Essays on the Impact of Renegotiating Trade Agreements

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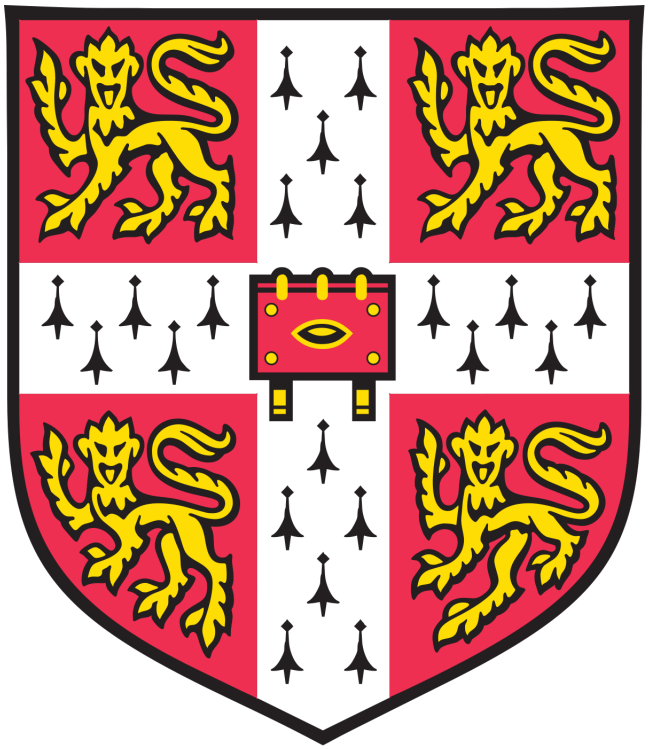

Declaration

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Oliver Exton

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Summary of Essays on the Impact of Renegotiating Trade Agreements by Oliver Exton

This thesis explores the impact of the renegotiation of trade agreements when there is a threat that trade barriers could increase. The thesis addresses the following questions:

1. What is the impact on firm exporting decisions of the trade policy uncertainty generated by the renegotiation of trade agreements?

2. What is the role of a customer base in export dynamics, and does an exporter customer base respond to the renegotiation of trade agreements?

3. How do industries restructure in response to changing economic competition driven by trade agreements?

4. What is the impact of exchange rate movements (driven by the renegotiation of a trade agreement) on exporter prices and quantities, and are the effects heterogeneous across firms?

5. How important are firms that trade goods internationally for the UK economy and how could these firms respond to the future renegotiation of trade agreements following Brexit?

The second chapter (joint with Meredith Crowley and Lu Han) introduces the concept that 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 a model of exporting under trade policy uncertainty, we derive testable predictions of firm entry into and 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 entry in 2016 would have been

5.0% higher and exit 6.1% lower if firms exporting from the UK to the EU had not faced increased trade policy uncertainty after June 2016.

In the third chapter (joint with Davide Rigo) we investigate the role of customer base in export market dynamics. First, we provide evidence that exporters grow in a foreign market by accumulating customer base. Second, we show that customer base can explain up to 30% of the growth in a destination market. Third, we explore potential mechanisms and find no evidence that exporters use customer specific price dynamics to attract new customers or expand existing customer relationships. Fourth, we explore how exporters adjust customer base in response to changes in market access by exploiting the trade policy uncertainty associated with the renegotiation of the UK-EU trade relationship and Sterling depreciation following the Brexit referendum. We show that French exporters in 2016-2017 were less likely to enter into exporting to the UK and incumbent exporters acquired a lower number of new buyers in the UK compared with the other European countries. Overall our results indicate that customer base is an important margin for export market growth and provides another margin that firms may adjust in response to changing market conditions.

The fourth chapter shows that the rise in import competition from China following China's accession to the World Trade Organization contributed to the decline in UK manufacturing activity post 2000. A significant proportion of this decline in manufacturing activity is driven by firms switching their industrial activity out of manufacturing production and towards services. In particular, firms switch into business services such as research and development and wholesale and retail. This paper also shows that the speed of the transition across industries is fast, with the majority of the employment and turnover effects occurring in the first few years. This is primarily driven by the largest firms, as the switching effect on the number of firms is substantially smaller.

The final chapter explores why the value of UK goods exports increased following depreciation of Sterling after the Brexit referendum. This paper shows that most of the response was initially

driven by an increase in prices, although export quantities did also increase. The largest exporters were most responsive to the depreciation, increasing both quantities and prices more than smaller exporters. The paper also provides new facts on the importance of firms engaged in international trade in goods for the UK economy. Only 3% of UK firms are engaged in international trade in goods, yet these firms account for over 30% of employment and over 50% of UK turnover. The top 1% of goods exporters are pivotal in shaping UK export patterns as they account for 70% of exports, 5% of employment, and 12% of turnover.

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The fifth chapter builds off work by the author which was conducted while the author was a PhD intern at the Bank of England and was part of a joint project by the author, Tommaso Aquilante, Sandra Batten, Rebecca Freeman, Marco Garofalo and Enrico Longoni. That said, the work reflects the views of the author and cannot be taken to represent those of the Bank of England or any of its policy committees. The author would like to thank Philip Wales and Russell Black from the ONS for sharing their work on linking the ONS and HMRC administrative databases, and Enrico Longoni of the Bank of England for incorporating this work into the HMRC Datalab.

The second and fifth chapters contain statistical data from HMRC, which is Crown Copyright. The research datasets used may not exactly reproduce HMRC aggregates. The use of HMRC statistical data in this work does not imply the endorsement of HMRC in relation to the inter-

pretation or analysis of the information. Unless otherwise stated, the source for all information in those chapters is 'Calculations based on HMRC administrative datasets'. I would like to thank the staff of the HMRC datalab, especially Yee-Wan Yau, for supporting us in our analysis of UK administrative data. The third chapter is produced on the basis of data from French Foreign Trade Statistics of the General Directorate of Customs and Indirect Excises which was accessed by Davide Rigo. The fourth and fifth chapters were produced using statistical data from ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

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1. Introduction

The prominence of trade policy in the global economy has been transformed in recent years. In June 2016 the British public voted to leave the European Union, the economic and political bloc with the world's largest customs territory. At the end of 2016, the United States elected President Trump, who withdrew the United States from the Trans-Pacific Partnership, threatened to withdraw the United States from the North American Free Trade Agreement, and instigated a new era of Trade Wars with retaliatory rounds of tariffs imposed between the United States and China. Until the political events of the past few years, it was commonly perceived that renegotiations of trade agreements would lead to more liberal trading relationships, and that tariffs would be kept at existing levels if negotiations were to collapse. Recent events have shown that this is no longer the case, and this thesis explores the impact of the renegotiation of trade agreements when there is a threat that trade barriers could increase.

Numerous studies have quantified the importance of preferential trade agreements in increasing trade and economic welfare. Trade agreements significantly increase the value of trade flows between partner countries as trade agreements reduce both tariff and non-tariff barriers. Trade agreements also increase trade between signatories by reducing uncertainty over future tariff schedules, as they provide binding commitments that prevent future tariff increases. There is however little evidence of the impact of economic dis-integration, when barriers to trade between partners increase, as almost all trade agreements seek to lower trade barriers between partners.

This thesis exploits the unique natural experiment of the Brexit vote of 23 June 2016, where the UK electorate voted to leave the European Union, to investigate the impact of renegotiating trade agreements where the future trading relationship may be less liberal than the status quo. The vote to leave ensured that the UK has the opportunity to leave the EU Customs Union and to renegotiate the UK and EU trading relationship. The Brexit vote initiated a 'renegotiation regime' – a period of heightened uncertainty about future trade policy between the UK and EU. The uncertainty arises from the arrival of different future scenarios: for example a 'Deal' scenario

in which the UK would retain tariff free access to the EU Customs Union and a 'No Deal' scenario the UK would trade with the EU under the EU's WTO tariff schedule.

Following this motivation, this thesis addresses issues on the impact of renegotiating trade agreements:

1. What is the impact on firm exporting decisions of the trade policy uncertainty generated by the renegotiation of trade agreements?

2. What is the role of a customer base in export dynamics, and does an exporter customer base respond to the renegotiation of trade agreements?

3. How do industries restructure in response to changing economic competition driven by trade agreements?

4. What is the impact of exchange rate movements (driven by the renegotiation of a trade agreement) on exporter prices and quantities, and are the effects heterogeneous across firms?

5. How important are firms that trade goods internationally for the UK economy and how could these firms respond to the future renegotiation of trade agreements following Brexit?

1.1. Renegotiation of Trade Agreements and Firm Exporting Decisions

The second chapter *Renegotiation of Trade Agreements and Firm Exporting Decisions: Evidence from the Impact of Brexit on UK Exports* (joint with Meredith Crowley and Lu Han) examines 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. In a 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 chapter presents 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. The chapter uses the EU's WTO schedule of tariff commitments to compile granular 'threat point' trade policies that British firms exporting to the EU would face if the renegotiation were to break down. The empirical specification implements a generalized difference-in-difference strategy and uses information on the universe of UK exports from customs declarations provided by HMRC. The chapter estimates the impact of a switch into a renegotiation regime on the growth in the number of UK firms entering and exiting the EU market in 2016 relative to 2015 with different 8-digit products that face different threat point trade policies during the renegotiation period.

The results show that the switch to a renegotiation regime decreased firm entry into and increased firm exit from exporting to the EU for UK-based firms. The impact was largest for products facing as threat points (i) higher ad valorem tariffs, (ii) tariff rate quotas, and (iii) specific duties, suggesting that UK firms placed positive probability on the likelihood that negotiations could break down and leave some firms facing substantially higher barriers in exporting to the EU. On average, the threat of a 1 percentage point increase in the ad valorem tariff decreased the growth rate of entry by 1.1 percentage point and increased the growth rate of entry by 0.5 percentage point. The responses are assessed at a more granular level with discrete categories of ad valorem tariffs and other trade policies. The results fine that 'extreme' ad valorem tariffs of more than 15% ad valorem were associated with a 22.4 percentage point decline in the growth rate of entry, 'high' ad valorem tariffs from 10% up to 15% were associated with a 13.2 percentage point decline, tariff rate quotas were associated with a 16.9 percentage point decline, and specific duties were associated with a 18.9 percentage point decline.

The chapter conducts a partial equilibrium aggregation exercise to calculate the number of missing entrants into and exiters from the EU as a result of the heightened trade policy uncertainty post-Brexit. This exercise estimates that 5,344 firms did not enter into exporting new products to the EU in 2016, whilst 5,437 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 the EU would have been 5.0% higher and exit from the EU 6.1% lower in 2016 relative to a counterfactual of zero tariffs on all products and no uncertainty about future tariff rates.

The results show that trade policy uncertainty matters for firm exporting decisions and significantly reduces entry into exporting. However, as entrants are small in terms of value, the large change in the number of firms entering into and exiting from exporting generated only a moderate impact on aggregate exports in 2016. Specifically, the decline in entry and induced exit reduced the value of exports by between £394 million and £3.0 billion in 2016, a modest amount relative to total value of UK exports to the EU in 2016 of £139 billion.

1.2. The Role of Customer Base in Exporter Dynamics

The third chapter *The Role of Customer Base in Exporter Dynamics* (joint with Davide Rigo) provides evidence on how firms accumulate customers over their life cycle, and whether firms actively adjust their customer base in response to changing market conditions. This chapter uses rich customs data from France to shed light on the role of customer base in exporter dynamics and provides an empirical contribution through testing the predictions of models of customer base. The chapter then builds on the preceding chapter by investigating whether exporting firms adjust their customer base within a market in response to the renegotiation of a trade agreement.

First, the chapter describes the dynamics of customer base over the life cycle of an exporter in a destination, and decomposes the contribution of customer base in the value of exports. This

exercise then decomposes the contribution of customer base in a firm's total value of exports to a destination market, and shows that customer base can explain up to 30% of the growth in a destination market. Further, the contribution of customer base remains constant throughout the life cycle, providing evidence of the importance of continued investment by firms in their customer base.

The chapter then explores the mechanisms through which firms grow in export markets by analysing the evolution of price dynamics to test the competing models of marketing costs and pricing activities in theories of customer markets. These results provide evidence of very little to no dynamics in pricing through the life cycle of an exporter in a destination market, as well as through the life cycle of specific customer relationships. These findings lend support to the theoretical models in which firms use non-price activities, such as advertising and marketing, to accumulate customer base, and call into question theories of customer markets that emphasize dynamic pricing activities.

The chapter also investigates how exporters adjust their 'portfolio' of customers in response to changes in market access. The empirical strategy exploits the natural experiment of the result of the 2016 Brexit Referendum in a difference in difference strategy to estimate how French firms adjusted their customer base in response to changing demand conditions as a result of the increased uncertainty over the future UK-EU trading relationship. The empirical specification estimates the impact of the heightened trade policy uncertainty facing French exporters to the UK relative to other markets before and after the referendum result. The results show that French exporters reduced their number of customers in response to changes in market access. French exporters were less likely to add new customers in the period of heightened trade policy uncertainty following the Brexit referendum, with a reduction in the probability of a firm adding a new buyer of 2.3%. French firms were also more likely to stop exporting to a given customer in a market in the period of heightened uncertainty. These findings show that firms actively adjust their customer base in response to changes in the access to destination markets and lends further support to theories that emphasize the importance of customer base for exporter growth.

1.3. Import competition and the Reallocation of Manufacturing Activity

The fourth chapter *Import competition and the Reallocation of Manufacturing Activity: Evidence from the impact of the China Shock on UK Manufacturing* shows that the rise in import competition from China following China's accession to the World Trade Organization contributed to the decline in UK manufacturing activity post 2000, with a significant proportion of this decline in manufacturing activity driven by firms switching their industrial activity out of manufacturing production and towards services. This chapter provides evidence that UK firms reorientated activity away from production activities and towards both research and development and wholesale and retail activities in response to increased low wage import competition following China's accession to the World Trade Organization in 2001. The chapter uses detailed microlevel data on the universe of UK firms over the 1998-2015 period to estimate the direction and magnitude of structural change in response to increased import competition from China. The main finding is that 42% of the decline in manufacturing employment in response to increased import competition occurred through firms which were initially in manufacturing and which switched out of this sector. These firms move into business services such as research and development, or into wholesale and retail.

The chapter estimates the direction and magnitude of the UK firm response to increased import competition. The chapter decomposes the change in manufacturing employment along the intensive margins (expansion and contraction of incumbent firms), extensive margins (entry and exit of firms), and industry switching (incumbent firms who switch into or out of exposed industries). A significant proportion (42%) of the decline in manufacturing employment in response to increased import competition occurred through firms switching out of manufacturing. Exploring the industries which firms switch to, firms react by reclassifying into business services such as research and development (15% of all manufacturing employment), or into wholesale and retail (26% of all manufacturing employment).

The chapter then explores the timing of the structural change of firms out of manufacturing

and into business services. It estimates the predicted impact of Chinese import competition on each of the firms' margins for each year between 2001 and 2015. Rapid and large estimates of the effects of switching out of manufacturing for employment and turnover occur in the first few years following China's accession to the WTO. Exploring which firms drive the reallocation, much smaller effects are found for the number of firms switching out of manufacturing, indicating that the large employment effects are driven by the largest manufacturing firms.

The results of this chapter provide empirical evidence that increased international competition can stimulate increases in research effort which can enhance economic welfare if it boosts the rate of technological progress. However, the results also highlight that a significant proportion of economic activity moves out of manufacturing production into wholesale and retail, which would not stimulate technological progress.

1.4. Large Depreciations and Export Booms

The fifth chapter *Do Large Depreciations Lead to Export Booms? Facts on UK Firms in International Trade and Evidence on Exchange Rate Elasticities from the Brexit Depreciation* was conducted whilst the author was at the Bank of England. This paper estimates the elasticity of UK exports to the large depreciation of sterling around the Brexit Referendum and the heterogeneity of responses across UK exporters of different sizes. The paper uses transaction level administrative customs data for the UK sourced from HMRC to identify how each UK exporter changes its prices and quantities of exports of detailed products in a given destination in response to bilateral exchange rate movements.

This paper finds that the 20% increase in the value of UK goods exports following the Brexit Referendum was driven primarily by higher sterling prices, rather than by larger quantities sold. Decomposing the firm-product-destination level response into price versus quantity channels, this paper finds that the response was mainly driven by increases in the price of exports in the initial period, followed later in 2017 by a smaller increase in the quantity of exports. Across all export

destinations, a 10% depreciation results in a 5.4% increase in export prices and just a 1.2% increase in export quantities.

The largest exporters are shown to be the most responsive to the depreciation, increasing both quantities and prices more than smaller exporters. Since large exporters account for the lion's share of the value of exports, their response to exchange rate movements will drive the aggregate response. Importantly, this effect is not just driven by differences in the elasticity of exports to the exchange rate across industries, as the results are robust to ranking exporters within industry.

This paper also utilises a new dataset linking the UK Business Register and Customs Data to document the importance of UK firms in international trade as a share of economic activity. Trade in goods is concentrated in a small number of firms that account for the lion's share of exports and imports. Only 3% of UK firms are engaged in international trade in goods yet these firms account for over 30% of employment and over 50% of UK turnover. The response of the largest firms to trade shocks are pivotal in shaping UK export patterns, with the top 1% of goods exporters accounting for 70% of exports, 5% of employment, and 12% of turnover. This indicates that there could be significant implications for economic activity if the largest exporting firms were to exit the UK after Brexit.

2. Renegotiation of Trade Agreements and Firm Exporting Decisions: Evidence from the Impact of Brexit on UK Exports (*joint with Meredith Crowley and Lu Han*)

2.1. 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.

[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)).

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 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

[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.

[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.

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 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.

2.1.1. 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.

[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).

2.1.2. Outline

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

2.2. 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 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 subsection, we briefly outline the necessary components of this model and derive our key empirical predictions. The subsection first outlines the static per period model and then states the dynamic Bellman equation. As it does not specify the full dynamic stochastic optimal control problem it should be viewed as illustrative rather than definitive.

2.2.1. 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 Ω_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/τ_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 δ and the real interest rate r. When future trade policy is certain and given by τ_h, the cost threshold of product h under which a firm enters the

[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.

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

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 γ, 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 λ_{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 γ). 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 λ_{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, τ_{WTO}.

The value of waiting during the renegotiation state R is:

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

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 λ_{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 (γ), and (3) the probability that renegotiation will terminate without an agreement to trade freely (λ_{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 $\tau_h(WTO)$, 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, γ, 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

[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 γ is the probability of renegotiation concluding and trade policy shifting into one of the two outcome states:

$$c_h^U(R)/c_h^{certain} = U(\omega_h, \gamma) = \left(\frac{1 + u(\gamma)\omega_h}{1 + u(\gamma)}\right)^{\frac{1}{\sigma-1}} \tag{6}$$

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.

of the renegotiation breaking down and terminating with no deal, λ_{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.

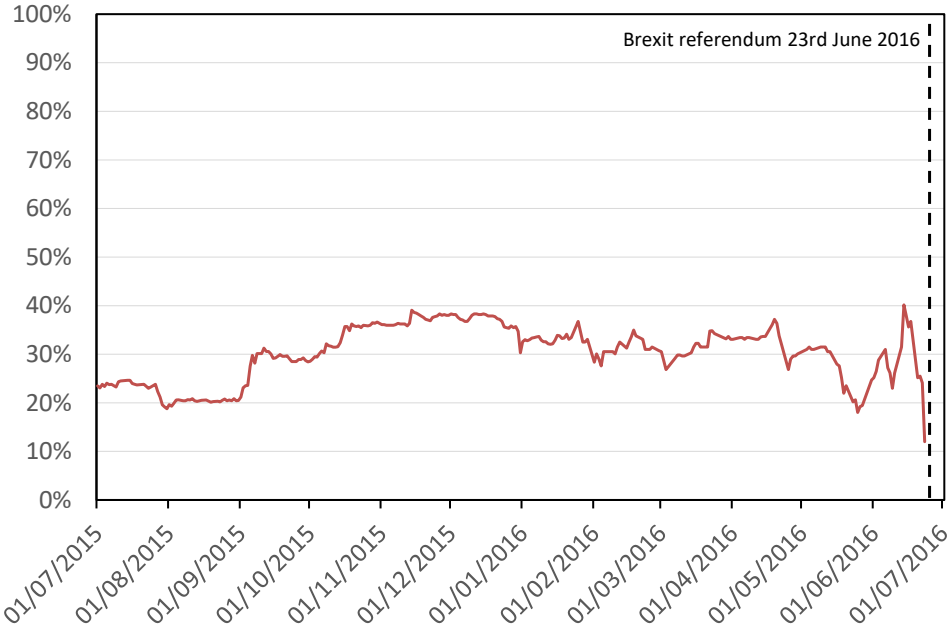
Firms will also exit from exporting in response to an increase in trade policy uncertainty. Firms that experience the exogenous death shock with probability δ exit, but have the opportunity to re-enter. A change in exit will be observed during the renegotiation state as firms hit with a death shock whose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

2.2.2. 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 rene-

[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.

gotiation 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 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 $c_h^{U'}(R) < c \leq c_h^U(R)$ 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.

[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.

2.3. 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).

2.3.1. 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:

$$\Delta Y_{ht} = b_0 + b_1 \, \tau_h^{threat\,point} + \eta_{ht} \tag{7}$$

where ΔY_{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] The coefficient of interest b_1 is assumed to apply equally across all industries and therefore only captures the average effect of uncertainty across the products h and sectors k. Restrictions in sample size prevented assessment of heterogeneous results across sectors.[14]

2.3.2. 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

[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] Additional sensitivity analysis was conducted removing different HS sections and results remained similar for each set of results. These results are not presented in this thesis.

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 (7) if the results capture product-specific responsiveness to the exchange rate movements, rather than the cross-subsectional 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.

$$\Delta_{z_{|hfd}} uv^k_{hfdt} = \alpha^k_e \Delta_{z_{|hfd}} e_{dt} + \Delta_{z_{|hfd}} X'_{dt} \alpha^k_x + \Delta_{z_{|hfd}} \epsilon^k_{hfdt} \tag{8}$$

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^k_{hfdt} represents the unit value denominated in sterling[15]; 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.[16]

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 (8) 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 α^k_e in

[15]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.

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

our estimating equation on firm entry and exit:

$$\Delta Y_{ht}^{EU} = b_0 + b_1 \, \tau_h^{threat\,point} + b_2 \, \hat{\alpha}_e^k + \eta_{ht}. \tag{9}$$

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.

2.3.3. Triple difference model

The observed cross-subsectional 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:

$$\Delta Y_{ht}^{EU} - \Delta Y_{ht}^{non-EU} = b_0 + b_1 \, \tau_h^{threat\,point} + \eta_{ht} \tag{10}$$

where ΔY_{ht}^{EU} and ΔY_{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.

2.4. 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).

2.4.1. 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.[17] 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.

2.4.2. 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.[18] We define a firm f as exporting to destination d with a product h if the firm has a positive value of exports

[17] 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.

[18] 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.

in time period t to any country in destination d.[19] 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).[20] 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.[21] 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.

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.

2.4.3. 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):

[19]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.

[20]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.

[21]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.

$$\Delta Y_{ht} = \frac{2(Y_{ht} - Y_{ht-1})}{(Y_{ht} + Y_{ht-1})} \tag{11}$$

where ΔY_{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].[22]

2.4.4. 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)[23] 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.

These tariff categories are mutually exclusive categories - each product h is in one, and only one, of specific duties, quota or the continuous or discrete ad valorem tariffs. If a product has a compound structure (a mix of ad valorem tariffs and specific tariffs) then the product was classified

[22]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.

[23]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.

as specific. If a product was subject to a WTO TRQ then the product was classified as quota and not also classified based on its MFN tariff structure. This mutually exclusive categorisation ensured that the more restrictive specific component did not contaminate the ad valorem assessment. Ad valorem equivalents were not used due to their uncertainty around which prices to use in their calculation that may not have accurately reflected UK trade with the EU.

2.4.5. Distribution of UK-EU exporters across industries

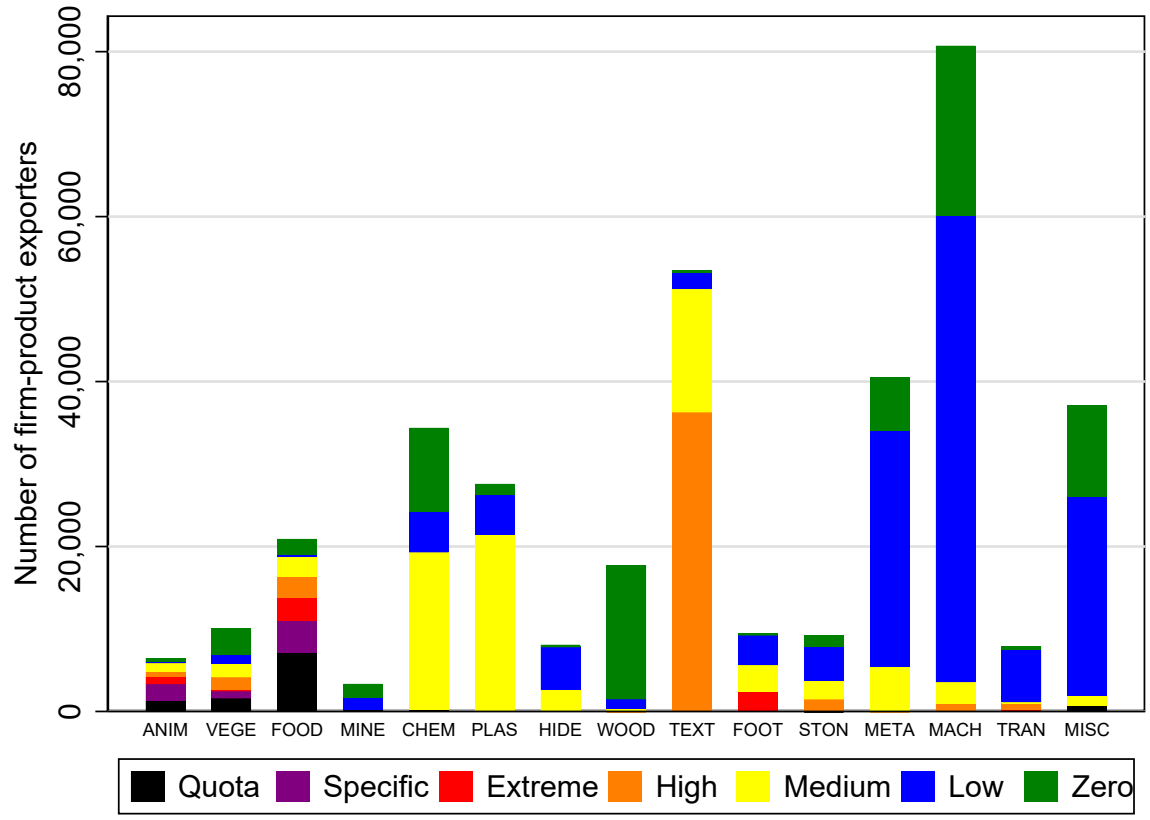
The exposure of UK exporters to EU trade policy uncertainty is distributed across industries. Figure 2 shows the count of products within firms exported to the EU and the total value of exports, by broad industry and trade policy uncertainty, in 2015. Figure 2 shows that a significant number and trade 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.

