(\frac{a_h}{(1-\beta)K_h}\right)^{\frac{1}{\sigma-1}}. \quad (1)$$

2.2.2. Firm exporting decisions under uncertain trade policy

We consider the problem facing potential exporters in an environment of trade policy uncertainty. Following Handley and Limão (2017) we describe an environment in which the world can switch, with probability γ from an initial 'certain' state with with free trade in all goods to a renegotiation state ($s = R$). The renegotiation state is an uncertain state in which free trade prevails, but can change in the future. Specifically, from the renegotiation state two outcomes are possible.[9] The first possible outcome, free trade ($s = FT$), an absorbing state in which the UK secures continued tariff free access to the EU market, occurs with probability λ_{FT}. The other possible outcome, WTO rules ($s = WTO$) is characterized by a collapse of negotiations so that UK exporters face the EU's WTO tariff schedule. This outcome occurs with probability $\lambda_{WTO} = 1 - \lambda_{FT}$.

During the uncertain renegotiation regime, firms face the decision of whether to enter and obtain the expected discounted profits $\Pi_e(\tau_{R,h}, c)$, or to wait and obtain the expected discounted profits $\Pi_w(\tau_{R,h}, c)$.

The value of starting to export during the renegotiation period R for a firm with cost c exporting a product h (where we omit the product subscript for simplicity) is:

$$\Pi_e(\tau_R, c) = \pi(\tau_R, c) + \beta\big[\gamma\big(\lambda_{WTO}\Pi_e(\tau_{WTO}, c) + (1-\lambda_{WTO})\Pi_e(\tau_{FT}, c)\big) + (1-\gamma)\Pi_e(\tau_R, c)\big] \quad (2)$$

where the first term on the right hand side is the per-period profit from exporting during the renegotiation period, the second term is the discounted value of being an exporter if the trade policy negotiations break down and exporters face threat point tariffs (multiplied by the product of the probability of entry into negotiations γ and the probability that negotiations breakdown λ_{WTO}), the third term is the discounted value of being an exporter if the negotiations do not break down and exporters face zero tariffs to export under a free trade agreement (multiplied by the product of the probability of entry into negotiations γ and the probability that negotiations do not breakdown $1 - \lambda_{WTO}$), the final term if the discounted value of profits from entry if no change in trade policy occurs (multiplied by the probability of no policy change).

The value of waiting during the renegotiation period R (where we omit the product subscript

[9] The *trade policy regime* is characterized formally by a Markov process with time-invariant distribution, denoted by $\Lambda(\tau_s, \gamma)$.

h for simplicity) is:

$$\Pi_w(\tau_R, c) = 0 + \beta\big[\gamma\big(\lambda_{WTO}\Pi_w(\tau_{WTO}, c) + (1-\lambda_{WTO})\, max\left\{\Pi_e(\tau_{FT}, c) - K, \Pi_w(\tau_{FT}, c)\right\}\big) + (1-\gamma)\Pi_w(\tau_R, c)\big] \tag{3}$$

where the first term on the right hand side captures the zero per-period profit from waiting during the renegotiation period, the second term is the discounted value of waiting if the trade policy negotiations breakdown (multiplied by the product of the probability of entry into negotiations γ and the probability that negotiations breakdown λ_{WTO}), the third term is the discounted value of the maximum of (i) being an exporter if the negotiations do not break down and exporters face zero tariffs to export under a free trade agreement, or (ii) choosing not to enter into exporting and receiving the discounted value of waiting under a free trade agreement[10] (multiplied by the product of the probability of entry into negotiations γ and the probability that negotiations do not breakdown $1 - \lambda_{WTO}$), the final term if the discounted value of profits from waiting if no change in trade policy occurs (multiplied by the probability of no policy change).

Handley and Limão (2017) show that for a given τ_{sh} there is a marginal entrant firm with cost equal to threshold value, c^U_{sh}, who is exactly indifferent between entering and waiting in a given state s. This therefore gives an indifference condition in the renegotiation period with threshold cost $c^U_{R,h}$:

$$\Pi_w(\tau_{R,h}, c^U_{R,h}) = \Pi_e(\tau_{R,h}, c^U_{R,h}) - K_h. \tag{4}$$

Handley and Limão (2017) derive the following implications of the renegotiation of trade agreements on trade policy uncertainty from their model:[11]

1. Threat point tariffs: A higher threat point tariff $\tau_{WTO,h}$, holding constant applied tariffs during the renegotiations $\tau_{R,h}$ and the probability of entering into renegotiations γ and the probability of negotiations breaking down λ_{WTO}, is associated with a lower expected return to exporting in the break down outcome state $s = WTO$; this implies a larger real option value of waiting and lowers the cost cut-off for entry. Cross-sectionally, the cost-cutoff for entry will vary across products h, with a lower cutoff for products facing higher threat point tariffs.
2. Probability of entering into renegotiations: An increase in the probability of entering into renegotiation of the trade agreement γ, holding constant applied tariffs during the renego-

[10] Firms will enter following the realisation of the absorbing Free Trade outcome if their cost is below the certain trade policy threshold cost $c^{certain}_{FT,h}$ specified in (1).

[11] Handley and Limão (2017) show that there is a distinct cutoff c^U_{sh} for each τ_{sh} that determines whether a firm enters into exporting. The cutoff in the uncertain negotiation state, $c^U_{R,h}$, is proportional to the cutoff in a certain policy state with the same applied tariffs as the negotiation state, $c^{certain}_{R,h}$, by an *uncertainty factor* $U(\omega_h, \gamma)$, where γ is the probability of renegotiations commencing and trade policy shifting into one of the two outcome states:

$$c^U_{R,h}/c^{certain}_{R,h} = U(\omega_h, \gamma) = \left(\frac{1 + u(\gamma)\omega_h}{1 + u(\gamma)}\right)^{\frac{1}{\sigma-1}} \tag{5}$$

where $\omega_h = (\tau_{WTO,h}/\tau_{R,h})^{-\sigma}$ is ratio of operating profits in high tariff state relative to uncertain state, and $u(\gamma) = \gamma\lambda_{WTO}\beta/(1-\beta)$ is the expected spell in the high tariff state.

tiation $\tau_{R,h}$, threat point tariffs $\tau_{WTO,h}$, and the probability of negotiations breaking down λ_{WTO}, increases the option value of waiting and this lowers the cost cut-off for entry. Hence an increase in the probability of renegotiation reduces entry by higher cost firms.

3. Probability of renegotiation breaking down: An increase in the probability of renegotiation breaking down λ_{WTO}, holding constant applied tariffs during the renegotiation $\tau_{R,h}$ and threat point tariffs $\tau_{WTO,h}$ and the probability of entering into renegotiations γ, increases the option value of waiting and this lowers the cost cut-off for entry. Hence an increase in the probability of renegotiations breaking down reduces entry by higher cost firms.

Firms will also exit from exporting in response to changes in economic conditions. Endogenous exit decisions by firms are not explicitly modelled as there are no per period fixed costs to export. Firms that experience the exogenous death shock with probability δ will exit, but have the opportunity to re-enter. Exit will be observed following a negative shock to economic conditions a_{sh} as firms hit with a death shock choose not to re-enter if their costs lie between the new and old cutoffs (Crowley et al., 2016).

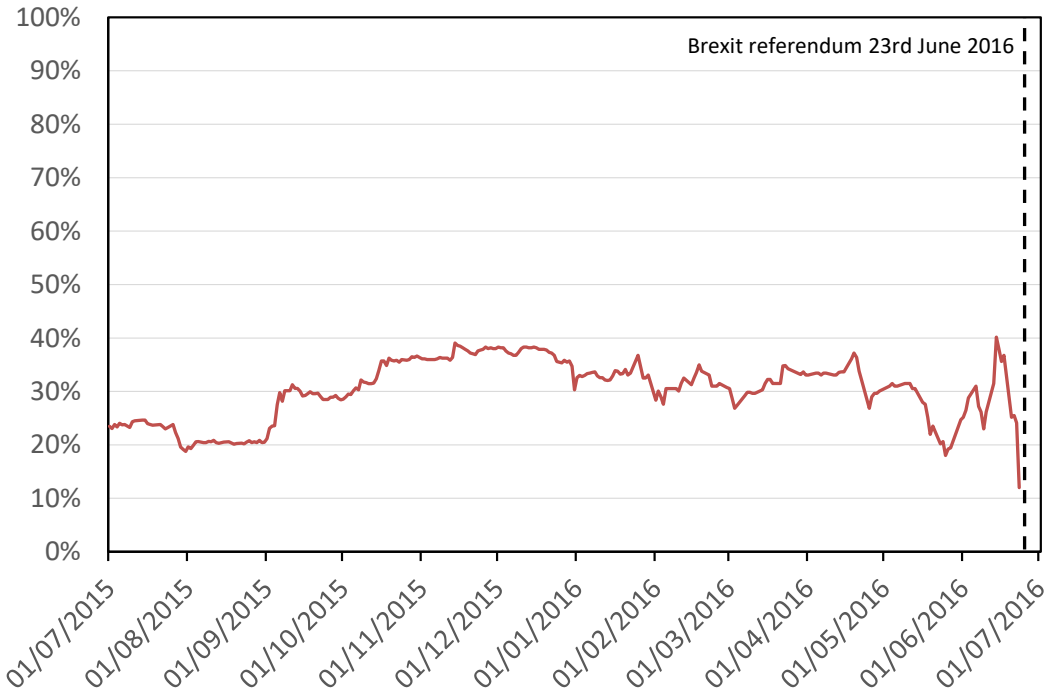
2.3. Empirical predictions

The Brexit referendum can be modelled in the Handley and Limão (2017) framework as an increase in the probability of renegotiation, γ.[12] The vote by the British public to leave the European Union was unexpected by forecasters and the markets. Figure 1 shows the market implied probability that the British public would vote to 'leave' the EU in the year leading up to the Brexit referendum on 23rd June 2016.[13] The market implied probability that Britain would vote to leave the European Union averaged 30.5% and did not exceed 40% in the year leading up to the referendum, and implied that there was just a 12% chance that the British public would vote to leave on the day of the referendum. The market implied probability that Britain will leave the EU is not available for after the 23rd June 2016, as the betting markets suspended these odds. This suspension implies that markets expected the UK to leave the EU with certainty, or 100% probability. In the Handley and Limão (2017) framework, the result of the Brexit referendum can be modelled as an unexpected increase in γ, from $\gamma = 0.3$ in the year leading up to the Brexit referendum, to certainty ($\gamma = 1$) following the leave vote.

