# 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 renegotiation 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 5300 exporters did not enter into exporting new products to the EU, whilst over 5400 exporters exited from exporting products to the EU. Entry (exit) in 2016 would have been 5.0% higher (6.1% 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), Handley and Limão (2017), and Crowley, Meng, and Song (2018)) 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

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

[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.

in a referendum on 23rd June 2016. Using the EU's World Trade Organization schedule of tariff 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 a switch into a renegotiation regime on the growth in the number of UK firms entering (exiting) the EU market in 2016 relative to 2015 (first difference) with different 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 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 22.4 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 13.2 percentage point. We conduct a partial equilibrium aggregation exercise to calculate the number of missing entrants into (exiters from) the EU as a result of the switch to the renegotiation regime post-Brexit. This exercise estimates that 5344 firms did not enter into exporting new products to the EU in 2016, whilst 5437 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 5.0% higher (6.1% 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 et al. (2018)), 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 renegotiations and the uncertainty over policy that they bring.

We further 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 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 the

[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.

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. (2018)). 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 exporters' 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. (2018) is the first paper to examine how an *increase* in trade policy uncertainty affects firm entry dynamics, using 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. An analysis of UK and EU trade in the year prior to the Brexit referendum (Handley and Limão, 2018) complements our post-Brexit analysis in finding that greater uncertainty corresponds to reduced trading activity.

Our paper is structured as follows. Section 2 describes the institutional framework of the Brexit referendum and the theoretical model. Section 3 outlines the empirical models. Section 4 introduces the data and describes the measurement of firm exporting decisions. Section 5 presents the empirical results and Section 6 concludes.

## 2. Renegotiation of the terms of UK-EU trade

Changes to the level of tariffs or the likelihood that a country's tariff schedule will persist into the future represent a switch in the trade policy regime. The Brexit vote of 23 June 2016 initiated a 'renegotiation regime' – a period of heightened uncertainty about future trade policy between the UK and EU characterized by a change in the probabilities over the sets of possible future tariff schedules. The decision by the British electorate to end its long-standing participation in the European Union in favour of a new to-be-negotiated relationship surprised many – betting markets had placed the likelihood of a 'leave' outcome at around 30% for most of the preceding year (See

[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).

Figure 1.) After June 2016, firms exporting from the UK to the EU faced two possible future trade policies with clearly defined tariff schedules: in the most liberal possible trade policy scenario the UK would retain tariff free access to the EU Customs Union; in the most restrictive, or 'threat point', trade policy scenario the UK would trade with the EU under the EU's WTO tariff schedule.

We use the model developed by Handley and Limão (2017) as the main theoretical framework for our analysis. In this section, we briefly outline the necessary components of this model and derive our key empirical predictions.

### 2.1. Firm entry into exporting under a renegotiation regime

The representative consumer in each country spends a fixed share of income on a homogeneous good and the remaining on a continuum of differentiated products, all of which are freely traded on world markets. For each differentiated product $h$, there is a continuum of monopolistically competitive firms each producing a variety $v \in \Omega_h$, where $\Omega_h$ represents the set of varieties of product $h$. Consumers have constant elasticity of substitution preferences over varieties $v$ within each differentiated product $h$, and the aggregate demand of product $h$ is given by $D_h = \left[\int_{v\in\Omega_h}(q_v)^{\frac{\sigma-1}{\sigma}}dv\right]^{\frac{\sigma}{\sigma-1}}$. The optimal consumer demand for variety $v$ is given by $q_v = p_v^{-\sigma}P_h^{\sigma}D_h$, where $p_v$ is the price of variety $v$ and $P_h = \left[\int_{v\in\Omega_h}(p_v)^{1-\sigma}dv\right]^{\frac{1}{1-\sigma}}$ is the price index of product $h$. Consumer prices $p_v$ include an ad valorem tariff $\tau_h \geq 1$, such that foreign exporters receive $p_v/\tau_h$ per unit of good sold, whilst domestic producers face no taxes.

In what follows, we focus on the export decisions of firms in the home country to a foreign destination under uncertainty of different tariff states $\tau_h(s)$. Firms producing the same good $h$ differ in their marginal cost of production, $c_v$, drawn from an inverse Pareto distribution. Upon entry in each state $s$, a firm set its optimal price $p_v(s)$ to maximize operating profit taking the aggregate market conditions as given. The operating profit of an exporting firm selling variety $v$ of product $h$ is state contingent:

$$\pi[\tau_h(s), M_h(s), c_v] = [\tau_h(s)]^{-\sigma}c_v^{1-\sigma}M_h(s) \tag{1}$$

where $M_h(s) = [(\sigma-1)/\sigma P_h(s)]^{\sigma}D_h(s)$ is an aggregate demand shifter of product $h$. We assume that Britain is a small exporting country to the European Union and British exporters do not internalize their impact on price and demand in the destination country, such that $M_h(s) = M_h$ for any $s$.[7] Under this assumption, the profit under state $s$ can be written as $\pi[\tau_h(s), M_h, c_v] = \pi_h[\tau_h(s), c_v]$.

Firms enter into exporting if the expected operating profit of entry outweighs the sunk entry cost, $K_h$. Firms discount the future profits at the rate $\beta = (1-\delta)(1+r) < 1$, which depends on the probability of an exogenous death shock $\delta$ and the real interest rate $r$. When future trade policy is certain and given by $\tau_h$, the cost threshold of product $h$ under which a firm enters the foreign

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

market, $c_h^{certain}$, is given by:

$$c_h^{certain} = \left[\frac{\tau_h^{-\sigma} M_h}{(1-\beta)K_h}\right]^{\frac{1}{\sigma-1}} \tag{2}$$

where $M_h = [(\sigma-1)/\sigma P_h]^\sigma D_h$.

### 2.1.1. Firm exporting decisions under uncertain trade policy

Following Handley and Limão (2017), we consider a world in which there are three possible policy states: free trade ($s = FT$), renegotiation ($s = R$), and non-zero tariffs in at least some sectors ($s = WTO$). Both the free trade and WTO tariff states are absorbing states; this captures the idea that any agreements governing policy in these states are fully credible. Future trade policy in state R is uncertain; in this state, under on-going renegotiation, the current policy is zero tariffs in all sectors. However, in every period, with probability $\gamma$, the renegotiation will conclude and result in one of two possible outcomes. In the first possible outcome, free trade, the UK secures continued tariff free access to the EU market. This outcome occurs with probability $\lambda_{FT}$. The other possible outcome, WTO rules, is characterized by a collapse of negotiations between the UK and EU which results in UK exporters facing non-zero tariffs to export to the EU, specifically, 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 profits $\Pi_{e,h}(\tau_h(R), c)$, or to wait and obtain the expected profits $\Pi_{w,h}(\tau_h(R), c)$. The value of starting to export in the renegotiation state, $R$, for a firm with cost $c$ exporting a product $h$ is:

$$\begin{aligned}\Pi_{e,h}(\tau_h(R), c) = \quad & \pi_h(\tau_h(R), c) \\ & + \beta\big\{\gamma\big[\lambda_{WTO}\Pi_{e,h}(\tau_h(WTO), c) + (1-\lambda_{WTO})\Pi_{e,h}(\tau_h(FT), c)\big] \\ & + (1-\gamma)\Pi_{e,h}(\tau_h(R), c)\big\}\end{aligned} \tag{3}$$

where the first term on the right hand side is the per-period profit from exporting during the current period and the second term is the discounted value of being an exporter in the renegotiation state. The second term is a probability weighted average of the value of being an exporter if renegotiation (and the associated tariff-free access) continues (which occurs with a probability $(1-\gamma)$) and the value of being an exporter if the negotiations conclude (which occurs with a probability $\gamma$). If negotiations conclude in the next period, the value of being an exporter is given by $\Pi_{e,h}(\tau_h(WTO), c)$ if the final result is no deal on tariffs (occurring with probability $\lambda_{WTO}$) and is given by $\Pi_{e,h}(\tau_h(FT), c)$ if the negotiations result in an agreement for continued free trade. The key concern of an exporter during the renegotiation state is that there is a $\gamma\lambda_{WTO}$ probability that tariffs will be raised in the next period to a permanently higher level, $\tau_{WTO}$.