2.5. 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-subsectional 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

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



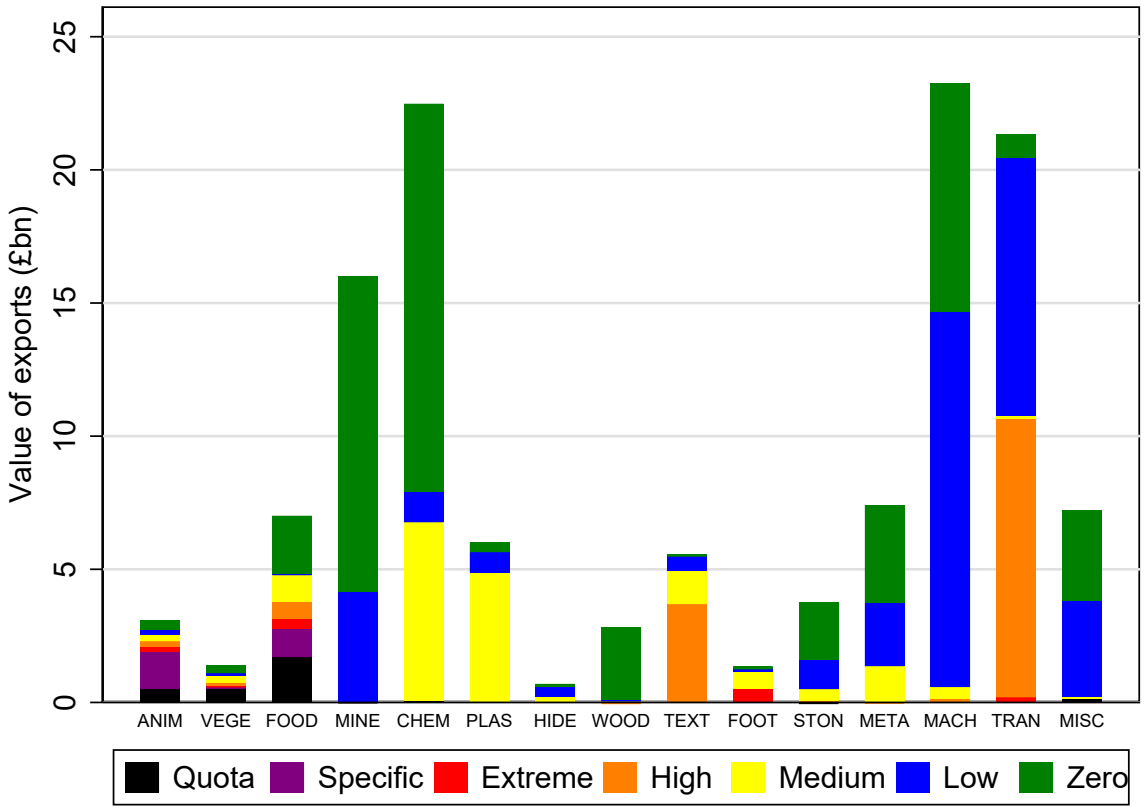
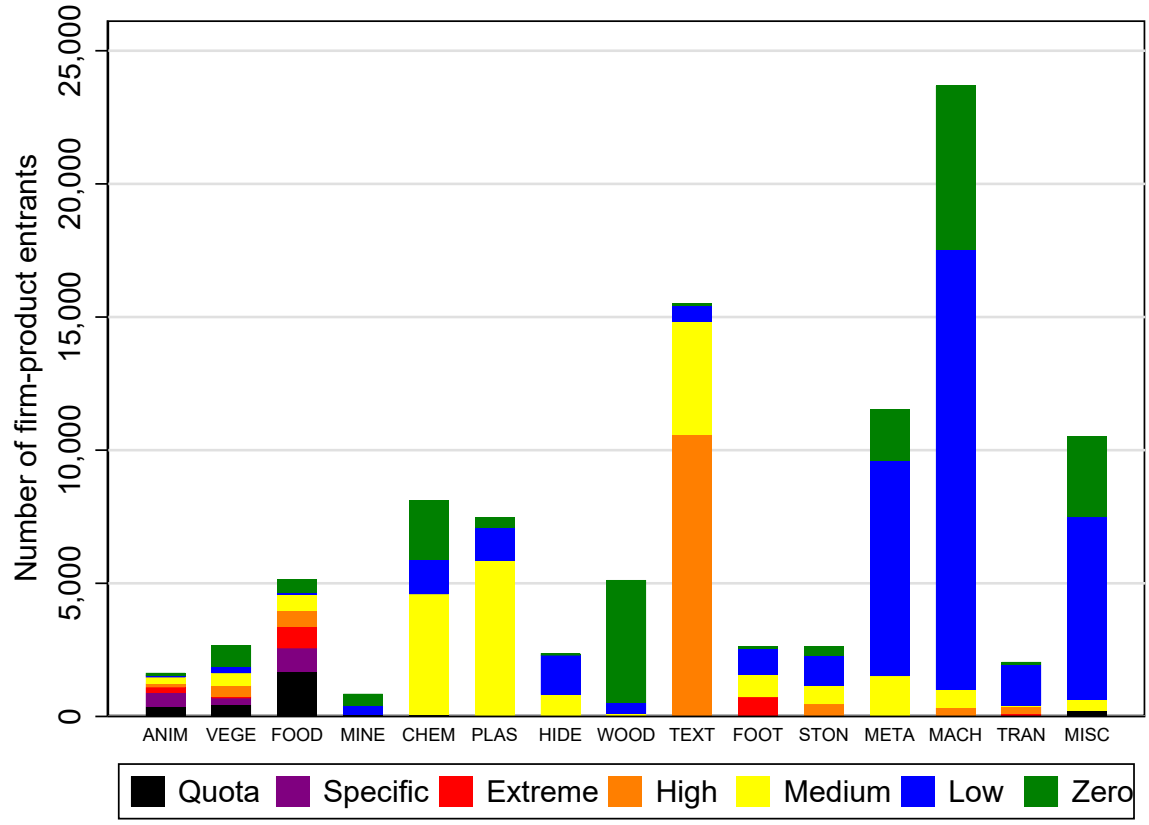
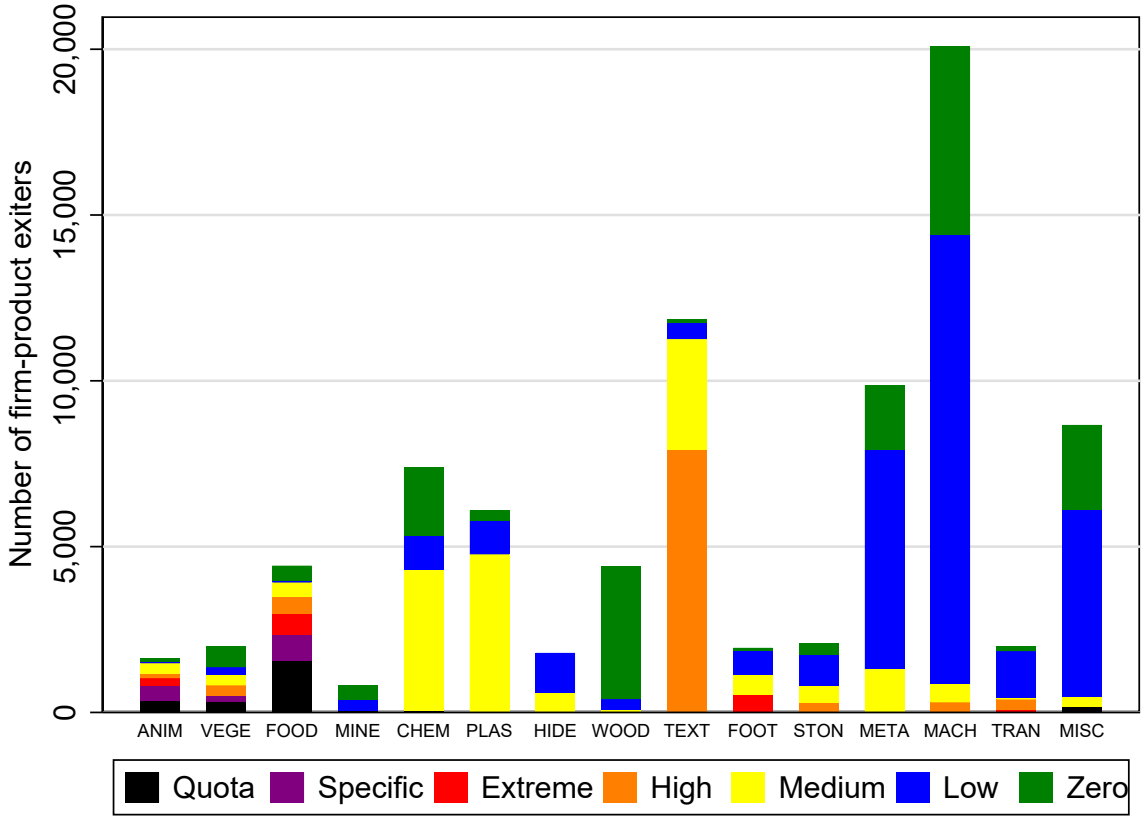


Fig. 3. Trade policy risk under renegotiation by number of entrants and exiters





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.

2.5.1. Impact of Trade Policy Uncertainty

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.

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 subsection 2.5.3.

2.5.2. 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 million 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.

2.5.3. 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.

2.5.4. 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.[24]

2.5.5. 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

[24]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.

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.

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.[25] 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 (7) 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.

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

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.

2.6. 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.

2.7. 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.

3. The Role of Customer Base in Exporter Dynamics (*joint with Davide Rigo*)

3.1. Introduction

Almost all economic transactions require both a supplier and a customer for a good or service. The number of customers that a firm serves − the firm's customer base − is important in explaining many economic phenomena. International trade is unique in that the distance, cultural and language barriers make the matching of the two sides of the relationship even more difficult. Customer base is central to explaining why so many exporters remain small, as exporters find it increasingly costly to reach more customers (Arkolakis, 2010). Firm-to-firm relationships are also important for understanding relative international price movements as exporters build market shares (Drozd and Nosal, 2012) and exploit relationship specific investments (Heise, 2015). The role of customer base also appears central to understanding how firms respond to different shocks with implications for the international elasticity puzzle (Fitzgerald and Haller, 2018). Despite the growing importance of customer base in these literatures, there is little direct evidence on how firms accumulate customers over their life cycle, nor whether firms actively adjust their customer base in response to changing market conditions.

This paper uses rich customs data from France to shed light on the role of customer base in exporter dynamics. The paper provides an empirical contribution through testing the predictions of models of customer base. First, we show the dynamics of customer base in the life cycle of exporters in a destination, and decompose the contribution of customer base in the value of exports. Second, we provide a direct test of competing theories of customer dynamics, and find no evidence of pricing dynamics in markets or customer relationships. This provides support for models where customer base is accumulated through non-price activities, such as marketing and advertising. Third, we hypothesise that customer base is an active margin through which exporters respond to changes in market access. We show that French exporters disengaged from exporting to the UK market and reduced their customer base within the UK in response to the increase in trade policy

uncertainty and sterling depreciation following the Brexit referendum in 2016.

We provide direct evidence for the role of customer base in export dynamics. Arkolakis (2010) develops a theory of marketing costs to explain the existence of a large number of small exporters in each destination market. Within each market, firms invest in marketing to reach more customers, but the cost of attracting each additional customer increases with the number of customers reached. Firms therefore do not serve the market in its entirety, and it is possible for less productive exporters to enter a market but reach relatively few customers. Fitzgerald, Haller, and Yedid-Levi (2016a) incorporate the customer accumulation of Arkolakis (2010) in a dynamic setting to explain how exporters grow. We show empirically that customer base is an important driver in firm export dynamics, with firms accumulating customers as they grow in the early years of an export spell, and dropping customers in the final years of an export market spell. We decompose the contribution of customer base in a firm's total value of exports to a destination market, and show that customer base can explain up to 30% of the growth in a destination market. Further, the contribution of customer base remains constant throughout the life cycle, providing evidence of the importance of continued investment by firms in customer base.

We explore the mechanisms through which firms grow in export markets by analysing the evolution of price dynamics to test the competing models of marketing costs and pricing activities in theories of customer markets. The theory of marketing costs to attract customer base purports that firms grow in a market through non-price activities such as investing in marketing and advertising,[26] which contrasts to customer markets models of firm dynamics, which model the accumulation of customers through explicit pricing strategies.[27] We find no evidence of pricing dynamics through the life cycle of an exporter in a destination market,[28] nor through the life cycle of specific customer relationships. These findings contrast to the role of dynamic pricing activities in theories

[26]In Arkolakis (2010) and Fitzgerald et al. (2016a) the elasticity of demand is independent of customer base, and which therefore no pricing dynamics in their models.

[27]In the seminal work of Phelps and Winter (1970) and Bils (1989), pricing decisions are a form of investment, when consumer base is sticky, as lower initial prices build customer base. Firms can then price with higher markups once customers are locked in. This therefore would suggest clear patterns in pricing dynamics over the life of a relationship.

[28]Fitzgerald et al. (2016a) find the same dynamics looking at Irish exporters.

of customer markets, and instead support theories of non-price mechanisms of firm growth, with activities such as advertising and marketing, to accumulate customer base.

Finally, we investigate how exporters adjust their 'portfolio' of customers in response to changes in market access. Arkolakis (2010) introduces the margin of customer base which exporters can adjust in response to shocks and shows that it is the most important quantitatively for the response of export values to small changes in trade costs. We exploit the natural experiment of the result of the 2016 Brexit Referendum in a difference in difference strategy to estimate how French firms adjusted their customer base before and after the Brexit referendum (first difference) in the UK relative to other EU countries (second difference). We estimate the impact of the heightened trade policy uncertainty and reduction in competitiveness following sterling's depreciation against the Euro facing French exporters to the UK. We find that French exporters reduced their number of customers in response to changes in market access.[29] We find that French exporters were less likely to add new customers in the period of heightened trade policy uncertainty following the Brexit referendum, with a reduction in the probability of a firm adding a new buyer of 0.2% and 0.5% more likely to drop customers. These findings show that firms actively adjust their customer base in response to changes in the access to destination markets and lend further support to the models of customer base.

3.1.1. Related literature

Our paper serves as a direct empirical test of models of customer base in export dynamics. Arkolakis (2010) was the first to theorize that exporters reach individual consumers rather than the market in its entirety and so investing in marketing and advertising would allow firms to reach an increasing number of consumers in a country. Fitzgerald et al. (2016a) extend the theory of customer base in a dynamic model and using customs data for Ireland calibrate a model where firms accumulate their customer base through marketing and advertising to match the evolution of firms' export revenue in a destination market. We show that French exporters accumulate foreign

[29]The alternative channel is that British customers of French suppliers decide to switch sourcing away from imports and towards domestic suppliers as uncertainty about the UKs trade policy increased.

buyers over their life cycle and decompose the role of customer base in export market dynamics.[30] Our findings that customer accumulation plays a significant contribution to export dynamics supports the explicit modelling of customer base in models of international trade.

Recent literature has increasingly focussed on firm-to-firm relationships in international trade, which is reviewed by Bernard, Bler, and Dhingra (2018a). Eaton, Eslava, Krizan, Kugler, and Tybout (2014) use information on Colombian exporters and their US importers to develop a model where exporters search for importers and learn about relationships to explain patterns of entry and survival. Bernard, Moxnes, and Ulltveit-Moe (2018d) develop a model with relationship-specific costs and firm heterogeneity to match empirical findings based on Norwegian importer-exporter data. Also using the French customs data, Lenoir, Martin, and Mejean (2019) study how search frictions, captured empirically by stocks of migrants, distort competition by preventing buyers from identifying the most productive sellers. Eaton, Kortum, and Kramarz (2015a) develop a model of firm-to-firm trade where buyers connect randomly with sellers, which generates predictions that are consistent with the data for French manufacturers and customers within the European Union. Other papers have focussed on the implications of firm-to-firm relationships to switching costs (Monarch, 2018), relationship stickiness (Martin, Mejean, and Parenti, 2018) and the division of the gains from trade (Bernard and Dhingra, 2016).

A recent body of empirical research investigates the role of firm-to-firm relationships in response to shocks. Monarch and Schmidt-Eisenlohr (2016) highlight the importance of long-lasting relationships for US importers and their suppliers abroad, with long-term relationships being more resilient in the 2008-09 financial crisis. Heise (2015) shows the effects that firm-to-firm relationships have on price rigidity and exchange rate pass-through. Martin et al. (2018) reveal significant heterogeneity in the duration of individual relationships and show that macroeconomic uncertainty

[30] We also contribute to a wider literature understanding how firms grow as our findings on firm-to-firm relationships are not unique to exporters. This literature documents that firms grow by adding new products (Argente, Lee, and Moreira, 2018) or through the intensive margins by adjusting their prices (Piveteau, 2019; Bastos, Dias, and Timoshenko, 2018; Berman, Rebeyrol, and Vicard, 2019). However, some recent works predicts that firms mainly grow by adding new customers through non-price activities (Fitzgerald and Priolo, 2018; Hottman, Redding, and Weinstein, 2016; Foster, Haltiwanger, and Syverson, 2016).

in destination markets can affect trade patterns by impeding the creation of new business relationships. We complement this literature by showing that French exporters actively adjust their customer base in response to changes in market access by exploiting the natural experiment of the reduction in market access resulting from the increase in trade policy uncertainty and sterling depreciation following the unexpected result of the Brexit referendum. Our paper is the first to investigate the dynamics of customer accumulation and the contribution to firm growth within a market.

3.1.2. Outline

This paper is organized as follows: subsection 2 describes our data; subsection 3 documents the accumulation of customer base in export markets and decomposes the contribution for firm export market dynamics; subsection 4 outlines our empirical strategy and presents results of our analysis of how exporters adjust customer base in response to a shock to market access in the context of the Brexit referendum; subsection 5 concludes.

3.2. Data

The empirical analysis is conducted using detailed export data covering the universe of French firms.[31] Our working data set covers all transactions that involve a French exporter and an importing firm located in the European Union in the 1996-2017 period. The data are based on records of cross-border transactions collected by the French customs. Each transaction shows the identifier of the exporting firm, the anonymised version of the VAT identifier of the importer, the date of transaction (month and year), the product category (at the 8-digit level of the combined nomenclature), the country of destination and the value (in Euro)[32] and quantity (in kg) of the shipment for firms above the customs reporting threshold. French firms have a legal obligation to submit a full declaration of their intra-EU exports if their total foreign sales were above 250,000 French Franc in 1996-2000, above 100,000 Euro in 2001-2006, above 150,000 Euro in 2007-2010 and above

[31] For more information on the data see Bergounhon, Lenoir, and Mejean (2018).

[32] For all destination countries the trade data is specified in French franc for the period before France joined the euro, or euro after as the data is from French administrative sources. Trade date prior to the euro is converted using the official exchange rates used to convert the currencies to euro.

460,000 Euro since 2011. Otherwise, they have to submit a simplified declaration including all the variables listed before, expect for the product category. For our analysis, we define an exporter at the firm-CN08 product level, leading to the exclusion of all exporters not reaching in a year export value above the reporting threshold.[33] To define exporters at the firm-CN08 product level, 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).

Given the quality of the data, little cleaning is necessary to construct the final data set. We only deal with the cases in which the physical trade flow may not be geographically confounded with the financial trade flow. For instance, when a French firm ships a good to a plant in Germany of a UK VAT registered firm. These trade flows are dropped to avoid any confounding factors in our analysis. The number of observations excluded is however small, 3 per cent of total transactions representing 5 per cent of the total value of exports in 2017.

3.2.1. Descriptive statistics

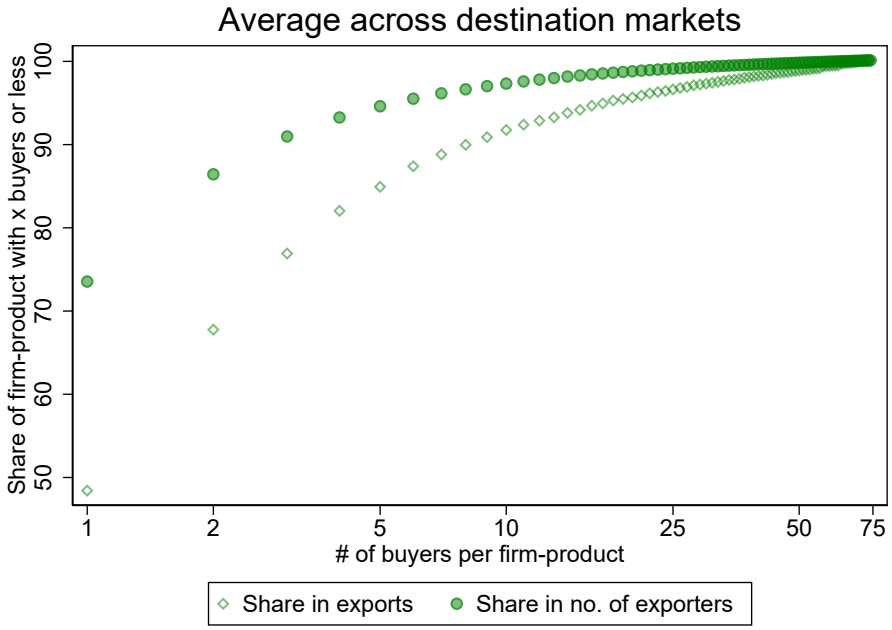
In 2017, there are more than 278,000 exporter-products and 500,000 importers, combining into more than 3.2 million exporter-importer-product relationships.[34] Exporters selling to multiple customers account for a disproportionate share of export sales in a destination, with at least 50% of French export value accounted for by exporters serving at least 2 customers in each destination country (Figure 4). While, on average, each French exporter sells to 2.2 buyers in a destination market in 2017, the distribution of the number of buyers is highly skewed, with more than 70% per cent of French exporters selling to one buyer only. As whilst 90% of firms connect with fewer than 3 businesses in a destination, some firms sell to over 100 businesses in a destination.[35]

[33]One potential concern is that the exclusion of these below threshold transactions may create selection bias in our results. We thus replicate our key findings using the whole universe of French exporters by aggregating over the product dimension and defining an exporter at the firm level, as we have information on the total value of firm level exports for firms below the reporting threshold. The results are qualitatively unchanged and consistent with our main conclusions, downplaying the role of selection bias in affecting our results. Full regression output tables are available upon request.

[34]Tables in the Appendix show descriptive statistics on the number of French exporters, EU importers and exporters-importers relationships across destination countries.

[35]There is also heterogeneity in the number of customers that French exporters serve in each destination even within narrowly defined product categories.

Fig. 4. Firm-product-market customers distribution

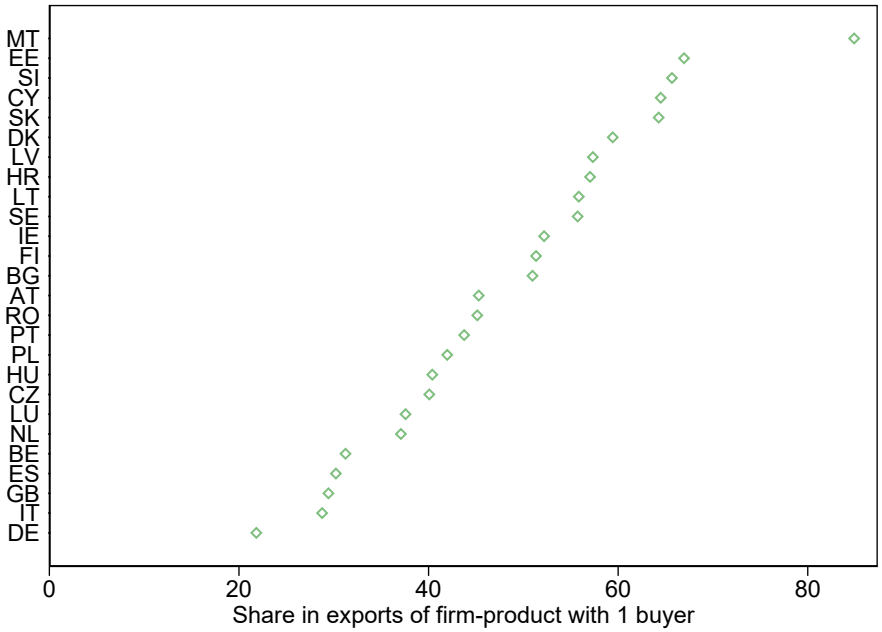


We have shown that French exporters selling to multiple buyers make up for around half of French exports. However, there is significant heterogeneity in the average number of customers each exporter serves across markets, with French exporters having an average of 6.3 Italian importers and only 1.3 Latvian buyers. Figure 5 shows the share in exports of single-buyer exporters for each European market. Single-buyer exporters account for a small fraction of exports in large and close economies, such as Germany, Belgium, UK, Italy and Spain.

The fact that exporters have few partners per national market has also been established in the growing literature on firm to firm relationships in international trade. Eaton, Kortum, Kramarz, et al. (2015b) also find that the number of buyers for each French exporter is low with the median number of buyers per French exporter is 1 in smaller economies and 2 in larger economies, whilst the mean number of buyers ranges from 1 in some countries to 10 in larger countries. Bernard, Moxnes, and Ulltveit-Moe (2018e) also show that the distribution of buyers per exporter is characterized by many exporters having a small number of buyers, and a small number of exporters

having a large number of buyers. Bernard et al. (2018e) also find similar patterns on the importing side, which has also been established for the US (Monarch, 2014).

Fig. 5. Firm-product-market customers distribution



To investigate further the determinants of the distribution of buyers across destination markets, we estimate a gravity model for the years 1996 to 2015.[36]

Table 8 summarises the results - as there is no exogenous variation these results should be not be interpreted as necessarily causal. Column (1) shows that the number of buyers in a destination market is associated with the size of the bilateral trade relationship between a French exporters and the destination country. Market tenure in a destination market also associated with the number of buyers, suggesting that French exporters may accumulate buyers over time. Column (2) and (3) show the results including several gravity variables. The number of buyers is also associated with

[36]The gravity variables are taken from the CEPII database and are available until the year 2015. The dependent variable takes the log of the number of buyers for each firm in each destination. This leads to a potential issue of missing values for the values that take a value of zero and are missing from the data. The results should therefore be interpreted cautiously as associations of the intensive margin only as no account is taken of the underlying latent relationship of the extensive margin. For further information on any of the variables please see the detailed descriptions at: *http* : *//www.cepii.fr/cepii/en/bddmodele/bdd.asp*. GDP is nominal in dollar (converted using market exchange rates) and not deflated to make them consistent with the trade data that is not deflated. GDPs and populations come from the World Bank's World Development Indicators (WDI). Variables related to bilateral distance, contiguity and common language come from the CEPII GeoDist database (*http* : *//www.cepii.fr/anglaisgraph/bdd/distances.htm*).

the geographical proximity to France, with higher number of buyers in closer and bigger destination markets and in countries using the Euro. However, wealthier destination markets are negatively associated with the number of buyers, suggesting that richer countries are more concentrated in terms of number of buyers.

Table 8: Gravity model, 1996 - 2015

	(1)	(2)	(3)
Dep. Var. (log)	# buyers	# buyers	# buyers
Export (log)	0.170***	0.170***	0.171***
	(0.000475)	(0.000475)	(0.000476)
Market tenure	0.0294***	0.0292***	0.0299***
	(0.000313)	(0.000309)	(0.000300)
GDP (log)		0.428***	0.0931***
		(0.0118)	(0.000673)
GDP per capita (log)		-0.370***	-0.124***
		(0.0130)	(0.00129)
Distance (log)			-0.0465***
			(0.00206)
Contiguity			0.0762***
			(0.00164)
Common language			0.191***
			(0.00241)
Common currency			0.0823***
			(0.00126)
Observations	15,313,488	15,313,488	15,313,488
R-squared	0.570	0.570	0.568
FE	fpt-dt	fpt-d	fpt

Notes: Dependent variable is the log number of buyers in a destination market in a year. $Export(log)$ is firm-product's export value to a destination; $Market\,tenure$ is the number of years that a firm-product has been continuously exporting to a destination; $Distance\,(log)$ is the log of the weighted distance between France and the destination market; $GDP\,(log)$ is the log of the destination's GDP; $GDP\,per\,capita\,(log)$ is the log GDP per capita in the destination. Column (1) includes firm-product-year and market-year fixed effects; column (2) includes firm-product-year and market fixed effects; column (3) includes firm-product-year fixed effects. Stata command used is reghdfe. Robust standard errors in parentheses. The p-values read as follow: *** p < 0.01, ** p < 0.05, * p < 0.1.

3.3. Role of customer base in export market growth

In this subsection we exploit the unique information on the identity of customers in the French export data to decompose the role of customer base accumulation for the growth of firm exports, and then explore potential mechanisms in the dynamics of specific customer relationships.

3.3.1. Empirical strategy

There are two main elements of our empirical strategy to identify the dynamics of export market growth: (i) We control for variation in export market performance driven by supply side or common demand shocks across products; (ii) We separately identify the dynamic life cycle contribution of market tenure from selection effects in different spell lengths.[37]

We isolate the dynamics over the firm life cycle in the market from supply-side or common demand shocks through the inclusion of comprehensive firm-product-time fixed effects. These fixed effects absorb all of the common variation of a firm-product export performance across markets in a given time period. For instance, we may be concerned that shocks to the productivity of firms could lower the cost of producing a good and hence improve the export competitiveness and therefore the export performance of the firms, leading to fluctuations in the export value and number of customers served. However, as these supply side shocks will likely occur at the firm(-product) level, they will be common across markets and therefore the inclusion of firm-product-time fixed effects will allow us to isolate the effect of market dynamics.

We address issues of selection by separating dynamics over the market tenure of an exporter from the performance of firms with different spell lengths. If we do not condition on the spell length of an exporter then we could incorrectly capture dynamics over the length of time an exporter operates in a market. For example, if exporters are more likely to exit from markets where there is a low demand. Then by pooling across all export episodes, we would observe that the number

[37]This methodology was introduced by Fitzgerald et al. (2016a) to study Irish exporters' growth trajectories in a destination market. We build on this method to look at customer accumulation within a market, and also growth trajectories within each exporter-importer relationship.

of buyers would increase over the duration in a market, even if there are no dynamics within each export episode. Separately estimating the dynamics of each export episode by their eventual spell length allows us to identify the effects of selection, as well as identifying different dynamics across export episodes of different spell lengths.

Table 9 provides an illustration of how our measures of market tenure and spell length are constructed. We define *Tenure* as the length of time that a firm has been exporting to a given destination within each spell. We set *Tenure* equal to 1 in the first year a firm exports to a given market after not exporting in the previous period. We are not able to retrieve this measure of market tenure when we do not observe a firm's entry in a market (in Table 9 we show this in Markets A and E). For instance, since our period of analysis starts in 1996, we do not know if firms were or not exporting to a destination market in the year 1995. These observations are control for in our analysis using a dummy variable *Cens*. The variable *Tenure* is then incremented by 1 in each subsequent year of continuous participation. If the firm exits a market for some period, *Tenure* is reset to 1 when the exporter re-enters (e.g. Market C in Time 4). We define the *Spell length* of the relationship as the total number of years that a firm exports to a given market continuously. We top-code both *Tenure* and *Spell length* at 10 years in our baseline specification.[38] To ensure a correct assignment of spell lengths, we exclude spells still active in the final year of the panel and whose length is right-censored at a level below the top-code (these observations are identified using a dummy variable *Cens* and in Table 9 we show this in Market D). We analogously define the relationship *Tenure* and relationship *Spell length* for export episodes at the exporter-customer level. The relationship *Spell length* is the total number of years that a French exporter will sell to a specific customer in a foreign market. The relationship *Tenure* is the number of years that an exporter has sold to a specific customer.

Throughout we treat markets as wholly independent. On the one hand this may be a reasonable assumption due to differences in language and national regulations. This assumption is also standard in the trade literature on both gravity (Head et al., 2010) and export dynamics (Fitzgerald,

[38]The top-coding is necessary given the limited capacity of our computing machine. Our key results are consistent with top-coding our measures for higher levels and are available in the Appendix - subsection B.

Haller, and Yedid-Levi, 2016b). On the other hand distinct patterns in export destinations have been established (Eaton, Kortum, and Kramarz, 2011). If established firms in one market are also more likely to have more buyers when they enter a subsequent market then this would imply that that the results presented here are an underestimate of the number of buyers. If on the other hand firms treat the EU market as a single market then the results could represent an underestimate for the number of buyers when a firm first enters a market. We tested the sensitivity of the results to treating the EU as a single market and find similar results to the results treating each market as independent. These results are not presented in this thesis.