[12]The result of the Brexit referendum may also have changed the probability that negotiations would break down λ_{WTO} as, for instance, the Prime Minister of the UK before the referendum, David Cameron, resigned and the government elected a new Prime Minister, Theresa May. Unfortunately it is not possible to find equivalent betting odds on the probability of 'No deal' in the Brexit renegotiations. An increase in λ_{WTO} has the same qualitative effects on trade policy uncertainty and impact on firm exporting decisions as an increase in γ. It is possible that the result of the Brexit referendum increased γ and decreased λ, however the large observed change in the former will in all likelihood have dominated any plausible change in the latter, giving the same qualitative predictions which we take into our reduced form analysis.

[13]The market implied probability takes the odds provided by Betfair and converts them to the market implied probability. We would like to thank Oliver Wood from the Bank of England for providing us with the time series of these odds and market implied probability.

Fig. 1. Market implied probability that Britain would vote to leave the EU



The observed change in the probability of renegotiating the trade relationship has empirical implications derived from the model:

Prediction 1. Firm-product entry: Products facing higher threat point tariffs will experience decreased entry relative to products facing lower threat point tariffs.

Products facing larger threat point tariffs will experience greater declines in firm entry into exporting. The increased trade policy uncertainty lowers the entry cutoff in each product h from $c^U_{R,h}$ in the pre-referendum period to $c^{U'}_{R,h}$ during the renegotiation period, with $c^{U'}_{R,h} < c^U_{R,h}$. This is driven by two effects working in the same direction: the renegotiation regime raises the *expected mean* level of future tariffs facing exporters; and the increased uncertainty generates a *pure risk* effect by raising the real option value of waiting to enter.[14] All products are covered in the renegotiation and each product would face its respective threat point tariff if no trade agreement were concluded. The *expected mean* and *pure risk* effects lower the expected returns to entry more for

[14]The switch to a renegotiation regime would generate only the *pure risk* effect if the level of tariffs in the renegotiation state were equal to the expected mean of the future tariff ($\tau_{R,h} = (1 - \lambda_{WTO})\tau_{FT,h} + \lambda_{WTO}\tau_{WTO,h}$), where the increase in trade policy uncertainty would just be a mean-preserving expansion of tariffs. However, this is not the case for Britain as tariffs are at zero whilst Britain remains part of the EU Customs Union during the renegotiations.

products facing higher threat point tariffs and therefore lower the cost cutoff for entry by a greater magnitude for these products.[15]

Prediction 2. Firm-product exit: Products facing higher threat point tariffs will experience increased exit relative to products facing lower threat point tariffs.

Firms will exit in response to the increase in trade policy uncertainty, with greater exit in products facing higher threat point tariffs. Firms do not make an endogenous exit decision in the model, but firms hit by an exogenous death shock face a re-entry decision.[16] Firms can repay the sunk cost of entry into exporting and immediately re-enter, but as the cost cutoff for (re-)entry falls following a switch to a renegotiation regime, incumbent firms with $c_{R,h}^{U'} < c \leq c_{R,h}^{U}$ will not re-enter. The fall in the cost cutoff is greater for products facing higher threat point tariffs, which will therefore experience a greater increase in exit following the switch to a renegotiation regime.

Prediction 3. Firm-product participation: Products facing higher threat point tariffs will experience a fall in the stock of exporters relative to products facing lower threat point tariffs.

The empirical predictions for firm entry (Prediction 1) and firm exit (Prediction 2) are both derived, directly and indirectly, from the impact of the switch to a renegotiation regime on the entry cutoff. These two predictions impact the total number of exporters in the same direction, generating the empirical prediction that the total number of exporters of products exposed to higher threat point tariffs will fall by the greatest magnitude.

3. Empirical model

In this section we outline the empirical models used in our analysis. We first outline our main difference-in-difference model, where we implement a generalized difference-in-difference strategy by regressing the growth in entrants exporting a Combined Nomenclature 8 digit (CN8) product to the EU in 2016 relative to 2015 (first difference) on the CN8 product-specific threat point tariff (second difference). We second outline our triple difference model where we implement our difference-in-difference model for firm exporting decisions to the EU relative to firm exporting decisions to non-EU markets (third difference).

[15] Handley and Limão (2017) show that entry in the uncertain state is lower than if policy was deterministic, $c_{R,h}^{U} < c_{R,h}^{certain}$ if and only if tariff increases are possible, $\tau_{WTO,h} > \tau_{R,h}$ and $u(\gamma) > 0$.This result generalizes to a switch in trade policy regimes resulting from an increase in uncertainty (higher γ), as the cost cutoff is monotonically decreasing in γ, $\partial c_{R,h}^{U}/\partial\gamma < 0$.

[16] An example of such an exogenous death shock would be the closure of a firm's distributor in a foreign country. When firms enter into exporting they pay the sunk cost of entry to set up distribution networks. If a firm's distributor closes, firms are faced with the choice of exiting from exporting, or to repay the sunk cost to find a new distributor in their foreign market.

3.1. Difference-in-difference model

In our main specification we estimate the impact of the increased trade policy uncertainty across CN8 products (first difference) on the extensive margin response of firms exporting from the UK to the EU aggregated to the product level h in time t, 2016 relative to 2015 (second difference). We estimate the following regression:

$$\Delta Y_{ht} = b_0 + b_1 \, \tau_h^{threat\,point} + \eta_{ht} \tag{6}$$

where ΔY_{ht} represents the growth rate in the outcome variable Y (number of firm-products, firm-product entrants, firm-product exiters) in product h in time t. The independent variable $\tau_{h,t}^{threat\,point}$ are the threat point tariffs faced by each product h, measured by the EU's WTO tariff for each product h. In this scenario Britain will revert to trading with the EU as a Third Country member of the WTO.[17]

3.1.1. Controlling for exchange rate pass through sensitivity

The Brexit referendum did not just increase the probability of the threat point tariffs and raise the level of tariff uncertainty facing exporters from the UK. The immediate impact of the referendum result was a depreciation in the value of sterling which fell by 15% against a trade weighted basket of currencies. This depreciation of sterling is expected to provide a boost to firms exporting from the UK through either increased competitiveness in international markets if firms adjust prices, or through increased profits if firms do not fully adjust prices and increase mark-ups. This presents a potential concern to the main identification outlined in equation 6, if the results capture product specific responsiveness to the exchange rate movements, rather than the cross-sectional variation in the tariff uncertainty. To control for the potential impact of exchange rate sensitivity we implement a two stage procedure. First, we estimate equation (7) at the 2-digit HS sectoral level.

$$\Delta_{z|hfd} uv_{hfdt}^k = \alpha_e^k \Delta_{z|hfd} e_{dt} + \Delta_{z|hfd} X_{dt}' \alpha_x^k + \Delta_{z|hfd} \epsilon_{hfdt}^k \tag{7}$$

where k stands for the 2-digit HS sector; h, f, d, t represent product, firm, destination country in the EU, and time period (year) respectively; uv_{hfdt}^k represents the unit value denominated in sterling[18]; e_{dt} is the sterling-destination rate where an increase of e_{dt} means an appreciation of the destination country currency; X_{dt} is a vector of aggregate-level control variables including CPI index, the real GDP and import-to-GDP ratio[19] in the destination country. All variables enter our estimation equation in logarithms and $\Delta_{z|hfd}$ denotes a time difference operation at the product-

[17] The UK will be able to maintain its membership of the WTO if it leaves the EU Customs Union (Bartels, 2016).

[18] HMRC reports the value of transactions denominated in sterling and two quantity measures (net mass and quantity) on a monthly basis. We aggregate the total quantity and value at firm-8 digit HS-destination-year level and calculate the unit value as total value divided by the quantity with reported quantities (net mass in kilos, units, pairs, etc) and as the total sterling value divided by the net mass (in kilos) for products for which there is no specific quantity units reported.

[19] Annual macroeconomic variables are taken from the World Bank.

firm-destination level with z being the number of lagged periods.

Estimates are based on the universe of UK exports to EU countries during the period 2010 - 2015 for exporters meeting the HMRC reporting threshold. Separately estimating (7) for each sector gives k coefficients that measure the sectoral level sensitivity to exchange rate shocks. Our estimates suggest significant heterogeneity in the degree of exchange rate pass through across sectors as commonly found in the literature.

Second, we use the estimated α_e^k as a control variable in our estimating equation on firm entry and exit in regression 8:

$$\Delta Y_{ht}^{EU} = b_0 + b_1 \, \tau_h^{threat\,point} + b_2 \, \hat{\alpha}_e^k + \eta_{ht} \tag{8}$$

where the α_e^k are the HS02 industry k sensitivity to exchange rate estimates for firms exporting from the UK to the EU from (7).[20] Industries more sensitive to fluctuations in the exchange rate should benefit more from the large depreciation following the announcement of the Brexit referendum results, shown by a positive (negative) b_2 coefficient in the exporter and entry (exit) specifications.

3.2. Triple difference model

A possible concern is that the observed cross-sectional variation in firm exporting decisions across products is not driven by the tariff uncertainty associated with the switch to the renegotiation regime following the Brexit referendum, but rather by product specific supply chain or product demand shocks. Products produced in the UK that require imported inputs may experience a similar uncertainty shock to their upstream supply chain from the switch to the renegotiation regime (such as the increased cost of importing inputs or potential for de-location following Brexit), which could increase costs of production. Alternatively, the observed changes in firm exporting decisions across products could represent global product demand changes between 2015 and 2016, or expectations of greater domestic protection at the product level in UK markets post-Brexit. To ensure that we have not captured these potentially confounding effects, we use a generalized triple difference specification where we compare the change in exporting decisions before and after the switch to the renegotiation regime (first difference) by firms in the UK into the different CN8 EU product markets (second difference) with the change in exporting decisions by UK firms into non-EU markets (third difference). Supply chain shocks and global product demand shocks will be common for products exported to both the EU and non-EU. Therefore the triple difference specification differences out these confounding factors in the regression:

$$\Delta Y_{ht}^{EU} - \Delta Y_{ht}^{non-EU} = b_0 + b_1 \, \tau_h^{threat\,point} + \eta_{ht} \tag{9}$$

where ΔY_{ht}^{EU} and ΔY_{ht}^{non-EU} are the growth in the exporting decision of firms in the UK of out-

[20] It is not possible to control for the exchange rate sensitivity at a finer industry disaggregation than the 2 digit HS classification due to insufficient observations, even in the universe of customs transactions.

come variable $Y \in \{exporters, entrants, exiters\}$ to EU markets and non-EU markets respectively between 2015 and 2016.[21] The results are presented in Table 4, where Panel A presents the results using a continuous measure of tariff uncertainty and Panel B presents the results using the discrete measure of tariff uncertainty as in Table 8. The identification assumption in the triple difference specification is that non-EU markets have not seen a contemporaneous rise in tariff uncertainty with the rise in uncertainty to EU markets.

4. Data and measurement

The empirical analysis is conducted by merging confidential microdata on the universe of foreign transactions from the UK's Her Majesty's Revenue and Customs (HMRC) Overseas Trade Statistics (HMRC, 2017), tariff data from the European Commission TARIC database (Commission, 2018), and bilateral exchange rate data from the US Department of Agriculture (USDA, 2017).