The value of waiting during the renegotiation state $R$ is:

$$\begin{aligned}\Pi_{w,h}(\tau_h(R),c) = \quad & 0 \\ & +\beta\Big[\gamma\Big(\lambda_{WTO}\Pi_{w,h}(\tau_h(WTO),c) \\ & \quad + (1-\lambda_{WTO})\ \max\left\{\Pi_{e,h}(\tau_h(FT),c) - K, \Pi_{w,h}(\tau_h(FT),c)\right\}\Big) \\ & \quad + (1-\gamma)\Pi_{w,h}(\tau_h(R),c)\Big] \end{aligned} \tag{4}$$

where the first term on the right hand side captures the zero profits obtained in the current period by not entering into exporting (because the firm does not export in the current period) and the second term is the discounted value of waiting to export during renegotiation. Similar to (3), the second term in square brackets can be broken down into the final term, $\Pi_{w,h}(\tau_h(R),c)$, which is the value of waiting if renegotiation continues (occurring with probability $1-\gamma$) and the discounted value of waiting if negotiations terminate in the next period. There are two possibilities if the renegotiation concludes. With a probability of $\lambda_{WTO}$, no deal is agreed and the firm receives the value of waiting given WTO tariffs are imposed, $\Pi_{w,h}(\tau_h(WTO),c)$. Alternatively, with a probability of $1-\lambda_{WTO}$, the negotiations conclude with an agreement for tariff-free trade and the firm receives the larger of the value of exporting less the fixed cost of entering given free trade, $\Pi_{e,h}(\tau_h(FT),c) - K_h$, and tha value of waiting given free trade, $\Pi_{w,h}(\tau_h(FT),c)$.

In this model, for a given state $s$, there is a threshold value of the marginal cost, $c_h^U(s)$, such that the marginal firm with this cost is indifferent between entering and waiting. The threshold marginal cost for entry during renegotiation, $c_h^U(R)$, is defined by the following indifference condition:

$$\Pi_{w,h}(\tau_h(R), c_h^U(R)) = \Pi_{e,h}(\tau_h(R), c_h^U(R)) - K_h. \tag{5}$$

The key testable implications of the effect of renegotiation of a trade agreement on firm entry into (and exit from) exporting relate to (1) the magnitude of the 'threat point tariffs' that exporters would face under the no deal WTO outcome, (2) the probability the renegotiation will conclude ($\gamma$), and (3) the probability that renegotiation will terminate without an agreement to trade freely ($\lambda_{WTO}$).[8]

1. Threat point tariffs: If the renegotiation breaks down, the EU's WTO tariff schedule provides the 'threat point' tariffs that UK exporters would face. A higher threat point tariff $\tau_h(WTO)$,

[8]Handley and Limão (2017) show that there is a distinct cutoff $c_h^U(s)$ for each $\tau_h(s)$ that determines whether a firm enters into exporting. The cutoff in the uncertain renegotiation state, $c_h^U(R)$, is proportional to the cutoff in a certain policy state with the same applied tariffs as the renegotiation state, $c_h^{certain}$, by an *uncertainty factor* $U(\omega_h,\gamma)$, where $\gamma$ is the probability of renegotiation concluding and trade policy shifting into one of the two outcome states:

$$c_h^U(R)/c_h^{certain} = U(\omega_h,\gamma) = \left(\frac{1+u(\gamma)\omega_h}{1+u(\gamma)}\right)^{\frac{1}{\sigma-1}}$$

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

holding other parameters constant, is associated with a lower expected return to exporting if the state $s = WTO$ is realized; this implies a larger real option value of waiting and a lower cost cutoff for entry. Cross-sectionally, products facing higher threat point tariffs will have lower cost cutoffs than products facing low or zero tariffs. Thus, among firms facing higher threat point tariffs, only the most productive will enter.

2. Probability of concluding the renegotiation: An increase in the probability of concluding the renegotiation, $\gamma$, holding other parameters constant, increases the option value of waiting and thus lowers the cost cut-off for entry. Hence an increase in this probability reduces entry by higher cost firms.
3. Probability of terminating the renegotiation with no deal: An increase in the probability of the renegotiation breaking down and terminating with no deal, $\lambda_{WTO}$, holding other parameters constant, increases the option value of waiting and thus lowers the cost cutoff for entry. Hence an increase in the probability of terminating with no deal reduces entry by higher cost firms.

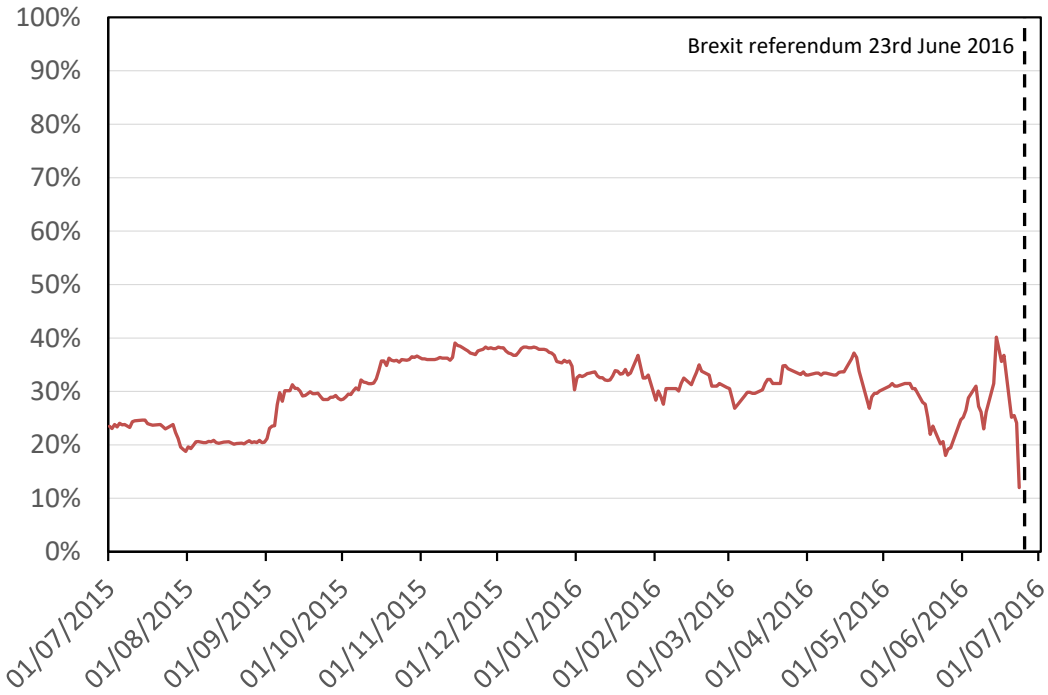
Firms will also exit from exporting in response to an increase in trade policy uncertainty. Firms that experience the exogenous death shock with probability $\delta$ exit, but have the opportunity to re-enter. A change in exit will be observed during the renegotiation state as firms hit with a death shock whose costs lie between the new and old cutoffs choose not to re-enter.