Table 9: Market tenure and spell length variables

Time	1	2	3	4	5	6
Market	Participation					
A	X	X	X	X	X	X
B			X	X	X	
C		X		X		
D				X	X	X
E	X					
Market	Market Tenure					
A	cens	cens	cens	cens	cens	cens
B			1	2	3	
C		1		1		
D				1	2	3
E	cens					
Market	Spell Length					
A	cens	cens	cens	cens	cens	cens
B			3	3	3	
C		1		1		
D				cens	cens	cens
E	cens					

3.3.2. Exporter dynamics in destination markets

The relationship between firm tenure in a market and the number of buyers captures both a potential selection effect as well as an accumulation effect. We isolate the dynamics of different export outcomes over the life cycle through including the interaction terms between *Tenure* and

Spell length in the regression specification:[39]

$$log(Y_{idt}) = \beta'(Tenure_{idt} \otimes Spell\,length_{idt}) + \gamma Cens_{idt} + \eta_{it} + \delta_d + \varepsilon_{idt}, \qquad (12)$$

where $Y_{idt} \in \{number\,of\,buyers, value, quantity, price\}$ are measures of exporter i's outcomes in destination market d in time period t. $Tenure_{idt}$ is a vector of dummy variables for seller i's tenure in destination market d, $Spell\,length_{idt}$ is the spell length of seller i to destination country d, $\otimes$ denotes the Kronecker product of these two terms. $Cens_{idt}$ is a dummy variable accounting for censored observations. We control for supply side factors that affect a firm's performance in any given time period using firm-product-year fixed effects η_{it} and we control for destination specific factors using destination market fixed effects δ_d.[40] The vector β includes our coefficients of interest which will capture the effects of selection in the base values of each spell length and the life cycle dynamics in the evolution of each outcome over the tenure for each spell length.

3.3.3. Exporter dynamics within customer relationships

We also investigate the evolution of exports with each customer over the tenure of the relationship. This analysis provides information on two additional aspects of exporter dynamics. First, it shows how the size of each customer relationship changes through the life cycle providing evidence on how exporters grow within a relationship. Second, the dynamics on pricing within a customer relationship reveal information on the mechanisms for exporter growth. In particular, we will use the evidence on the evolution of relationship specific component on prices to provide a direct test of theories of customer markets, where firms actively adjust customer prices to accumulate market share by acquiring new customers or growing existing relationships. We estimate the regression specification:

$$log(Y_{ijdt}) = \beta'(Tenure_{ijdt} \otimes Spell\,length_{ijdt}) + \gamma Cens_{ijdt} + \eta_{idt} + \delta_j + \varepsilon_{ijdt}, \quad (13)$$

[39] The subfix p for product category is dropped for clarity.

[40] Our empirical strategy is identified by French exporters selling to multiple countries. As a result, exporters selling to only one country are dropped from the analysis. These exporters represent a minority, with French exporters selling to multiple countries accounting for 95% of export value in 2017.

where $Y_{ijdt} \in \{value, quantity, price\}$ are measures of exporter i's outcomes with customer j in destination market d in time period t. $Tenure_{ijdt}$ vector of dummy variables for seller i's tenure with customer j in destination market d, $Spell\,length_{ijdt}$ is the final spell length of the relationship between seller i and customer j in destination country d, $\otimes$ denotes the Kronecker product of these two terms. $Cens_{idt}$ is a dummy variable accounting for censored observations. We control for supply side factors that affect a firm's performance in any given time period within a destination using seller-destination-year fixed effects η_{idt} and we control for customer specific factors using customer fixed effects δ_j. The vector β are our coefficients of interest which will capture the effects of selection in the base values of each spell length and the life cycle dynamics in the evolution of each customer outcome over the tenure for each spell length.

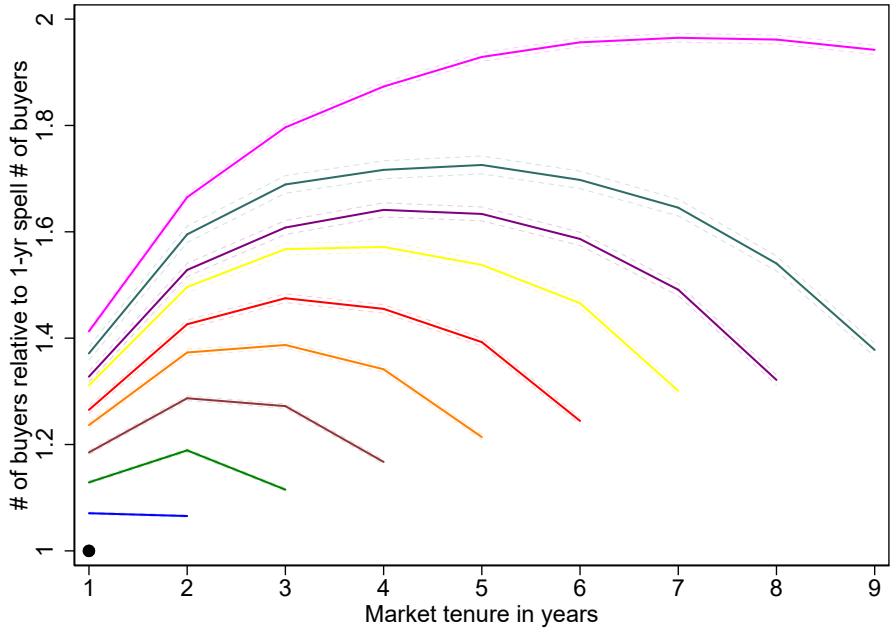
3.3.4. Customer base dynamics in destinations

In this subsection we present results which identify the role of customer base in exporter market dynamics and explore mechanisms for these dynamics. The results presented in Figure 6 (and corresponding tables in the appendix) show evidence of both selection effects across different spell lengths and evidence of life cycle dynamics. For each regression the omitted category is that of spells of exactly one year, where the dependent variable of these 1 year spells is normalized to 0 and all other coefficients are relative to the 1 year spell. We plot the results in Figure 6 by taking the exponential of the relevant coefficient and so each data point represents the difference in the number of buyers by spell and market tenure with the one-year spell average number of buyers.

We present two new results on the dynamics of customer base in export markets: (1) There is a pattern of selection where firms that will serve a market for a longer duration have more customers when they first enter the market; (2) across all spell lengths, French exporters exhibit a life cycle pattern, accumulating customers at the start and dropping customers towards the end of an export spell.

We now theorize on potential mechanisms that could be driving the shape of these relationships. In models of customer base, firms grow through reaching increasing numbers of customers through

Fig. 6. Firm-product-market customer accumulation by spell length and tenure



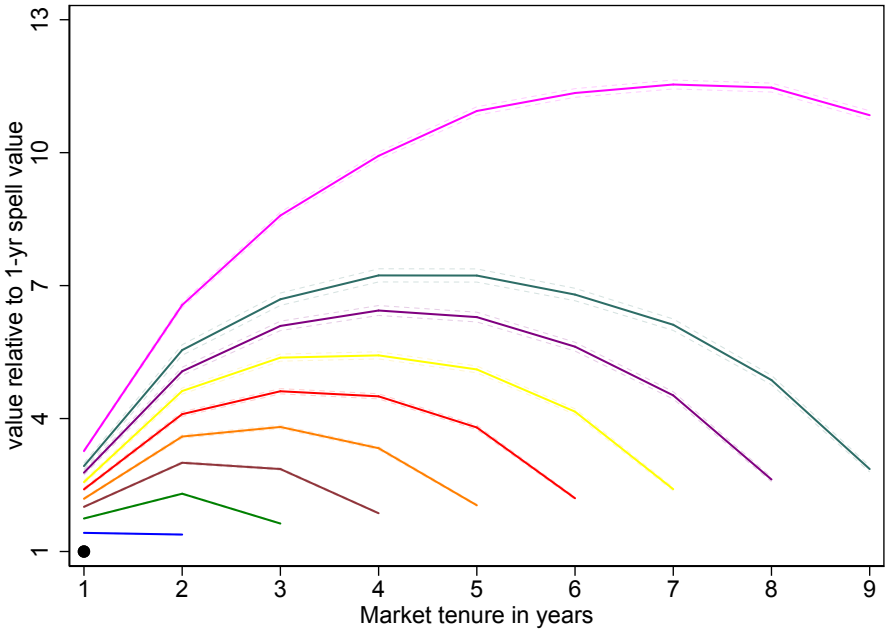
Notes: Figure shows evolution of number of buyers at the firm-product-market level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted.

non-price activities such as advertising and marketing (later in this subsection we provide evidence that suggests that firms do not engage in pricing activities to grow customer base), where each additional investment in advertising allows the firm to reach and increasing number of customers, but at a diminishing rate (Arkolakis, 2010). The process of reaching additional customers could take time (unlike the static model of (Arkolakis, 2010)), generating the increase in the number of customers at a diminishing rate in the first few years of a firm's lifecycle. The decline in the number of customers could be driven by another force generating the separation of relationships. This could arise if customer preferences change over time, or if customers shut down to generate an exogenous death shock for the exporter. As the effectiveness of advertising diminishes with the extent of advertising, the separation forces start to dominate generating the decline in number of customer relationships in the final years of a firm lifecycle in a market.

3.3.5. Exporter dynamics in destinations

We also show results for value and quantity (in kg) in Figure 7 and 8, respectively. Similarly to Fitzgerald et al. (2016a), exporters exhibit both selection effects with higher initial values and quantities predicting longer export spells, and life cycle dynamics with significant export growth in the initial years of an export spell, and a decline in exports values and quantities near to the end of a spell period.

Fig. 7. Firm-product-market value by spell length and tenure



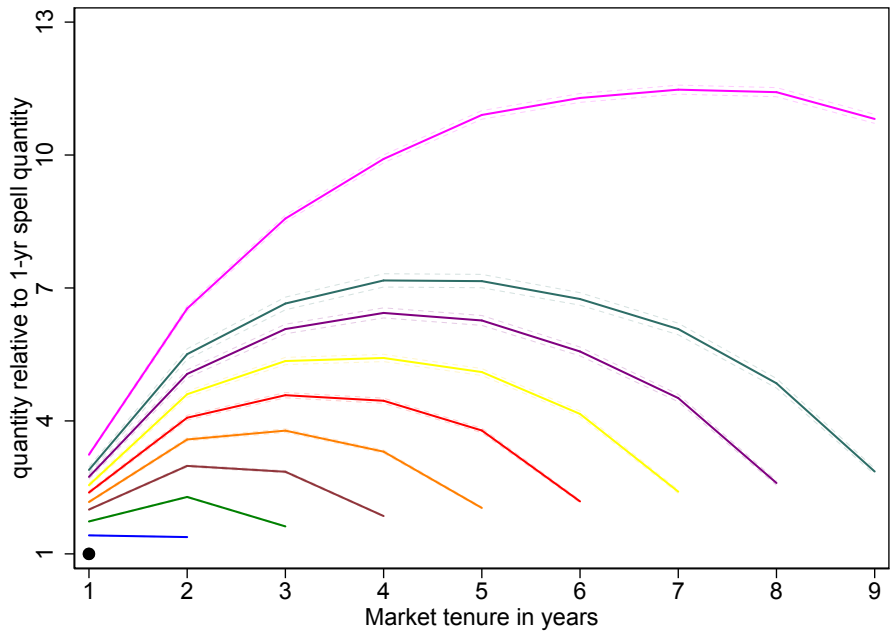
Notes: Figure shows evolution of export values at the firm-product-market level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted.

3.3.6. Decomposition of the role of customer base in export dynamics

The results presented above show that exporters accumulate buyers in a destination market over their life cycle. However, how much does the buyer margin account in the firm's growth in a destination market? We decompose the value of exports into the number of buyers and the average value per buyer, with results presented in Table 10.[41] The results show that customer base accounts for an increasing proportion of the higher export value in longer spell lengths, contributing around

[41] $Value_{idt} = number\,of\,customers * avg\,value\,per\,customer$

Fig. 8. Firm-product-market quantity by spell length and tenure



Notes: Figure shows evolution of quantities (in kg) at the firm-product-market level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted.

18% for the higher value of 2 year spells and 28% of the higher value of the longest length spells. The contribution of customer base to the trajectory of the value of exports over the life cycle is also constant with tenure in the market across all spell lengths. The fact that the contribution of customer base remains constant throughout the life cycle suggests the possibility that firms have to continuously invest in their customer base.

3.3.7. Mechanisms

We now test for several mechanisms that may explain how exporters accumulate customers in a destination market. The results in Figures 9 show the trajectory of a firm-product's price (as measured in unit values) in a destination market by spell length and market tenure. We find no evidence of market specific price dynamics within a destination.[42] The initial price does not predict how long an exporter will stay in a destination market, with no economically or statistically significant differences in the initial prices across different spell lengths for an exporter. We find

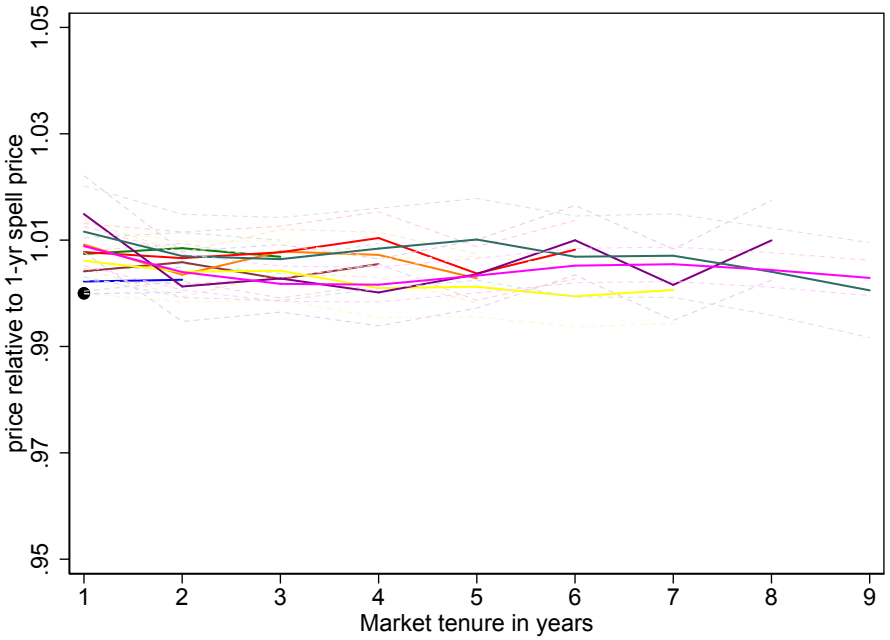
[42]These results are consistent with the pricing dynamics of Irish exporters shown by Fitzgerald et al. (2016a), who also find that initial prices do not predict the spell length of an export episode, and no dynamics for prices over the tenure of an export market spell.

Table 10: Contribution of customer base to export values

Spell length	2	3	4	5	6	7	8	9	10
Market tenure									
1	0.18	0.20	0.23	0.25	0.25	0.27	0.26	0.27	0.27
2	0.18	0.19	0.22	0.23	0.24	0.25	0.25	0.26	0.26
3		0.21	0.22	0.23	0.24	0.26	0.25	0.26	0.26
4			0.23	0.23	0.24	0.26	0.26	0.26	0.27
5				0.25	0.23	0.25	0.26	0.27	0.27
6					0.26	0.26	0.26	0.27	0.27
7						0.28	0.26	0.26	0.27
8							0.27	0.26	0.27
9								0.29	0.28
10									0.28

no evidence that firms actively use market specific prices to accumulate demand over their tenure in a market. This contrasts with theories of customer markets, where firms may use lower prices in the initial years following market entry to attract demand before increasing prices in the later years.

Fig. 9. Firm-product-market price by spell length and tenure



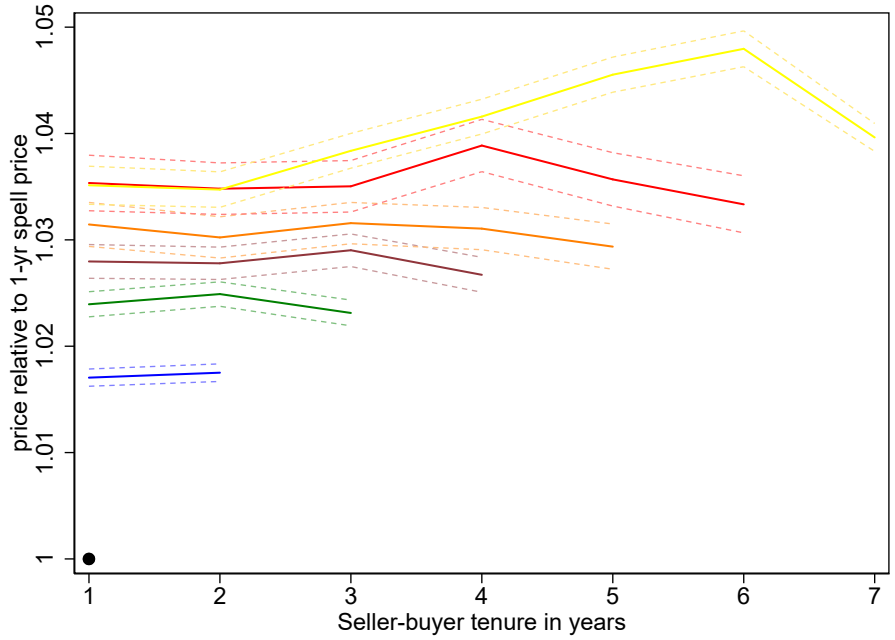
Notes: Figure shows evolution of prices at the firm-product-market level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted.

The previous results may be driven by French exporters' price discrimination strategies, i.e. exporters charging customers different prices for the same product. To test for this prediction, we

present results on the evolution of specific customer relationships. Our two main findings are: (1) higher initial prices predict longer total spell length of a relationship; (2) there are no relationship specific price dynamics over the duration of specific customer relationships.

Figure 10 shows that there is significant heterogeneity in the relationship specific prices charged across customers. Higher initial prices predict longer lasting relationships, with relationships that will last 2 years having prices that are 1.8% higher than relationships that last only 1 year, whilst relationships that will last 7 years have prices that are over 3.5% more expensive. These differences in prices across the different lengths of relationships could represent differences in the products exported, with higher quality or more relationship specific investments helping to sustain more long lasting relationships, but also being associated with higher priced goods.

Fig. 10. Firm-product-buyer price by spell length and tenure



Notes: Figure shows evolution of prices at the firm-product-buyer level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-market-year and buyer effects. 95% confidence intervals are plotted.

Relationship specific prices do not exhibit significant dynamics over the duration of firm to firm relationships. For spell lengths of 2 years up to spell lengths of 6 years the average relationship specific component of the price does not differ significantly from the initial price. For successful export spells of 7 years or more, relationship specific prices rise by around 1% by the sixth year

of the export spell.[43] The evidence that there are little or no dynamics in relationship specific prices over the duration of a customer relationship sheds light on possible firm pricing strategies: (i) if we were to assume that the products sold to each buyer in a destination have the same changes to marginal costs, then firms do not adjust relationship specific markups on average over the course of a specific relationship, or (ii) if relationship specific costs do change over the duration of a customer relationship, then exporters are not passing through these cost changes and instead adjusting relationship specific markups.

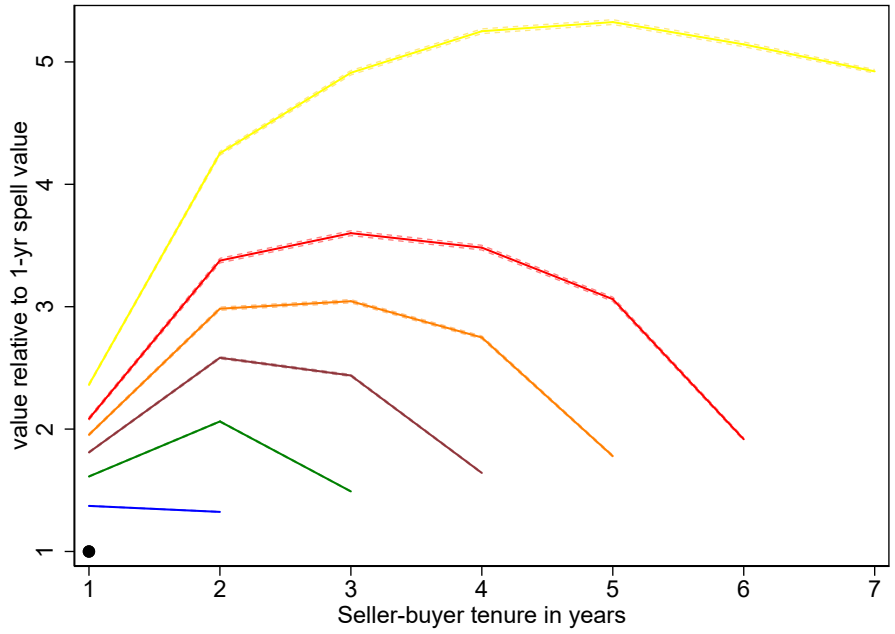
The role of the accumulation of customer base in export market growth, and the absence of price dynamics in customer relationships has implications for theories of customer markets, which posit that firms initially charge low prices to attract new customers and demand, before increasing prices in established relationships. We find no evidence that firms are actively using relationship specific pricing to increase their market share, either through attracting new customers or size of existing relationships. These findings are consistent with Arkolakis (2010) and Fitzgerald et al. (2016a) where demand depends on customer base, which firms acquire through non-price activities such as marketing and advertising.

3.3.8. Size dynamics within customer relationships

Finally, we present results with the size of the relationship measured by value and quantity (in kg). The main finding is that the size of specific customer relationships grows with the duration of the relationship. We present the results in Figure 11 with the size of the relationship measured by value in Euros and in Figure 12 by quantity (in kg). The size of exports to a specific customer exhibits a similar life cycle profile as the dynamics at the destination level. The value of a customer relationship increases in the initial years of the relationship and falls in the latter years of the relationship for all spell lengths. As with destination specific exports, there is also a selection effect with a higher value of initial exports predicting longer spell lengths of the relationship.

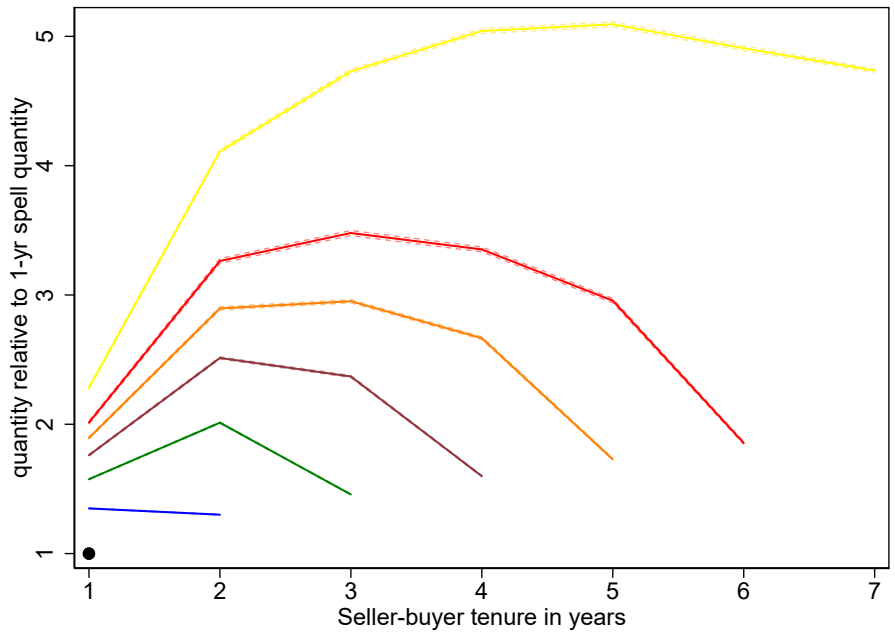
[43] This small dynamic is likely to be driven by long-lasting relationships and should disappear once interacting with longer spell lengths. However, we are not able to top-code our measures for higher levels due to limited capacity in computing power.

Fig. 11. Firm-product-buyer value by spell length and tenure



Notes: Figure shows evolution of export values at the firm-product-buyer level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-market-year and buyer effects. 95% confidence intervals are plotted.

Fig. 12. Firm-product-buyer quantity by spell length and tenure



Notes: Figure shows evolution of quantities (in kg) at the firm-product-buyer level with market tenure, allowing trajectories to differ by export spell length. Trajectories are conditional on firm-product-market-year and buyer effects. 95% confidence intervals are plotted.

3.4. Customer base in response to shocks

In this subsection we test whether firms adjust their customer base in response to shocks affecting their access to export markets. Investments to accumulate or maintain customer base provides a new margin of adjustment where firms choose not only which markets to operate in, but how many and which consumers to serve. We exploit the natural experiment of the result of the 2016 Brexit Referendum to test how firms adjust their customer base in the UK in response to an unexpected increase in trade policy uncertainty and a concurrent depreciation of sterling, both reducing competitiveness and market access for French exporters to the UK.

3.4.1. Predicted response of French exporters to the Brexit referendum

The decision for the UK to leave the European Union, following the Brexit referendum on 23rd June 2016, meant that the UK entered into a renegotiation period to determine the new trading relationship with the EU. The renegotiation of a trade agreement can introduce a period of heightened uncertainty if there is a possibility that the future tariff rates or barriers could increase in the future. The renegotiation period introduced trade policy uncertainty into the trading environment between the UK and all of the EU trading partners, with the possibility that the future trading relationship could include tariff barriers (if, for example, no Free Trade Agreement was agreed between the UK and EU) and the possibility of non-tariff barriers including changes in regulations and increased delays arising from customs procedures.[44] The Brexit referendum result also initiated a significant depreciation of sterling which makes French exports less competitive in the UK market.[45] The combined effects of the trade policy uncertainty and currency movements equate to a loss of competitiveness and reduction in market access for French exporters to the UK

[44]The UK government announced immediately following the referendum that the UK intended to leave the EU Customs Union and renegotiate a new trade agreement with the EU. The outside option, or threat point, tariffs for UK exporters to the EU were clearly defined by the EU's WTO commitments if negotiations were to break down and the UK were to leave with no trade agreement in place, as the UK would revert to trading with the EU as a WTO member. However, the threat point tariffs for EU (including French) exporters to the UK in such a scenario are less clearly defined, as the UK would have the option of creating its own WTO tariff commitments as a member of the WTO. Indeed in March 2019 the UK published its 'No Deal' tariff schedule which significantly departed from the EU's applied MFN tariffs.

[45]sterling fell by 10% against the Euro on 24th June 2016 when the result of the Brexit referendum was announced. This will have impacted French exporters by making French exports less competitive in the UK market (either by mechanically increasing the sterling cost of Euro denominated exports or lowering the Euro value of sterling denominated exports), and by increasing UK inflation.

and we explore how they respond to these trade shocks.

In Arkolakis (2010) and Fitzgerald et al. (2016a) firms choose which markets to enter and how much customer base to accumulate through advertising and marketing activities. The increase in trade policy uncertainty following the Brexit referendum acts as a market access shock for French exporters. In response to an adverse market access shock, where the current or future cost to export to a market may increase, firms will optimally readjust their market penetration strategies by not entering, being more likely to exit and reducing their customer base in markets facing an increase in uncertainty and less favourable market conditions.

3.4.2. Empirical strategy

The result of the Brexit referendum on the 23rd June 2016 was unexpected by forecasters and the markets, with betting markets predicting only a 30% chance of a leave vote on average in the year running up to the Brexit referendum, a probability which had even dropped to just 12% on the day of the referendum itself. We exploit this unexpected change in the market access for French exporters to the UK in a difference in difference strategy to investigate how French firms adjust their customer base in response to changing demand conditions. We estimate the impact of the heightened trade policy facing French exporters to the UK before and after the referendum result (first difference) relative to other EU markets (second difference).

We estimate the impact of the reduction in market access facing French exporters to the UK relative to other markets before and after the referendum result. We define an indicator for the heightened trade policy uncertainty arising from the Brexit referendum $Brexit_{dt}$ that takes a value of 1 for French exporters to the UK in the period after the Brexit Referendum (June 2016), and a value of zero for all other destinations and time periods. This analysis is based on the quarterly export data to correctly measure the pre- and post- referendum period. We then estimate a linear probability model for the period 2011-17:

$$Y_{idt} = \beta_1 Brexit_{dt} + \alpha_{id} + \alpha_t + \varepsilon_{idt} \tag{14}$$

where $Y_{idt} \in$ {Export, Entry, Exit, Add buyer, Drop buyer} are binary dependent variables for firm i in destination d at time t (which are quarterly frequency). We also include a full set of time and firm-destinations fixed effects. We are therefore able to separate out the effects of the Brexit Referendum from the general economic conditions facing French exporters through the time fixed effects.

We now describe how the dependent variables are constructed. *Export* takes a value of 1 in periods t when a firm i exports to destination d and 0 otherwise. *Entry* takes a value of 1 in periods t when firm i exports to destination d, when firm i did not export to destination d in the previous 4 quarters,[46] entry takes a value of 0 in periods before a firm enters the market and is missing for periods when a firm is an incumbent in the market. *Exit* takes a value of 1 in period t when a firm i does not export to destination d, having exported to destination d in quarter $t-1$. *Add buyer* captures the customer accumulation of firms that are already incumbents in a market and takes a value of 1 if firm i exports to more customers in destination d in time t than firm i exported to in quarter $t-1$. *Add buyer* takes a value of 0 in all periods when a firm is an incumbent in destination d, but does not add a new customer. *Drop buyer* captures a continuing firm i in a market d reducing the number of customers in time t, relative to the number of customers that firm i exported to in destination market d in period $t-1$.

3.4.3. Results of Brexit uncertainty and French exporter dynamics

We estimate the response of firms along the customer margin in response to the reduction in market access for French exporters into the UK market induced by the decision of the UK to leave the EU using a difference in difference model. We exploit variation arising from the heightened trade policy uncertainty for French exports to the UK following the leave vote of the Brexit referendum relative to the periods before the referendum (first difference) relative to other export destinations within the EU (second difference). In the next subsection, we present the main results showing the impact of the destination specific uncertainty on French exporter dynamics.

[46] Our results hold using other definitions of market entry including entry relative to 1 quarter before and 8 quarters before. Results available upon request.

We find that French exporters significantly disengaged from exporting to the UK in response to the increase in trade policy uncertainty following the Brexit referendum relative to other EU markets. Table 11 presents the results of the difference in difference research design estimated using a linear probability model of firm exporting decisions and customer base accumulation. The results in Column 1 show that French exporters were 0.3% less likely to export to the UK in the period following the Brexit referendum, relative to the period before the referendum. This extensive margin effect was driven by an increase in exit of French exporters to the UK, shown in Column 3, with French exporters being 0.3% more likely to exit the UK market following the Brexit referendum. French exporters were also less likely to enter into exporting to the UK in the period post-Brexit referendum with a 0.2% decline in the probability of entry.