4.1. UK customs data

HMRC Overseas Trade Statistics (OTS) is our source for data on exports by UK firms at the disaggregated CN8 product level. HMRC provides exports at the product level for individual firms in two distinct datasets: the OTS EU Dispatches dataset and the OTS non-EU Exports dataset. The EU dispatches data includes monthly records of export value and quantity at the firm-product-destination-time level for UK firms whose exports to the EU exceed £250,000 in a given calendar year.[22] The non-EU exports dataset includes transaction level records of export value and quantity at the firm-product-destination-time level for all trade between the UK and non-EU foreign markets. We aggregate data on firm export dynamics at the product level into calendar year annual observations (January-December) as well as half-yearly observations (H1 is defined at January through June and H2 is defined as July through December). We present descriptive statistics on the aggregate value and numbers of firms engaged in exporting to the EU from 2013-2016 in Table 1.[23]

4.1.1. UK firm entry and exit into foreign markets

The focus of our analysis is on participation of UK firms in foreign markets. We divide the world into two destinations d, the EU and non-EU, $d \in \{EU, non-EU\}$ and construct relevant statistics on participation in both of these destinations. For each time period, destination, and CN8 product

[21] See appendix for further discussion and derivation of the triple difference specification.

[22] The requirement to report exports at the detailed product level applies to firms whose total value of exports exceeds the Intrastat reporting threshold. The Intrastat threshold has changed over time, rising progressively from £135,000 in 1993 when the UK joined the Single Market to £270,000 in 2009. Since 2009 the nominal value of the threshold for dispatches has remained fixed at £250,000 and therefore is constant over the time period of the analysis in this paper.

[23] Table 1 accounts for the majority of value of UK-EU exports. Whilst the legal requirement for the Intrastat reporting threshold is that 93% of the value of trade must be recorded, comparisons with official statistics indicates that the £250,000 threshold captures 96-98% of the total value of UK exports to the EU.

category, we calculate the number of UK firms engaged in exporting to the destination (the stock of exporters), the number of UK firms newly entering a destination (number of entrants), and the number of UK firms exiting a destination (number of exiters).[24] We define a firm f as exporting to destination d with a product h if the firm has a positive value of exports in time period t to any country in destination d.[25] We define new entry by a firm with a product h to destination d in a year t in which a positive value for product h exports in t is recorded to destination d and the firm did not export the same product h to destination d in the previous year $t-1$ (at least a 1 year break from exporting).[26] Similarly, exit by a firm f of product h to destination d is defined in year t if a firm recorded zero value of exports for product h to destination d in time t after recording a positive export value in $t-1$ to destination d of product h.

In Table 1 we present descriptive statistics on the stock of exporters and flow of entrants and exiters of firm-products from the UK to the EU in the period (2013-2016) from the OTS data. The number of firm-product exporters from the UK to the EU has increased over the period from 334,095 in 2013 to 384,044 in 2016. There is considerable churn with around 100,000 firm-product exporters each year that did not export the previous year, and around 85,000 firm product exporters who did note export in a given year having previously exported to the EU in the previous year.

Table 1: Value and numbers of UK-EU exporters, entrants and exiters, 2013-16

	Export value	Firms	Firm-product exporters	Firm-product entrants	Firm-product exiters
2013	£145bn	21,301	334,095	96,510	85,996
2014	£141bn	20,918	348,872	99,340	84,563
2015	£128bn	21,124	366,169	102,792	85,495
2016	£140bn	21,103	384,044	107,436	89,561

Table 1 notes: Value of exports represents the total value of exports recorded by firms in their Intrastat returns in the Overseas Trade Statistics (OTS). The number of firms is calculated by counting the number of firms with positive values of exports to the EU in a given year. Exporters, entrants and exiters are all identified at the firm-product level, with a separate entity for each CN8 product exported by a given firm. Exporters are defined as a firm-product with positive export value in a calendar year. Entrants are defined as a firm-product with positive value in year t with a zero value in year $t-1$. Exiters are defined as a firm-product with positive export value in year $t-1$ and zero export value in year t. Source: Calculations based on HMRC administrative datasets.

[24]The baseline analysis in this paper is conducted at the annual frequency. In a robustness check, we reproduce our entire analysis at the half-yearly frequency.

[25]Information on the country of destination is available to create firm-product-destination measures of exporting within the EU Customs Union. However, products are able to move freely within the Customs Union and this destination may not reflect the true market in which the good is sold. As the trade policy uncertainty shock of the Brexit referendum affected all of the markets within the Customs Union equally, we define all the countries within the EU Customs Union as one market.

[26]In additional specifications we present results using the definition of firm-product entry following a 2 year break in exporting to destination d, with no observed exports in $t-1$ or $t-2$ to destination d, and 3 year break in exporting to destination d, with no observed exports in $t-1$ or $t-2$ or $t-3$ to destination d.

4.2. Growth rate of exporters, entrants and exiters

In our analysis, we use the percentage point change in the growth rate of foreign market participation, new entrants and exiters as our dependent variable, where our calculation of growth rates follows Davis and Haltiwanger (1992):

$$\Delta Y_{ht} = \frac{2(Y_{ht} - Y_{ht-1})}{(Y_{ht} + Y_{ht-1})}$$

where ΔY_{ht} is the growth rate in the aggregate of outcome variable $Y \in \{exporters, entrants, exiters\}$ for product h in time t. This measure of growth rate lies in the interval [-2, 2]. This measure is preferred to the alternative percentage point growth measure in difference of logarithms when the aggregate of interest often takes a zero value in one of the two periods (Davis and Haltiwanger, 1992). Davis and Haltiwanger (1992) show that the estimates from the difference in logarithms and Davis and Haltiwanger (1992) growth measure are equivalent for small growth rates.[27]

4.3. Tariff exposure

We measure the level of trade policy uncertainty facing firms in each product category using tariff exposure identified by the Most Favoured Nation (MFN) tariff at the CN8 level applied to imports from Third Country members of the World Trade Organization into the EU. These tariff rates are made publicly available on the European Commissions TARIC website.[28] These are the tariffs that firms exporting from the UK to the EU will face if negotiations on the future UK-EU trade relationship breakdown and the UK reverts to trading with the EU under WTO commitments.

We use two measures of tariff uncertainty in our regression analysis. First, we construct a continuous measure of tariff uncertainty measured by the level of MFN tariff that firms exporting from the UK would face to export to countries in the EU Customs Union under WTO rules. Across all industries, 24% of products[29] and 21% of value would face a zero tariff, even under MFN tariffs. The maximum threat point tariff faced at the CN8 digit level is 74.9%, whilst the mean is 4.72%.

Second, we classify products into categories of tariff exposure based upon the level of MFN tariff: products facing a zero tariff face 'zero' exposure; products facing tariff exposure of greater than zero, but less than or equal to 5%, face 'low' levels of uncertainty; products facing tariff

[27] Alternative specifications using the difference in logarithms as the dependent variable find that our results are robust to the different calculation of growth rates and are available upon request.

[28] The tariffs at the 8 digit product level are used over the more standard 6 digit product level tariffs sourced from the World Trade organization tariff download website. Normally analysis of the impact of tariffs is only possible at the 6 digit level as commodity codes are inconsistent across country classification systems at a more disaggregated 8 digit level. This is not the case in our analysis as the UK currently uses the same Combined Nomenclature as the threat point tariffs in the export destination. The finer disaggregation significantly increases the number of products in our analysis and increases the precision at which we estimate threat point tariffs. Further, the EC TARIC database provides the most threat points tariffs that UK firms will most likely perceive. First, these are the tariffs that the UK and EU currently apply on competing imports from outside of the EU. Second, UK firms can search for these tariffs through online search engines provided by both the UK Department for International Trade and the European Commission.

[29] 8559 CN8 products were exported from the UK to the EU that have defined MFN tariffs by the WTO in 2015. See appendix for further details on the breakdown of products across industries and tariff exposure categories.

exposure of greater than 5%, but less than or equal to 10%, face 'medium' levels of uncertainty; products facing tariff exposure of greater than 10%, but less than or equal to 15%, face 'high' levels of uncertainty; products facing tariff exposure of greater than 15% face 'extreme' levels of uncertainty. Products facing non ad valorem tariffs are categorized under 'quota'.[30] This discrete classification can capture the potential non-linear effects of increased tariff exposure.

4.3.1. Distribution of UK-EU exporters across industries

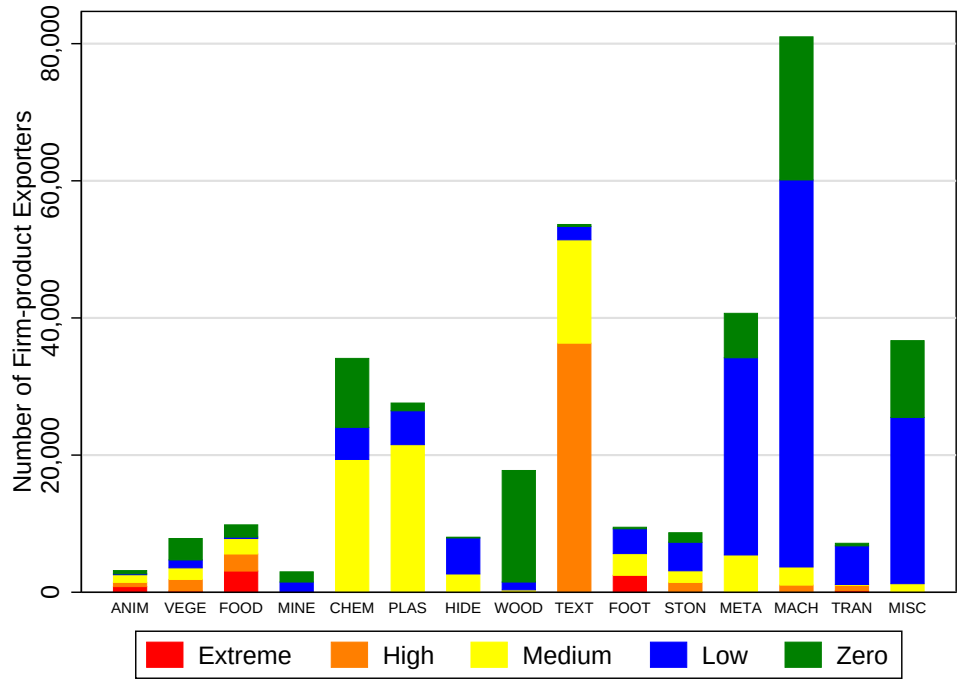
The exposure of UK exporters to EU threat point MFN tariffs is distributed across industries. Across HS industries and categories of exposure to EU tariffs, Figure 2 shows the number of firm-products exporting to the EU and the total trade value in 2015, and 3 presents bar charts of the number of new firm-product entrants and the number of firm-product exiters in 2015. Figure 2 shows that a significant number and trade value of exporters face threat point tariffs. 348,536 firm-products were exported to the EU in 2015 for which EC ad valorem tariff is available (we exclude products with non-ad valorem tariffs from our main results), with exposure across the tariff categories: 2% of exporters face exposure to 'extreme' tariff, 13% of exporters face exposure to 'high' tariff, 22% of exporters face exposure to 'medium' tariff, 41% of exporters face exposure to 'low' tariff, 22% of exporters face exposure to 'zero' tariff.[31] In 2015 the percentage of total export value in each tariff exposure category is: 1% in 'extreme', 13% in 'high', 14% in 'medium', 31% in 'low', 41% in 'zero'.