## 2.2. Empirical predictions

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.[9] 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 would vote to leave the EU is not available for after the 23rd June 2016, as the betting markets suspended these odds. This suspension implies that markets believed with 100% certainty that the UK would renegotiate its trade relationship with the EU.

[9]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 commencement of renegotiation between the UK and EU implies changes in behaviour by UK firms.

*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 product $h$ from $c_h^U(R)$ in the pre-referendum period to $c_h^{U'}(R)$ during the renegotiation period, with $c_h^{U'}(R) < c_h^U(R)$. 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.[10] 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

[10]The *pure risk* effect would be the only effect in the renegotiation state if the level of tariffs in the renegotiation state were equal to the expected mean of the future tariff ($\tau_h(R) = (1 - \lambda_{WTO})\tau_h(FT) + \lambda_{WTO}\tau_h(WTO)$); the increase in trade policy uncertainty would just be an mean-preserving increase in the variance of tariffs. However, for Britain, both effects are relevant as tariffs remain at zero during the renegotiation with the EU.

products facing higher threat point tariffs and therefore lower the cost cutoffs for entry by a greater magnitude for these products.[11]

*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.[12] Firms can (re)pay 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 $c_h^{U\prime}(R) < c \leq c_h^U(R)$ 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 change in the entry cutoff. These two predictions impact the total number of exporters in the same direction, implying that the total number of exporters of products with relatively higher threat point tariffs will fall by more.

# 3. Empirical model

We employ difference-in-difference models to assess the impact of trade policy uncertainty. We first implement a generalized difference-in-difference strategy by regressing the growth in exporters (entrants, exiters) of a disaggregated CN08 product to the EU in 2016 relative to 2015 (first difference) on the CN08 product's threat point tariff (second difference). We then present the triple difference model in which we add a comparison of firms exporting to the EU relative to non-EU markets (third difference).

## 3.1. Difference-in-difference model

We estimate the impact of the increased trade policy uncertainty across CN08 products on the extensive margin response of firms exporting from the UK to the EU in 2016 relative to 2015. We estimate the following regression:

[11] Handley and Limão (2017) show that entry in the uncertain state is lower than if policy is deterministic, $c_h^U(R) < c_h^{certain}$ if and only if tariff increases are possible, $\tau_h(WTO) > \tau_h(R)$ and $u(\gamma) > 0$.

[12] 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.

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

where $\Delta Y_{ht}$ represents the growth rate in the outcome variable $Y$ (number of firm-product exporters, firm-product entrants, firm-product exiters) in product $h$ in time $t$. The independent variable $\tau_{h,t}^{threat\,point}$ is the threat point tariff faced by each product $h$, measured by the EU's WTO tariff for each product $h$.[13]

### 3.1.1. Controlling for exchange rate pass through sensitivity

The Brexit referendum did not just increase the probability of tariff increases and raise the level of trade policy uncertainty facing exporters from the UK. The immediate impact of the referendum was a depreciation in the value of sterling which fell by 15% against a trade weighted basket of currencies. This depreciation might have provided 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 did not fully adjust prices and, instead, increased mark-ups. This raises a potential identification problem with (6) if the results capture product-specific responsiveness to the exchange rate movements, rather than the cross-sectional variation in trade policy uncertainty. To control for the potential impact of exchange rate sensitivity we implement a two stage procedure. First, we estimate exchange rate pass through into UK export prices 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; $h, f, d$, and $t$ represent product, firm, destination country in the EU, and time period (year), respectively; $uv_{hfdt}^k$ represents the unit value denominated in sterling[14]; $e_{dt}$ is the sterling-destination country exchange rate where an increase of $e_{dt}$ means an appreciation of the destination country currency; and $X_{dt}$ is a vector of aggregate-level control variables including CPI. All variables enter our estimation equation in logarithms and $\Delta_{z_{|hfd}}$ denotes the z-period difference at the product-firm-destination level.[15]

Estimates are based on the universe of UK exports to EU countries during the period 2012 - 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 control for sensitivity to the exchange rate by including estimated values of $\alpha_e^k$ in our estimating equation on firm entry and exit:

[13] We accept (Bartels, 2016)'s arguments that the UK will be able to maintain its membership of the WTO if it leaves the EU Customs Union.

[14] 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 for sales by a firm of a CN08 product to a destination country within a year and calculate the unit value as total value divided by quantity in unit-quantity measures (e.g. units, pairs) whenever available and in kilos otherwise.

[15] The z-period difference in estimating exchange rate pass through follows Gopinath and Rigobon (2008).

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

Industries more sensitive to fluctuations in the exchange rate should benefit more from the large depreciation following the announcement of the Brexit referendum result, shown by a positive (negative) $b_2$ coefficient in the exporter and entry (exit) specifications.

### 3.2. Triple difference model

The observed cross-sectional variation in UK firms' exporting decisions could be driven by product-specific supply chain or global product-specific demand shocks, rather than trade policy uncertainty. To address this concern, we refine the identification of the trade policy uncertainty effect with a triple difference model. Products produced in the UK that require imported inputs could have experienced a cost shock in their upstream supply chain following the Brexit vote. 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 Brexit vote (first difference) by firms in the UK into the different CN08 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 countries. Therefore the triple difference specification removes 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 $\Delta Y_{ht}^{EU}$ and $\Delta Y_{ht}^{non-EU}$ are the growth in the number of exporters, entrants, or exiters to EU markets and non-EU markets, respectively, between 2015 and 2016.

## 4. Data and measurement

The empirical analysis is conducted on a confidential microdataset of the universe of foreign transactions from Her Majesty's Revenue and Customs (HMRC) Overseas Trade Statistics (HMRC, 2017) which incorporates tariff data at the 8 digit level from the WTO's Tariff Analysis Online (WTO, 2018) and bilateral exchange rate data from the US Department of Agriculture (USDA, 2017).

### 4.1. UK customs data

HMRC Overseas Trade Statistics (OTS) reports 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.[16] 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 ensure a consistent concordance across the CN08 products over the sample period following Pierce and Schott (2012) and Van Beveren, Bernard, and Vandenbussche (2012) and remove the HS98 and HS99 special trade categories to match to the tariff data.

#### 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, and construct relevant statistics on participation in both of these destinations. For each time period, destination, and CN08 product category, we calculate the number of UK firms engaged in exporting to the destination, the number of UK firms newly entering a destination, and the number of UK firms exiting a destination.[17] 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 $d$.[18] 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).[19] 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 over 2013-2016 from the OTS data.[20] The number of firm-product exporters from the UK to the EU has increased over the period from 337,072 in 2013 to 383,669 in 2016. There is considerable churn with around 100,000 firm-product entrants and around 85,000 firm product exiters in each year.

[16]The requirement to report exports at the detailed product level applies to firms whose total value of exports exceeds the Intrastat reporting threshold. 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.

[17]The baseline analysis in this paper is conducted at the annual frequency. In tables 5 and 6, we reproduce our analysis at the half-yearly frequency.

[18]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.

[19]We present results using alternative definitions of firm-product entry based on 2 year and 3 year breaks in exporting in table 7 of Appendix A.

[20]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 indicate that the £250,000 threshold captures 96-98% of the total value of UK exports to the EU.