We also present evidence that continuing firms adjust their customer base in response to the reduction in market access. Column 4 shows that continuing French exporters were less likely to add new customers following the Brexit referendum, with a reduction in the probability of a firm adding a new buyer of 0.2%. We also find that firms are 0.5% more likely to drop customers in a market as shown by the results in Column 5. This suggests that firms may adjust their portfolio of buyers in response to a negative shock.

Table 11: Extensive margin response to Brexit

	(1)	(2)	(3)	(4)	(5)
VARIABLES	exporter	entrant	exiter	add buyer	drop buyer
Brexit	-0.00276***	-0.00163***	0.00253***	-0.00201***	0.00499***
	(0.000355)	(0.000247)	(0.000618)	(0.000748)	(0.000758)
Observations	76,027,560	59,059,696	21,323,484	16,503,031	16,503,031
R-squared	0.432	0.030	0.265	0.220	0.222
FE	fpd-t	fpd-t	fpd-t	fpd-t	fpd-t
SE	Robust	Robust	Robust	Robust	Robust

3.4.4. Results of separating trade policy uncertainty and exchange rate

We attempt to separate the effects of the sterling depreciation and trade policy uncertainty generated by the Brexit referendum in Table 12. We include the logarithm of the bilateral exchange

rate between the Euro and destination market currency as an additional independent variable.[47] We find that a depreciation of sterling, an increase in the dependent variable, is associated with an increase in entry and adding additional customers, and decrease in exit. This is expected as a depreciation increases the competitiveness of French exporters. However we do find opposite results for exporting and drop buyer. After controlling for the movements in the exchange rate, we find that the coefficients on the dummy variable for periods after the Brexit referendum in the UK, which captures the remaining trade policy uncertainty, remain robust for exporting, entry and drop buyer.

Table 12: Extensive margin response to Brexit (separating exchange rate)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	exporter	entrant	exiter	add buyer	drop buyer
Brexit	-0.00333***	-0.000957***	0.000142	-0.000744	0.0101***
	(0.000379)	(0.000263)	(0.000681)	(0.000826)	(0.000837)
Exchange rate	-0.00830***	0.00946***	-0.0672***	0.0151***	0.0614***
	(0.00190)	(0.00130)	(0.00343)	(0.00418)	(0.00423)
Observations	76,027,560	59,059,696	21,323,484	16,503,031	16,503,031
R-squared	0.432	0.030	0.265	0.220	0.222
FE	fpd-t	fpd-t	fpd-t	fpd-t	fpd-t
SE	Robust	Robust	Robust	Robust	Robust

3.5. Conclusions

In this paper we provide an empirical test of the importance of customer base accumulation for the dynamics of market growth in foreign markets. We make three main contributions: (i) We show that customer base plays a prominent role in export market growth, accounting for 30% of the growth in export value; (ii) We find no evidence of price dynamics over the duration of a market or customer spell suggesting that firms accumulate customer base through non-price activities such as advertising and marketing; (iii) We find that firms actively adjust customer base within a market in response to adverse shocks to market access.

[47] As most EU countries use the Euro, this exchange rate is fixed, providing a good control against movements in sterling.

We provide direct evidence that firms accumulate customers over their tenure in a destination market. The more customers that an exporter sells to upon initially entering a market makes it more likely that the exporter will survive for more years in that market. Firms also accumulate customers over their tenure in a destination market, with firms that survive for 10 or more years doubling their customer base by their tenth year in a market. This increase in customer base accounts for 30% of the growth in export value, with the remainder driven by firms increasing the average size of each relationship. These results lend weight to models of international trade which actively model the accumulation of customer base to explain the rate of entry across export markets (Arkolakis, 2010) and how exporters grow (Fitzgerald et al., 2016a).

We also explore the potential mechanisms through which firms accumulate customer base. We find no evidence of pricing dynamics over the life cycle within EU markets for French exporters, as found in Fitzgerald et al. (2016a). This suggests that firms are not exploiting rising market share to increase their prices in a given market. Interestingly, we also find no evidence of pricing dynamics within a given relationship, furthering rejecting the idea that firms may offer low prices to initially attract customers before then later increasing the price as the specificity of the relationship locks consumers in. The absence of pricing dynamics rejects conventional models of market penetration and instead suggests that firms likely grow market share through non-price activities such as marketing and advertising (Arkolakis, 2010; Fitzgerald et al., 2016a).

Customer base does not just play an important role in explaining exporter growth in a market, but also how exporters respond to market access shocks. In the context of Brexit, which represents an adverse (potential) shock to future market access, we show that French exporters have not only been more likely to exit and less likely to enter the UK relative to other EU markets, but also that French exporters continuing to export to the UK have been more likely to drop existing customers and less likely to add new customers. In a world of complex global value chains, this evidence highlights an important role for stable trade policy to sustain production and sourcing decisions across borders.

3.6. Appendix

A Tariff uncertainty

We find evidence that French exporters respond to the potential tariff risk associated with the tariff schedule defined under the EU's WTO commitments. The results of the specifications are presented across the five outcome variables in Columns 1-5 in Table 16. We find that the impact of aggregate trade policy uncertainty is related to measures of tariff and non-tariff barriers. We find evidence that French exporters are discouraged from exporting to the UK in products with exposure to higher potential tariffs if the UK were to implement the EU's WTO commitments on French exporters. The results show that for exporters selling products facing higher ad valorem tariffs are more likely to exit from the UK relative to other EU markets in the period following the Brexit referendum. There is also evidence that potential exposure to quotas or specific duties affects the exporting decisions of French exporters as found in Crowley, Exton, and Han (2019) for UK exporters to the EU following the Brexit referendum. For products that face potential specific duties, we find that French exporters are less likely to enter and add buyers in the UK market in the post Brexit referendum period.

A surprising result is that in products with higher tariffs, see an increase in French exporters adding buyers. However we note that there is still a (much larger) negative result on the Brexit dummy indicating that exporters may be more responsive to the aggregate uncertainty around the future UK-EU relationship with uncertainty over potential customs checks and differences in regulation appear to be more important and consistent in determining changes in French exporting patterns to the UK in the period following the Brexit referendum.

The results of the potential tariff uncertainty suggests that French exporters may have perceive the existing EU WTO tariff schedule as future potential tariff rates if negotiations between the UK and EU were to break down. This is not surprising as although the UK had flexibility as an independent member of the WTO to set its own MFN applied tariff rates upon leaving the EU

Custom's Union, French exporters may have expected similar tariff rates to the existing EU MFN applied tariffs (especially as the UK set the same bound commitments as the EU).

Table 13: Linear Probability Model extensive margin response to Brexit and EU WTO commitments

	(1)	(2)	(3)	(4)	(5)
VARIABLES	exporter	entrant	exiter	add buyer	drop buyer
Brexit	0.00147**	0.000367	-0.00173	-0.00298**	0.000792
	(0.000690)	(0.000480)	(0.00120)	(0.00145)	(0.00147)
Brexit*Quota	-0.00777***	-0.00357**	0.000252	-0.00888*	0.00688
	(0.00241)	(0.00174)	(0.00385)	(0.00455)	(0.00462)
Brexit*Specific	-0.00219	-0.00571***	0.00487	-0.00128	0.00146
	(0.00213)	(0.00153)	(0.00343)	(0.00404)	(0.00410)
Brexit*Tariff	-0.000756***	-0.000260***	0.000823***	0.000452**	0.000955***
	(8.93e-05)	(6.14e-05)	(0.000161)	(0.000197)	(0.000199)
Observations	53,888,072	41,966,616	15,019,668	11,589,886	11,589,886
R-squared	0.428	0.030	0.263	0.220	0.224
FE	fpd-t	fpd-t	fpd-t	fpd-t	fpd-t
SE	Robust	Robust	Robust	Robust	Robust

B Tables

Table 14: French sellers and EU buyers, 2017

	Number of		
	Exporters-Product	Importers	Exporter-Importers-Product
All	333,487	582,552	4,448,717
AT	35,709	16,580	109,926
BE	160,275	75,748	807,969
BG	16,958	3,943	25,255
CY	11,106	1,558	14,191
CZ	37,489	9,216	69,352
DE	128,753	118,641	726,766
DK	30,893	9,068	71,891
EE	11,944	2,168	17,511
ES	119,893	70,577	570,055
FI	21,913	6,202	46,397
GB	91,916	47,432	331,894
HR	11,617	2,582	16,696
HU	25,099	6,140	41,828
IE	22,169	5,971	44,524
IT	109,731	91,477	697,524
LT	13,470	2,832	19,529
LU	57,448	7,596	116,921
LV	10,812	2,029	14,844
MT	9,296	1,215	11,770
NL	73,271	37,008	245,203
PL	51,652	18,240	109,574
PT	55,970	20,088	154,472
RO	32,113	7,632	53,676
SE	34,771	11,560	80,684
SI	15,295	3,291	24,170
SK	16,429	3,758	26,095

Table 15: Dynamics of number of buyers, value, quantity and price: firm-product-market

Dep. var. (ln)		No. buyers		No. buyers		Value		Quantity		Price	
Spell length	Market tenure	coef	se	coef	se	coef	se	coef	se	coef	se
2 years	1 year	0.0637***	(0.000968)	0.00654***	(0.000921)	0.351***	(0.00266)	0.349***	(0.00269)	0.00222*	(0.00117)
2 years	2 years	0.0591***	(0.000969)	0.00640***	(0.000925)	0.324***	(0.00271)	0.322***	(0.00274)	0.00254**	(0.00120)
3 years	1 year	0.113***	(0.00138)	0.0227***	(0.00131)	0.557***	(0.00363)	0.549***	(0.00369)	0.00738***	(0.00153)
3 years	2 years	0.165***	(0.00139)	0.0287***	(0.00132)	0.835***	(0.00356)	0.826***	(0.00361)	0.00846***	(0.00148)
3 years	3 years	0.103***	(0.00136)	0.0232***	(0.00129)	0.489***	(0.00369)	0.483***	(0.00374)	0.00685***	(0.00158)
4 years	1 year	0.159***	(0.00184)	0.0460***	(0.00173)	0.697***	(0.00465)	0.693***	(0.00473)	0.00412**	(0.00190)
4 years	2 years	0.241***	(0.00186)	0.0622***	(0.00176)	1.100***	(0.00451)	1.094***	(0.00458)	0.00583***	(0.00180)
4 years	3 years	0.230***	(0.00183)	0.0590***	(0.00174)	1.051***	(0.00451)	1.049***	(0.00458)	0.00269	(0.00182)
4 years	4 years	0.146***	(0.00178)	0.0442***	(0.00169)	0.623***	(0.00471)	0.617***	(0.00478)	0.00549***	(0.00197)
5 years	1 year	0.197***	(0.00230)	0.0692***	(0.00217)	0.784***	(0.00570)	0.775***	(0.00579)	0.00914***	(0.00228)
5 years	2 years	0.299***	(0.00235)	0.0913***	(0.00222)	1.279***	(0.00545)	1.276***	(0.00554)	0.00348*	(0.00212)
5 years	3 years	0.309***	(0.00234)	0.0915***	(0.00221)	1.338***	(0.00546)	1.330***	(0.00555)	0.00782***	(0.00212)
5 years	4 years	0.278***	(0.00229)	0.0825***	(0.00216)	1.203***	(0.00549)	1.196***	(0.00557)	0.00720***	(0.00215)
5 years	5 years	0.180***	(0.00223)	0.0642***	(0.00210)	0.714***	(0.00581)	0.712***	(0.00587)	0.00281	(0.00236)
6 years	1 year	0.222***	(0.00288)	0.0797***	(0.00272)	0.877***	(0.00688)	0.869***	(0.00703)	0.00773***	(0.00271)
6 years	2 years	0.340***	(0.00295)	0.110***	(0.00279)	1.411***	(0.00654)	1.404***	(0.00669)	0.00659***	(0.00249)
6 years	3 years	0.374***	(0.00294)	0.125***	(0.00278)	1.530***	(0.00651)	1.522***	(0.00665)	0.00769***	(0.00247)
6 years	4 years	0.361***	(0.00290)	0.116***	(0.00274)	1.504***	(0.00653)	1.494***	(0.00665)	0.0103***	(0.00249)
6 years	5 years	0.316***	(0.00284)	0.0986***	(0.00268)	1.335***	(0.00660)	1.331***	(0.00672)	0.00372	(0.00256)
6 years	6 years	0.208***	(0.00273)	0.0795***	(0.00258)	0.789***	(0.00696)	0.781***	(0.00706)	0.00817***	(0.00278)
7 years	1 year	0.257***	(0.00355)	0.104***	(0.00334)	0.943***	(0.00819)	0.937***	(0.00836)	0.00609*	(0.00314)
7 years	2 years	0.388***	(0.00365)	0.139***	(0.00344)	1.531***	(0.00774)	1.527***	(0.00794)	0.00405	(0.00289)
7 years	3 years	0.433***	(0.00365)	0.160***	(0.00345)	1.682***	(0.00759)	1.677***	(0.00777)	0.00424	(0.00282)
7 years	4 years	0.435***	(0.00362)	0.160***	(0.00342)	1.691***	(0.00759)	1.690***	(0.00774)	0.000977	(0.00282)
7 years	5 years	0.413***	(0.00356)	0.148***	(0.00336)	1.631***	(0.00769)	1.630***	(0.00783)	0.00123	(0.00290)
7 years	6 years	0.366***	(0.00349)	0.134***	(0.00328)	1.425***	(0.00782)	1.425***	(0.00795)	-0.000572	(0.00294)
7 years	7 years	0.249***	(0.00334)	0.106***	(0.00315)	0.878***	(0.00832)	0.878***	(0.00844)	0.000634	(0.00322)
8 years	1 year	0.269***	(0.00416)	0.103***	(0.00392)	1.022***	(0.00975)	1.007***	(0.00995)	0.0148***	(0.00361)
8 years	2 years	0.413***	(0.00432)	0.149***	(0.00408)	1.623***	(0.00911)	1.621***	(0.00932)	0.00128	(0.00336)
8 years	3 years	0.459***	(0.00432)	0.165***	(0.00408)	1.807***	(0.00888)	1.804***	(0.00910)	0.00279	(0.00323)
8 years	4 years	0.481***	(0.00430)	0.178***	(0.00407)	1.862***	(0.00886)	1.862***	(0.00905)	0.000158	(0.00321)
8 years	5 years	0.477***	(0.00424)	0.177***	(0.00401)	1.839***	(0.00893)	1.835***	(0.00910)	0.00359	(0.00326)
8 years	6 years	0.448***	(0.00417)	0.167***	(0.00393)	1.727***	(0.00901)	1.717***	(0.00916)	0.00993***	(0.00330)
8 years	7 years	0.384***	(0.00406)	0.139***	(0.00383)	1.509***	(0.00924)	1.508***	(0.00939)	0.00158	(0.00341)
8 years	8 years	0.263***	(0.00386)	0.106***	(0.00363)	0.965***	(0.00987)	0.955***	(0.00997)	0.00990***	(0.00378)
9 years	1 year	0.301***	(0.00501)	0.126***	(0.00466)	1.074***	(0.0116)	1.063***	(0.0118)	0.0115***	(0.00431)
9 years	2 years	0.452***	(0.00518)	0.173***	(0.00486)	1.713***	(0.0109)	1.706***	(0.0111)	0.00698*	(0.00397)
9 years	3 years	0.508***	(0.00520)	0.199***	(0.00488)	1.901***	(0.0107)	1.895***	(0.0109)	0.00640	(0.00395)
9 years	4 years	0.526***	(0.00521)	0.205***	(0.00490)	1.978***	(0.0105)	1.970***	(0.0107)	0.00838**	(0.00382)
9 years	5 years	0.531***	(0.00514)	0.209***	(0.00484)	1.978***	(0.0105)	1.968***	(0.0107)	0.0101***	(0.00388)
9 years	6 years	0.513***	(0.00508)	0.201***	(0.00478)	1.917***	(0.0105)	1.910***	(0.0107)	0.00686*	(0.00386)
9 years	7 years	0.481***	(0.00503)	0.187***	(0.00471)	1.811***	(0.0108)	1.804***	(0.0110)	0.00704*	(0.00398)
9 years	8 years	0.417***	(0.00483)	0.159***	(0.00454)	1.583***	(0.0111)	1.579***	(0.0113)	0.00404	(0.00416)
9 years	9 years	0.305***	(0.00458)	0.134***	(0.00430)	1.051***	(0.0118)	1.050***	(0.0119)	0.000556	(0.00456)
10 years	1 year	0.327***	(0.00208)	0.134***	(0.00197)	1.184***	(0.00497)	1.175***	(0.00510)	0.00883***	(0.00188)
10 years	2 years	0.492***	(0.00212)	0.186***	(0.00201)	1.881***	(0.00462)	1.877***	(0.00473)	0.00399**	(0.00172)
10 years	3 years	0.571***	(0.00215)	0.221***	(0.00204)	2.150***	(0.00450)	2.148***	(0.00462)	0.00178	(0.00168)
10 years	4 years	0.612***	(0.00217)	0.238***	(0.00206)	2.295***	(0.00445)	2.294***	(0.00456)	0.00162	(0.00166)
10 years	5 years	0.642***	(0.00218)	0.253***	(0.00208)	2.393***	(0.00441)	2.389***	(0.00452)	0.00332**	(0.00165)
10 years	6 years	0.657***	(0.00218)	0.262***	(0.00208)	2.429***	(0.00441)	2.424***	(0.00451)	0.00519***	(0.00164)
10 years	7 years	0.663***	(0.00219)	0.265***	(0.00209)	2.446***	(0.00444)	2.440***	(0.00453)	0.00545***	(0.00164)
10 years	8 years	0.661***	(0.00221)	0.264***	(0.00210)	2.440***	(0.00450)	2.435***	(0.00459)	0.00437***	(0.00165)
10 years	9 years	0.653***	(0.00226)	0.265***	(0.00214)	2.384***	(0.00464)	2.381***	(0.00473)	0.00289*	(0.00169)
10 years	10 years	0.691***	(0.00151)	0.289***	(0.00145)	2.471***	(0.00334)	2.466***	(0.00339)	0.00522***	(0.00127)
cens		0.787***	(0.00109)	0.347***	(0.00106)	2.707***	(0.00266)	2.726***	(0.00273)	-0.0189***	(0.00103)
Export (log)				0.163***	(0.000149)						
Observations		13,915,664		13,915,644		13,915,644		13,915,664		13,915,644	
R-squared		0.524		0.583		0.774		0.830		0.907	
FE		fpt-d		fpt-d		fpt-d		fpt-d		fpt-d	
SE		Robust		Robust		Robust		Robust		Robust	

Notes: Dependent variable is the log number of buyers, log value, log quantity and log price in a destination market in a year. All specifications include firm-product-year and market fixed effects. Omitted category is spells that last one year. Stata command used is *reghdfe*. Robust standard errors are not reported for clarity. The p-values read as follow: *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 16: Dynamics of value, quantity and price: firm-product-buyer

Dep. var. (ln)		Value		Quantity		Price	
Spell length	Market tenure	coef	se	coef	se	coef	se
2 years	1 year	0.317***	(0.000816)	0.300***	(0.000810)	0.0169***	(0.000407)
2 years	2 years	0.280***	(0.000830)	0.263***	(0.000822)	0.0174***	(0.000414)
3 years	1 year	0.478***	(0.00124)	0.454***	(0.00124)	0.0237***	(0.000589)
3 years	2 years	0.724***	(0.00124)	0.699***	(0.00124)	0.0246***	(0.000573)
3 years	3 years	0.399***	(0.00125)	0.377***	(0.00125)	0.0229***	(0.000603)
4 years	1 year	0.593***	(0.00172)	0.566***	(0.00173)	0.0276***	(0.000788)
4 years	2 years	0.949***	(0.00170)	0.922***	(0.00172)	0.0274***	(0.000755)
4 years	3 years	0.891***	(0.00170)	0.863***	(0.00172)	0.0286***	(0.000760)
4 years	4 years	0.496***	(0.00174)	0.469***	(0.00175)	0.0264***	(0.000816)
5 years	1 year	0.670***	(0.00228)	0.639***	(0.00231)	0.0310***	(0.00102)
5 years	2 years	1.093***	(0.00223)	1.063***	(0.00227)	0.0298***	(0.000961)
5 years	3 years	1.113***	(0.00222)	1.082***	(0.00226)	0.0311***	(0.000961)
5 years	4 years	1.011***	(0.00225)	0.981***	(0.00228)	0.0306***	(0.000983)
5 years	5 years	0.576***	(0.00231)	0.548***	(0.00233)	0.0289***	(0.00105)
6 years	1 year	0.735***	(0.00293)	0.700***	(0.00298)	0.0347***	(0.00129)
6 years	2 years	1.217***	(0.00283)	1.183***	(0.00289)	0.0342***	(0.00119)
6 years	3 years	1.281***	(0.00281)	1.247***	(0.00287)	0.0344***	(0.00119)
6 years	4 years	1.248***	(0.00283)	1.210***	(0.00288)	0.0381***	(0.00121)
6 years	5 years	1.119***	(0.00288)	1.084***	(0.00293)	0.0351***	(0.00124)
6 years	6 years	0.651***	(0.00298)	0.618***	(0.00301)	0.0328***	(0.00133)
7 years	1 year	0.860***	(0.00200)	0.825***	(0.00203)	0.0345***	(0.000883)
7 years	2 years	1.448***	(0.00189)	1.414***	(0.00193)	0.0341***	(0.000822)
7 years	3 years	1.592***	(0.00186)	1.554***	(0.00190)	0.0377***	(0.000803)
7 years	4 years	1.658***	(0.00185)	1.618***	(0.00189)	0.0407***	(0.000801)
7 years	5 years	1.673***	(0.00187)	1.628***	(0.00190)	0.0445***	(0.000806)
7 years	6 years	1.638***	(0.00191)	1.591***	(0.00194)	0.0468***	(0.000820)
7 years	7 years	1.594***	(0.00150)	1.555***	(0.00153)	0.0389***	(0.000644)
cens		1.469***	(0.00172)	1.457***	(0.00176)	0.0120***	(0.000639)
Observations		42,043,511		42,044,649		42,043,511	
R-squared		0.807		0.874		0.905	
FE		fpdt-b		fpdt-b		fpdt-b	
SE		Robust		Robust		Robust	

Notes: Dependent variable is the log number of buyers, log value, log quantity and log price in a destination market in a year. All specifications include firm-product-year and market fixed effects. Omitted category is spells that last one year. Stata command used is *reghdfe*. Robust standard errors are not reported for clarity. The p-values read as follow: *** p < 0.01, ** p < 0.05, * p < 0.1.

4. Import competition and the Reallocation of Manufacturing Activity: Evidence from the impact of the China Shock on UK Manufacturing

4.1. Introduction

Import competition increases the competitive environment facing firms and is associated with significant industrial change. One of the most significant developments for the global economy since the start of the 21st Century has been China's accession to the World Trade Organization in 2001 and China's subsequent rise as a global manufacturing superpower. Firms in advanced countries respond to increased import competition from low wage countries by shutting down (Pierce and Schott, 2016; Asquith, Goswami, Neumark, and Rodriguez-Lopez, 2019), switching into less competitive manufacturing industries (Bernard, Jensen, and Schott, 2006) , engaging in research and development (Bloom, Draca, and Van Reenen, 2016), and engaging in increased offshoring activities (Bernard, Fort, Smeets, and Warzynski, 2018b). The long run welfare effects of offshoring in response to import competition depends on the reallocation of resources away from production activities and towards research and development (Rodríguez-Clare, 2010; Bloom, Romer, Terry, and Van Reenen, 2013). Despite the critical importance of the impacts of import competition on the magnitude and speed of structural change, there is a dearth of micro level evidence on the transition away from production and towards research and development.

This paper provides evidence that UK firms reorientated activity away from production activities and towards both research and development and wholesale and retail activities in response to increased low wage import competition following China's accession to the World Trade Organization in 2001.[48] The paper uses detailed microlevel data on the universe of UK firms over the 1998-2015 period to estimate the direction and magnitude of structural change in response to increased import competition from China. The main finding is that 42% of the decline in manu-

[48] Autor, Dorn, and Hanson (2016) provide a comprehensive review of China's rise as a global manufacturing superpower and the wide reaching implications for the competition on manufacturing employment.

facturing employment in response to increased import competition occurred through firms which were initially in manufacturing and which switched out of this sector. Firms which switch move into business services such as research and development, or into wholesale and retail.

The direction of structural change in response to import competition is important for assessing the welfare implications. A significant proportion of the increase in Chinese exports following accession to the WTO in 2001 was driven by foreign firms offshoring their manufacturing production to China (Pierce and Schott, 2016) in line with the theoretical predictions of models of fragmentation (Antràs, Garicano, and Rossi-Hansberg, 2006; Grossman and Rossi-Hansberg, 2008). Rodríguez-Clare (2010) shows in a Ricardian model that the welfare consequences of offshoring for advanced nations, such as the UK, are negative in the short run as a negative terms of trade effect dominates the positive productivity and efficiency effects of offshoring. In the long run, offshoring can be welfare improving for advanced nations if there is a reallocation of resources away from production towards research and development which can increase the growth rate of technological progress. The importance of the reallocation of resources away from production towards research and development within firm is also emphasized by Bloom et al. (2013) in increasing the gains from trade liberalisation.

The paper makes three main contributions. First, the paper estimates the direction and magnitude of the UK firm response to increased import competition. The paper decomposes the change in manufacturing employment along the intensive margins (expansion and contraction of incumbent firms), extensive margins (entry and exit of firms), and industry switching (incumbent firms who switch into or out of exposed industries). A significant proportion (42%) of the decline in manufacturing employment in response to increased import competition occurred through firms switching out of manufacturing. Exploring the industries which firms switch to, firms react by reclassifying into business services such as research and development (15% of all manufacturing employment), or into wholesale and retail (26% of all manufacturing employment). The results indicate that there was a significant transformation of manufacturing production firms towards

research and development. The structural transformation was so large that these manufacturing firms reclassified from manufacturing to business service firms. This suggests that the increased international competition may have stimulated offshoring and the welfare improving increase in research effort emphasized by Rodríguez-Clare (2010). However, the results also highlight that a significant proportion of economic activity moves out of manufacturing production into wholesale and retail, which would not provide the welfare enhancing boost to technological progress.

Second, the paper explores the timing of the structural change out of manufacturing and into business services. The paper estimates the predicted impact of Chinese import competition on each of the firms' margins for each year between 2001 and 2015. The paper finds rapid and large estimates of the effects of switching out of manufacturing for employment and turnover occurring in the first few years following China's accession to the WTO. In the light of the theoretical findings of Rodríguez-Clare (2010), the implications of these empirical findings are that the welfare benefits of the switch to research effort are realised quickly, an important criteria for the long run welfare benefits of offshoring to exceed the negative short term welfare losses. Exploring which firms drive the reallocation, much smaller effects for the number of firms switching out of manufacturing, indicating that the large employment effects are driven by the largest manufacturing firms. If large firms reorganize their global production to take advantage of the international offshoring, this opens the possibility that firms could increase their overall level of research effort to complement the lower cost of other inputs created using lower wage input in line with the theoretical predictions of Bloom et al. (2013).

The third contribution shows the impact of industry switching on firm level outcomes. Using firm level analysis, the paper estimates the change in firm outcomes in response to the change in industry import penetration. The results on the indicators of firm switching behaviour show that firms in any industry that switch out of manufacturing into other sectors reduce their employment and turnover. This effect is not found to be stronger in industries more exposed to import competition, with little evidence that in industries initially more exposed to import competition firms

which switch out of manufacturing into other, wholesale and administrative industries have more negative effects than firms initially in industries initially less exposed to import competition.

4.1.1. Related literature

This paper develops empirical evidence of the response of UK firms to increased international competition. A significant literature has documented the negative impact of increased low wage import competition on employment outcomes of exposed industries (Revenga (1992), Bernard et al. (2006), Autor, Dorn, Hanson, and Song (2014), Acemoglu, Autor, Dorn, Hanson, and Price (2016)). In particular, the literature has highlighted the role of firm and plant exit in line with theoretical trade models such as Melitz (2003) in driving the response to low wage competition back to the 1970s (Bernard et al. (2006)) and more recently in response to increased import competition following China's accession to the World Trade Organization in the early 2000s (Pierce and Schott (2016), Pessoa (2016), Asquith et al. (2019)). This paper builds on this evidence of firm dynamics in response to import competition, but further emphasizes the dynamic response that can be identified using detailed microdata in firms switching out of manufacturing industry. This switching out of manufacturing is an even greater adjustment than suggested by theoretical and empirical papers investigating product switching behaviour in response to increased competition (Eckle and Neary, 2010, Bernard, Redding and Schott, 2011, Impullitti and Licandro, 2010 and Bernard, Jensen and Schott, 2006).

In line with the research of this paper, an emerging literature has begun to investigate how import competition stimulates within firm structural change. Bernard et al. (2006) was the first paper to document that firms switch their industry of production into more capital intensive industries in response to the low wage import competition of the 1970s and 1980s. Looking at the more recent waves of globalization, the nature of structural change has moved from firms switching their product mix, to completely reorganizing their sector of activity in developed countries. Magyari et al. (2017) finds that in the US, the increase in firm non-production staff more than compensated for the loss of production staff in response to increased Chinese import competition. Bloom, Han-

dley, Kurmann, and Luck (2019) finds significant heterogeneity in the response of firms to Chinese competition across regions in the US with manufacturing job losses in high-human capital areas coming from establishments switching to services, whereas in the low human-capital areas firms closed plants without increasing service employment. Increased import competition has also been shown to increase the incentives for firms to increase their volume of innovation and stimulate technical change through patenting, IT and R&D (Bloom et al. (2016)), although the aggregate level of industry investment falls as firms exit (Pierce and Schott (2018), Autor et al (2017)). Bernard et al. (2018b) find that Danish firms reorganized activity in response to increased offshoring opportunities and increased R&D investment. Breinlich, Soderbery, and Wright (2018) find evidence of within firm shift from manufacturing goods to provision of services in response to trade liberalization of UK reductions in tariffs with implementation of Uruguay Round. This paper builds on this literature by focussing on the role of industry switching and the speed of firm transition from production to services activities. The paper therefore provides initial evidence towards the potential long run welfare implications for advanced nations in response to the import competition and offshoring opportunities.