There is significant churning in firm dynamics of exporting to the EU shown in Figure 3, with high gross flows of entry and exit across all industries and tariff exposure categories. Across the product categories facing increased exposure to ad valorem tariffs, 102,792 (85,495) firm-products enter into (exit from) exporting to the EU in 2015, accounting for 26% (21%) of total firm-products exported to the EU in 2015. The gross firm-product extensive margin is less important for the total value of UK exports to the EU in a given year (in part due to the bias from partial year effects Bernard, Boler, Massari, Reyes, and Taglioni, 2017) with the gross firm-product entry margin contributing £4.4 billion in 2015, whilst the gross margin of firm-product exit contributed a drag of £4.3 billion.

[30] Regression results including this additional quota category are presented in the appendix.

[31] A full break down of the counts for exporters, entrants and exiters across industries and tariff exposure categories is presented in the appendix.

Fig. 2. Numbers of exporters and value in 2015 exporting to EU across HS industries and exposure to EU tariffs



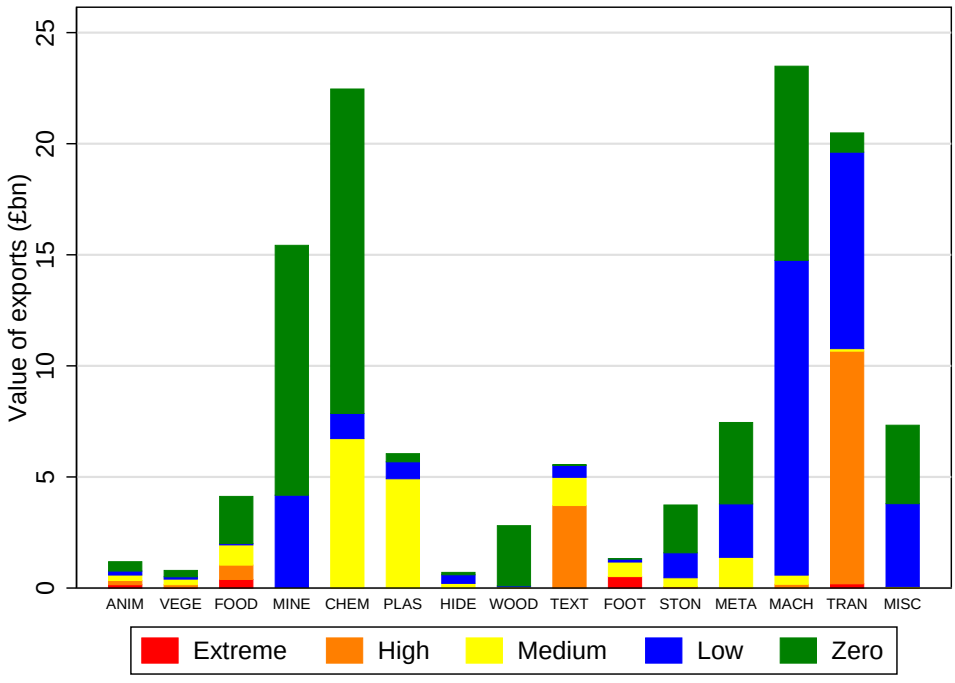
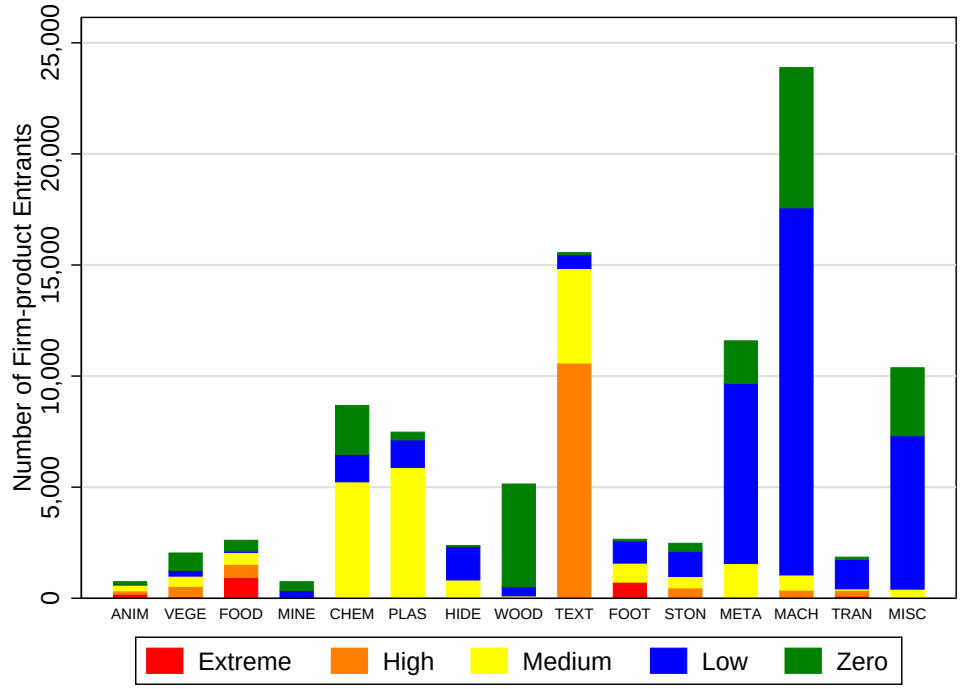
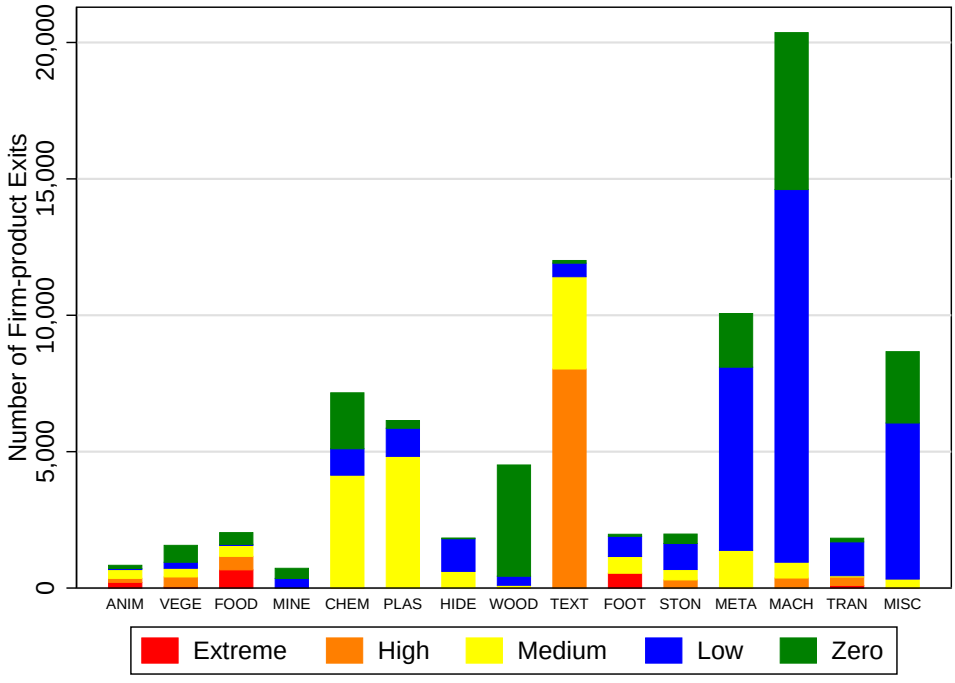


Fig. 3. Numbers of entrants, and exiters in 2015 exporting to EU across HS industries and exposure to EU tariffs





5. Results

We estimate the impact of trade policy uncertainty shock of the Brexit referendum result on the extensive margin exporting response of firms in the UK using a generalized differences-in-differences strategy. The strategy exploits cross-sectional variation in exposure to changes in threat point tariffs faced by products if Britain were to leave the EU Customs Union with no agreement on trade access and revert to World Trade Organisation (WTO) Most Favoured Nation (MFN) tariffs. The impact is measured using the differences in firm exporting decisions across CN8 products (first difference) and difference between product level aggregates of firm level exporting decisions before and after the referendum result (second difference). The main specification compares the annual outcomes for 2016 and 2015 to identify periods before and after the switch to the renegotiation regime. Comparison of annual outcomes removes the possibility that a comparison of pre and post referendum changes are driven by seasonal effects. Further analysis compares the outcomes from the post referendum outcomes in 2016 (which fell exactly in the middle of the year on the 23rd, announced on 24th, June 2016) to the same period in the previous year to directly identify the impact of the change in probability of the MFN tariffs on firm exporting decisions.

5.1. Uncertainty

The main results of the paper show that products exposed to increased trade policy uncertainty experienced decreased growth in entry and increased exit. Table 8 presents the main results of the impact of the continuous measure of tariff uncertainty on firm exporting decisions in Panel A. CN8 products facing exposure to higher threat point tariffs experienced a greater decrease in the growth rate of firms exporting to the EU, a decrease in the growth rate of entrants into exporting to the EU and an increase in the growth rate of exiters from exporting to the EU between 2016 and 2015. These results provide evidence towards our main empirical prediction that higher tariff uncertainty lowers the number of firms entering into exporting, where the magnitude of the estimates indicates that a 1 percentage point rise in the tariff in the threat point tariff reduces the growth rate of firm-product entrants by 1.05 percentage point shown in Panel A Column 2. Higher tariff uncertainty for a product also increases the growth rate of firms exiting from exporting the product to the EU by 0.49 percentage point for each 1 percentage point rise in the threat point tariff. A 1 percentage point rise in the tariff facing British exporters lowers the growth rate of firms exporting that product by 0.16 percentage point shown in Panel A Column 1.