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 | 146 | 21,263 | 337,072 | 96,328 | 87,407 |
| 2014 | 142 | 20,884 | 350,259 | 98,180 | 84,993 |
| 2015 | 129 | 21,092 | 367,107 | 102,002 | 85,154 |
| 2016 | 139 | 21,074 | 383,669 | 105,862 | 89,300 |

Source: Calculations based on HMRC administrative datasets.

### 4.2. Growth rate of exporters, entrants, and exiters

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 $\Delta Y_{ht}$ is the growth in $Y \in \{exporters, entrants, exiters\}$ for product $h$ in time $t$. This measure of growth lies in the interval [-2, 2].[21]

### 4.3. Exposure to trade policy uncertainty

We initially measure the level of trade policy uncertainty facing firms in each CN08 product category as the difference between the tariff a UK product would face if exported under WTO rules and the zero tariff it would face under continued free trade.

We next create a set of discrete measures of trade policy uncertainty based upon the level of the WTO tariffs. These discrete measures can capture any potential non-linear effects of increased tariff exposure. Products facing a zero tariff face 'zero' exposure; products facing ad valorem tariff rates of greater than zero, but less than or equal to 5%, face 'low' levels of uncertainty; products facing tariff rates of greater than 5%, but less than or equal to 10%, face 'medium' levels of uncertainty; products facing tariff rates of greater than 10%, but less than or equal to 15%, face 'high' levels of uncertainty; products facing tariff rates of greater than 15% face 'extreme' levels of uncertainty. We separately classify products facing 'specific duties' (e.g., duties defined as euros per tonne)[22] and products that would face 'quotas' (i.e. products with tariff rate quotas reported in the EU's WTO schedule in the WTO's Tariff Analysis Online facility) if the UK were to trade with the EU under WTO rules.

[21]This measure is preferred to the log growth rate for studying entry and exit when the variable 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 log growth rate and the Davis and Haltiwanger (1992) growth measure are equivalent for small growth rates. Results based on the log growth rate are similar and are available upon request.

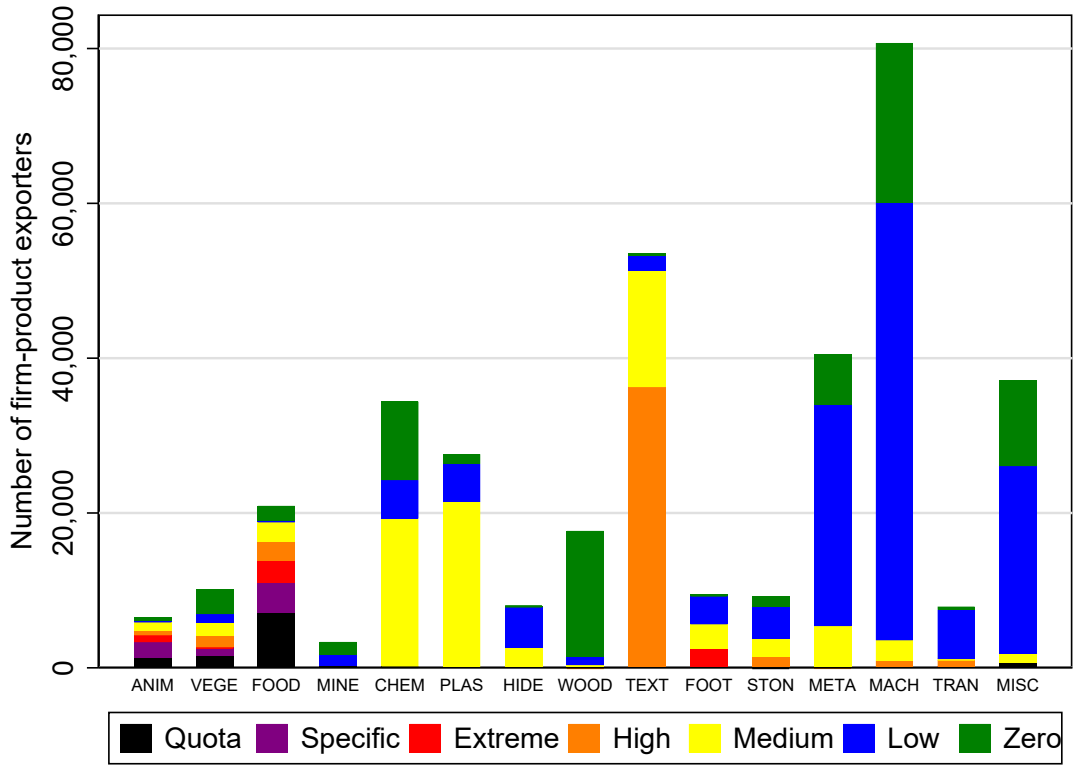
[22]Products in this group include products facing specific duties as well as products facing compound tariffs with both an ad valorem and specific component, e.g., an ad valorem tariff plus a euros per tonne charge.

#### 4.3.1. Distribution of UK-EU exporters across industries

The exposure of UK exporters to EU trade policy uncertainty is distributed across industries. Figure 2 shows the count of products within firms exported to the EU and the total value of exports, by broad industry and trade policy uncertainty, in 2015. Figure 2 shows that a significant number and trade value of exporters face threat point tariffs or quotas. Of the 367,107 firm-product exporters to the EU in 2015, under renegotiation 1.8% would face 'quotas', 3.1% would face 'specific duties', 1.8% would face 'extreme' tariffs, 12.0% would face 'high' tariffs, 21.4% would face 'medium' tariffs, 39.4% would face 'low' tariffs, and 20.0% would face 'zero' tariffs.

Figure 3 presents bar charts of the number of entrants and exiters at the level of a product within a firm in 2015. This figure documents significant churning in firm export dynamics, with high gross flows of entry and exit across all industries and tariff exposure categories. Across the product categories facing increased tariff risk, 102,002 (85,154) firm-products enter into (exit from) exporting to the EU in 2015, accounting for 27.8% (23.2%) of the total number of firm-products exporting to the EU in 2015.

Fig. 2. Trade policy risk under renegotiation by number of exporters and export value