Finally, the paper contributes to the burgeoning literature on the effects of China's accession to the World Trade Organization. The labour market effects of the China Shock are summarised in Autor et al. (2016) with evidence that increased Chinese import competition has led to manufacturing job losses at the worker and firm level (Autor et al. (2014); Pierce and Schott (2016)), local labour market level (Autor, Dorn, and Hanson (2013)), and spread to affect upstream industries and non-manufacturing industries (Acemoglu et al. (2016)). This paper extends that literature first by highlighting how the response of the UK manufacturing industry to the China shock manifested through the different margins of firm response. These results show that whilst manufacturing employment declined mechanically due to these firms exiting exposed industries, this is not necessarily a negative shock for firms who are optimally taking advantage of new global possibilities. The paper also illustrates that only comparing the change in manufacturing employment across different industries may overstate the aggregate employment change as many firms

switched out of manufacturing, without necessarily firing workers.

4.2. Data

This subsection outlines the datasets used to construct and measure the industry and firm level outcomes, and the measure of import competition using the China shock. The firm outcomes are constructed with the confidential and secure access Business Structure Database (BSD) sourced from the Office for National Statistics (ONS) and UK Data Service (Office for National Statistics, 2017) which covers the universe of UK manufacturing firms. The measure of import competition is constructed using trade data is sourced from bilateral product level trade flows from the UN COMTRADE/ BACI CEPII database (Gaulier and Zignago, 2010).

4.2.1. UK manufacturing industries and firms

Firm outcomes are provided by the ONS Business Structure Database (BSD) which provides detailed data on the universe of UK firms. The Business Structure Database (BSD) contains annual data on the universe of UK firms and plants between 1997 and 2016. It is derived from the Inter-Departmental Business Register (IDBR) collected by the Office for National Statistics and HM Revenue and Customs from any company with VAT[49] or Pay As You Earn (PAYE) records. Additional enterprise information is added from the Business Register from Companies House. It therefore contains data on firms that account for over 99% of economic activity in the UK, with only very small business, such as the self-employed, not in the register. The dataset contains approximately 4 million firms and 5.5 million plants each year as a panel dataset. The BSD provides detailed information on firms including revenue, legal status, foreign ownership, birth date and death date.

In the BSD the main UKSIC industry of a firm is recorded which captures the administrative main activity of single unit enterprises, and the dominant activity in terms of employment for multiple unit enterprises. The 4 digit UKSIC industry codes is concorded to the ISIC3 codes to match to the HS6 product level trade flows. This produces a final industry set of 117 4 digit ISIC3

[49]The VAT eligibility threshold for firms is currently £82,000 annual revenue.

manufacturing industries covering all UK manufacturing firms.[50]

The allocation of industry classifications is a critical element of this paper to identify whether firms switch industry in response to import competition. In the underlying Inter-departmental Business Registry (IDBR) of which the BSD is an annual snapshot, industrial classification information is obtained from administrative sources supplemented with survey information collected by ONS. These sources in priority order of information are i) ONS Surveys, ii) HMRC Value Added Tax, iii) Companies House information, and iv) HMRC Pay As You Earn. The allocation of an enterprise to an industry depends on its structure. For enterprises that have only a single local unit the classification comes directly from the administrative data source in priority order listed above. When an enterprise has multiple local units, the industry classification is determined by the dominant industry in terms of employment across local units. The ONS methodology considers units based on their SIC sector, then works down to the 2, 3, 4 and 5 digit level.

There are multiple ways in which an enterprise could change its industry classification. First, The enterprise could change the SIC classification of its local units. Second, the enterprise could change the level of employment across local units of different SIC industries. Finally an enterprise could open or close (or take over) local units. This highlights that the change in industry classification could be driven by fundamental changes in the sector of the business through changing the activity of the majority of local units, or by closing local units in one industry and/or opening local units in other industries. However, industry classification changes at the enterprise level could also be driven by more marginal changes in the composition of employment across local units. Whilst the estimates of industry switching in this paper could be interpreted as an upper bound, by focussing on sector switching from manufacturing industries to services industries, the incidence of marginal industry switching would be smaller than if looking at switching within manufacturing.

Multiple industry level controls are included to account for possible confounding factors that could also drive the changes in industry outcomes during the period. In particular, there are

[50]The concordance available for UKSIC classification aggregates to fewer industries than used in studies for the US due to the availability of different classification systems.

concerns that the rapid rise of information technology and automation during the period could have driven the observed changes in UK manufacturing employment. The regressions therefore include industry controls for the capital share of GVA and investment in computers at the industry level in 1998 sourced from the ONS Annual Respondents Database (Office for National Statistics). The empirical specification also controls for the industry employment structure at the beginning of the period to capture any heterogeneous impacts of general employment trends such as automation. The regressions include controls for the industry average wage and industry share of production workers in 1998 sourced from the Annual Survey of Hours and Earnings (Office for National Statistics, 2018).

4.2.2. Trade data

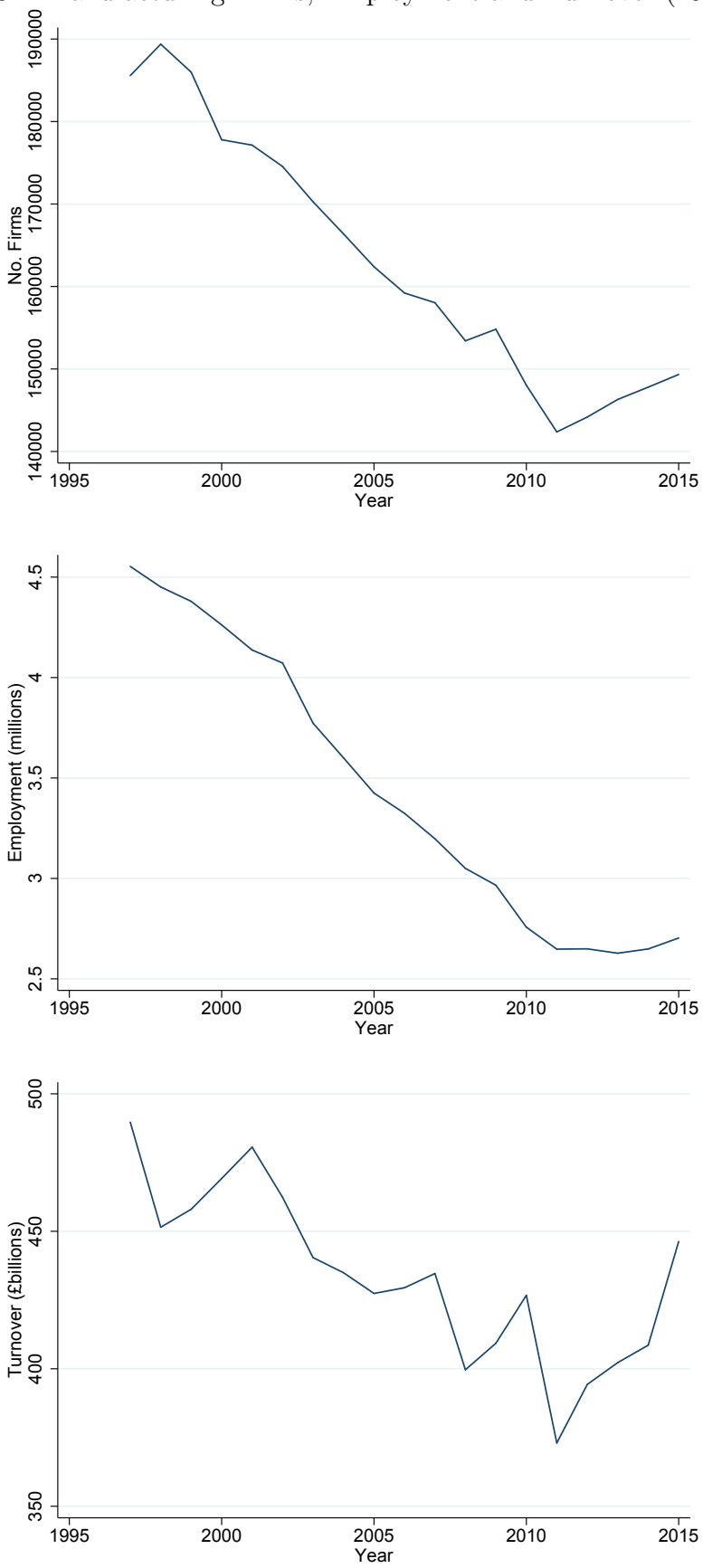
Trade data to measure the increase in industry competition arising from increased Chinese import penetration into the UK is taken from the BACI dataset from CEPII which cleans trade flow data from UN COMTRADE. The BACI dataset uses disaggregated product level data from UN COMTRADE to the six-digit harmonized system (HS) level, and reconciles the declarations from both exporters and importers to create a consistent database of disaggregated trade flows between countries. Product level trade flows can then be mapped to industry classifications, in which firm and industry level outcomes are reported. This paper uses the 4-digit international standard industrial classification revision 3 (ISIC3) as this provides a concordance with the UK SIC which defines industry classification in the BSD (Pessoa, 2016).

4.2.3. Motivating charts

Figures (13 a, b, c) shows the dramatic structural shift in UK manufacturing, which has seen the numbers of manufacturing firms and workers fall sharply since the start of the 21st Century. The number of UK manufacturing firms fell from almost 190,000 in 1998 to under 150,000 in 2015, whilst UK manufacturing employment fell from around 4.6 million in 1997 to 3.2 million in 2009, then crashed in the Great Recession period to 2.6 million in 2011, a level which has remained constant through to 2015. Turnover in UK manufacturing firms has also fallen considerably over

the same period, from £490 billion in 1997 to a low of £373 billion in 2011, although aggregate UK manufacturing turnover had picked up again to £446 billion in 2015.

Fig. 13. UK Manufacturing Firms, Employment and Turnover (1998-2015)



4.2.4. Identification of import competition: China shock

China's accession to the World Trade Organization represented a significant renegotiation of China's trading relationship with the Rest of the World. Although the applied rates imposed by the World's two major trading blocks, the US and EU did not change, the trade costs facing exports from China were significantly reduced. The US and EU both granted China full MFN tariff access even before China acceded to the WTO. However, in the case of the US this was reviewed annually with the threat that higher tariffs would be removed if China lost this special 'Normal Trading Relations' access. This uncertainty significantly reduced Chinese exports to the US and discouraged mutlinational organizations from establishing production facilities for export in China. The resolution of this uncertainty upon acceding to the WTO stimulated the rapid rise in Chinese exports and multinational investment during the 2000s (Pierce and Schott, 2016; Handley and Limao, 2017). Second, China lowered input tariffs to meet the WTO requirement, which lowered tariffs on intermediate inputs and made firms exporting from China more competitive in global markets (Amiti, Dai, Feenstra, and Romalis (2017)). Therefore the increase in Chinese import competition following China's accession to the WTO reflects many similarities to bilateral renegotiations of trade agreements.

Exposure to import competition in all specifications is measured by the change in Chinese import penetration over the relevant period t following (Autor et al., 2014 and Acemoglu et al., 2016). Import competition is measured using industry import penetration for UK manufacturing industry j, $\Delta IIP_{j,t}$, over the period 1998-2015 defined as:

$$\Delta IIP_{j,t} = \frac{\Delta M_{j,t}^{UC}}{Y_{j,0} + M_{j,0} - A_{j,0}} \tag{15}$$

where for industry j, ΔM_{jt}^{UC} is the change in imports to the UK from China C. $Y_{j,0} + M_{j,0} - A_{j,0}$ is the initial industry absorption, consisting of industry output plus industry imports, $Y_{j,0} + M_{j,0}$, minus industry exports, $A_{j,0}$ at the start period $t = 0$. 1998 is chosen as the first year of observation as this precedes the rapid rise in Chinese imports in anticipation of China's accession to the

WTO in 2001.[51] There is a possible limitation in the UK context for defining the China shock in terms of the import penetration of the UK market, given that around half of UK manufacturing is exported. Similar results are also produced when using just the change in imports rather than import penetration, suggesting that the impact of this concern is limited. Those results are not presented in this thesis.

The main identification concern of using changes in import penetration as a a measure of competition is that this might be a response to changes in UK domestic industry outcomes. This reverse causality is most likely from two possible channels. First, increased imports may be a response to reductions in domestic supply caused by poor productivity growth or negative shocks to particular UK industries. This would cause downwards bias on the estimated coefficients. Second, both imports and domestic production may rise in response to idiosyncratic industry demand shocks caused by taste and preference changes. This would cause upwards bias in the OLS coefficients. This paper also follows the Autor et al. (2014) instrumental variables methodology to control for the potential endogeneity between changes in Chinese import penetration and industry demand shocks in the UK. This paper instruments for each of $\Delta IIP_{j,t}$ using the import penetration observed in other similar developed countries, giving instruments that can be defined as

$$\Delta IIPO_{j,t} = \frac{\Delta M_{j,t}^{OC}}{Y_{j,0} + M_{j,0} - A_{j,0}} \tag{16}$$

where ΔM_{jt}^{OC} is the realized change in imports to the other selected countries O from China C. The industry instruments $\Delta IIPO_{j,t}$ use initial industry absorption levels $Y_{j,0} + M_{j,0} - A_{j,0}$ to capture the pre-shock industry demand. The instrument is relevant if changes in UK import penetration and changes in import penetration in the selected other countries are driven by the same underlying supply shock. The motivation for this common supply shock is the rapid rise in Chinese manufacturing capability driven by the supply side reforms in the 1990s, and the reduced trade policy uncertainty from the accession of China into the WTO.

[51] Although this is a later initial date than equivalent papers for the US, which have an initial period of 1991, it still identifies the health of British industry at the start of the period of China's rapid rise, prior to China's accession to the WTO and the most rapid phase of Chinese import penetration.

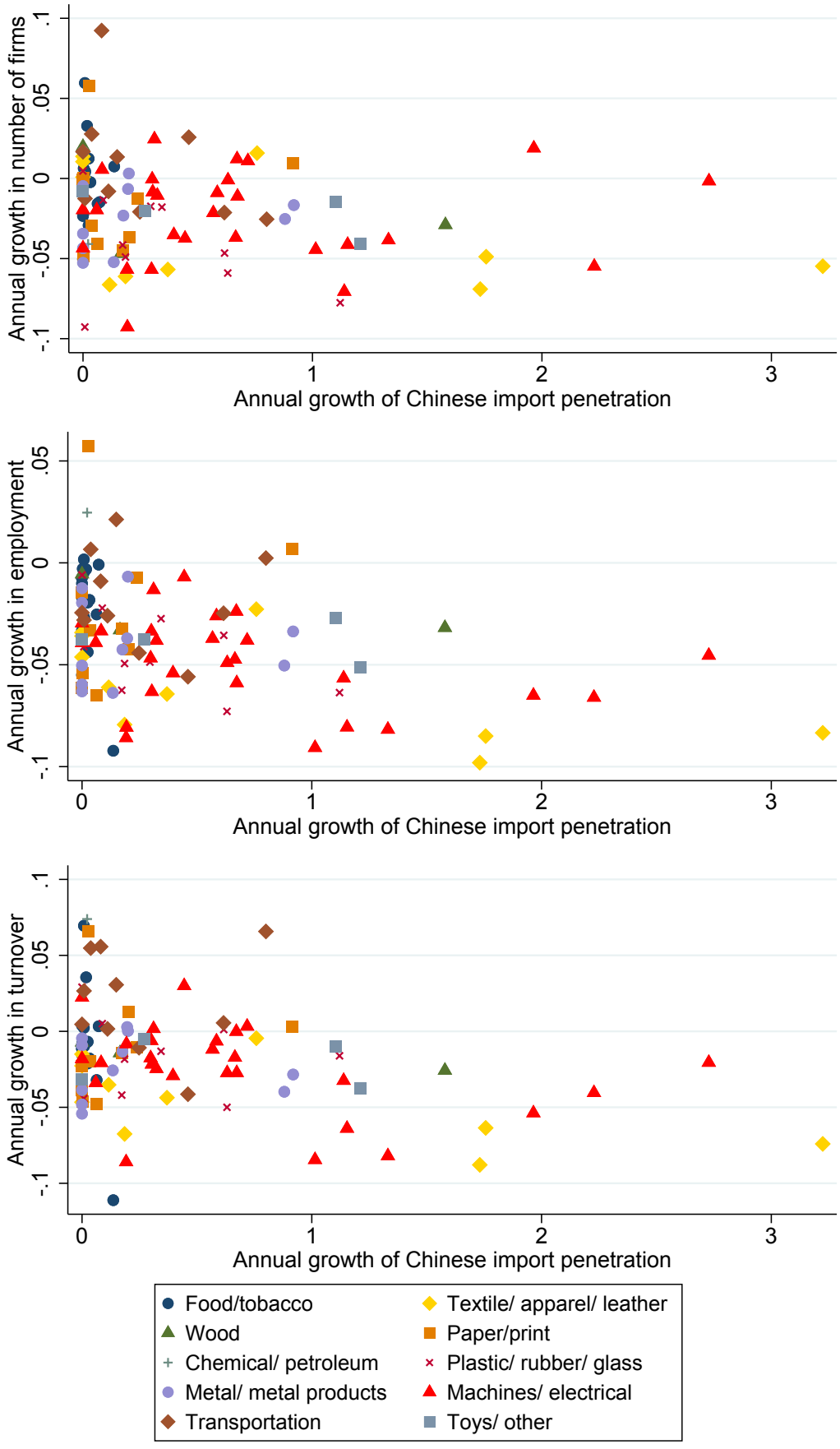
The selection of other countries to generate the instrument chooses countries with a similar income per capita, with the final instrument set consisting of Australia, Canada, Denmark, France, Germany, Japan, New Zealand, Switzerland. This paper follows a similar selection process as outlined in Dauth, Findeisen, and Suedekum (2014) for Germany and which differs slightly to the instrument set for the US, used in the Autor et al. (2013) literature, due to membership of a common EU customs union and the role of the US in the global economy. Countries which share the same trade policy through membership of the EU and Common External Tariff are included (such as the Germany and France). This assumes that changes to import competition don't lead to changes in European trade policy, as this would have a direct impact on UK regions and violate the exclusion restriction. The US is excluded due to its importance to the world economy, and therefore import competition shocks to the US could propagate to impact UK outcomes directly, violating the exclusion restriction.

The validity of the instrumental variable comes from the fact that the instrument, changes in Chinese trade flows to third countries, is only related to the outcome variable, change in industry outcomes, through the endogenous variable, the change in Chinese import competition in the UK. The instrumental variable assumes that the instrument is driven by the underlying variation of interest, the increased Chinese competitiveness and reduce uncertainty arising from joining the WTO. However there is a risk that the underlying variation that could cause the reverse causality in the relationship between UK industry outcomes and Chinese trade with the UK could also be present in the instrument in trade data between China and the selected other partner countries. For example if the rise in Chinese exports to the UK was driven by a global demand shock, such as the growth of the telecommunications industry, this would also increase Chinese exports to all partner countries. This would exacerbate the impact of the bias and would be a concern for the results.

4.2.5. Descriptive evidence of impact of import penetration

This subsection presents descriptive evidence of the impact of changes in import competition on industry level outcomes across different sectors. Figures 14 a, b and c present scatter plots of changes in industry outcomes (number of active firms, employment and turnover) against changes in industry exposure to Chinese import competition for the periods 1998-2015. Each point represents an industry, with different manufacturing sectors presented in different symbols. The scatter plot results show that industries exposed to increased import competition from China experience a greater contraction in the number of active firms and more negative falls in employment and slower growth of turnover. The figures show that the sectors most exposed to increases in Chinese import competition were textiles and machinery, and that the industries in these sectors experienced slower growth of the number of firms, employment and turnover between 1998 and 2015.

Fig. 14. Growth in firms, employment and turnover and Chinese import penetration (1998-2015)



4.3. Empirical specification

The main aim of this paper is to understand how firms have responded to increased product market competition associated with the rise in Chinese import competition over the period 1998-2015. The rise of China as a global manufacturing power over this period was unprecedented in terms of its magnitude and speed (Autor et al., 2016). This paper follows Autor et al. (2013) in using the China shock to identify the impact of import competition to exploit the unique natural experiment of an economically large and supply driven import shock.

4.3.1. Effect of import competition on industry outcomes

This subsection begins by presenting results for the impact of trade competition on aggregate industry outcomes including the number of active firms, employment and aggregate turnover. The analysis presents aggregate industry changes over the time periods of interest across the 117 4 digit ISIC industries. Two time periods are selected, the first covers outcomes from 1998 to 2007 and the second covers a longer period from 1998 to 2015. The start date is restricted by the availability of firm level outcomes in the BSD and the end dates for the two periods are chosen to cover the period before the Great Recession and the full available period of data respectively. For clarity, the regressions have the change in outcomes over the given period as the dependent variable and the change in Chinese import penetration as the independent variable, they are not panel regressions with outcomes for each year included.

The impacts of Chinese import competition is first estimated at the national industry level. The industry level model regresses the change industry outcomes y_{jt} on the change in industry import penetration, weighted by the initial level of industry outcome. The regressions are estimated over the pre-crisis (1998-2007) and full period (1998-2015) using a first difference approach. Growth rates are calculated following Davis and Haltiwanger (1992):

$$y_{jt} = \frac{(Y_{jt_{\tau,end}} - Y_{jt_{\tau,start}})}{\frac{1}{2}(Y_{jt_{\tau,end}} + Y_{jt_{\tau,start}})} \tag{17}$$

The main specification is identified using the industry instrument $\Delta IIPO_{j,t}$ outlined above:

$$y_{jt} = \alpha_t + \beta_1 \Delta IIP_{jt} + X_{jt}^{'} \gamma_j + \epsilon_{jt} \tag{18}$$

where y_{jt} is the annualized change in industry j employment, turnover, number of active firms and plants over the period t. In the industry level regressions, each outcome is weighted by the start-of-period industry outcome, so the regression of the change in annualized employment growth is weighted by industry employment in 1998.[52] The analysis compares industries which are exposed to increased import competition, with those that are not. Chinese import competition is associated with a decline in industry employment if β_1 is negative and significant. The empirical model incorporates a vector of controls X_{it}, including the industry characteristics and industry employment characteristics outlined in the data subsection.

The aggregate industry figures are adjusted to remove firms switching within manufacturing between the start and end of the period of interest. Switching within manufacturing margins are not utilised in the industry level regressions as this would violate the group exogeneity assumption.

4.3.2. How did firm dynamics contribute to aggregate changes?

This subsubsections details a decomposition of the changes in industry level outcomes into different margins of firm dynamics. Manufacturing employment in an industry could change along the intensive margin (firms contracting/not expanding), extensive margin (firm exit or no entry) or firms switching in or out of the industry (the decomposition using mid point growth rates follows (Davis and Haltiwanger, 1992; Asquith et al., 2019), and in particular (Bloom et al., 2019)).[53] The change in the levels of outcome Y_j between the start of a period t and end of a period t can be

[52] Weighting the regression by the initial outcome is important for assessing the impact of the increase in Chinese import competition for explaining the aggregate change in UK industry outcomes in the partial equilibrium exercise in a later section. That said, a weighted regression by definition applies more weight to larger industries which may be less representative of the unweighted average industry outcome, especially if a small number of industries are disproportionately large.

[53] As mentioned previously, if changes in employment arising from firms switching from one manufacturing industry to another manufacturing industry are included, this will violate the group exogeneity assumption. Therefore the analysis only includes firms switching out from manufacturing, or into an industry from outside manufacturing.

decomposed as:

$$Y_{jt_{\tau,end}} - Y_{jt_{\tau,start}} = B_{jt} - D_{jt} + E_{jt} - C_{jt} + SI_{jt} - SO_{jt} \tag{19}$$

The overall changes in the growth rate of each industry outcome Y_j in $\{employment, turnover, number\,of\,firms\}$ are decomposed according to the six different margins of firm dynamics: birth, death, expansion, contraction, switching in and switching out.

$$y_{jt} = \frac{B_{jt} - D_{jt} + E_{jt} - C_{jt} + SI_{jt} - SO_{jt}}{\frac{1}{2}(Y_{jt_{\tau,end}} + Y_{jt_{\tau,start}})} \tag{20}$$

$$y_{jt} = b_{jt} - d_{jt} + e_{jt} - c_{jt} + si_{jt} - so_{jt} \tag{21}$$

The decomposition of the different firm margins $f \in \{b, d, e, c, si, so\}$ is included in the main China shock instrumental variable regression specification to decompose the aggregate impact of import competition:

$$\Delta f_{jt} = \beta_0 + \beta_1 \Delta IIP_{jt}^{UK,China} + \epsilon_{jt}. \tag{22}$$

4.3.3. What happens to firms when they switch industry?

The regression estimates of Chinese import competition on UK industry is estimated at the firm level. The firm model regresses the change in firm outcomes y_{ijt} on the change in industry import penetration $\Delta IIP_{j,t}$ over the period 1998-2015 using a first difference approach, identified using the industry instrument $\Delta IIPO_{j,t}$ outlined above. The firm level intensive margin is identified using a first difference model estimated for firms i in industries j who are active over period t, also identified using the China shock instrument at the industry level $\Delta IIPO_{j,t}$:

$$y_{ijt} = \sum_k \alpha_k Switch_{ikt} + \beta_1 \Delta IIP_{jt} + \sum_k \beta_k Switch_{ikt} * \Delta IIP_{jt} + Z_{it}^{'}\theta_i + X_{jt}^{'}\gamma_j + \epsilon_{ijt} \tag{23}$$

where y_{ijt} is the annual change in firm level turnover and employment. Different types of switching behaviour are indexed by $k \in \{switch\,out\,(other),\ switch\,out\,(wholesale),\ switch\,out\,(administration),\ switch\,within\,manufacturing\}$ Switching industry is more negative in industries facing greater Chinese import competition if β_k is negative and significant. The empirical model incorporates a vector of controls, including industry X_{jt} and employment controls Z_{it}, but also firm level controls for age and foreign ownership.

4.4. Results

This subsection presents the results on the impact of Chinese import competition on firms in the UK manufacturing sector. First, the results show the impact of increased Chinese import competition across a range of outcomes in UK manufacturing. Second, the paper decomposes these effects across the different margins of firm adjustment over different periods to understand the structure and nature of transition costs associated with increased import competition. Third, the paper explores how firms adapt to the increased import competition and which industries they move into if they leave manufacturing. Finally, the paper explores the outcomes at the firm level depending on the margin of adjustment to import competition.

4.4.1. Effect of import competition on industry employment

Table (17) presents results for the impact of increased Chinese import competition on UK manufacturing employment, turnover and number of firms for the periods 1998-2007 and 1998-2015.[54] The results show that industries facing greater increases in import penetration have experienced slower growth in employment (columns (1) and (2)), slower growth in turnover (columns (3) and (4)) and slower growth in the number of firms (columns (5) and (6)) over both periods. The results can be interpreted as a 1 percentage point increase in the annual growth in Chinese import competition lowered the growth rate of employment in an industry by 4.67 percentage points over

[54] All of the regressions include 117 manufacturing ISIC3 industries, industry and employment controls, with standard errors clustered at the ISIC3 Division level, with each industry regression weighted by the outcome of interest at the aggregate industry level in 1998. The regressions are all estimated using the instrumental variable strategy of using the change in Chinese imports to other high income countries as described in the methodology subsection. The appendix presents the equivalent OLS results, results sequentially adding the control variables and estimates of the first stage regressions.

1998-2007 (column 1).

The results are significantly larger in magnitude for the growth of employment and turnover in the 1998-2007 rather than the 1998-2015 period. This can be taken as evidence that the majority of the decline in UK manufacturing employment and turnover resulting from increased import competition occurred early in the period of China's rapid rise as a global manufacturing exporter following China's accession to the World Trade Organization in 2001. There is no evidence of a significant difference in the estimated response of the number of firms in each manufacturing industry between the shorter and longer period (although there is a reduction in statistical significance in the longer period). The extensive margin of adjustment is therefore shown to operate throughout the period, reflecting the time required for firms to shut down operations.

The paper provides an estimate of the economic impact of the regression estimates in a counterfactual where there was no increase in Chinese import competition across all industries. This exercise identifies the causal impact of Chinese import competition in terms of jobs lost, turnover foregone and (net) loss of firms. The coefficients are estimated from the industry level regressions of change in manufacturing outcomes on changes in import competition from Table (17) and the counterfactual impact is presented in Table (18). Following (Acemoglu et al., 2016) the paper then estimates change in employment relative to counterfactual of no increase in Chinese import competition using the estimated regression coefficient, change in (projected) import penetration[55] using the formula in equation (24) for each outcome $Y \in \{Employment, Turnover, Firms\}$.

$$Predicted\,outcome\,change(IP) = \sum_{j} \left(1 - e^{-\hat{\beta}\rho(IP_{j15} - IP_{j98})}\right) Y_{j15} \tag{24}$$

The results show that the increased Chinese import penetration between 1998 and 2015 causally cost 287,496 manufacturing jobs, reduced the number of manufacturing firms by 8,517 and reduced manufacturing turnover by £50 billion in 2015. The paper then compares the estimated effects

[55]The (projected) import penetration is calculated as the actual change in import competition $IP_{j15} - IP_{j98}$ multiplied by the explanatory power of the first stage regression of the change in UK import penetration on the change in other high income country imports from China (ρ).

to the total reduction in the number of manufacturing firms, employment and turnover over the 1998-2015 period and estimated the share of each outcome that the increase in Chinese import competition accounts for. The results estimate that increased Chinese import competition accounts for 16% of the reduction in manufacturing employment, 11% of the reduction in turnover in the manufacturing sector and 21% of the reduction in manufacturing firms comparing 1998 with 2015.