The results of the second tariff uncertainty specification uses five categories of exposure to identify the impact of trade policy uncertainty on firm exporting decisions and Table 8 presents the results in Panel B. The results show that products exposed to increasingly severe tariffs have a decrease in the growth rate of exporting firms, fall in the growth rate of entrants and rise in the growth rate of exiters between 2016 and 2015 relative to products exposed to a zero threat point tariff (the base case). Exposure to higher threat point tariffs, categorized as high or extreme tariffs, generates the largest magnitude effects. Exposure to extreme threat point tariffs (EU MFN tariffs

of over 15%) are associated with a 5.1 percentage point fall in the growth rate of exporters, a 25.3 percentage point decline in the growth rate of entrants relative to products that face a no increase in threat point tariffs. Exposure to high threat point tariffs (EU MFN tariffs between 10% and 15%) generates smaller, although still highly significant, 12.3 percentage point fall in the growth rate of entrants. Exposure to high threat point tariffs also generates a statistically significant 10.0 percentage point rise in the growth rate of exiters relative to products facing no threat point tariff. These discrete tariff category estimates are in line with the continuous tariff measure, suggesting that there is not a non-linear response of firm exporting decisions to exposure to threat point tariffs.

The constant in the second tariff uncertainty specification represents the growth for each firm-product outcome in products that face a zero MFN tariff and hence no increase in threat point tariff. Products facing no tariff uncertainty have experienced a significant growth of 3.8% in the number of firms exporting to the EU in 2016 relative to 2015, shown in Panel B Column 1. This has been driven by an increase in firm entry into exporting these products to the EU, with zero tariff products experiencing a 8.7% growth rate of entry in 2016 relative to 2015, and decline in the growth rate of exit of 4.4%. This positive baseline growth can explain why in the aggregate statistics Britain has not seen a decline in the aggregate value or number of firms, or firm-products exported to the EU in 2016, despite the heightened trade policy uncertainty. The products which face no increase in threat point tariffs have grown significantly, which has counterbalanced the negative impact that the heightened uncertainty has had on firm entry and exit in products exposed to the high and extreme threat point tariffs. One possible reason for the rapid growth rates of entrants and fall in the growth rate of exiters is the large, unexpected depreciation of sterling in 2016, which we explore further in the next subsection (5.2).

Table 2: Growth in UK-EU exporters, entrants and exiters at product level in 2016 relative to 2015

	(1) Firm-product exporters	(2) Firm-product entrants	(3) Firm-product exiters
Panel A			
Threat point tariff rate	-0.00155**	-0.0105***	0.00490**
	(0.000668)	(0.00225)	(0.00219)
Constant	0.0443***	0.0858***	-0.0236
	(0.00456)	(0.0146)	(0.0144)
Observations	7,665	7,436	7,336
R-squared	0.001	0.004	0.001
Panel B			
Extreme threat point tariffs	-0.0509***	-0.253***	0.0795
	(0.0184)	(0.0648)	(0.0659)
High threat point tariffs	-0.00109	-0.123***	0.100***
	(0.0107)	(0.0335)	(0.0338)
Medium threat point tariffs	0.00905	-0.0288	0.0393
	(0.00893)	(0.0288)	(0.0294)
Low threat point tariffs	-0.00348	-0.0616**	0.0606**
	(0.00854)	(0.0268)	(0.0265)
Constant	0.0383***	0.0871***	-0.0437**
	(0.00671)	(0.0216)	(0.0214)
Observations	7,665	7,436	7,336
R-squared	0.002	0.004	0.001

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is finalised when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

5.1.1. Partial equilibrium aggregation

We quantify the aggregate impact from the rise in trade policy uncertainty under Brexit in a partial equilibrium exercise. We estimate that in the counterfactual of no trade policy uncertainty and zero possible future tariffs, entry into exporting to EU markets would have been 5.1% higher in

2016 than the realized level of entry, whilst exit would have been 4.3% lower.

We estimate the partial equilibrium impact of the trade policy uncertainty using the regression coefficients reported in Table 8 and firm-product exporter statistics[32] across the discrete measure of exposure to tariffs. For each non-zero tariff exposure category (extreme, high, medium and low) we estimate the product of the relevant exporter count in 2015 and the regression coefficient to quantify the model predicted impact of trade policy uncertainty relative to the baseline case of zero tariffs. We sum the model predicted impact over each tariff exposure category to derive the aggregate impact. The partial equilibrium exercise estimates that 5,221 firm-products did not enter (1 year break definition) into exporting to the EU that would have in the counterfactual of no trade policy uncertainty illustrated by the baseline zero tariff products. As 103,151 firm-products actually entered into exporting to the EU in 2016 (excluding entry into products possibly exposed to quotas), the partial equilibrium exercise implies that if firms exporting from the UK to the EU had not faced increased trade policy uncertainty, firm-product entry would have been 5.1% higher in 2016.[33] Equivalent exercises for the number of exporters and number of exiters implies that the number of exiters would have been 4.3% lower in the zero tariff uncertainty counterfactual.

We also provide an estimate of the export value that was lost as a result of the reduced entry into exporting to EU markets. We apply the partial equilibrium aggregation estimates to the average value of exports by each firm-product exporter to the EU in 2015. When we use the average value of *entrants* in 2015 (not accounting for partial year effects) in each tariff exposure category, we estimate that the reduced entry accounts for a £226 million loss of export value from the UK to the EU in 2016. If we use the average value of exports for *all* firm-product exporters in each exposure category, we find a significantly larger impact with a loss of export value from the UK to the EU of £1.4 billion in 2016.

5.2. Uncertainty and exchange rate sensitivity

The impact of increased trade policy uncertainty are robust to controls for industry level exchange rate sensitivity. Table 3 presents the results for the difference-in-difference specification, controlling for HS02 industry exchange rate sensitivity. The magnitude and significance of the results are predominantly robust to controlling for exchange rate sensitivity. In the difference-in-difference specification, the point estimates do not change significantly for the continuous measure of tariff uncertainty presented in Panel A of Table 3, with a small decrease in the magnitude of the impact of tariff uncertainty on the growth of firm-product entrants and the growth in firm-product exiters. Comparable effects are found when controlling for exchange rate pass through sensitivity in the discrete measure of tariff uncertainty in Panel B in Table 3. Industries with greater exchange rate sensitivity experience an insignificant increase in the growth of firm-products in 2016 relative to 2015, driven by a significant decrease in the growth rate of exits. The relationship between exchange

[32] See Table 12-15 in the Appendix.

[33] When we account for the uncertainty caused by possible quota restrictions, we estimate that 6,294 firms did not enter of 107,298 firms suggesting that entry would have been 5.9% higher in the no uncertainty counterfactual.

rate sensitivity and entry rates is not significant, suggesting that exchange rate sensitivity is more important for incumbents and the gross exit margin of exporting. After controlling for industry sensitivity to exchange rates, the fall in the growth rate of exiters for the base case of zero threat point tariffs becomes insignificant, indicating that the depreciation of sterling was a significant factor in the aggregate firm dynamics of UK export in 2016.

Table 3: Growth in UK-EU exporters, entrants and exiters at product level in 2016 relative to 2015, controlling for industry exchange rate sensitivity (unit value)

	(1)	(2)	(3)
	Firm-product exporters	Firm-product entrants	Firm-product exiters
Panel A			
Threat point tariff rate	-0.00173**	-0.0103***	0.00575***
	(0.000678)	(0.00230)	(0.00223)
Sensitivity to exchange rate	0.0241	-0.0240	-0.114*
	(0.0184)	(0.0589)	(0.0613)
Constant	0.0404***	0.0898***	-0.00484
	(0.00561)	(0.0178)	(0.0180)
Observations	7,665	7,436	7,336
R-squared	0.001	0.004	0.002
Panel B			
Extreme threat point tariffs	-0.0526***	-0.249***	0.0918
	(0.0184)	(0.0650)	(0.0659)
High threat point tariffs	-0.00389	-0.117***	0.121***
	(0.0110)	(0.0346)	(0.0351)
Medium threat point tariffs	0.00699	-0.0247	0.0542*
	(0.00906)	(0.0293)	(0.0298)
Low threat point tariffs	-0.00477	-0.0589**	0.0702***
	(0.00862)	(0.0270)	(0.0266)
Sensitivity to exchange rate	0.0172	-0.0349	-0.126**
	(0.0187)	(0.0596)	(0.0620)
Constant	0.0362***	0.0914***	-0.0280
	(0.00722)	(0.0232)	(0.0234)
Observations	7,665	7,436	7,336
R-squared	0.002	0.004	0.002

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. A control is included for the HS02 industry sensitivity of exchange rate pass through (Sensitivity of unit values to exchange rate) calculated from the change in the unit value price in response to movements in bilateral exchange rates (see text for more details). Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

5.3. Controlling for product specific shocks

The impacts of increased trade policy uncertainty are also are robust to controlling for potential supply chain or global product demand shocks. In both the continuous and discrete specification, the magnitude and significance of the estimated effects increases in the majority of the triple difference specification results. These results suggest that firms in the UK may have switched from exporting to EU markets, to exporting to non-EU markets in response to the rise in trade policy uncertainty in EU markets.

Table 4 presents the results for the triple difference specification for the continuous measure of tariff uncertainty in Panel A. The impact of tariff uncertainty on the growth in the number of firm-products exported to the EU relative to non-EU markets between 2015 and 2016 is shown in Column 1 of Panel A, where a 1 percentage point rise in tariff uncertainty reduces the number of firms exporting to the EU relative to non-EU by 4.5 percentage point. The large magnitude of this effect (relative to the main difference-in-difference specification) results from the large decrease in the growth of entrants (shown in Panel A, column 2 in Table 4) and a larger increase in the number of firm exiters (Panel A, column 3 in Table 4).[34]

The results for the discrete measure of tariff uncertainty are also robust to the triple difference specification presented in Panel B in Table 4. The results across most of the different categories of tariff exposure increase in magnitude and significance for the number of firm-products and firm-product entrants. The estimates for the impact of different categories of tariff exposure do change for firm-product exiters, where the significant increase in the growth rate of firm-product exiters exposed to high threat point tariffs (tariff of between 10 and 15%) falls in magnitude and significance, and the impact of exposure to extreme threat point tariffs with a rise in the growth rate of exiters between 2015 and 2016 of 20.5 percentage point from EU markets relative to non-EU markets.

[34]The number of products included as observations falls relative to the main difference in difference specification as not all products are exported to both the EU and non-EU, or products do not have positive numbers of entrants and/or exiters in at least one year of 2015 or 2016 for both EU and non-EU markets. Results using a consistent sample size across both the main difference in difference and triple difference specifications give similar effects in sign, magnitude and significance.