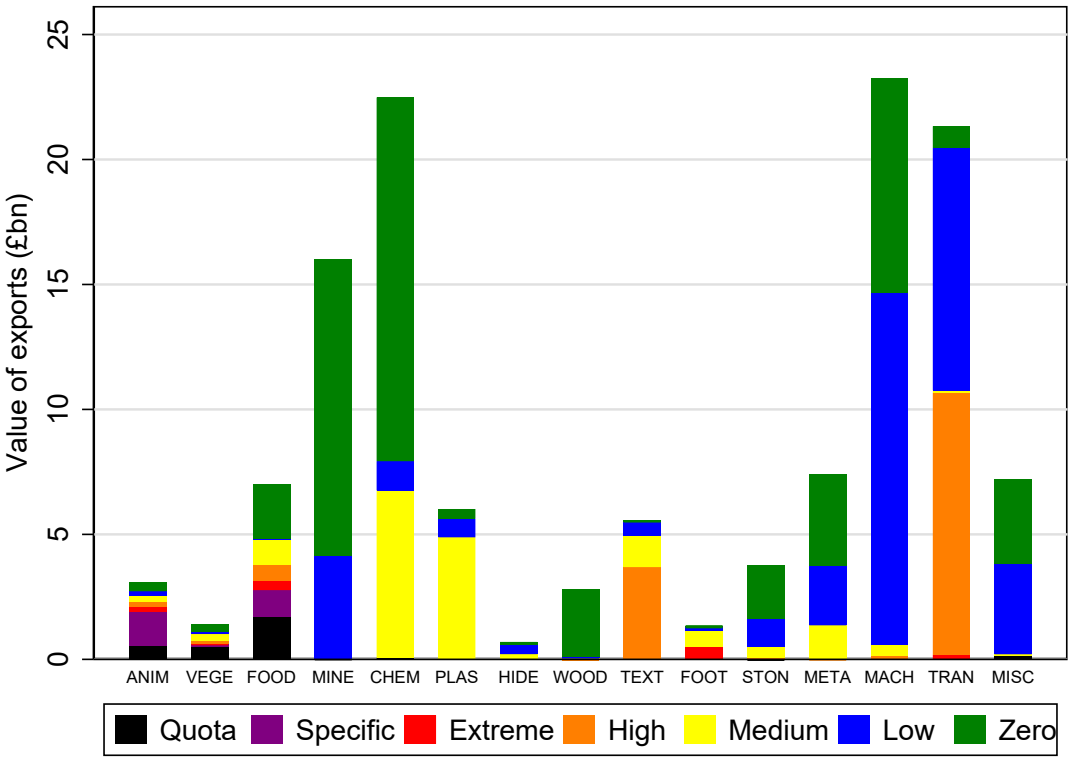
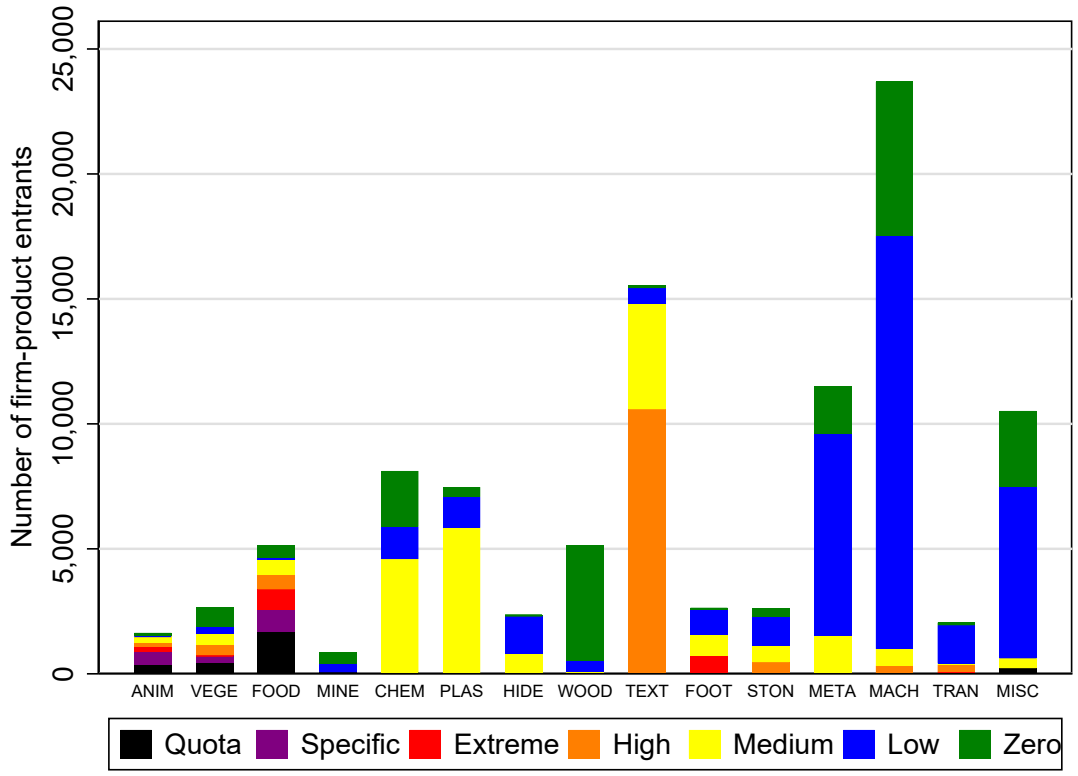
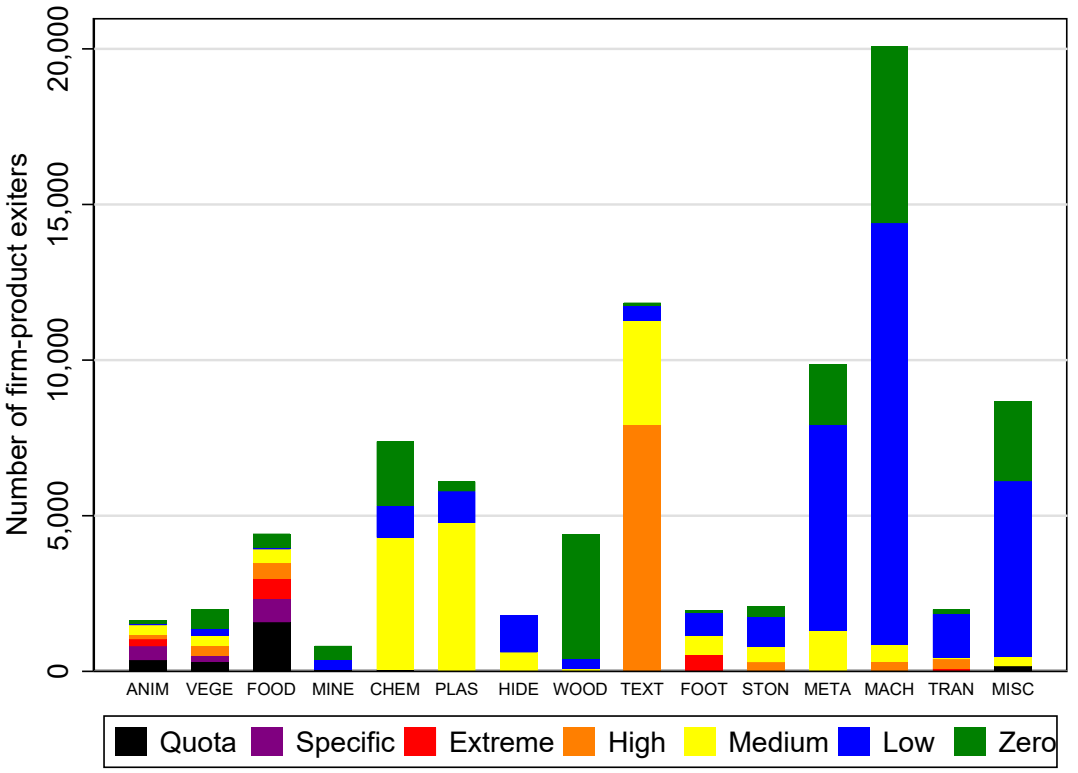



Fig. 3. Trade policy risk under renegotiation by number of entrants and exiters



# 5. Results

We estimate the impact of the trade policy uncertainty shock arising from the Brexit referendum on the extensive margin of UK firms. The strategy exploits cross-sectional variation in exposure to trade policy uncertainty across products arising because of the different WTO tariff rates these British products would face in the EU in the event that the UK and EU are unable to negotiate a new tariff-free trading arrangement post-Brexit. The main specification compares the annual outcomes for 2016 and 2015. Because the referendum took place on 23 June 2016, we also compare entry and exit in second half of 2016 to the second half of 2015 to more precisely target the timing of the uncertainty shock while controlling for any seasonal factors.