Table 17: Impact of Chinese import competition on UK manufacturing outcomes over the period 1998-2015 (Regression coefficients)

	Employment		Turnover		Firms	
	1998-2007	1998-2015	1998-2007	1998-2015	1998-2007	1998-2015
	(1)	(2)	(3)	(4)	(5)	(6)
Annual Δ in Chinese IP	-0.0467***	-0.0262***	-0.0444***	-0.0338***	-0.0110**	-0.0115*
	(0.00698)	(0.00443)	(0.0135)	(0.00689)	(0.00542)	(0.00690)
Industry controls	YES	YES	YES	YES	YES	YES
Employment controls	YES	YES	YES	YES	YES	YES
Division cluster	YES	YES	YES	YES	YES	YES

Notes - Each industry regression based on sample of 117 ISIC3 manufacturing industry observations. Dependent variables are annualised mid point growth rates of industry outcomes. Industries are weighted by the 1998 level of the outcome variable of interest: Number of firms in an industry for regressions, Employment in an industry, and industry aggregate turnover (measured in 1998 prices). IV regressions instrument the change in Chinese import penetration into the UK with a set of instruments using the change in Chinese import competition into other high income countries (see text for more details). Standard errors are robust and clustered at the 2 digit ISIC3 division level. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 18: Impact of Chinese import competition on UK manufacturing outcomes over the period 1998-2015 (Predicted effects)

	All	China	China share
Employment	-1,773,876	-287,496	0.16
Number of firms	-40,042	-8,517	0.21
Turnover (£bn)	-440.24	-50.47	0.11

Notes - Predicted changes estimated using the formula $Predicted\,outcome\,change(IP) = \sum_j \left(1 - e^{-\hat{\beta}\rho(IP_{j15} - IP_{j98})}\right) Y_{j15}$ as described in the text.

4.4.2. Decomposition of industry employment changes

This subsection decomposes the aggregate changes in manufacturing outcomes in each industry in response to the increase in Chinese import competition into the different margins across which

firms can adjust: expanding, contracting, entering, exiting, switching out of manufacturing and switching into manufacturing. The results of the regressions for the long period 1998-2015 are presented in Table (19) for each of the outcomes: Panel A presents the decomposition results for employment, Panel B presents the decomposition results for turnover, Panel C presents the decomposition results for the number of firms.[56] Table (20) presents the contribution (share) of each margin of firm adjustment to the aggregate response, and estimates of the predicted impact of the increase in Chinese import competition as described in the previous subsubsection. In table 19 the dependent variable is always the change in the outcome variable, such as the change in employment. A negative coefficient implies that industry employment falls when Chinese import competition has increased. All of the coefficients are negative as each margin is on average associated with a fall in employment (even if that fall in employment results from, for example, an increase in deaths of firms).

Panel A shows that the negative effects of increased Chinese import competition on UK manufacturing employment are driven by three main channels: (i) Firms switching their industry from manufacturing to a non-manufacturing industry accounts for 42% of the reduction in industry employment; (ii) Firms exiting accounts for 30% of the reduction in industry employment; and (iii) Firms not expanding their employment relative to other industries accounts for 16% of the reduction in industry employment. Similar contributions for industry turnover response to import competition are found across the different margins of adjustment, with results presented in Panel B. However, as shown in Panel C, the contribution of firms switching out of manufacturing is significantly smaller when explaining the impact of Chinese import competition on the number of firms in each industry (accounting for only 8% of the change in number of firms), with a far greater role for increased firm exit (accounting for 61% of the change in number of firms) and a reduction in firm entry (accounting for 30% of the change in number of firms).

The most interesting result in the decomposition is the importance of firms switching their in-

[56]Results for the shorter 1998-2007 are presented in the appendix. The results are generally similar, although different time periods will have different decomposition estimates, with longer time periods allocating a greater contribution to the extensive margin.

dustry from manufacturing into non-manufacturing. This result has two interesting implications. First, the result can explain part of the large reduction in the number of jobs in manufacturing with over 120,000 jobs mechanically removed through firms no longer being classified in the manufacturing sector.[57] Second, the results imply a dynamic response of firms reorganizing activity in response to the changing international competition. In particular, the fact that existing firms are not shutting down or contracting as may be expected in standard theories of creative destruction or models of international trade, but switching into non-manufacturing industries suggests that firms may adapt within global supply chains to exploit the changing landscape of production and sourcing opportunities, at the expense of local employment.[58] The differences between the decomposition results for employment and turnover in contrast to the number of firms in manufacturing shows that it is the largest firms in terms of both employment and turnover that are switching into non-manufacturing, accounting for a small number of firms, but a large proportion of employment and turnover.

The results show a significant role for the extensive margin of adjustment, in particular firms exiting from industries exposed to greater import competition, for explaining the decline in manufacturing employment and number of firms between 1998 and 2015. Therefore, for the majority of (mainly small) UK manufacturing firms affected by the increased competition, they are not able to respond by reallocating activity within the firm (which would be accounted for by the intensive margin and contractions) or through reorganizing activity through changing industry.

The intensive margin accounts for a surprisingly small proportion of the response of manufacturing employment to the increased import competition. One explanation is that the time period under investigation is long, which suggests that the extensive margin will account for a more pronounced role. In the next subsection and in more detail in the appendix presents results of the decomposition of the effects of increased import competition between 1998 and 2007, where the

[57]The paper explores in a later subsection how employment changed at these firms which switched out of manufacturing.

[58]The paper explores these possibilities in a later subsection where the paper investigates which industries these firms are switching in to.

results find a larger role of the intensive margin which accounts for 22% of the total manufacturing employment decline due to Chinese import competition. Firms contracting accounts for 9% and firms not expanding accounts for 13% of the total manufacturing employment decline due to Chinese import competition in this shorter period.

Table 19: Impact of Chinese import competition on UK manufacturing outcomes across different margins of firm adjustment over the period 1998-2015 (Regression coefficients)

Margins	(1) All	(2) Expand	(3) Contract	(4) Birth	(5) Death	(6) Switch out	(7) Switch in
Panel A: Employment							
Annual Δ in Chinese IP	-0.0262***	-0.00415***	-6.65e-05	-0.00191	-0.00792***	-0.0110***	-0.00117**
	(0.00443)	(0.000807)	(0.000930)	(0.00119)	(0.00224)	(0.00208)	(0.000571)
Panel B: Turnover							
Annual Δ in Chinese IP	-0.0338***	-0.00629***	-0.00229	0.000202	-0.00813***	-0.0161***	-0.00124*
	(0.00689)	(0.00168)	(0.00357)	(0.00146)	(0.00228)	(0.00300)	(0.000652)
Panel C: Firms							
Annual Δ in Chinese IP	-0.0115*			-0.00339	-0.00698**	-0.000864*	-0.000193
	(0.00690)			(0.00359)	(0.00315)	(0.000459)	(0.000465)

Notes - Each industry regression based on sample of 117 ISIC3 manufacturing industry observations. Dependent variables are annualised mid point growth rates of industry outcomes. Industries are weighted by the 1998 level of the outcome variable of interest: Number of firms in an industry for regressions, Employment in an industry, and industry aggregate turnover (measured in 1998 prices). IV regressions instrument the change in Chinese import penetration into the UK with a set of instruments using the change in Chinese import competition into other high income countries (see text for more details). Standard errors are robust and clustered at the 2 digit ISIC3 division level. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 20: Impact of Chinese import competition on UK manufacturing outcomes across different margins of firm adjustment over the period 1998-2015 (Predicted effects)

	Birth	Death	Expand	Contract	Switch in	Switch out
Panel A: Employment						
Predicted impact	-20,978	-86,918	-45,579	-730	-12,889	-120,143
Share	0.07	0.30	0.16	0.00	0.04	0.42
Panel B: Turnover						
Predicted impact	0.30	-12.13	-9.40	-3.42	-1.85	-23.97
Share	-0.01	0.24	0.19	0.07	0.04	0.47
Panel C: Firms						
Predicted impact	-2,538	-5,196			-145	-639
Share	0.30	0.61			0.02	0.08

Notes - Predicted changes estimated using the formula $Predicted\,outcome\,change(IP) = \sum_j \left(1 - e^{-\hat{\beta}\rho(IP_{j15} - IP_{j98})}\right) Y_{j15}$ as described in the text.

4.4.3. Predicted effects and timing

This subsection explores how the timing of the response to the increased import competition can reveal the mechanisms of how firms adjust to changes in international trade. This subsection reruns the decomposition analysis for each time period between 1998 and each year between 2001 and 2015 using the instrumental variable estimation strategy. This results show how the impacts of increased import competition have evolved over time and the contribution of each margin over time. The results of the predicted effects (using the methodology outlined above) are presented graphically in Figure (15).

The results for the predicted impact of Chinese import competition on UK manufacturing employment between 1998 and each year in the period 2001-2015 are presented in Figure 5. Most of the net employment effects occurred in the the first years after China's accession to the WTO, with the net employment effects levelling out after 2007. Throughout the entire period the two main margins of adjustment are firms switching out of manufacturing and firms exiting. These margins increase over the period in both absolute magnitude and their share of the contribution. A surprising small contribution for the intensive margin of adjustment through firms contracting and expanding. The relative contribution of the intensive margin declines over the period, with firms contracting accounting for a significant share in the early period but almost no contribution by 2015. This pattern is expected as firms initially contract in the facing if increasing competition, but then exit or switch industry once it is no longer profitable to compete. Firms expanded less in industries facing greater increases in import competition, with the size of this effect increasing throughout the period. Overall, the structure of the response of UK manufacturing to the increased import competition suggests significant transition costs at the firm level, with little role for internal restructuring, and a significant role for creative destruction leading to firm exit and firms switching industries, possibly to fragment the production process in line with changing comparative advantage.

The effects of Chinese import competition on the number of manufacturing firms, presented in

Figure 15, differs in both magnitude and composition from the effects on employment. The net effect of the impact of increased import competition on the number of manufacturing firms emerges later in the period, with sharp rise from 2008 and levelling off only after 2013. In terms of the composition across the different margins of adjustment, firm exit is the dominant margin of adjustment throughout the whole period, with an increase in the absolute magnitude after 2007. The timing of the firm exits with the 2007-09 recession suggests a dynamic of creative destruction where firms continued to survive against increased competitive pressure until another shock to business conditions induces exit. The contribution of firm entry to the cross industry differences in growth also increases after 2007. Interestingly, this suggests that in the initial years after China's accession to the WTO, firms continued to enter into more exposed industries just as much as other industries, possibly believing that there were still opportunities to compete. However, it is only after the significant increase in the level of competition by the later period that firms no longer enter to try to compete in the industries with which China has comparative advantage.

The impact of Chinese import competition on manufacturing turnover has also increased over time, accounting for an estimated £50 billion of reduced manufacturing turnover by 2015. There is a more gradual effect of competition on turnover than employment, with a an initial decline between 2001 and 2006 and second decline between 2011 and 2015. The extensive margin is again the most important, with firms switching out of manufacturing providing the largest contribution to the reduction in manufacturing turnover. Firms switching out of manufacturing drives the increase in reduced turnover in the early period up to 2007, whilst the reduction in turnover in the later period comes from increasing exit and firms not expanding. Overall these results again highlight the importance of the largest manufacturing firms responding quickly to the more competitive business conditions from the increase in Chinese imports, and adapting through moving into different lines of business rather than exiting the market.

The important role of the extensive margin, and in particular firms switching out of manufacturing, is highlighted when comparing the impact of increased import competition across the three

outcomes. This firm switching is dominated by largest firms, with only a small impact on the number of firms, but accounting for a lion's share of employment and turnover. Firm exit is also important, with a significant contribution to the estimated impact on employment by the end of the analysed period. The impact of this extensive margin is considerably larger for employment than turnover, suggesting that it is less productive firms that are forced out of the market, possibly as they are not able to compete with low labour costs that determine China's comparative advantage in industries.

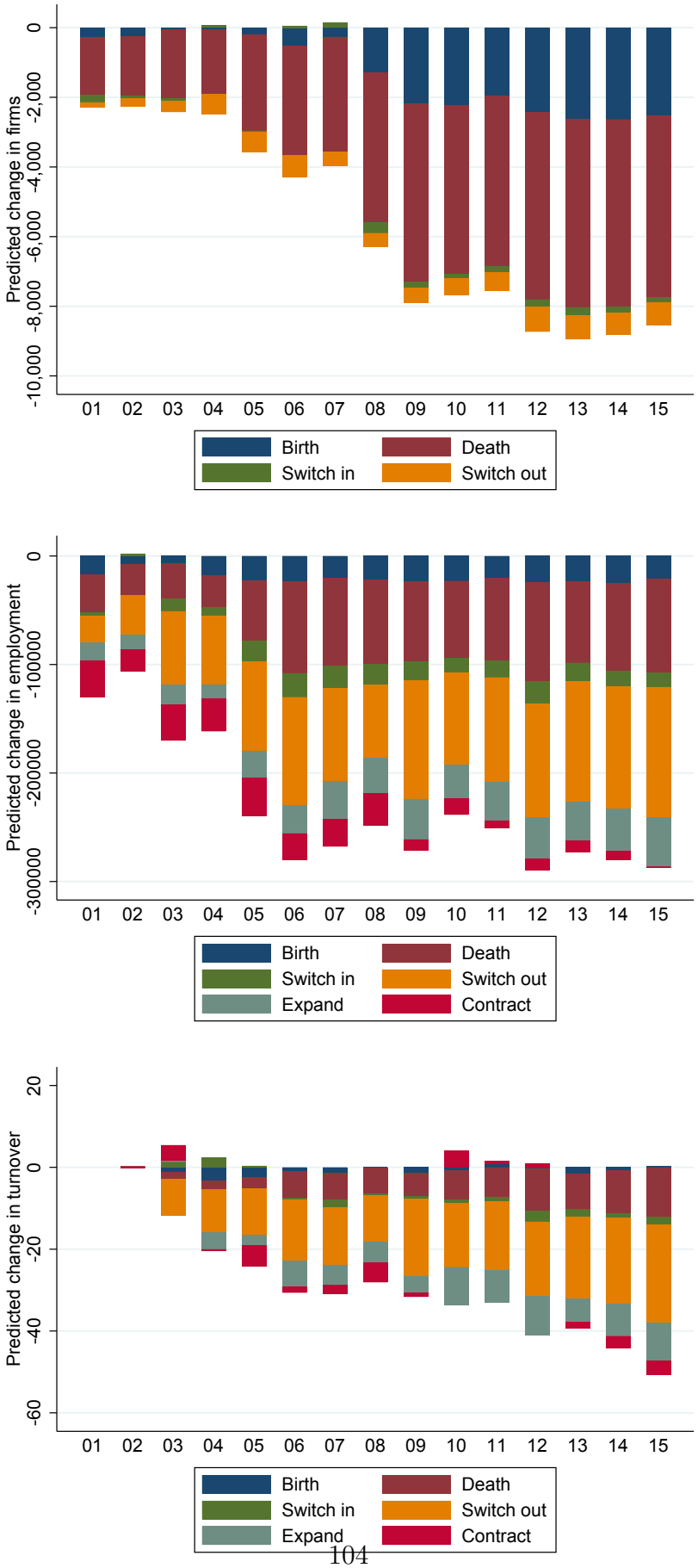
One of the most surprising results highlighted by the timing results is that the response is rapid, with large falls in employment in the first years of increased Chinese import competition. This rapid response is driven by the largest companies switching out of manufacturing and therefore exploiting the changing competitive landscape rather than exiting completely. Finally, the employment effects occur more rapidly than the effects on turnover. These effects are driven by both an immediate intensive restructuring, shown by early effects of contraction of employment but not in turnover, and also selection with the least efficient firms in terms of labour productivity choosing to exit.

4.4.4. Where are firms switching to?

The decision of UK manufacturing firms to switch their activities into non-manufacturing is the most significant driver of the magnitude and timing of the response of UK industries most exposed to increased Chinese import competition. This subsection further explores which activities these firms switch to and the implications for the UK's place in global value chains. The results show that firms have switched out of manufacturing and into wholesaling and retailing, and business activities.

This subsection decomposes the results for firms switching out of manufacturing in Table (5) into the different industries which firms are switching to. For firms that switch between the period 1998 and 2015, the results identify the sector that the firm switches to in 2015 into three

Fig. 15. Predicted change in manufacturing firms, employment and turnover



options: Wholesaling and retailing (ISIC 50-52), Business administration (ISIC 70-74) and Other non-manufacturing industries.[59] The results also present the predicted effects in terms of number of manufacturing jobs lost, reduced turnover and fewer firms, and the share of the total changes in UK manufacturing.[60]

The results in Tables (21) and (22) show that the majority of firms switching out of manufacturing in response to increased import competition switch to wholesaling and retailing, and business activities. More firms switch out of manufacturing into wholesale and retail, over 60%, than business administration, although the total predicted number of firms is low (with only 435 firms predicted to have switched from manufacturing into wholesale and retail, and 196 firms switching into business administration) as a result of the increase in Chinese import competition. There are much larger effects for employment and turnover, in line with the previous results indicating that it is the largest firms that switch out of manufacturing. Over 70,000 manufacturing jobs are lost from manufacturing as a result of firms switching into wholesale and retail by 2015, accounting for over 60% of jobs lost from switching out of manufacturing, with business administration accounting for almost all of the remainder and over 40,000 jobs lost. Wholesale and retail accounts for an even greater share of turnover lost, at around 77%, with business administration bringing the total to just over 100% of the total turnover lost, with other industries create a small (and insignificant) drag.

The sectors that firms switch to when they move out of manufacturing in response to the increased import competition illustrates a dynamic restructuring of UK manufacturing within global value chains. Firms that switch out of the production activities of manufacturing into wholesale and retail move downstream in their value chains. These firms probably continue to leverage their distribution network and retail brand, but outsource (more of) their production. These downstream

[59] Although the paper initially decompose the sector that firms switch to into all 10 non-manufacturing sectors, only Wholesaling and retailing, Business administration contribute significantly in the decomposition so the analysis groups all remaining sectors that firms switch to into other.

[60] As mentioned earlier, these jobs are mechanically lost from manufacturing by the firms switching out of manufacturing, although the firms may not be reducing their employment, turnover or close down. The paper explores the changes in firm level employment and turnover in a later subsection.

activities are not possible to outsource as they require a physical presence which possibly explains why they account for the majority of the firms, employment and turnover in the decomposition. However, the downstream activities are also associated with lower skilled and lower paid jobs, with negative implications for worker outcomes. In contrast, firms that concentrate their activities in Business and administration move upstream in their value chains, whilst still leveraging the new outsourcing opportunities opened up by the development of Chinese manufacturing. These business activities include both the control processes of the global manufacturing operations, but also the research and development.[61] These activities are typically associated with more skilled and higher paying professions and represent a shift of industries more in line with the UK's comparative advantage with an abundance of high skilled labour.

Table 21: Where are firms switching to? (Regression coefficients)

	Any non-manufacturing	Wholesale & retail	Business administration	Other
	(1)	(2)	(3)	(4)
Panel A: Employment				
Annual Δ in Chinese IP	-0.0110***	-0.00668***	-0.00396**	-0.000304
	(0.00208)	(0.00118)	(0.00159)	(0.000584)
Panel B: Turnover				
Annual Δ in Chinese IP	-0.0161***	-0.0125***	-0.00399**	0.000435
	(0.00300)	(0.00358)	(0.00167)	(0.000771)
Panel C: Firms				
Annual Δ in Chinese IP	-0.000864*	-0.000588	-0.000265**	-1.13e-05
	(0.000459)	(0.000370)	(0.000112)	(0.000162)

Notes - Each industry regression based on sample of 117 ISIC3 manufacturing industry observations. Dependent variables are annualised mid point growth rates of industry outcomes. Industries are weighted by the 1998 level of the outcome variable of interest: Number of firms in an industry for regressions, Employment in an industry, and industry aggregate turnover (measured in 1998 prices). IV regressions instrument the change in Chinese import penetration into the UK with a set of instruments using the change in Chinese import competition into other high income countries (see text for more details). Standard errors are robust and clustered at the 2 digit ISIC3 division level. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.4.5. What happens to firms when they switch industry?

This subsection explores how firm employment and turnover changes when firms switch out of an industry. The analysis moves to the firm level to track individual firms over time, rather than the

[61] One of the most commonly cited examples in the US is Apple, which explicitly says 'Designed by Apple in California. Assembled in China.' In the UK, Dyson (one of the UK's recent manufacturing success stories) offshored all of its production facilities in 2002 and 2003, leaving only its research and development facilities in the UK.

Table 22: Where are firms switching to? (Predicted effects)

	Switch out	Wholesale & retail	Business administration	Other
	(1)	(2)	(3)	(4)
Panel A: Employment				
Predicted impact	-120143	-72960	-43251	-3320
Share	0.42	0.26	0.15	0.01
Panel B: Turnover				
Predicted impact	-24.0	-18.6	-5.9	0.6
Share	0.47	0.36	0.12	-0.01
Panel C: Firms				
Predicted impact	-639	-435	-196	-8
Share	0.08	0.05	0.02	0.00

Notes - Each industry regression based on sample of 117 ISIC3 manufacturing industry observations. Industries are weighted by the 1998 level of the outcome variable of interest: Number of firms in an industry for regressions, Employment in an industry, and industry aggregate turnover (measured in 1998 prices). IV regressions instrument the change in Chinese import penetration into the UK with a set of instruments using the change in Chinese import competition into other high income countries (see text for more details). Standard errors are robust and clustered at the 2 digit ISIC3 division level. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

outcomes of manufacturing industries. A firm's exposure to import competition is defined based on their initial industry, but separately identify firms depending on whether they do not switch industry, whether they switch industry but to another manufacturing industry, and whether they switch out of manufacturing (and whether they switch into wholesaling and retailing, and business activities).

The results of the firm level analysis are presented in Table (23) for both periods 1998-2007 and 1998-2015. Regressions are specified estimating the change in employment and turnover outcomes on changes in industry Chinese import penetration, indicators for the switching behaviour of firms and interactions between the switching behaviour of firms ad changes in industry import penetration. There are two sets of coefficients of interest. First, the results on the different types of switching behaviour show the impact that these behaviours have on firm outcomes (relative to firms that don't switch). Second, the coefficients on the interactions of the switching behaviour and changes in import penetration show whether the effects of the switching behaviour are smaller or larger for firms in industries more exposed to import competition. The results suggest that

firms are negatively affected in terms of employment and turnover when they switch out of manufacturing into other, wholesale and administrative industries, but that these effects are not larger for industries initially more exposed to import competition.

The results on the indicators of firm switching behaviour show that firms that switch out of manufacturing into other sectors reduce their employment and turnover.[62] Firms that switch into wholesaling experience a 2.5% reduction in per annum growth of employment across both periods, with evidence that they also experience reductions in the growth rate of turnover of 2.1% in the 1998-2007 period. Firms that switch into business and administration experience an even greater reduction in employment and turnover, with a 5.1% reduction in per annum employment growth and 4.7% reduction in turnover growth in the 1998-2015 period. Firms that switch into other sectors reduce experience reductions in their turnover over both periods, with some evidence that they may experience positive employment effects.

Firms have slower growth of employment and turnover if they are initially in industries that are exposed to greater import competition. However, the effects of different firm switching behaviour are larger for industries initially more exposed to import competition (as shown by the insignificant interaction terms). Although firms that switch out of manufacturing into other sectors (than wholesaling and business administration) have significant interaction terms, the net effect with the coefficient for all firms that switch is insignificant.

Firms switching within manufacturing do not experience significantly different growth rates in employment or turnover than firms that do not switch, and these firms have significantly different effects if they are in industries that are exposed to greater import competition. This result suggests that excluding these firms from the main analysis would not invalidate the group exogeneity

[62] In industries which face little import competition, as well as in industries that do, there is a question of why firms would switch out of manufacturing. A concurrent trend occurring at the same time as the increase in Chinese import competition was an increase in the automation of manufacturing. This could explain why firms would switch out of manufacturing, if their employment in manufacturing fell as a result of automation, even if the industry remained in the UK. However, the evidence in this paper of the fall in industry and firm turnover at the same time as the fall in employment suggests that industries and firms are becoming smaller, rather than just engaging in capital labour substitution.

conditions for the difference in difference regression strategy.

Table 23: What happens when firms switch out of manufacturing?

	Employment		Turnover	
	1998-2007	1998-2015	1998-2007	1998-2015
	(1)	(2)	(3)	(4)
Annual Δ in Chinese IP	-0.0254***	-0.0176***	-0.00986	-0.0174*
	(0.00464)	(0.00372)	(0.00998)	(0.0124)
Switch out (other)*Annual Δ in Chinese IP	-0.0655***	0.0192	0.0997**	0.0779**
	(0.0199)	(0.0212)	(0.0460)	(0.0324)
Switch out (wholesale)*Annual Δ in Chinese IP	-0.0193*	0.00142	-0.0155	-0.0117
	(0.0106)	(0.00647)	(0.0156)	(0.0183)
Switch out (administration)*Annual Δ in Chinese IP	0.00167	-0.000677	0.0725*	0.00383
	(0.0225)	(0.0118)	(0.0422)	(0.0255)
Switch within manufacturing*Annual Δ in Chinese IP	5.43e-05	-0.00218	-0.0389*	-0.0177*
	(0.0114)	(0.00779)	(0.0219)	(0.0101)
Switch out (other)	0.0379***	-0.00389	-0.103**	-0.0632***
	(0.0101)	(0.0147)	(0.0405)	(0.0193)
Switch out (wholesale)	-0.0246*	-0.0244***	-0.0214**	-0.0115
	(0.0137)	(0.00497)	(0.0107)	(0.0133)
Switch out (administration)	-0.0377	-0.0507***	-0.0714	-0.0471***
	(0.0234)	(0.00988)	(0.0514)	(0.0150)
Switch within manufacturing	0.00397	0.00282	0.0152*	0.0111
	(0.00773)	(0.00499)	(0.00820)	(0.00912)
Observations	82,137	52,853	82,113	52,834
R-squared	0.087	0.128	0.125	0.061
Firm controls	YES	YES	YES	YES
Industry controls	YES	YES	YES	YES
Employment controls	YES	YES	YES	YES
Division cluster	YES	YES	YES	YES
Weight	employment	employment	turnover	turnover

Notes - Regressions are weighted by the 1998 level of the outcome variable of interest: Employment at the firm, and turnover (measured in 1998 prices) at the firm. Dependent variables are annualised mid point growth rates of firm outcomes. IV regressions instrument the change in Chinese import penetration into the UK with a set of instruments using the change in Chinese import competition into other high income countries (see text for more details). Standard errors are robust and clustered at the 2 digit ISIC3 division level. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.5. Conclusion

This paper shows that the rise in import competition from China following China's accession to the World Trade Organization contributed to the decline in UK manufacturing activity post 2000. A significant proportion of this decline in manufacturing activity is driven by firms switching their in-

dustrial activity out of manufacturing production and towards services. In particular, firms switch into business services such as research and development and wholesale and retail. This switching behaviour is consistent with theoretical models of offshoring and other empirical evidence that a significant proportion of the increase in Chinese and other low wage country exports is from foreign owned firms. This paper also shows that the speed of the transition across industries is fast, with the majority of the employment and turnover effects occurring in the first few years. This is primarily driven by the largest firms, as the switching effect on the number of firms is substantially smaller.

The empirical results of this paper support the idea of a transition of manufacturing firms and the economy from production to services in response to increased international competition from low wage countries. The importance of the transition from production to research has been emphasized at the firm level by Bloom et al. (2013) and at the economy level by Rodríguez-Clare (2010). The transition to increase research effort accelerates the rate of technological progress and ensures that offshoring is welfare enhancing. From a welfare perspective, the fast rate of transition is also essential to ensure that the long run positive welfare effects of offshoring dominate any short run negative welfare effects.

This paper has made an initial step in understanding the transition from production to services in response to increased international competition. This will be important looking forward for the UK as it leaves the European Union and renegotiates its trading relationship with both the EU, advanced nations such as the US and possibly developing nations such as China, India and Brazil. The implications of this line of research suggests that policy should be less focussed on helping firms to remain competitive in manufacturing production, but to help firms to transition to productivity enhancing services such as research and development.

Future work could build on the work of this paper to further understand the transition to research and development. Using more detailed firm level information on the amount of research

and development along the lines of Bloom et al. (2016) could help address the issue of industry classification raised in the data subsection. Further analysis at the worker level using matched employer-employee data could illustrate the changes in worker composition when a firm switches industry to further test whether the activity of the firm fundamentally changes, but also to understand the implications for workers.

4.6. Appendix

A Data

Tables 24 and 25 show the decomposition of number of firms and employment across different firms by whether they entered, exited, switched, expanded or contracted in the period.

Table 24: Total numbers across firm margins (1998-2015)

	firm1998	firm2015	employment1998	employment2015
Entrant	0	121,974	0	875,742
Exit	138,932	0	2,459,698	0
Switch (out of manufacturing)	12,177	12,177	531,393	323,500
Switch (into manufacturing)	9,582	9,582	112,542	259,030
Switch (within manufacturing)	9,699	9,699	360,755	378,574
Expand	23,442	23,442	422,269	863,639
Contract	13,993	13,993	894,263	467,097
Total	207,825	190,867	4,780,920	3,167,582

Table 25: Total numbers across firm margins (1998-2007)

	firm1998	firm2007	employment1998	employment2007
Entrant	0	122,544	0	831,887
Exit	75,545	0	1,419,942	0
Switch (out of manufacturing)	14,414	14,414	403,721	294,686
Switch (into manufacturing)	14,517	14,517	150,263	341,286
Switch (within manufacturing)	12,323	12,323	406,427	396,040
Expand	62,769	62,769	901,250	1,508,499
Contract	33,254	33,254	1,541,661	858,750
Total	212,822	259,821	4,823,264	4,231,148

B Results

Tables 26, 27, 28 show the predicted changes illustrated graphically in the main text.