Table 4: Growth in UK-EU exporters, entrants and exiters relative to UK-non-EU exporters, entrants and exiters at product level in 2016 relative to 2015

	(1) Firm-product exporters	(2) Firm-product entrants	(3) Firm-product exiters
Panel A			
Threat point tariff rate	-0.00447***	-0.0116***	0.00741***
	(0.00121)	(0.00289)	(0.00277)
Constant	0.0422***	0.0801***	-0.0369**
	(0.00741)	(0.0174)	(0.0172)
Observations	7,198	7,006	6,890
R-squared	0.002	0.003	0.001
Panel B			
Extreme threat point tariffs	-0.0943**	-0.221**	0.205**
	(0.0396)	(0.0966)	(0.0966)
High threat point tariffs	-0.0632***	-0.188***	0.0796*
	(0.0192)	(0.0422)	(0.0431)
Medium threat point tariffs	-0.00987	-0.0629*	0.0490
	(0.0149)	(0.0350)	(0.0358)
Low threat point tariffs	-0.0207	-0.0982***	0.0705**
	(0.0135)	(0.0312)	(0.0315)
Constant	0.0406***	0.103***	-0.0547**
	(0.0108)	(0.0251)	(0.0257)
Observations	7,198	7,006	6,890
R-squared	0.002	0.004	0.002

Notes: Table reports results of the OLS generalized triple difference regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between 2015 and 2016 relative to the growth rate of the same exporting decision from the UK to the non-EU. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

5.4. Half year estimates post referendum

The Brexit referendum occurred on the 23rd June 2016, with the results announced on the 24th June. The level of tariff uncertainty therefore differed across the two halves of 2016 (H1 - January

to June and H2 - July to December). Separate estimation of the pre-referendum period of 2016 (when the market implied probability of a leave vote and hence the probability of enterring into a renegotiation regime averaged 30.5% as shown in Figure 1) and the post-Brext period (when the probability of the UK enterring into a renegotiation regime with the EU increased to 100%) should give greater magnitude results in the post-referendum period if the results are driven by the effects of trade policy uncertainty following the switch to the renegotiation regime.[35] However, a comparison of the number of exporters, entrants and exiters between H2 2016 to H1 2016 would potentially suffer from bias from seasonal trends in exporting. To consistently estimate the effects pre and post referendum without bias from seasonal trends, we split the universe of customs transactions into H1 and H2 samples.[36] In the H1 sample, we discard all customs transactions conducted in H2 of every year and re-calculating entry and exit only based upon firm-product observations in the first six months of every year. We perform an equivalent strategy to create the H2 sample, discarding all information on customs transactions in H1 of every year, and re-calculating entry and exit. This approach controls for seasonal demand effects which might otherwise suggest that firm-products may not have entered or exited, when in fact they were seasonal fluctuations.

Table 5 presents the results for the H2 July to December samples. In the period after the referendum, when the UK had enterred into the renegotiation regime with the EU there is a significant impact on firm exporting decisions. The results for H2 2016 relative to H2 2015are consistent in magnitude and significance with the results found for the full year specification (6) presented in Table 8. The continuous measure of tariff uncertainty shows that the growth of firm-product entrants is slower in products facing higher levels of threat point tariffs, where a 1 percentage point increase in the threat point tariff decreases the growth rate in firm entry by 1.1 percentage point. The discrete measure of tariff uncertainty again shows that exposure to high and extreme tariffs generates larger and more significant reductions in the growth rate of the number of exporters and growth rate in the number of entrants. Exposure to high tariffs generates an increase in the growth of firm exiters.

Table 6 presents results for the H1 samples, our placebo test. The results show that when tariff uncertainty was low, due to a low probability that the threat point tariff would be realized in H1 2016, there was almost no significant impact on firm exporting decisions across all measures.

[35]There are five notable dates affecting tariff uncertainty in the years before the Brexit referendum: On 23rd January 2013, Prime Minister David Cameron promised an "In-Out" referendum on membership of the EU; 7th May 2015 the Conservative Party (led by David Cameron) wins a majority in the 2015 General Election with a manifesto that promised the In-Out referendum; 20th February 2016 Prime Minister David Cameron sets the 23rd June 2016 as the date for the referendum on membership of the EU; 23rd June 2016 the Brexit referendum takes place; 24th June 2016 Brexit referendum result announced as a 48-52 result in favour of 'leave'.

[36]As the half year samples differ, the regression coefficients are not directly comparable with the full year results.

Table 5: Growth in UK-EU exporters, entrants and exiters at product level in July-December 2016 relative to July-December 2015

	(1)	(2)	(3)
	Firm-product exporters	Firm-product entrants	Firm-product exiters
Panel A			
Threat point tariff rate	-0.00145*	-0.0108***	0.000536
	(0.000741)	(0.00238)	(0.00236)
Constant	0.0494***	0.111***	0.0131
	(0.00489)	(0.0154)	(0.0156)
Observations	7,521	7,270	7,146
R-squared	0.001	0.004	0.000
Panel B			
Extreme threat point tariffs	-0.0424**	-0.264***	-0.0911
	(0.0202)	(0.0663)	(0.0686)
High threat point tariffs	-0.00450	-0.130***	0.152***
	(0.0118)	(0.0356)	(0.0379)
Medium threat point tariffs	0.00230	-0.0324	0.0913***
	(0.00970)	(0.0306)	(0.0316)
Low threat point tariffs	-0.00855	-0.0653**	0.117***
	(0.00907)	(0.0282)	(0.0290)
Constant	0.0472***	0.114***	-0.0577**
	(0.00726)	(0.0227)	(0.0234)
Observations	7,521	7,270	7,146
R-squared	0.001	0.004	0.005

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between H2 2015 and H2 2016. H1 is defined as July to December of a given year. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

Table 6: Growth in UK-EU exporters, entrants and exiters at product level in January-June 2016 relative to January to June 2015

	(1) Firm-product exporters	(2) Firm-product entrants	(3) Firm-product exiters
Panel A			
Threat point tariff rate	0.000246	-0.00360	0.00302
	(0.000701)	(0.00231)	(0.00234)
Constant	0.0235***	0.0212	0.00560
	(0.00473)	(0.0152)	(0.0153)
Observations	7,505	7,231	7,141
R-squared	0.000	0.000	0.000
Panel B			
Extreme threat point tariffs	-0.0177	-0.0901	0.0700
	(0.0199)	(0.0671)	(0.0704)
High threat point tariffs	0.0293**	-0.0398	0.0355
	(0.0119)	(0.0357)	(0.0361)
Medium threat point tariffs	0.0288***	0.0202	0.0278
	(0.00947)	(0.0305)	(0.0309)
Low threat point tariffs	0.0109	0.000366	0.0473*
	(0.00884)	(0.0279)	(0.0281)
Constant	0.0116*	0.00635	-0.00966
	(0.00704)	(0.0225)	(0.0225)
Observations	7,505	7,231	7,141
R-squared	0.002	0.001	0.001

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between H1 2015 and H1 2016. H1 is defined as January to June of a given year. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

6. Conclusion

In this paper, we estimate the impact of the announcement of a renegotiation of the UK-EU trade relationship on firm exporting decisions from the UK to the EU. We develop a granular measure

of cross-sectional variation in trade policy uncertainty across all CN8 products exported from the UK to the EU using the threat point tariffs that firms exporting from the UK to the EU will face if no agreement is reached in the UK-EU Brexit trade negotiations. Products facing higher threat point tariffs experience a significant decrease in the number of entrants into exporting to the EU, a significant increase in the number of firms exiting from exporting to the EU and hence a decrease in the overall number of firms exporting to the EU. The magnitude of these results is economically significant, with exposure to extreme threat point tariffs ($\geq 15\%$) and high ($10\% \leq$ threat point tariff $\leq 15\%$) generating a 25 percentage point and 12 percentage point decline in the growth rate of entrants into exporting relative to products facing zero threat point tariffs. A partial equilibrium aggregation exercise implies that if firms exporting from the UK to the EU had not faced an increase in trade policy uncertainty, then 5.1% more firms would have entered into exporting to the EU in 2016, whilst 4.3% fewer firms would have exited from exporting to the EU.

The paper considers the importance of the extensive margin in driving aggregate export growth. We document that there is significant churn in the flows of entrants and exiters across all industries exporting from the UK to the EU as found in other countries (Albornoz, Pardo, Corcos, and Ornelas (2012)). Trade policy uncertainty significantly reduces the gross extensive margin flows, especially entry into exporting. However, as entrants are small in terms of value, a large change in the number of firms entering into and exiting from exporting does not generate a large aggregate impact on the value of exports in the first year following a change in trade policy. Specifically, we estimate that the decline in entry reduced the value of exports by between £226 million and £1.4 billion in 2016, a small total value relative to total exports to the EU in 2016 of £140 billion.

The magnitude of the extensive margin responses to the trade policy uncertainty are economically large. The magnitudes of the gross entry margin response to extreme and high threat point tariffs are a similar magnitude to the gross entry margin response of French exports during the Great Trade Collapse of 2008-9 (Bricongne, Fontagné, Gaulier, Taglioni, and Vicard, 2012). We also find a novel response on the gross exit margin of exports, with a significant increase in firm-product exit in products exposed to higher threat point tariffs. Previous studies have found this gross exit margin to be resilient to (temporary) trade and economic shocks (Bricongne et al., 2012 and Bernard, Jensen, Redding, and Schott, 2009). Our results show that the extensive margin response is more elastic to a small probability of a large tariff hike and the associated uncertainty than equivalent estimates of trade elasticities. This therefore illustrates further heterogeneity in the response of exporters to economic shocks as studied in Fitzgerald and Haller (2018). Future research could further study the heterogeneity in extensive margin response of exporters across different types of trade policy, as well as different types of products.