## 5.1. Uncertainty

We find that products exposed to increased trade policy uncertainty experienced decreased growth in entry and increased exit. Table 2 presents the main results. Products facing exposure to higher threat point ad valorem tariffs, specific duties and quotas experienced a greater decrease in the growth rate of the number of firms exporting to the EU (column 1), a decrease in the growth rate of entry into exporting to the EU (column 2), and an increase in the growth rate of exit from exporting to the EU (column 3) between 2016 and 2015.

These results validate the model's prediction that higher trade policy uncertainty lowers the number of firms entering into exporting, where the point estimate indicates that a 1 percentage point rise in the threat point tariff reduces the growth rate of firm-product entrants by 1.1 percentage points (Panel A column 2). Higher trade policy uncertainty induces exit from the EU; exit growth increases by 0.5 percentage point for each 1 percentage point rise in the threat point tariff (Panel A column 3). Altogether, a 1 percentage point increase in the tariff lowers the growth rate of the number of firms exporting that product by 0.3 percentage point (Panel A column 1). Panel A also presents results for products that would face specific duties and quotas under a breakdown of negotiations. We find that exposure to specific duties reduced the growth of entry by 20.4 percentage points and risk of a quota reduced the growth rate of entry by 16.9 percentage points, relative to the predicted baseline of zero trade policy uncertainty. We also find that exposure to quotas increased the growth rate of exit by 18.9 percentage points. Overall, exposure to specific duties and quotas reduced the number of exporters to the EU in 2016 relative to 2015. The magnitude of these non-ad valorem measures is large, indicating that UK firms perceive specific duties and quotas as significant barriers to export.

Results based on the five discrete categories of ad valorem tariff risk are presented in table 2 Panel B. Products exposed to increasingly severe tariffs experience a larger decline in the growth of exporters (column 1), a larger decline in the growth of entry (column 2), and a larger increase in exit (column 3) relative to products facing no risk of a tariff increase. Exposure to higher threat point tariffs, categorized as high or extreme tariffs, generates the largest effects. Exposure to extreme threat point tariffs of over 15% is associated with a 22.4 percentage point fall in the growth rate

of entrants (column 2) relative to products that face no risk of tariff increases. Exposure to high threat point tariffs, between 10% and 15%, generates a smaller, yet substantial 13.2 percentage point fall in the growth rate of entry and a 10.2 percentage point higher growth rate of exit relative to products facing no risk of tariff hikes.

In Panel B in table 2, we also present results for products that are exposed to specific duties and quotas; findings consistent with Panel A. Exposure to specific duties (quotas) reduced the growth of entry by 19.8 (16.2) percentage points, relative to the zero threat point tariff baseline in Panel B. We also find that exposure to quotas increased the growth rate of exit by 20.8 percentage points. The magnitude of the estimates of the impact on entry for specific duties and quotas are comparable to the impact of high and extreme threat point tariffs. The estimates for the impact of quotas on exit is significantly larger than the ad valorem estimates of the impact of exit.

Interestingly, the Brexit referendum only introduced trade policy uncertainty for some products. Products facing no trade policy uncertainty experienced a significant growth of 4.4% in the number of firms exporting to the EU in 2016 relative to 2015 (the constant in Panel B column 1). This was driven by entry growth that was 7.5% higher (column 2) for products that will continue to enjoy duty free treatment in the EU post-Brexit. This heterogeneity across products offers some insight into why aggregate statistics did not show a decline in aggregate export value or the number of exporters in 2016, despite the heightened trade policy uncertainty. The products which face no trade policy uncertainty grew significantly, which counterbalanced the negative impact that the heightened uncertainty had on firm entry and exit in products exposed to the high and extreme threat point tariffs. One possible reason for the rapid growth rate for entrants and fall in the growth rate of exiters is the large depreciation of sterling in 2016, which we explore further in section 5.2.

Table 2: Trade policy uncertainty and growth of exporters, entrants, and exiters, UK to the EU

| | (1) Firm-product exporters | (2) Firm-product entrants | (3) Firm-product exiters |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.00344*** | -0.0105*** | 0.00459** |
| | (0.00127) | (0.00238) | (0.00217) |
| Quota | -0.0770** | -0.169*** | 0.189*** |
| | (0.0303) | (0.0651) | (0.0612) |
| Specific duty | -0.0538** | -0.204*** | 0.0451 |
| | (0.0244) | (0.0494) | (0.0488) |
| Constant | 0.0519*** | 0.0813*** | -0.00160 |
| | (0.00815) | (0.0155) | (0.0144) |
| Observations | 8,804 | 8,464 | 8,140 |
| R-squared | 0.002 | 0.005 | 0.002 |
| Panel B | | | |
| Extreme threat point tariffs | -0.0720** | -0.224*** | 0.0987 |
| | (0.0328) | (0.0698) | (0.0673) |
| High threat point tariffs | -0.0277 | -0.132*** | 0.102*** |
| | (0.0181) | (0.0360) | (0.0341) |
| Medium threat point tariffs | 0.00431 | -0.0137 | 0.0251 |
| | (0.0147) | (0.0303) | (0.0295) |
| Low threat point tariffs | -0.0120 | -0.0515* | 0.0605** |
| | (0.0145) | (0.0285) | (0.0267) |
| Quota | -0.0695** | -0.162** | 0.208*** |
| | (0.0314) | (0.0673) | (0.0633) |
| Specific duty | -0.0464* | -0.198*** | 0.0640 |
| | (0.0258) | (0.0523) | (0.0515) |
| Constant | 0.0444*** | 0.0747*** | -0.0205 |
| | (0.0116) | (0.0230) | (0.0217) |
| Observations | 8,804 | 8,464 | 8,140 |
| R-squared | 0.002 | 0.005 | 0.003 |

Notes: Standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from HMRC administrative datasets.

#### 5.1.1. Quantifying the impact of trade policy uncertainty

How important is uncertainty associated with the renegotiation of a trade agreement for current trade activity? We use the estimates from table 2 to quantify the 'missing trade' following the Brexit vote in a partial equilibrium exercise. If UK exporters had been convinced that the EU

would guarantee continued free trade in a post-Brexit agreement, we estimate that entry into exporting to EU markets would have been 5.0% higher in 2016 than the observed level of entry, whilst exit would have been 6.1% lower.

We use the estimates from panel B of table 2 and the count of firm-products in each of the discrete tariff risk categories in 2015 in our calculations. For each non-zero tariff exposure category (quotas, specific duties, extreme, high, medium and low) we multiply the count of entrants (exiters) in the relevant category in 2015 with the associated tariff risk parameter to quantify the model predicted impact of trade policy uncertainty relative to a counterfactual in which there was no risk of tariff increases. We then sum the model predicted number of missing entrants (exiters) in each tariff exposure category to obtain an estimate that there were 5344 missing firm-product entrants in 2016. As 105,862 firm-products actually entered into exporting to the EU in 2016, this implies that if firms exporting from the UK to the EU had not faced increased trade policy uncertainty, firm-product entry would have been 5.0% higher in 2016. We also estimate the induced exit resulting from the trade policy uncertainty, where we estimate that 5437 exporters more exporters exited from exporting to the EU than the counterfactual, accounting for 6.1% of exit in 2016.

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 assume that each missing entrant in the exercise above would have exported the average value for firm-products serving the EU market. When we use the average value of *entrants* in 2015 in each tariff exposure category, we estimate that the reduced entry accounts for a £201 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 of missing entrants with a loss of export value from the UK to the EU of £1.5 billion in 2016. The missing trade value from the increase in exiters is only £193 when we use the average value of exiters, whilst the missing value of trade is £1.4 billion when we use the average value of exporters. Thus, the total value of 'missing exports' associated with reduced entry and induced exit ranges from a low of £394 million to a high of £3.0 billion.