Table 26: Predicted Change in Employment

Date	China	Birth	Death	Expand	Contract	Switch in	Switch out	All	China share
01	-129,989	-17,027	-35,464	-16,605	-33,799	-3,195	-23,899	-309,376	0.42
02	-104,754	-7,744	-28,867	-13,736	-20,207	1,683	-35,883	-351,406	0.30
03	-170,137	-6,713	-32,578	-18,527	-32,840	-11,571	-67,910	-671,993	0.25
04	-161,586	-18,084	-29,116	-13,121	-30,021	-8,328	-62,915	-876,810	0.18
05	-239,474	-22,783	-55,143	-24,152	-35,253	-19,578	-82,565	-1,055,560	0.23
06	-279,666	-23,677	-84,284	-25,652	-23,993	-22,141	-99,919	-1,136,160	0.25
07	-267,829	-20,461	-81,039	-35,083	-25,114	-20,354	-85,777	-1,266,745	0.21
08	-248,316	-21,661	-77,788	-32,274	-29,623	-19,027	-67,944	-1,408,266	0.18
09	-271,471	-23,410	-74,151	-37,287	-10,286	-17,549	-108,788	-1,479,909	0.18
10	-238,502	-23,031	-71,382	-31,188	-14,737	-12,889	-85,276	-1,714,467	0.14
11	-250,410	-20,512	-76,234	-35,289	-6,629	-15,188	-96,557	-1,786,655	0.14
12	-289,906	-24,255	-91,342	-38,660	-10,403	-20,835	-104,411	-1,807,255	0.16
13	-272,899	-23,223	-75,094	-35,084	-10,840	-17,405	-111,253	-1,826,036	0.15
14	-280,119	-25,440	-80,305	-38,873	-8,338	-14,789	-112,374	-1,841,821	0.15
15	-287,496	-20,978	-86,918	-45,579	-730	-12,889	-120,143	-1,773,876	0.16

Tables 29, 30, 31 show the first stage of the instrumental variable results, showing that the first stage is strong and significant and therefore the IV strategy is valid.

Table 27: Predicted Change in Number of Firms

Date	China	Birth	Death	Switch in	Switch out	All	China share
01	-2,277	-276	-1,666	-201	-134	-12,241	0.19
02	-2,258	-255	-1,693	-82	-228	-14,826	0.15
03	-2,425	-61	-1,970	-87	-307	-19,109	0.13
04	-2,418	-57	-1,843	71	-589	-23,002	0.11
05	-3,382	-197	-2,786	-10	-583	-26,987	0.13
06	-4,250	-516	-3,151	53	-636	-30,166	0.14
07	-3,835	-265	-3,308	138	-401	-31,341	0.12
08	-6,291	-1,293	-4,306	-299	-393	-35,967	0.17
09	-7,923	-2,176	-5,125	-166	-440	-34,559	0.23
10	-7,685	-2,221	-4,863	-106	-495	-41,344	0.19
11	-7,556	-1,968	-4,880	-171	-537	-47,010	0.16
12	-8,733	-2,433	-5,371	-216	-713	-45,201	0.19
13	-8,948	-2,630	-5,401	-237	-683	-43,070	0.21
14	-8,821	-2,634	-5,385	-164	-638	-41,583	0.21
15	-8,550	-2,531	-5,209	-144	-645	-40,042	0.21

Table 28: Predicted Change in Turnover

Date	China	Birth	Death	Expand	Contract	Switch in	Switch out	All	China share
01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-5.32e+11	0.00
02	-117,307.89	0.00	0.00	-0.00	-0.00	-0.00	0.00	-7.05e+11	0.00
03	-6263687680.00	-1.22	-1.65	0.41	3.71	1.31	-8.85	-1.08e+12	0.01
04	-1.79e+10	-3.28	-2.08	-4.03	-0.34	2.43	-10.63	-5.90e+11	0.03
05	-2.37e+10	-2.49	-2.66	-2.45	-5.06	0.38	-11.42	-6.65e+11	0.04
06	-3.07e+10	-1.01	-6.53	-6.25	-1.48	-0.29	-15.10	-7.94e+11	0.04
07	-3.09e+10	-1.45	-6.46	-4.90	-2.20	-1.98	-13.93	-7.71e+11	0.04
08	-2.81e+10	-0.14	-6.37	-5.07	-4.79	-0.31	-11.42	-6.60e+11	0.04
09	-3.17e+10	-1.33	-5.84	-4.03	-0.92	-0.50	-19.05	-7.05e+11	0.04
10	-2.95e+10	-0.87	-6.99	-9.21	4.08	-0.84	-15.70	-6.06e+11	0.05
11	-3.15e+10	0.89	-7.32	-7.96	0.69	-1.07	-16.75	-7.56e+11	0.04
12	-4.00e+10	-0.21	-10.51	-9.51	1.00	-2.56	-18.23	-7.65e+11	0.05
13	-3.94e+10	-1.51	-8.73	-5.71	-1.49	-1.80	-20.18	-6.86e+11	0.06
14	-4.41e+10	-0.86	-10.33	-7.88	-2.91	-1.14	-21.03	-6.53e+11	0.07
15	-5.05e+10	0.30	-12.13	-9.40	-3.42	-1.85	-23.97	-4.40e+11	0.11

Table 29: Annualised mid point growth in industry employment

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	9815 FS	9815 SS	9815 FS	9815 SS	9815 FS	9815 SS
imp_pen_inst9815	0.146***		0.141***		0.139***	
	(0.0177)		(0.0140)		(0.0136)	
imp_pen9815		-0.0267***		-0.0260***		-0.0262***
		(0.00369)		(0.00401)		(0.00443)
Observations	117	117	117	117	117	117
R-squared	0.795	0.332	0.831	0.347	0.834	0.351
Industry controls	NO	NO	NO	NO	NO	YES
Employment controls	NO	NO	NO	YES	NO	YES
Division cluster	YES	YES	YES	YES	YES	YES
Sample	All	All	All	All	All	All
Weight	employment	employment	employment	employment	employment	employment
First stage F		68.80		101.0		104.9

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 30: Annualised mid point growth in industry turnover

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	9815 FS	9815 SS	9815 FS	9815 SS	9815 FS	9815 SS
imp_pen_inst9815	0.129***		0.126***		0.126***	
	(0.0133)		(0.0109)		(0.0111)	
imp_pen9815		-0.0337***		-0.0335***		-0.0338***
		(0.00740)		(0.00670)		(0.00689)
Observations	117	117	117	117	117	117
R-squared	0.822	0.245	0.849	0.313	0.852	0.328
Industry controls	NO	NO	NO	NO	NO	YES
Employment controls	NO	NO	NO	YES	NO	YES
Division cluster	YES	YES	YES	YES	YES	YES
Sample	All	All	All	All	All	All
Weight	turnover	turnover	turnover	turnover	turnover	turnover
First stage F		94.21		133.4		127.2

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 31: Annualised mid point growth in industry number of firms

VARIABLES	(1) 9815 FS	(2) 9815 SS	(3) 9815 FS	(4) 9815 SS	(5) 9815 FS	(6) 9815 SS
imp_pen_inst9815	0.155***		0.142***		0.140***	
	(0.0171)		(0.0120)		(0.0130)	
imp_pen9815		-0.0126**		-0.0120**		-0.0115*
		(0.00494)		(0.00611)		(0.00690)
Observations	117	117	117	117	117	117
R-squared	0.771	0.120	0.841	0.150	0.844	0.170
Industry controls	NO	NO	NO	NO	NO	YES
Employment controls	NO	NO	NO	YES	NO	YES
Division cluster	YES	YES	YES	YES	YES	YES
Sample	All	All	All	All	All	All
Weight	firm	firm	firm	firm	firm	firm
First stage F		81.70		140.5		116.8

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Do Large Depreciations Lead to Export Booms? Facts on UK Firms in International Trade and Evidence on Exchange Rate Elasticities from the Brexit Depreciation

5.1. Introduction

Large depreciations are expected to boost exports by making domestic goods cheaper in foreign currencies and thus increasing their demand from abroad. As the quantity of the exported products rises, so does the value of total exports. This may not be the case if firms actively adjust their prices in response to a depreciation and engage in pricing-to-market. If large firms have enough market power they might take advantage the exchange rate depreciation to increase their margins in their own currency (Atkeson and Burstein, 2008). Although an increasing number of studies test these theories of pricing to market by estimating the elasticity of exports to exchange rates over a long time series (Berman, Martin, and Mayer, 2012; Fitzgerald and Haller, 2013; Corsetti, Crowley, Han, and Song, 2019), there is little evidence of the magnitude and heterogeneity in exporter pricing to market in response to large depreciations.

This paper estimates the elasticity of UK exports to the large depreciation of sterling around the Brexit Referendum and heterogeneity in this elasticity across UK exporters. The paper uses transaction level administrative Customs data for the UK sourced from HMRC to identify how each UK exporter changes their prices and quantities of exports of detailed products in a given destination. The paper finds significant evidence that firms do price to market through increasing the sterling value of their exports in response to the large depreciation, providing further evidence towards models with variable markups (Melitz and Ottaviano, 2008; Atkeson and Burstein, 2008; Corsetti and Dedola, 2005). The paper also explores differences in the responses of exporters and finds results consistent with the heterogeneous pricing to market in models such as Atkeson and Burstein (2008). This means that the largest UK exporters increase their export prices more than

smaller exporters in response to a large depreciation. A surprising finding is that the largest UK exporters increased both their export prices and export quantities more in response to the depreciation, in contrast to the theoretical predictions of Atkeson and Burstein (2008) and empirical findings of previous work by Berman et al. (2012). One possible explanation for these different results could be short run constraints on smaller exporters to increase their quantities and the impact of the contemporaneous increase in trade policy uncertainty facing UK exporters (Crowley et al., 2019).

In the immediate aftermath of the Brexit Referendum on 23rd June 2016, sterling depreciated by around 10% against all major currencies and by the end of 2016 had depreciated by over 20% relative to 2015. Figure 16 shows that the value of UK goods exports increased in the period following the Brexit Referendum. The value of UK quarterly exports in levels was on average over 20% higher in 2017 and 2018 relative to their 2015 levels. Using exchange rate pass through estimates of the effect of the change in bilateral exchange rates on firm-product-destination level export values, this paper shows that this rise in exports was driven by the large depreciation of the (trade-weighted) exchange rate in the run up to and following the Brexit referendum.

This paper finds that the 20% increase in the value of UK goods exports following the Brexit Referendum was driven primarily by higher sterling prices, rather than by larger quantities sold. Decomposing the firm-product-destination level response into price versus quantity channels, this paper finds that the response was mainly driven by increases in the price (unit values) of exports in the initial period, followed by a smaller increase in the quantity of exports in later 2017. Across all export destinations, a 10% depreciation results in a 5.4% increase in export prices and just a 1.2% increase in export quantities. These estimates are considerably larger for the price elasticity of exports compared to Berman et al. (2012) and Amiti, Itskhoki, and Konings (2014), but also significantly smaller for the quantity elasticity.

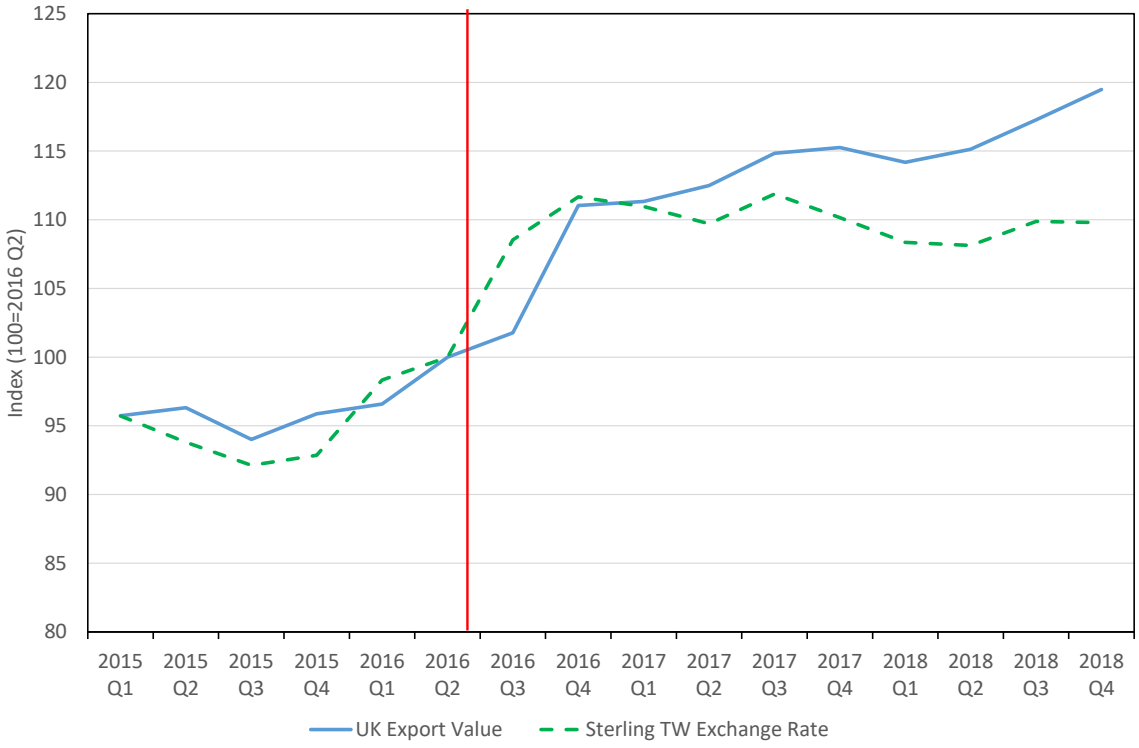
The largest exporters were most responsive to the depreciation, increasing both quantities and

prices more than smaller exporters. Since large exporters account for the lions share of the value of exports, their responses to exchange rate movements will drive the aggregate response. Importantly, this effect is not just driven by differences in the elasticity of exports to the exchange rate across industries, as the results are robust to ranking exporters within an industry. The finding that larger exporters have greater export price elasticities is consistent with the theoretical predictions of Atkeson and Burstein (2008). However, the degree of heterogeneity is much smaller than predicted by Atkeson and Burstein (2008) or found in Berman et al. (2012).

In order to better understand the sources of heterogeneity in responses across British firms, this chapter opens by developing a rich and detailed picture of the role of firms engaged in international trade in the UK economy. The chapter develops a new database linking the universe of British firms from UK Business Register (Office for National Statistics, 2017) and the universe of international trade transactions from the customs data (HMRC, 2018). The resulting dataset covers almost all international trade, employment and turnover in the UK economy.

The chapter utilises this new dataset to document the importance of UK firms in international trade as a share of economic activity. Trade in goods is concentrated in a small number of firms that account for the lion's share of exports and imports. As a result the response of the largest firms determines the aggregate response to trade shocks. Only 3% of UK firms are engaged in international trade in goods yet these firms account for over 30% of employment and over 50% of UK turnover. The top 1% of goods exporters are pivotal in shaping UK export patterns, accounting for 70% of exports, 5% of employment, and 12% of turnover.

Fig. 16. UK export value and the sterling trade weighted exchange rate (2015-2018)



Source: Bank of England.

5.2. Data and Facts on UK Firms in International Trade

Before turning to an analysis of the Brexit depreciation, the chapter documents in rich detail facts about firms directly engaged in international trade in goods as well as their key characteristics. This paper capitalises on a newly constructed dataset to shed light on the UK trade and economic landscape. The descriptive evidence also highlights the heterogeneity across firms which can then help to explain why the response to economic shocks of the largest firms may differ to smaller firms.

UK firms that are directly engaged in international trade in goods are important for the UK economy and are different from non-importing and non-exporting firms across several dimensions. While they make up only 3% of all UK firms, they account for just under a third of UK employment and more than half of UK total turnover across the economy as a whole.[63] Among these firms, a small fraction account for the lions share of trade in goods and a significant proportion of economic activity. The top 1% of exporters (just over 600 firms) make up 70% of total UK exports, 5% of UK employment, and 12% of UK turnover. Of these firms, 108 export to both EU and non-EU countries, accounting for 42% of UK exports and 53 import from both EU and non-EU countries, accounting for 25% of UK imports.

The next subsection describes firms which trade in goods in detail, highlighting stylized facts in terms of their sector composition, importance for the UK economy, and engagement as twoway traders (firms that are importers and exporters at the same time).

5.2.1. New linked firm-trade data

It is a well-established fact for developed and developing economies that firms engaged in international trade are the largest, most productive, and drive aggregate trends (Bernard, Jensen, Redding, and Schott, 2018c). With the exception of Wales, Black, Dolby, and Awano (2018), evidence on this for the UK has been missing due to hurdles linking detailed firm customs data

[63]Statistics on the importance of firms in international trade are often only reported for the manufacturing sector. This section also reports figures for the manufacturing sector, however it is also pertinent to highlight the importance of trading firms across the UK as a whole.

with corresponding business registry information. This paper constructs a new dataset which links business registry information on the universe of UK firms sourced from the ONS with their customs transactions sourced from HMRC. This dataset builds on existing work in three ways. First, this paper incorporates new firm level information into the trade in goods data. Second, the paper constructs data at the firm level using the ONS definition of an enterprise. Third, the paper assigns the value of UK trade in goods to UK SIC industries. The linked dataset contains information on every firm in the UK economy with complete information at the firm level on turnover, employment, foreign ownership, and foreign subsidiaries to complement that of firm level export and import activities.

The new linked dataset is constructed using the HMRC overseas Trade Statistics (OTS) with provides the firm, product, destination, time level import and export data. The HMRC overseas trade statistics are sourced from the customs declarations for import and export data with non-EU countries which provides data for each daily transaction and firm Intrastat declarations for EU import and export data for each month. The ONS intra-departmental business registry (IDBR) data provides the firm and time level data for employment, turnover, industry and ownership status. This is a constructed dataset from administrative HMRC data. HMRC data provides information on firm industry and turnover. HMRC PAYE data provides employment data. Companies House provides firm ownership data. The firm identifiers in each of the OTS and IDBR are specified differently due to their different administrative data sources, reflecting the different levels at which taxes are collected in the UK tax system. The firm identifiers in the OTS are the traderid (trader ID), which are the tax numbers used by trading firms on their customs forms. The firm identifiers in the IDBR are the entref (enterprise reference number), which are generated by the ONS. These are both anonymised to researchers, but provide a one to one mapping to their true identifiers. The key to linking the two datasets are the VAT numbers of firms. All trader IDs can be mapped to a unique VAT tax code (which are also reported on a customs declaration), and as the VAT data is one of the origin datasets for the IDBR, there exists a mapping from each VAT code to each enterprise reference number. The concordance here was conducted using lookups provided by the ONS and HMRC. The concordance has an a very high success rate, a small number of traderids

(and small share of trade values) do not match to VAT codes due to either incorrect VAT codes provided on customs forms, or firms that are not registered for VAT purposes in the UK (because they may be registered for VAT purposes in the EU).

5.2.2. How important are firms that trade goods in the UK?

The new linked firm-trade data documents the importance of importing and exporting firms in the UK economy. There are three main results presented in Table 32:

1. Very few firms are engaged in international trade. In the linked dataset,[64] just under 100,000 UK firms import, export or are twoway traders, accounting for just 3% of all firms in the economy. This is true even within the different sectors of the economy, which is explored in the next subsection. These results are in line with the theoretical predictions of Melitz (2003) style models, where only the most productive firms can profitably pay the sunk cost of exporting.

2. Firms that trade are disproportionately important for economic activity. The small number of importing and exporting firms make up 31% of total employment and 51% of total turnover. Following Melitz (2003) these results are unsurprising as only the most productive firms trade. The productivity advantage of firms which trade also ensures that these firms are largest in terms of employment and turnover. The facts on the importance of firms that trade goods in the UK is similar (although slightly smaller) to other advanced countries.[65]

3. Twoway traders undertake the lion's share of trade: 96% of exports and 92% of imports. They also account for the majority of employment and turnover in importing and exporting firms. Two important implications of the important role of twoway traders is first that the trade balance will be less affected if the largest exporters leave, as they are also the largest

[64] One limitation of the HMRC Customs Data is that exports (dispatches) and imports (arrivals) from the EU are only reported if a firm trades above a threshold. This excludes approximately 100,000 firms that trade small values with the EU, but these firms account for less than 3% of exports and import value to the EU.

[65] Bernard et al. (2018c) show that 35% of firms in US manufacturing export. Biscourp and Kramarz (2007) show that importing and exporting firms account for 25% of French manufacturing firms, but 89% of sales. This contrasts to 12% of UK firms in manufacturing exporting and 15% UK manufacturing firms accounting for 76% sales engaged in importing or exporting as shown in section 5.2.3.

importers. However, this does not mean there will be no effect on GDP, as these firms also have a large domestic reach and high levels of employment. Second, recognizing the role of twoway traders is important for predicting the response to future trade shocks, such as large exchange rate movements or bilateral trade (de-)liberalisation. For example, a depreciation of sterling would act both as a positive competitiveness shock on the export side, but also a negative cost shock on the import side. Therefore a depreciation could have a muted boost to exports through the imported inputs channel Amiti et al. (2014).

Table 32: Importance of importing and exporting firms in UK economy (2017)

	Firms	Employment (million)	Turnover (£billion)	Export (£billion)	Import (£billion)
Non-trader	3,090,254 (97%)	22.5 (69%)	2,626.0 (49%)	-	-
Exporter	21,427 (1%)	0.6 (2%)	184.3 (3%)	12.5 (4%)	-
Importer	36,116 (1%)	2.0 (6%)	293.1 (5%)	-	32.2 (8%)
Twoway trader	40,100 (1%)	7.6 (23%)	2,273.5 (43%)	274.4 (96%)	377.6 (92%)
Total	3,187,897	32.7 (100%)	5,376.8 (100%)	287.0 (100%)	409.8 (100%)

5.2.3. Which sectors trade goods?

Table 33 presents the distribution of economic activity and trade across different sectors of the economy. The 'Manufacturing' and 'Wholesale and Retail' sectors account for the majority of trade (80% of both exports and imports), but a much smaller share of economic activity. Analysis is limited to the sectors which are normally associated with trade in goods.

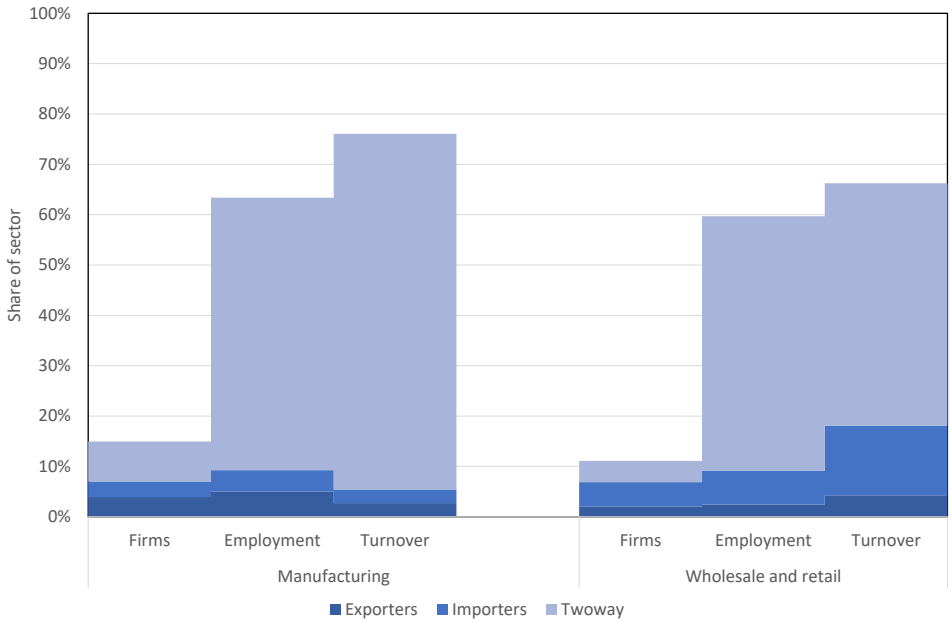
The 'Manufacturing' sector accounts for the majority (56%) of UK exports and 32% of UK imports. This is disproportionate relative to the total activity that 'Manufacturing' accounts for, with only 5% of firms; 8% of employment; and 10% of turnover (Table 2). The 'Wholesale and Retail' sector is the most dominant importing sector. It is responsible for 48% of imports and 27% of exports, yet accounts for a small proportion of activity with 14% of firms; 15% of employment; and 22% of turnover.

Table 33: Trade in goods is concentrated in manufacturing and wholesale and retail sectors (2017)

ONS SIC Sector	Sector description	Share of Firms	Share of Employment	Share of Turnover	Share of Exports	Share of Imports
A	AGRICULTURE	6.4%	1.8%	0.9%	0.3%	0.2%
B	MINING AND QUARRYING	0.1%	0.2%	0.6%	2.1%	0.3%
C	MANUFACTURING	4.7%	7.8%	9.8%	55.6%	31.7%
G	WHOLESALE AND RETAIL	13.6%	15.4%	22%	27.3%	48.1%
H	TRANSPORTATION	3.9%	4.3%	3.9%	1.7%	3%
D-F, I-R	OTHER	71.3%	70.5%	62.8%	13%	16.7%

Importing and exporting firms account for a disproportionate share of economic activity in every sector, including those which do not account for much trade. Figure 17 zooms in on Manufacturing and Wholesale and retail, as these are the most important sectors for trade in goods. In Manufacturing, only 15% of firms trade goods, with 12% of firms exporting and 11% of firms importing. These importing and exporting firms account for 63% of manufacturing employment and 76% of manufacturing turnover. The 'Wholesale and Retail' shows similar patterns, with 11% of firms engaged in international trade which account for 60% of sectoral employment and 66% of sectoral turnover. Figure 17 also illustrates the importance of twoway traders relative to only exporters or only importers in terms of their contribution to employment and turnover in the trading sectors.

Fig. 17. Share of economic activity undertaken by importing and exporting firms (2017)

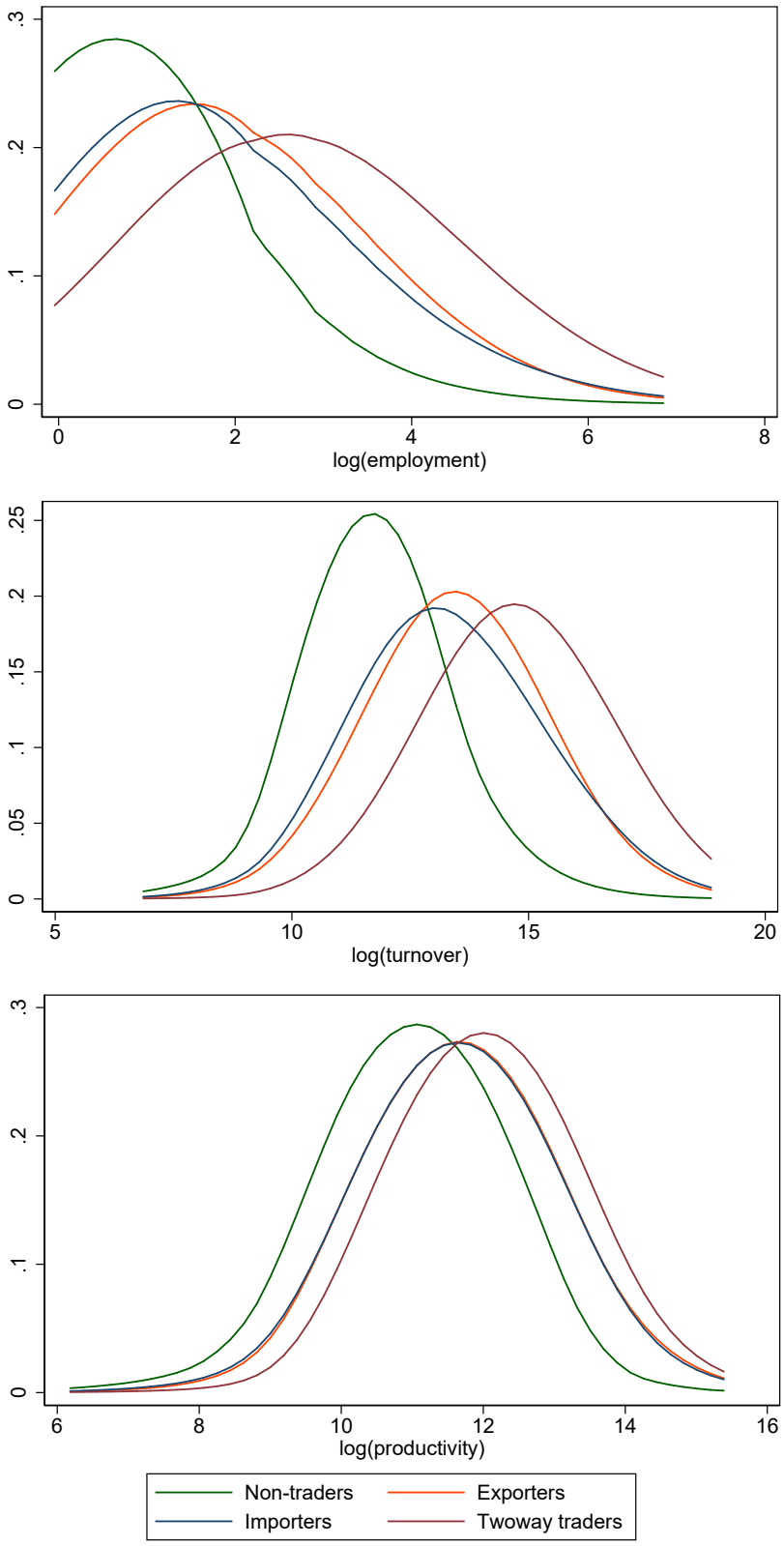


5.2.4. Are firms that trade larger and more productive?

Firms engaged in international trade are fundamentally different to other firms in the economy, even within narrowly defined sectors. Importing and exporting firms are, on average, significantly larger than non-importing and non-exporting firms in terms of turnover, employment, and productivity (where due to data limitations productivity is defined as labour productivity $productivity = turnover/employment$). This effect is driven by an entire shift of the firm size distribution, as shown in Figures 2, 3 and 4, which plot the density of firms by exporting type across the firm size and productivity distribution[66] using an Epanechnikov kernel with bandwidth of 1. These figures show that the distribution of firms that only import or only export is shifted to the right of that of non-traders. Further, the distribution of twoway traders is shifted even further to the right, with both a significantly higher average size of firms, as well as greater density of very large firms in the top of the distribution.[67]

[66]Figures trim the top and bottom 1% of the distribution for disclosure purposes.
[67]In the figure for productivity in Figure 18, the lines for importers and exporters perfectly overlap.

Fig. 18. Importing and exporting firms are larger and more productive than non-importing and non-exporting firms (kernel density plots, 2017)



The firm size and productivity premiums are estimated by regression. The regression specification is:

$$lnX_{ij} = \beta_X Exporter_i + \beta_I Importer_i + \beta_T Twoway_i + FE_j + \epsilon_{ij} \tag{25}$$

for firm i in sector j, $X \in (employment, output, productivity)$. Exporter, Importer and Twoway are equal to 1 for the relevant firm type and 0 otherwise. Non-traders are the base category. The magnitude and significance of the trading premia is relatively unaffected by the inclusion of more detailed fixed effects beyond the SIC Sector.