Appendix A. Moving from theory to estimation

A.1. Switch from deterministic to uncertain trade policy regime

The number of firms entering into exporting each product n_h changes following a switch in trade policy regime in time t from a certain policy regime $n_h^{certain}$ when $\gamma = 0$ to an uncertain policy regime n_h^U when $\gamma > 0$ is determined by $c_{R,h}^U / c_{R,h}^{certain} = U(\omega_h, \gamma)$.

$$\begin{aligned}
\Delta ln\, n_h &= ln\, n_h^U - ln\, n_h^{certain} \\
&= \int_{c_{R,h}^{certain}}^{c_{R,h}^U} ln(c)\, dG_h(c) \\
&= \int_{c_{R,h}^{certain}}^{c_{R,h}^U} ln\left(\frac{c}{c_v}\right)^{\kappa} dc \\
&= \kappa\, ln\left(\frac{c_{R,h}^U}{c_{R,h}^{certain}}\right) \\
&= \kappa\, ln\, U(\omega_h, \gamma) + \frac{\kappa}{\sigma - 1}\Delta ln(a_h)
\end{aligned} \tag{10}$$

A.1.1. First difference - control for product level rates of entry

The counterfactual outcome $c_{R,ht}^{certain}$ in the period t is unobserved. We therefore use the entry rate in the period $t-1$ before the switch into the renegotiation trade policy regime, associated with the cutoff $c_{R,ht-1}^U$, as our counterfactual rate of entry.

$$\begin{aligned}
\Delta ln\, n_{ht} &= ln\, n_{ht} - ln\, n_{ht-1} \\
&= \kappa\, ln\, U(\omega_h, \gamma) + \frac{\kappa}{\sigma - 1}(ln(a_{ht}) - ln(a_{ht-1}))
\end{aligned} \tag{11}$$

A.1.2. Second difference - control for aggregate economic conditions

The change in aggregate economic conditions $\Delta ln(a_v)$ facing the exporter can be decomposed, giving the effect of a switch in trade policy regime on rates of entry as:

$$\begin{aligned}
\Delta ln\, n_{ht} = \kappa\, lnU(\omega_h, \gamma) &\\
- \frac{\sigma\kappa}{\sigma - 1}\big(ln(\tau_{Rht}) - ln(\tau_{Rht-1})\big) &\\
- \kappa\big(ln(d_{ht}) - ln(d_{ht-1})\big) &\\
+ \frac{\kappa}{\sigma - 1}\big(ln\big(P_{ht}E_{ht}^{\frac{1}{\sigma-1}}\big) - ln\big(P_{ht-1}E_{ht-1}^{\frac{1}{\sigma-1}}\big)\big) &
\end{aligned} \tag{12}$$

The counterfactual in period $t-1$ assumes that there are no aggregate changes between the two periods that affect the rate of entry in period t. As the UK is assumed to be small relative to the

EU, we assume that any of the changes are exogenous to the shift in policy. The empirical model in the difference-in-difference specification assumes that any changes in transport costs Δd_{ht} and destination aggregate expenditure ΔE_{ht} are the same for all products, h. This gives the growth in entry as:

$$\Delta ln\, n_{ht} = \kappa\, lnU(\omega_h, \gamma) \tag{13}$$

A.1.3. Regression framework

The prediction that products with higher threat point tariffs experience reduced entry relative to products with lower threat point tariffs following the switch to the renegotiation regime can then be written in the regression framework with $lnU(\omega_h, \gamma)$ as $Uncertainty_h$:

$$\Delta ln\, n_{ht} = b_0 + b_1\, ln\, Uncertainty_h + e_{ht} \tag{14}$$

A.1.4. Theory consistent measure of uncertainty

The uncertainty factor $Uncertainty_h$ can be written in full as:

$$U(\omega_h, \gamma) = \left(\frac{1 + \frac{\gamma \lambda_2 \beta}{1-\beta} (\tau_{WTO,h}/\tau_{R,h})^{-\sigma}}{1 + \gamma \lambda_{WTO} \beta/(1-\beta)} \right)^{\frac{1}{\sigma - 1}} \tag{15}$$

where Handley and Limão (2017) show that approximating around $\gamma = 0$:

$$k\, lnU(\omega_h, \gamma) \approx b_\gamma \left(1 - \left(\frac{\tau_{WTO,h}}{\tau_{R,h}} \right)^{-\sigma} \right) \tag{16}$$

such that for $\sigma = 1$, $\tau_{R,h}^{certain} = 0$, MFN small:

$$ln\, U(\omega_h, \gamma) \approx \tau_{WTO,h} = \tau_h^{threat\, point} = MFN_h. \tag{17}$$

This therefore motivates our regression specification:

$$\Delta ln\, n_{ht} = b_0 + b_1\, MFN_h + e_{ht}. \tag{18}$$

A.2. Switch to a renegotiation regime

The assumption that $\gamma = 0$ in the pre-referendum period (t-1) is not necessary to obtain the direction of the empirical predictions as the effect of uncertainty on entry is monotonic: $\partial c_{R,h}^U / \partial \gamma < 0$ for all γ. The market implied probability of a 'leave' vote in the Brexit referendum averaged 30.5% in the year running up to the Brexit referendum shown in Figure 1. The growth in entrants following the switch in trade policy regimes resulting from an increase in $\gamma = 0.3$ to $\gamma = 1$ is:

$$\begin{aligned}\Delta ln\, n_{ht} &= ln\, n_{ht} - ln\, n_{ht-1} \\ &= \kappa \left(ln\, U(\omega_h, \gamma = 1) - ln\, U(\omega_h, \gamma = 0.3) \right)\end{aligned} \tag{19}$$

This cross-sectional variation in entry monotonically increases in τ_h, which continues to motivate our reduced form regression specification (although the structural interpretation of the coefficients changes).

A.3. Triple difference model: Controlling for product specific shocks

The outcome for firm entry without the increased probability of renegotiations following the Brexit referendum is not observed. We therefore need to control for other confounding factors that change as a result of the 'leave' vote, including controlling for other ad valorem export cost changes, $\Delta d_h t$. Handley and Limão (2017) control for changes in export costs changes using observed changes in freight and insurance costs in the time period following the resolution of trade policy uncertainty. In our analysis of the switch to the renegotiation regime, Brexit cost shocks may be in expectation and not yet realized, making it difficult to control explicitly. This measurement issue leads us to triple-difference identification exploiting differences in entry into exporting between the EU and non-EU countries. This inherently assumes any changes to the UK firms' production costs have the same effect on changes in export participation in the EU and non-EU countries ($\Delta d_h^{EU} = \Delta d_h^{non-EU}$).

$$\Delta\, ln\, n_{ht}^{EU} = b_0 + b_1 \tau_h^{threat\, point} + b_d \Delta d_{ht}^{EU} + e_{ht} \tag{20}$$

$$\Delta\, ln\, n_{ht}^{non-EU} = b_0 + b_d \Delta d_{ht}^{non-EU} + e_{ht} \tag{21}$$

$$\Delta\, ln\, n_{ht}^{EU} - \Delta\, ln\, n_{ht}^{non-EU} = b_0 + b_1 \tau_h^{threat\, point} + b_d (\Delta d_{ht}^{EU} - \Delta d_{ht}^{non-EU}) + e_{ht} \tag{22}$$

$$\Delta\, ln\, n_{ht}^{EU} - \Delta\, ln\, n_{ht}^{non-EU} = b_0 + b_1 \tau_h^{threat\, point} + e_{ht} \tag{23}$$

Appendix B. Additional results

B.1. Entrant definition

This section present results of the impact of trade policy uncertainty on entry into exporting across different definitions of entry. We increase the number of calendar years between the observed and previous exporting occurrence required to define entry. As the number of years increases, the definition of an entrant becomes increasingly strict and moves towards absolute entry, rather than re-entry decisions. The results show that as the estimates become increasingly strict that the estimated coefficients become more negative for the continuous tariff rate measures and the extreme and high categories of exposure to possible tariffs. This suggests that tariff uncertainty is more important for firms making initial entry decisions, who face potentially higher sunk costs of entry, than firms who are re-entering.

Table 7: Growth in UK-EU entrants (1, 2 or 3 year break definition) at product level in 2016 relative to 2015

	(1) Entrants (1 year)	(2) Entrants (2 year)	(3) Entrants (3 year)
Panel A			
Threat point tariff rate	-0.0105***	-0.0116***	-0.0118***
	(0.00225)	(0.00240)	(0.00246)
Constant	0.0858***	0.0848***	0.0885***
	(0.0146)	(0.0156)	(0.0160)
Observations	7,436	7,362	7,310
R-squared	0.004	0.004	0.004
Panel B			
Extreme threat point tariffs	-0.253***	-0.296***	-0.303***
	(0.0648)	(0.0696)	(0.0712)
High threat point tariffs	-0.123***	-0.126***	-0.124***
	(0.0335)	(0.0360)	(0.0373)
Medium threat point tariffs	-0.0288	-0.0183	-0.0196
	(0.0288)	(0.0309)	(0.0320)
Low threat point tariffs	-0.0616**	-0.0452	-0.0500*
	(0.0268)	(0.0288)	(0.0295)
Constant	0.0871***	0.0748***	0.0797***
	(0.0216)	(0.0231)	(0.0238)
Observations	7,436	7,362	7,310
R-squared	0.004	0.005	0.005

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of entry into exporting decision (1, 2 or 3 year break definition) from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

B.2. Quota

In this section we include products that face quotas in the threat point tariff, or non ad valorem tariffs. Products facing these quotas experience a decrease in entry and large and significant increase in exit.

Table 8: Growth in UK-EU exporters, entrants and exiters at product level in 2016 relative to 2015, including quotas

	(1)	(2)	(3)
	Firm-product exporters	Firm-product entrants	Firm-product exiters
Threat point quota	-0.0376***	-0.234***	0.0869**
	(0.0121)	(0.0425)	(0.0436)
Extreme threat point tariffs	-0.0509***	-0.253***	0.0795
	(0.0184)	(0.0648)	(0.0659)
High threat point tariffs	-0.00109	-0.123***	0.100***
	(0.0107)	(0.0335)	(0.0338)
Medium threat point tariffs	0.00905	-0.0288	0.0393
	(0.00893)	(0.0288)	(0.0294)
Low threat point tariffs	-0.00348	-0.0616**	0.0606**
	(0.00854)	(0.0268)	(0.0265)
Constant	0.0383***	0.0871***	-0.0437**
	(0.00671)	(0.0216)	(0.0214)
Observations	8,520	8,231	8,131
R-squared	0.003	0.007	0.001

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable is the discrete measure of the MFN tariff, which is split into 6 possible categories ('Quota' for non ad valorem tariff rate measures, 'Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

B.3. Alternative measure of exchange rate pass through sensitivity

To validate our estimates, we perform three robustness checks. First, we acknowledge that firms' sensitivity to exchange rate shocks may not necessarily being restricted to price (unit value) movements but also could be reflected in quantity changes. To this end, we separately estimate the quantity and value elasticity to exchange rates and use them as alternative controls. Second, we do not observe the pricing currency or the invoicing currency for products sold to the EU destinations. If most products sold to EU destinations are priced in euro rather than destination-specific currencies, the responsiveness to euro movements should be the relevant measure and using destination-

specific bilateral exchange rates would potentially produce biased estimates. To address this issue, we perform robustness checks using the sterling-euro rate rather than the sterling-destination rate as the exchange rate measure in equation (7). Third, we introduce firm fixed effects to absorb price level and trading frequency differences across firms.[37] We find our main result on firm entry and exit is robust to different sensitivity measures estimated using these alternative specifications.

The regression results incorporating measures of exchange rate sensitivity using the value of exports rather than the unit value do not change the direction of the main results of the impact of trade policy uncertainty, although the magnitudes of the main results are lower than in the main results or controlling for industry sensitivity measured using unit values. Surprisingly, we find that industries with greater exchange rate sensitivity in the value of exports in response to exchange rate movements experience decreased entry and increased exit in 2016 relative to 2015, despite the large depreciation of sterling. In the later results for the intensive margin, we find that industries with greater sensitivity of value to exchange rate movements experience a greater increase in the value of exports in 2016 relative to 2015.