### 5.2. Uncertainty and exchange rate sensitivity

How might an industry's sensitivity to exchange rate movements impact its response to trade policy uncertainty? If the trade policy uncertainty that varies across industries were systematically correlated with the price responsiveness of an industry to exchange rate fluctuations, then our estimated impact of trade policy uncertainty might be confounded with changes driven by the large sterling depreciation in 2016. To address this, we extend our empirical model to include controls for industry level exchange rate sensitivity. Table 3 presents the results for the difference-in-difference specification in which we add controls for exchange rate sensitivity at the HS02 industry level.

Results on the effect of trade policy uncertainty on entrants, exiters and the total number of firms are largely unchanged by the addition of the exchange rate sensitivity control, suggesting that the two forces - policy uncertainty and exchange rate variability - exert different influences on firm behaviour. We do observe an impact of exchange rate sensitivity on exporting decisions. In

panels A and B in table 3, we see that firms in industries whose export prices are more responsive to bilateral exchange rate movements were more likely to enter and less likely to exit in 2016, following the depreciation of sterling. In the case of the large depreciation, industries with more elastic export prices (in sterling) could have captured some of the depreciation as a markup increase (in sterling) without having to pass on this increase to their foreign consumers (in foreign currency). This implies continued operation to the EU market offered profit-making opportunities to these firms. The net result was greater entry and lower exit.

Table 3: Trade policy uncertainty and sensitivity to exchange rate movements

| | (1) Firm-product exporters | (2) Firm-product entrants | (3) Firm-product exiters |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.00319** | -0.00964*** | 0.00379* |
| | (0.00127) | (0.00216) | (0.00222) |
| Quota | -0.0840*** | -0.195*** | 0.214*** |
| | (0.0297) | (0.0696) | (0.0680) |
| Specific duty | -0.0569** | -0.213*** | 0.0539 |
| | (0.0265) | (0.0464) | (0.0502) |
| Sensitivity to exchange rate | 0.0347 | 0.120** | -0.114** |
| | (0.0282) | (0.0485) | (0.0454) |
| Constant | 0.0450*** | 0.0577*** | 0.0207 |
| | (0.00988) | (0.0173) | (0.0161) |
| Observations | 8,804 | 8,464 | 8,140 |
| R-squared | 0.002 | 0.006 | 0.003 |
| Panel B | | | |
| Extreme threat point tariffs | -0.0665** | -0.205*** | 0.0819 |
| | (0.0331) | (0.0646) | (0.0673) |
| High threat point tariffs | -0.0244 | -0.122*** | 0.0931*** |
| | (0.0167) | (0.0338) | (0.0319) |
| Medium threat point tariffs | 0.00484 | -0.0123 | 0.0237 |
| | (0.0135) | (0.0322) | (0.0308) |
| Low threat point tariffs | -0.0107 | -0.0474 | 0.0570** |
| | (0.0142) | (0.0291) | (0.0257) |
| Quota | -0.0767** | -0.189** | 0.232*** |
| | (0.0304) | (0.0736) | (0.0705) |
| Specific duty | -0.0496* | -0.207*** | 0.0731 |
| | (0.0276) | (0.0501) | (0.0529) |
| Sensitivity to exchange rate | 0.0352 | 0.119** | -0.111** |
| | (0.0281) | (0.0487) | (0.0455) |
| Constant | 0.0376*** | 0.0519** | 0.000619 |
| | (0.0127) | (0.0255) | (0.0216) |
| Observations | 8,804 | 8,464 | 8,140 |
| R-squared | 0.002 | 0.006 | 0.003 |

Notes: Bootstrapped standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from HMRC administrative datasets.

### 5.3. Controlling for product-specific shocks

Could our results on trade policy uncertainty be driven by product-specific supply chain or global demand shocks? We estimate a triple difference model to control for product-level shocks and find results for exporters and entrants are, if anything, slightly larger in magnitude. This suggests that some 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. The impact of trade policy 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 threat point tariffs reduces the number of firms exporting to the EU relative to non-EU by 1.3 percentage points. 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). The magnitude of the negative effect of trade policy uncertainty from quotas and specific duties on the entry and exporting decisions of exporters also increases in the triple difference specification. The results on entry and the total number of exporters for the discrete measure of trade policy uncertainty are also robust to the triple difference specification presented in Panel B in Table 4.[23]

[23]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 destinations, 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: Trade policy uncertainty and export participation in the EU versus non-EU markets

| | (1) Firm-product exporters | (2) Firm-product entrants | (3) Firm-product exiters |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.00591*** | -0.0128*** | 0.00383 |
| | (0.00201) | (0.00323) | (0.00291) |
| Quota | -0.148** | -0.304*** | 0.105 |
| | (0.0614) | (0.0950) | (0.0950) |
| Specific duty | -0.174*** | -0.316*** | -0.00677 |
| | (0.0417) | (0.0679) | (0.0688) |
| Constant | 0.0440*** | 0.0736*** | -0.00874 |
| | (0.0115) | (0.0190) | (0.0176) |
| Observations | 8,341 | 8,027 | 7,445 |
| R-squared | 0.005 | 0.007 | 0.001 |
| Panel B | | | |
| Extreme threat point tariffs | -0.128* | -0.251** | 0.0856 |
| | (0.0674) | (0.109) | (0.0992) |
| High threat point tariffs | -0.0753** | -0.198*** | 0.0703 |
| | (0.0302) | (0.0470) | (0.0439) |
| Medium threat point tariffs | -0.0338 | -0.0728* | 0.0427 |
| | (0.0227) | (0.0380) | (0.0357) |
| Low threat point tariffs | -0.0359* | -0.0920*** | 0.0562* |
| | (0.0205) | (0.0339) | (0.0315) |
| Quota | -0.154** | -0.323*** | 0.127 |
| | (0.0627) | (0.0971) | (0.0968) |
| Specific duty | -0.180*** | -0.335*** | 0.0159 |
| | (0.0435) | (0.0708) | (0.0713) |
| Constant | 0.0496*** | 0.0929*** | -0.0314 |
| | (0.0169) | (0.0275) | (0.0258) |
| Observations | 8,341 | 8,027 | 7,445 |
| R-squared | 0.005 | 0.007 | 0.001 |

Notes: Standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from 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 trade policy 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 a renegotiation averaged 30.5% as shown in Figure 1) and the post-referendum period (when the probability of the UK renegotiating with the EU increased to 100%) should give different estimates of the impact of trade policy uncertainty. More precisely, because the likelihood of a renegotiation remained low in the first half of 2016, we would expect uncertainty to have a much smaller, if any, effect on firm behaviour.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.[24] In the H1 sample, we discard all customs transactions conducted in H2 of every year and re-calculate 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 there 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 begun renegotiating with the EU, there is a significant impact on firm exporting decisions. The results for H2 2016 relative to H2 2015 are consistent in magnitude and significance with the results found for the full year specification (6) presented in Table 2. The continuous measure of threat point tariffs 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 1.0 percentage point. We also find that in the second half of 2016 the trade policy uncertainty induced by quotas and specific duties generates large negative effects on the entry decision of UK exporters, with specific duties also inducing exit.

In Panel B, the discrete measure of trade policy uncertainty 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 also 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 trade policy uncertainty was low in the first half of 2016, there was almost no impact on firm exporting decisions across almost all of the ad valorem tariff measures.