Table 34: Exporter, importer and twoway trader size and productivity premia (2017)

	(1)	(2)	(3)	(4)	(5)
Fixed effects	SIC Sector	SIC 2 digit	SIC 3 digit	SIC 4 digit	SIC 5 digit
Panel A: Employment					
Exporter	0.997***	1.003***	1.016***	1.029***	1.033***
	(0.00676)	(0.00668)	(0.00651)	(0.00646)	(0.00643)
Importer	0.886***	0.903***	0.942***	0.949***	0.949***
	(0.00529)	(0.00525)	(0.00512)	(0.00508)	(0.00506)
Twoway	2.011***	2.033***	2.039***	2.047***	2.048***
	(0.00502)	(0.00503)	(0.00493)	(0.0049)	(0.00488)
Observations	3,102,629	3,102,629	3,102,627	3,102,623	3,102,623
R(squared	0.146	0.173	0.218	0.234	0.241
Panel B: Turnover					
Exporter	1.632***	1.589***	1.591***	1.593***	1.596***
	(0.00932)	(0.00928)	(0.00912)	(0.00905)	(0.00902)
Importer	1.444***	1.415***	1.467***	1.476***	1.474***
	(0.0073)	(0.00729)	(0.00717)	(0.00712)	(0.00709)
Twoway	3.000***	2.950***	2.966***	2.967***	2.965***
	(0.00692)	(0.00699)	(0.00691)	(0.00688)	(0.00685)
Observations	3,095,842	3,095,842	3,095,840	3,095,836	3,095,835
R(squared	0.122	0.137	0.171	0.187	0.194
Panel C: Productivity					
Exporter	0.636***	0.587***	0.576***	0.565***	0.564***
	(0.0065)	(0.00642)	(0.00634)	(0.00629)	(0.00627)
Importer	0.558***	0.513***	0.525***	0.527***	0.526***
	(0.0051)	(0.00505)	(0.00498)	(0.00495)	(0.00493)
Twoway	0.990***	0.918***	0.927***	0.920***	0.918***
	(0.00483)	(0.00484)	(0.0048)	(0.00478)	(0.00476)
Observations	3,095,277	3,095,277	3,095,275	3,095,271	3,095,270
R(squared	0.1	0.13	0.158	0.173	0.18
Panel D: Productivity (controlling for size)					
Exporter	0.649***	0.585***	0.569***	0.558***	0.556***
	(0.00653)	(0.00645)	(0.00636)	(0.00632)	(0.0063)
Importer	0.569***	0.511***	0.519***	0.521***	0.519***
	(0.00512)	(0.00507)	(0.00501)	(0.00498)	(0.00496)
Twoway	1.016***	0.913***	0.914***	0.906***	0.903***
	(0.00496)	(0.00497)	(0.00493)	(0.00491)	(0.0049)
log(employment)	(0.0126***	0.00271***	0.00644***	0.00708***	0.00714***
	(0.000547)	(0.000547)	(0.000553)	(0.000554)	(0.000554)
Observations	3,095,277	3,095,277	3,095,275	3,095,271	3,095,270
R(squared	0.101	0.13	0.158	0.173	0.18

Importing and exporting firms are economically and statistically larger and more productive than non-importing and non-exporting firms as shown in Table 34. Within sectors, exporting only firms are 100% larger than non-importing and non-exporting firms in terms of employment, 160% bigger in terms of turnover and have 63% higher productivity than non-importing and non-exporting firms in 2017. Similar, although slightly smaller, estimates are found for firms that

only import. Twoway traders have the greatest size and productivity premium relative to non-importing and non-exporting firms. These firms are over 200% larger in terms of employment and almost 300% larger in terms of turnover than non-importing and non-exporting firms. They therefore have over double the export size premium of firms that only either export or import and their productivity premium is almost 100%. Controlling for firm size, the productivity premium increases (although the magnitude difference is economically small) across all types of importing and exporting firms. Thus, not only are importing and exporting firms significantly larger than non-importing and non-exporting firms, they also have an additional productivity premium. The estimated premia are similar, although slightly larger, than found for the US in Bernard et al. (2018c) which find an exporter premium of 111% for employment, 135% for turnover and 19% for productivity (value added over employment).

5.2.5. How concentrated is UK trade in goods?

UK goods exports are concentrated amongst the largest exporters. The top 10% of exporters (6,000 firms) account for 93% of UK exports, of which the top 1% of exporters (600 firms) account for 71%. Using the linked firm-trade data, the contribution of these top traders to economic activity shows that the top 10% of exporters are responsible for 10% of UK employment and 20% of UK turnover. These results indicate that UK goods exported are even more concentrated in the top firms than found in developing countries where the top 1% exporters account for on average 53% of exports and the top 10% exporters account for 90% of exports (Freund and Pierola, 2015). The concentration of economic activity in a small number of firms is of high policy relevance looking forward to Brexit, as the response of these granular firms to trade shocks will have aggregate implications for the UK economy more broadly speaking.

At the other end of the export distribution, the export contribution of the 1st to the 90th percentiles of exporters is relatively small, accounting for only 6% of UK exports. However, these smaller exporters still account for over 15% of all UK employment and 26% of UK turnover. Therefore, although the individual actions of these firms may not have aggregate impacts, changes that

affect exporters and importing and exporting firms more generally will have significant implications for the UK economy, even if they account for a relatively small proportion of all UK firms.

5.2.6. Who owns the most important importing and exporting firms?

Firms that import and export directly will be hit by increases in trade barriers in any Brexit scenario (tariff, non-tariff such as customs and regulatory procedures, and changes in the level and volatility of the exchange rate). The characteristics of these important traders are indicative of how they might respond to potential trade shocks. One natural angle is to ask whether they are foreign owned and/or have foreign affiliates. Table 35 shows that top exporters and importers have both a high incidence of foreign ownership and frequently have affiliates abroad. Firms which fall into both categories are among the most important in terms of employment and turnover, and these small number of firms account for a significant proportion of economic activity.

Table 35: Foreign ownership and affiliates (2017)

	Top 10% of exporters and Top 10% of importers	Top 1% of exporters and Top 1% of importers
Share foreign owned	43%	57%
Share with subsidiaries	38%	57%
Share foreign owned & subsidiaries	19%	35%

5.3. Empirical strategy

Having established the importance of trade in goods across firms in the UK economy, this chapter now turns to the main question of estimating the export elasticity to the depreciation of sterling in 2016. This section estimates the elasticity of UK exports to the large depreciation of sterling around the Brexit Referendum and heterogeneity across UK exporters.

5.3.1. Was the rise in exports mostly driven by prices rather than quantities?

First an event study methodology decomposes the quarterly value change of UK exports between 2015 and 2017 into quantity and price (unit value) channels. The paper plots the coefficients from the regression:

$$log(Y_{fidt}) = \alpha_{fid} + \sum_{t} \alpha_t D_t + \epsilon_{fidt} \tag{26}$$

where $Y_{fidt} \in \{price, quantity, value\}$ are firm f, product i, destination d in time t (quarters) level outcome variables with Q2 2016 as the base time period.

5.3.2. Was the rise in UK exports driven by bilateral exchange rates?

Second, the paper estimates bilateral exchange rate pass-through to identify the extent to which the depreciation drove the boost to UK exports. The regression estimated is:

$$log(Y_{fidt}) = \alpha_{fid} + \beta_e Exchange\, Rate_{dt} + \epsilon_{fidt} \tag{27}$$

where $Y_{fidt} \in \{price, quantity, value\}$ are firm f, product i, destination d in time t level outcome variables and $Exchange\, rate_{dt}$ is the log of the bilateral exchange rate between sterling and the currency of destination d in time t in quarters.

5.3.3. Which firms had the largest response to the exchange rate?

Finally, the paper explores whether there is heterogeneity in the elasticity to the exchange rate across firms of different sizes and hence which firms drove the increase in value following the 2016 depreciation. The regression specification:

$$log(Y_{fidt}) = \alpha_{fid} + \sum_s \beta_s size_f + \sum_s \beta_{es} size_f * Exchange\, Rate_{dt} + \epsilon_{fidt} \tag{28}$$

where $Y_{fidt} \in \{price, quantity, value\}$ are firm f, product i, destination d in time t (quarters) level outcome variables and s indicates exporter size deciles.[68] Firms are allocated to their size decile based upon their annual export values[69] and a regression is estimated including a full set of decile fixed effects and interactions between size deciles and the exchange rate to estimate heterogeneity in export elasticities.

[68]For each firm, the size decile is defined according to the firm's average size in each calendar year. A separate term with just the exchange rate is not needed as the 10 deciles include all of the firms and hence one decile interaction would need to be dropped.

[69]The exercise is also repeated using annual turnover as an alternative measure of size and finds comparable results.

5.4. Results

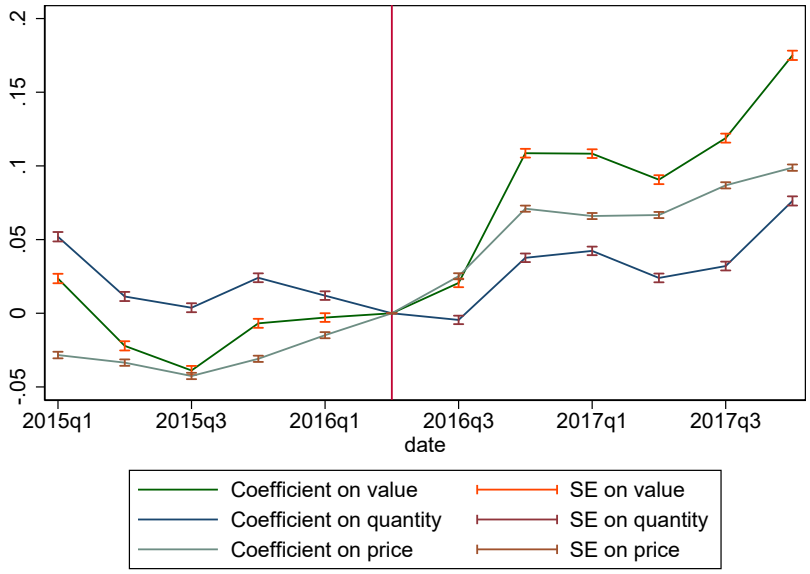
This subsection presents the results of the analysis detailed in the empirical strategy subsection.

5.4.1. The rise in exports was mostly driven prices rather than quantities

The rise in UK goods exports following the Brexit Referendum was mostly driven by an increase in export prices rather than an increase in export quantities. The response of individual transactions at the firm-product-destination level from equation 26 is plotted using UK customs data from HMRC. This granular level identifies the quantity of goods traded and unit values (value/quantity) as an approximation of prices. Figure 19 plots the event study of the evolution of values, quantities and prices to decompose the disaggregate goods export values response into the different margins of response. The point estimates are plotted using the regression coefficients and SE denotes the 95% confidence intervals.

Figure 19 shows that most of the initial value response of UK exports following the Brexit Referendum was driven by price effects. The micro level data in Figure 6 shows a faster response of export values than the aggregate data in Figure 1, with quarterly firm-product-destination level exports rising by over 10% by 2016 Q4, and rising to over 17% by 2017 Q4 relative to the 2016 Q2 level. Prices increased more quickly than quantities, rising by over 7% by the end of 2016, and by almost 10% by the end of 2017. Quantities by contrast had only increased by 5% by the end of 2016, and the most significant increase only occurred in the final quarter of 2017 by where quantities had risen by 8% relative to their pre-referendum level. The appendix shows that UK exports to both EU and non-EU markets show similar trends in Figures 21 and 22, although there is a larger price response in EU markets.

Fig. 19. Event study of firm-product-destination export response to Brexit Referendum



5.4.2. The rise in UK exports was driven by bilateral exchange rates

The increase in UK export values was driven by movements in bilateral exchange rates, with greater price elasticities than quantity elasticities with respect to the exchange rate. The rise in UK exports was driven by the depreciation of sterling shown by the elasticity of firm-product-destination level exports to bilateral exchange rates. Table 5 shows that over the 2015-2017 period, a 10% depreciation of the bilateral exchange rate between the UK and a given destination increased export values by 6.55%. Over this period, this increase was primarily driven by changes in the sterling price of the transaction, accounting for over 80% of the total value response of UK exports to the movement in the bilateral exchange rate. Quantities did also respond to movements in the exchange rate, with a 1.15% increase in quantities in response to a 10% depreciation. Table 36 also shows that there was a larger elasticity of export values to the exchange rate in EU markets than in non-EU markets.

The results in this paper provide supportive evidence towards models of variable markups and highlight the importance of pricing to market for understanding the impact of fluctuations in the exchange rates on exports. The estimates in this paper over the Brexit Referendum period differ to some of the central estimates in the literature. On the price elasticity side, the results of an

elasticity of 0.54 are significantly larger than those in Berman et al. (2012) which find that French exports have a price elasticity of 0.08, and to Amiti et al. (2014) who find that Belgian exports had a price elasticity of 0.2. One possible difference is that this paper uses data at the quarterly frequency, whereas these other papers use annual frequency, however this would not alone explain the differences. Further, this paper finds significantly smaller responses on the quantity side with an elasticity of 0.12 than Berman et al. (2012) who find a quantity elasticity of 0.4.

Fontagné, Martin, and Orefice (2018) stress that to estimate the pure trade cost elasticity for the change in quantity of exports to a change in the exchange rate then the impact on export prices must be accounted for. In their paper they are able to use a firm specific cost shock in the form of firm specific electricity prices to instrument for export prices when estimating the elasticity of firm export quantities to the exchange rate this thesis does not have access to such an instrument. Therefore the results presented here should be cautiously interpreted as descriptive elasticities with respect to the exchange rate shock in question, rather than the underlying trade cost elasticities.

Table 36: Regression coefficient estimates of export elasticity to exchange rate (2015-2017)

	(1)	(2)	(3)
VARIABLES	Value	Quantity	Price
Panel A: All exports			
Exchange rate	0.655***	0.115***	0.540***
	(0.00426)	(0.00425)	(0.00295)
Observations	12,293,201	12,293,201	12,293,201
R-squared	0.877	0.895	0.876
Sample	All	All	All
FE	firm-product-destination	firm-product-destination	firm-product-destination
Panel B: EU exports			
Exchange rate	0.765***	0.159***	0.606***
	(0.00505)	(0.00479)	(0.00339)
Observations	9,592,626	9,592,626	9,592,626
R-squared	0.862	0.892	0.854
Sample	EU	EU	EU
FE	firm-product-destination	firm-product-destination	firm-product-destination
Panel C: Non-EU exports			
Exchange rate	0.311***	-0.0225**	0.333***
	(0.00762)	(0.00915)	(0.00596)
Observations	2,700,575	2,700,575	2,700,575
R-squared	0.784	0.879	0.911
Sample	Non-EU	Non-EU	Non-EU
FE	firm-product-destination	firm-product-destination	firm-product-destination

Notes: An increase in the exchange rate is a depreciation. All variables are in logarithms. Robust standard errors in parenthesis. ***significant at 1% level Source: HMRC Trade in Goods, Bank calculations.

5.4.3. The response of large firms is greatest to movements in the exchange rate

The largest firms were the most responsive to movements in exchange rates around the Brexit Referendum, with monotonic increases in export elasticities moving up through the export size deciles. Figure 20 plots the regression coefficient results for the value, quantity and price elasticities (regression table in appendix). The largest exporters, measured by either export value or turnover, have statistically larger export elasticities,[70] with the top decile increasing exports by 6.8% in response to a 10% depreciation, and the bottom decile only increasing exports by 5.7%. The heterogeneous elasticity is driven by responses in both unit values and quantities, with larger differences across the deciles for quantity elasticities. In particular, the price elasticity accounts for 95% of the smallest firms' total value elasticity and 80% of the largest firms' value elasticity.

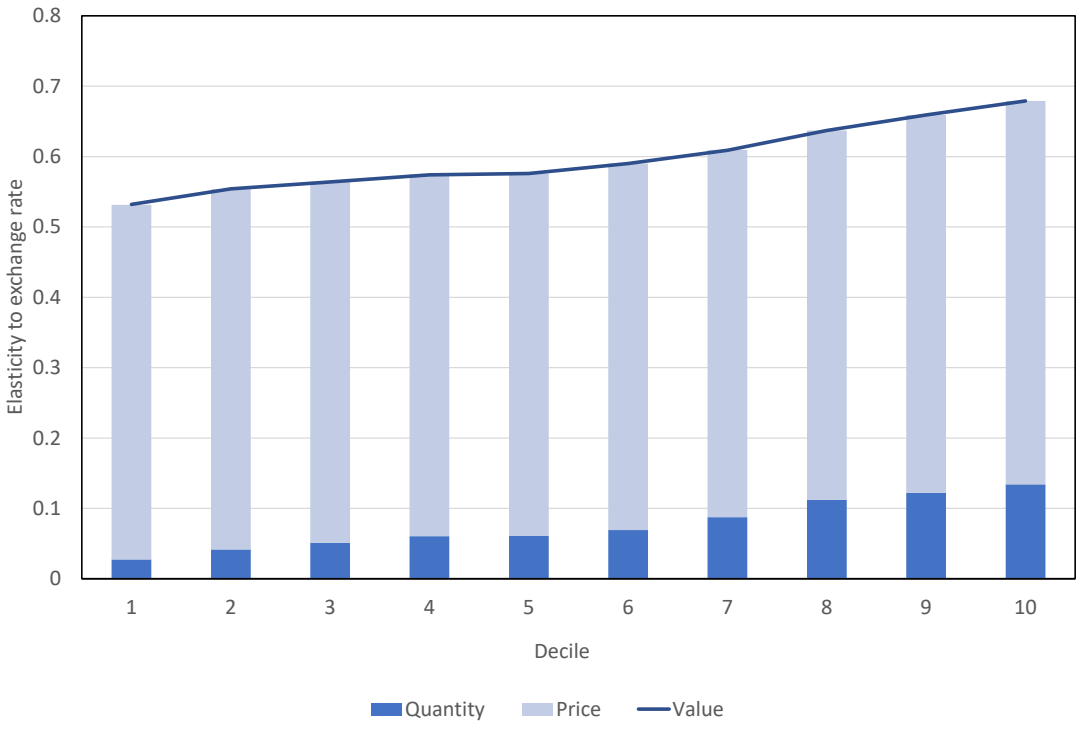
The heterogeneous elasticities across exporters of different sizes is not entirely driven by a selection effect across industries. Some industries may be dominated by large exporters (e.g. cars), whereas others may have many small exporters (e.g. agriculture). If these industries also have different responsiveness to relative prices then this could drive the heterogeneous size effect. Size percentiles are recalculated within 2 digit SIC industries and the analysis repeated (results in appendix). A similar pattern is found in the results, with very little change to the elasticities in the top deciles, although there is a lower gradient of elasticities across all the deciles. This suggests small evidence of selection effects, where the industries with small exporters have lower export elasticities to the exchange rate.

The result that the largest exporters respond relatively more on quantities than prices relative to small exporters is surprising (Berman et al. (2012); Atkeson and Burstein (2008)). These papers find that the largest exporters with the most market power increase markups in response to a depreciation and hence see a smaller quantity response for these firms. There are two possible explanations for why the results around the Brexit referendum could differ. First, this paper looks at a short time period where capacity constraints may bind more for the smallest exporters,

[70] The analysis formally tested for the differences in statistical significance of the result, and finds that the elasticities across all of the deciles are statistically significant.

whereas large exporters are able to increase production to respond to the increased competitiveness. Second, large exporters (which are presumably more profitable) may be more willing to pay sunk cost investments to expand supply in a period of high uncertainty as these would make less of a dent in their overall profit-loss statements.

Fig. 20. Elasticity of value, quantity and price to exchange rate by exporter size decile (2015-2017)



5.5. Conclusion

This paper shows that the depreciation of sterling following the Brexit referendum announcement in 2016 stimulated an increase in UK exports. This was primarily caused by an increase in prices, which account for 80% of the increase in export values at the firm-product-destination level. This suggests that firms do price to market through actively changing the sterling value of their exports in response to the large depreciation. Export quantities also increased following the Referendum, with some evidence of a more significant increase towards the end of 2017. However, the depreciation of sterling between 2015 and 2016 has a significantly lower impact on export quantities than typically found in the literature (Berman et al., 2012). Finally, the largest exporters increased exports the most in response to movements in the bilateral exchange rate around the Brexit referendum, with more elastic price and especially quantity responses. The evidence of greater pricing to market of the largest exporters is consistent with models of heterogeneous pricing to market such as Atkeson and Burstein (2008), however the quantity response is unexpected.

In the event of a no-deal or hard Brexit scenario, it is likely that sterling will further depreciate. The analysis in this paper has several implications for this scenario. First, a large depreciation will increase the value of UK exports, but predominantly through prices rather than quantities. Second, the largest exporters will benefit most from the depreciation, increasing values, quantities and prices by more than smaller exporters. Third, since the largest firms are not only most responsive to changes in economic competitiveness but also more likely to be foreign owned, have foreign subsidiaries and be embedded in global value chains, they may be the most likely to exit from the UK in response to increased trade barriers facing UK exporters to foreign markets. If this were to happen, the aggregate elasticity of UK exports to future movements in the exchange rate could be different (the results of this paper suggest that the elasticity would probably be lower).

5.6. Appendix

A EU and non-EU export response (2015-2017)

The following figures present the event study decomposition for separate EU and non-EU samples, where again the point estimate is plotted and SE represents the 95% confidence interval.

Fig. 21. Event study of firm-product-destination export response to Brexit Referendum (EU)

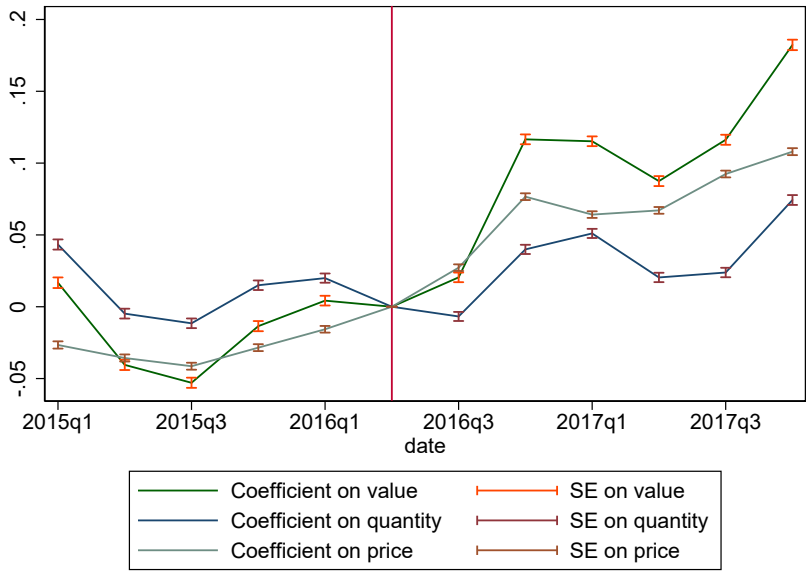
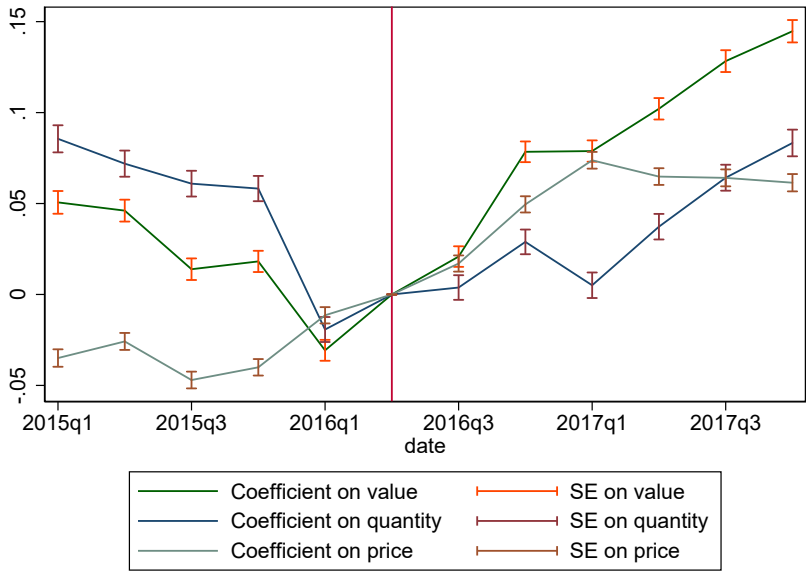


Fig. 22. Event study of firm-product-destination export response to Brexit Referendum (nonEU)



B The response of large firms is greatest to movements in the exchange rate

Table 37: Regression coefficient estimates of export elasticity to exchange rate split by exporter size decile (2015-2017)

	(1)	(2)	(3)
VARIABLES	Value	Quantity	Price
Decile 2	0.486***	0.332***	0.154***
	(0.0345)	(0.0385)	(0.0313)
Decile 3	0.724***	0.525***	0.198***
	(0.0371)	(0.04)	(0.0323)
Decile 4	0.992***	0.754***	0.239***
	(0.0393)	(0.0415)	(0.0331)
Decile 5	1.241***	0.947***	0.293***
	(0.0409)	(0.0427)	(0.034)
Decile 6	1.504***	1.172***	0.332***
	(0.042)	(0.0437)	(0.0345)
Decile 7	1.798***	1.451***	0.348***
	(0.0428)	(0.0442)	(0.0348)
Decile 8	2.062***	1.691***	0.371***
	(0.043)	(0.0444)	(0.0349)
Decile 9	2.318***	1.896***	0.422***
	(0.0432)	(0.0446)	(0.0349)
Decile 10	2.557***	2.076***	0.481***
	(0.0433)	(0.0447)	(0.035)
Exchange rate*Decile 1	0.532***	0.0274*	0.504***
	(0.0144)	(-0.0163)	(0.0129)
Exchange rate*Decile 2	0.554***	0.0416***	0.512***
	0.00974	(0.0115)	(0.00847)
Exchange rate*Decile 3	0.564***	0.0511***	0.513***
	(0.00821)	(0.00927)	(0.00723)
Exchange rate*Decile 4	0.574***	0.0605***	0.514***
	(0.00725)	(0.00806)	(0.00572)
Exchange rate*Decile 5	0.576***	0.0608***	0.515***
	(0.00642)	(0.00695)	(0.00482)
Exchange rate*Decile 6	0.590***	0.0692***	0.521***
	(0.0057)	(0.00604)	(0.00414)
Exchange rate*Decile 7	0.609***	0.0875***	0.522***
	(0.00512)	(0.0053)	(0.00363)
Exchange rate*Decile 8	0.637***	0.112***	0.525***
	(0.00471)	(0.0048)	(0.0033)
Exchange rate*Decile 9	0.659***	0.122***	0.537***
	(0.00444)	(0.00447)	(0.00309)
Exchange rate*Decile 10	0.679***	0.134***	0.545***
	(0.0043)	(0.00429)	(0.00298)
Observations	12,293,201	12,293,201	12,293,201
R-squared	0.877	0.895	0.877
Sample	All	All	All
FE	fpd	fpd	fpd

Notes: An increase in the exchange rate is a depreciation. Size deciles calculated as annual export values at the firm level across all industries. All variables are in logarithms. Robust standard errors in parenthesis. ***significant at 1% level Source: HMRC Trade in Goods, Bank calculations.

Table 38: Regression coefficient estimates of export elasticity to exchange rate split by exporter size decile (2015-2017)

	(1)	(2)	(3)
VARIABLES	Value	Quantity	Price
Decile 2	0.402***	0.304***	0.0978***
	(0.0328)	(0.0359)	(0.0274)
Decile 3	0.692***	0.531***	0.161***
	(0.036)	(0.0381)	(0.0288)
Decile 4	0.925***	0.727***	0.198***
	(0.0378)	(0.0394)	(0.0295)
Decile 5	1.172***	0.964***	0.209***
	(0.039)	(0.0405)	(0.0302)
Decile 6	1.355***	1.126***	0.229***
	(0.0395)	(0.0409)	(0.0304)
Decile 7	1.549***	1.308***	0.241***
	(0.0399)	(0.0411)	(0.0306)
Decile 8	1.722***	1.452***	0.270***
	(0.0401)	(0.0413)	(0.0307)
Decile 9	1.886***	1.589***	0.297***
	(0.0402)	(0.0414)	(0.0307)
Decile 10	2.106***	1.762***	0.344***
	(0.0404)	(0.0415)	(0.0308)
Exchange rate*Decile 1	0.574***	0.0498***	0.524***
	(0.0135)	(0.0156)	(0.0115)
Exchange rate*Decile 2	0.575***	0.0510***	0.524***
	(0.00888)	(0.0101)	(0.00736)
Exchange rate*Decile 3	0.594***	0.0717***	0.522***
	(0.00763)	(0.00853)	(0.00604)
Exchange rate*Decile 4	0.595***	0.0687***	0.526***
	(0.00658)	(0.00725)	(0.00501)
Exchange rate*Decile 5	0.609***	0.0850***	0.524***
	(0.00589)	(0.00635)	(0.00432)
Exchange rate*Decile 6	0.610***	0.0833***	0.527***
	(0.00527)	(0.00554)	(0.00375)
Exchange rate*Decile 7	0.623***	0.0947***	0.529***
	(0.00487)	(0.00503)	(0.00341)
Exchange rate*Decile 8	0.641***	0.112***	0.529***
	(0.0046)	(0.00468)	(0.00321)
Exchange rate*Decile 9	0.653***	0.116***	0.537***
	(0.00441)	(0.00445)	(0.00307)
Exchange rate*Decile 10	0.679***	0.134***	0.546***
	(0.0043)	(0.0043)	(0.00298)
Observations	12,293,201	12,293,201	12,293,201
R-squared	0.877	0.895	0.877
Sample	All	All	All
FE	fpd	fpd	fpd

Notes: An increase in the exchange rate is a depreciation. Size deciles calculated as annual export values at the firm level across 2 digit SIC industries. All variables are in logarithms. Robust standard errors in parenthesis. ***significant at 1% level Source: HMRC Trade in Goods, Bank calculations.

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