[37]The need to add firm-level dummies is mainly due to the unbalanced nature of the customs database driven by firms' endogenous choices of markets. In a balanced panel, the dimension along which exchange rate varies is naturally uncorrelated with factors that are firm invariant and thus no firm-level fixed effect is needed.

Table 9: Growth in UK-EU exporters, entrants and exiters at product level in 2016 relative to 2015, controlling for industry exchange rate pass through sensitivity (total value)

	(1)	(2)	(3)
	Firm-product exporters	Firm-product entrants	Firm-product exiters
Panel A			
Threat point tariff rate	-0.00130*	-0.00928***	0.00381*
	(0.000695)	(0.00229)	(0.00224)
Sensitivity to Exchange Rate	-0.0120	-0.0583*	0.0546*
	(0.0102)	(0.0325)	(0.0326)
Constant	0.0509***	0.118***	-0.0537**
	(0.00739)	(0.0239)	(0.0238)
Observations	7,665	7,436	7,336
R-squared	0.001	0.004	0.001
Panel B			
Extreme threat point tariffs	-0.0452**	-0.227***	0.0563
	(0.0187)	(0.0655)	(0.0665)
High threat point tariffs	0.00372	-0.102***	0.0802**
	(0.0111)	(0.0345)	(0.0351)
Medium threat point tariffs	0.0106	-0.0224	0.0333
	(0.00896)	(0.0286)	(0.0293)
Low threat point tariffs	-0.00329	-0.0609**	0.0595**
	(0.00853)	(0.0268)	(0.0265)
Sensitivity to Exchange Rate	-0.0132	-0.0589*	0.0562*
	(0.0104)	(0.0332)	(0.0333)
Constant	0.0457***	0.120***	-0.0752**
	(0.00914)	(0.0297)	(0.0294)
Observations	7,665	7,436	7,336
R-squared	0.002	0.005	0.002

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant exporting decision (exporters, entrants, exiters) from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. A control is included for the HS02 industry sensitivity of exchange rate pass through calculated from the change in the total value of trade in response to movements in bilateral exchange rates. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

B.4. Intensive margin

In this section we present results on the intensive margin of exports from the UK to the EU in 2016 relative to 2015, where the intensive margin is measured using the value of trade, the number of transactions, the number of units (when appropriate) and the weight of exports. The most consistent results show that products facing the greatest exposure to threat point tariffs increased in the value of exports to the EU in 2016 relative to 2015. These results are (weakly) robust to both measures of sensitivity to exchange rate movements. The results could possibly reflect firms increasing export sales at zero tariff rates in anticipation of future tariffs, however future work will explore whether the intensive margin results are driven by incumbents or the net entry margin, as well as decomposing the price and quantity movements further.

Table 10: Growth in UK-EU value, transactions, units and mass at product level in 2016 relative to 2015

	(1) Value	(2) Transaction	(3) Units	(4) Mass
Panel A				
Threat point tariff rate	0.00398**	-0.000829	-0.00628*	0.00185
	(0.00160)	(0.000795)	(0.00378)	(0.00179)
Constant	0.0556***	0.0549***	0.120***	0.0147
	(0.0107)	(0.00529)	(0.0270)	(0.0121)
Observations	7,665	7,665	2,214	7,664
R-squared	0.001	0.000	0.001	0.000
Panel B				
Extreme threat point tariffs	0.0680	-0.0438**	-0.0950	0.0596
	(0.0419)	(0.0211)	(0.125)	(0.0474)
High threat point tariffs	0.121***	0.0192	-0.0295	0.0450
	(0.0266)	(0.0125)	(0.0552)	(0.0330)
Medium threat point tariffs	0.0418**	0.00107	-0.00343	0.0217
	(0.0211)	(0.0101)	(0.0536)	(0.0243)
Low threat point tariffs	0.0333*	-0.00747	0.0312	0.0151
	(0.0199)	(0.00978)	(0.0501)	(0.0228)
Constant	0.0384**	0.0536***	0.0816*	0.00587
	(0.0160)	(0.00785)	(0.0424)	(0.0178)
Observations	7,665	7,665	2,214	7,664
R-squared	0.003	0.001	0.001	0.000

Notes: Table reports results of the OLS regressions. The dependent variable is the growth rate of the relevant intensive margin of exports from the UK to the EU measured at the CN8 product level between 2015 and 2016. The independent variable in Panel A is the continuous measure of the MFN tariff that firms will face to export from the UK to the EU under WTO rules if no trade access agreement is agreed when Britain leaves the EU. The independent variable in Panel B is the discrete measure of the MFN tariff, which is split into 5 possible categories ('Extreme' for $MFN \geq 15\%$, 'High' for $10\% \leq MFN < 15\%$, 'Medium' for $5\% \leq MFN < 10\%$, 'Low' for $0\% < MFN < 5\%$, 'Zero' for $MFN = 0$), the 'Zero' category is omitted and the growth rate for this category is shown by the constant. Observations represents the number of CN8 products. The regression results are unweighted across products. Source: Calculations based on HMRC administrative datasets.

Appendix C. Firm counts and value across product sections and tariff exposure categories

Statistical censoring: Some counts of exporters, entrants and exiters across industries and tariff exposure categories have been censored due to HMRC disclosure requirements. These figures have been replaced with 'S' and the totals across each row and down each column have also been adjusted. Source: Calculations based on HMRC administrative datasets.

Table 11: Number of products by section and exposure 2015 (EC TARIC tariff data)

	Tariff Exposure						
hs_category	Quota	Extreme	High	Medium	Low	Zero	Total
ANIM	308	112	70	138	8	60	696
VEGE	150	16	81	94	51	132	524
FOOD	359	219	93	69	14	93	847
MINE	3	0	0	1	54	123	181
CHEM	21	0	1	669	108	246	1,045
PLAS	0	0	0	185	53	54	292
HIDE	0	0	0	33	42	28	103
WOOD	0	0	6	26	58	270	360
TEXT	1	0	363	516	177	34	1,091
FOOT	0	25	0	44	35	2	106
STON	7	0	25	59	112	75	278
META	0	0	1	104	347	471	923
MACH	0	0	33	37	968	294	1,332
TRAN	0	17	31	15	143	24	230
MISC	19	0	1	21	357	153	551
Total	868	389	705	2,011	2,527	2,059	8,559

Table 12: Number of firm-product exporters by section and exposure 2015

	Tariff Exposure						
hs_category	Quota	Extreme	High	Medium	Low	Zero	Total
ANIM	3,335	820	618	1,114	129	480	6,496
VEGE	2,234	181	1,687	1,687	1,158	3,124	10,071
FOOD	10,842	3,091	2,485	2,260	202	1,792	20,672
MINE	260	0	0	S	1,483	1,486	3,229
CHEM	197	0	S	19,357	4,681	10,055	34,290
PLAS	0	0	0	21,522	4,939	1,132	27,593
HIDE	0	0	0	2,663	5,250	115	8,028
WOOD	0	0	43	306	1,138	16,268	17,755
TEXT	S	0	36,325	15,065	1,959	279	53,628
FOOT	0	2,469	0	3,166	3,618	229	9,482
STON	33	0	1,430	1,696	4,164	1,390	8,713
META	0	0	49	5,388	28,758	6,482	40,677
MACH	0	0	1,044	2,638	56,445	20,868	80,995
TRAN	0	230	789	115	5,631	379	7,144
MISC	674	0	S	1,217	24,245	11,202	37,338
Total	17,575	6,791	44,470	78,194	143,800	75,281	366,111

Table 13: Number of firm-product entrants by section and exposure 2015

	Tariff Exposure						
hs_category	Quota	Extreme	High	Medium	Low	Zero	Total
ANIM	1,032	186	145	263	33	120	1,779
VEGE	639	55	481	460	262	779	2,676
FOOD	2,560	937	591	537	55	489	5,169
MINE	63	0	0	S	346	399	808
CHEM	58	0	S	5,237	1,231	2,209	8,735
PLAS	0	0	0	5,889	1,240	349	7,478
HIDE	0	0	0	824	1,510	36	2,370
WOOD	0	0	S	90	404	4,631	5,125
TEXT	S	0	10,588	4,254	622	93	15,557
FOOT	0	727	0	855	999	75	2,656
STON	S	0	466	513	1,134	362	2,475
META	0	0	S	1,546	8,105	1,920	11,571
MACH	0	0	367	680	16,524	6,315	23,886
TRAN	0	94	263	65	1,321	107	1,850
MISC	231	0	S	399	6,903	3,063	10,596
Total	4,583	1,999	12,901	21,612	40,689	20,947	102,731

Table 14: Number of firm-product exiters by section and exposure 2015

	Tariff Exposure						
hs_category	Quota	Extreme	High	Medium	Low	Zero	Total
ANIM	771	208	146	324	36	120	1,605
VEGE	432	44	362	319	220	620	1,997
FOOD	2,309	666	494	401	38	434	4,342
MINE	47	0	0	S	349	373	769
CHEM	56	0	S	4,136	969	2,052	7,213
PLAS	0	0	0	4,827	1,031	284	6,142
HIDE	0	0	0	610	1,197	S	1,807
WOOD	0	0	S	85	332	4,079	4,496
TEXT	S	0	8,030	3,382	498	99	12,009
FOOT	0	542	0	614	741	75	1,972
STON	S	0	298	381	954	347	1,980
META	0	0	S	1,368	6,717	1,967	10,052
MACH	0	0	367	580	13,662	5,753	20,362
TRAN	0	95	310	46	1,241	136	1,828
MISC	170	0	S	318	5,722	2,616	8,826
Total	3,785	1,555	10,007	17,391	33,707	18,955	85,400

Table 15: Total value of firm-product exporters by section and exposure 2015 (£mn)

	Tariff Exposure						
hs_category	Quota	Extreme	High	Medium	Low	Zero	Total
ANIM	1,899	148	191	245	180	421	3,084
VEGE	578	11	139	252	103	289	1,372
FOOD	2,794	385	648	909	64	2,119	6,920
MINE	24	0	0	S	4,146	11,248	15,419
CHEM	60	0	S	6,726	1,132	14,604	22,523
PLAS	0	0	0	4,919	764	366	6,048
HIDE	0	0	0	209	388	109	706
WOOD	0	0	1	54	42	2,711	2,808
TEXT	S	0	3,714	1,270	535	41	5,560
FOOT	0	515	0	656	141	4	1,315
STON	1	0	67	396	1,123	2,153	3,739
META	0	0	12	1,372	2,405	3,665	7,452
MACH	0	0	168	414	14,167	8,740	23,489
TRAN	0	189	10,475	110	8,845	867	20,486
MISC	142	0	S	63	3,732	3,532	7,469
Total	5,500	1,249	15,414	17,594	37,767	50,867	128,391

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