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

Table 5: Trade policy uncertainty and export participation, H2 2016 vs. H2 2015

| | (1) Firm-product exporters | (2) Firm-product entrants | (3) Firm-product exiters |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.00191 | -0.0102*** | 0.00151 |
| | (0.00135) | (0.00253) | (0.00236) |
| Quota | -0.0754** | -0.278*** | -0.0647 |
| | (0.0295) | (0.0666) | (0.0672) |
| Specific duty | -0.0372 | -0.173*** | -0.166*** |
| | (0.0248) | (0.0517) | (0.0510) |
| Constant | 0.0571*** | 0.113*** | 0.0197 |
| | (0.00872) | (0.0164) | (0.0156) |
| Observations | 8,653 | 8,283 | 7,906 |
| R-squared | 0.001 | 0.005 | 0.002 |
| Panel B | | | |
| Extreme threat point tariffs | -0.00266 | -0.198*** | -0.0904 |
| | (0.0346) | (0.0717) | (0.0703) |
| High threat point tariffs | -0.0252 | -0.139*** | 0.158*** |
| | (0.0188) | (0.0378) | (0.0382) |
| Medium threat point tariffs | 0.000827 | -0.0369 | 0.0912*** |
| | (0.0162) | (0.0323) | (0.0316) |
| Low threat point tariffs | -0.0145 | -0.0657** | 0.109*** |
| | (0.0155) | (0.0301) | (0.0290) |
| Quota | -0.0734** | -0.283*** | -0.000284 |
| | (0.0308) | (0.0690) | (0.0695) |
| Specific duty | -0.0351 | -0.178*** | -0.102* |
| | (0.0264) | (0.0547) | (0.0540) |
| Constant | 0.0551*** | 0.118*** | -0.0447* |
| | (0.0126) | (0.0243) | (0.0235) |
| Observations | 8,653 | 8,283 | 7,906 |
| R-squared | 0.001 | 0.005 | 0.006 |

Notes: Standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from HMRC administrative datasets.

Table 6: Trade policy uncertainty and export participation, Placebo test: H1 2016 vs. H1 2015

| | (1) Firm-product exporters | (2) Firm-product entrants | (3) Firm-product exiters |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.00105 | -0.00354 | 0.00157 |
| | (0.00121) | (0.00245) | (0.00238) |
| Quota | -0.0360 | -0.0406 | 0.173*** |
| | (0.0328) | (0.0676) | (0.0661) |
| Specific duty | -0.0573** | -0.164*** | 0.0112 |
| | (0.0247) | (0.0520) | (0.0515) |
| Constant | 0.0274*** | 0.0182 | 0.0360** |
| | (0.00824) | (0.0162) | (0.0155) |
| Observations | 8,644 | 8,252 | 7,880 |
| R-squared | 0.001 | 0.002 | 0.001 |
| Panel B | | | |
| Extreme threat point tariffs | -0.0605* | -0.0941 | 0.0550 |
| | (0.0357) | (0.0713) | (0.0718) |
| High threat point tariffs | 0.0179 | -0.0591 | 0.0277 |
| | (0.0199) | (0.0384) | (0.0368) |
| Medium threat point tariffs | 0.0181 | 0.00924 | 0.0171 |
| | (0.0155) | (0.0320) | (0.0312) |
| Low threat point tariffs | 0.00494 | -0.0242 | 0.0483* |
| | (0.0154) | (0.0297) | (0.0284) |
| Quota | -0.0259 | -0.0392 | 0.191*** |
| | (0.0340) | (0.0698) | (0.0683) |
| Specific duty | -0.0472* | -0.163*** | 0.0296 |
| | (0.0263) | (0.0549) | (0.0542) |
| Constant | 0.0173 | 0.0168 | 0.0177 |
| | (0.0122) | (0.0239) | (0.0229) |
| Observations | 8,644 | 8,252 | 7,880 |
| R-squared | 0.002 | 0.002 | 0.002 |

Notes: Standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from HMRC administrative datasets.

## 6. Conclusion

The last few years have been remarkable with many trading partners around the world reassessing their existing free trade arrangements. In this paper, we have shown that uncertainty over future trade policy brought about by the renegotiation of a trade agreement can reduce current export

activity. Products facing trade policy uncertainty experience a significant decline 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 decline in the overall number of firms exporting to the EU. We estimate that if firms exporting from the UK to the EU had not faced an increase in trade policy uncertainty, then 5.0% more firms would have entered into exporting to the EU in 2016, whilst 6.1% 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 has been found in other countries (Albornoz, Calvo-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 and induced exit reduced the value of exports by between £394 million and £3.0 billion in 2016, a small total value relative to total exports to the EU in 2016 of £139 billion.

The magnitudes of the extensive margin responses to 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 earlier estimates of trade elasticities would suggest.

## Appendix A. Refining the definition of entry

In our analysis, entry into a foreign market occurs if we observe a product sale this year, but did not observe the firm selling that product last year. One criticism of this definition is that it classifies firms that merely take a one year break from export activity as entrants when they are more accurately described as repeat exporters. We consider the robustness of our results to more stringent definitions of entry. In addition to the baseline definition in which entry occurs if we observe no sales in the previous period, we analyse entry for firms that had no observed sales in the previous two years as well as the previous 3 years. As the number of years increases, the definition of an entrant becomes increasingly strict and moves towards a measure of initial entry, rather than re-entry. The results across the three definitions show that as the definition become increasingly strict, the estimated coefficients on the measures of trade policy uncertainty become more negative. This suggests that trade policy 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: Trade policy uncertainty and entry

| | (1) Entrants (1 year) | (2) Entrants (2 year) | (3) Entrants (3 year) |
|---|---|---|---|
| Panel A | | | |
| Tariff rate | -0.0105*** | -0.0112*** | -0.0110*** |
| | (0.00238) | (0.00252) | (0.00257) |
| Quota | -0.169*** | -0.190*** | -0.224*** |
| | (0.0651) | (0.0659) | (0.0664) |
| Specific duty | -0.204*** | -0.210*** | -0.231*** |
| | (0.0494) | (0.0509) | (0.0512) |
| Constant | 0.0813*** | 0.0813*** | 0.0834*** |
| | (0.0155) | (0.0164) | (0.0168) |
| Observations | 8,464 | 8,357 | 8,281 |
| R-squared | 0.005 | 0.005 | 0.005 |
| Panel B | | | |
| Extreme threat point tariffs | -0.224*** | -0.268*** | -0.263*** |
| | (0.0698) | (0.0743) | (0.0758) |
| High threat point tariffs | -0.132*** | -0.139*** | -0.131*** |
| | (0.0360) | (0.0378) | (0.0392) |
| Medium threat point tariffs | -0.0137 | -0.00813 | -0.00642 |
| | (0.0303) | (0.0320) | (0.0330) |
| Low threat point tariffs | -0.0515* | -0.0453 | -0.0457 |
| | (0.0285) | (0.0301) | (0.0308) |
| Quota | -0.162** | -0.179*** | -0.213*** |
| | (0.0673) | (0.0683) | (0.0689) |
| Specific duty | -0.198*** | -0.199*** | -0.220*** |
| | (0.0523) | (0.0539) | (0.0544) |
| Constant | 0.0747*** | 0.0704*** | 0.0726*** |
| | (0.0230) | (0.0241) | (0.0248) |
| Observations | 8,464 | 8,357 | 8,281 |
| R-squared | 0.005 | 0.006 | 0.006 |

Notes: Standard errors in parentheses with ***, **, and * indicating that the estimated parameter is statistically different from zero at the 1%, 5% and 10% level. All estimates from HMRC administrative datasets.

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