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# Export-platform FDI and Brexit Uncertainty

Nicolo' Tamberi Department of Economics, University of Sussex nt248@sussex.ac.uk

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Nicolo' Tamberi

UK Trade Policy Observatory Department of Economics, University of Sussex email: nt248@sussex.ac.uk

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#### Abstract

This paper analyses the effect of Brexit uncertainty on export-platform FDI in the United Kingdom. First, I develop a partial equilibrium framework with heterogeneous firms that involves the trade policy uncertainty about access to the EU. Second, I derive a difference in differences equation that I test empirically using data on manufacturing FDI up to 2018. Results show that trade policy uncertainty negatively impacted on firms' decision to invest in export-platform activities in the UK, and there is some evidence that firms preferred to locate in the continent. I estimate the effect of trade policy uncertainty as a reduction of around 13.5% export-platform FDI projects.

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## 1 Introduction

This paper investigates the impact of the uncertainty generated by the Brexit referendum on export-platform (EP) foreign direct investments (FDI) in the United Kingdom. The contribution is twofold: first I develop a partial equilibrium framework. Second, I test the model empirically to find evidence of Brexit uncertainty on export-platform FDI and finally I quantify the effect.

Against all expectations, in June 2016 the United Kingdom voted to leave the European Union. Many argued that this represents the most important change for the country since the accession to the union, and that it will have significant consequences for the British economy. All but one of the studies on the consequences of Brexit predict a decline for the British economy given by the increase in trade frictions with the European Union, the closest and largest commercial partner of the UK.<sup>12</sup>

When the British government triggered Art. 50 and formally commenced the departure process, the UK was supposed to leave the union in two years, as the treaty of the European Union legislates.<sup>3</sup> However, for almost three years after the triggering of Art. 50, the UK did not leave the European Union, and it is just about to enter the transition period in 2020. During these three years no formal changes to legislation and trade relation took place, and in principle the EU-UK relations remained unchanged. However, the referendum triggered a great deal of uncertainty. The British government changed three prime ministers in less than three years, an event rarely seen in the London Parliament. Governments repeatedly failed to pass an exit bill through Parliament, adding uncertainty to the future relation with the union. Baker, Bloom and Steven J Davis (2016) provide an interesting way of measuring economic policy uncertainty by browsing newspaper articles reporting words related to economic uncertainty. <sup>4</sup> Figure 1 shows the economic policy uncertainty index for the United Kingdom from Jan 2000 to Jan 2020. While before the referendum the index was stable at relatively low levels, uncertainty increased sharply in June 2016 and remained at sustained level thereafter.

 $<sup>^{1}</sup>$ The only study that predicts a welfare gain for the UK is Minford (2015). See Sampson et al. (2016) for a detailed critique.

 $<sup>^{2}</sup>$ For a summary of the studies on the consequences of Brexit, see table 1 in Gasiorek, Serwicka and Smith (2019).

 $<sup>{}^3</sup>See \ https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX\%3A12012M050$ 

<sup>&</sup>lt;sup>4</sup>See the website www.policyuncertainty.com



#### Figure 1: UK Economic Policy Uncertainty Index

The picture tells two stories. The first one is that the referendum triggered uncertainty, and that this is not confined to the referendum month only. Second, the referendum result arrived unexpectedly. To reiterate on this last point, figure 2a plots the probability of the leave vote winning from May 2015 until one day before the referendum (data from oddschecker.com). The time series shows that the market implied probability of leave was relatively low in the year to the referendum – always below 50% – and that the result arrived unexpectedly. The consequences have been an abrupt increase in uncertainty that has been reflected in the depreciation of the pound sterling, which never returned to pre-referendum levels. Figure 2b shows the spot exchange rate with the US dollar and the Euro (data from the Bank of England), with the vertical dashed line representing the referendum date. There is an extensive literature on the negative impact of uncertainty on economic activity, with a strong focus on how investment decisions are affected by uncertainty. In a similar fashion, the recent literature in international trade emphasizes the role of trade policy uncertainty as a deterrent for international trade. Handley (2014) and Handley and Limao (2015) developed a theoretical framework to analyse empirically the impact of trade policy uncertainty on the firm's decision to export. In the context of Brexit, Crowley, Exton and Han (2018) and Graziano, Handley and Limão (2018) find evidence that uncertainty deterred firms from exporting to the European Union. Other authors (Serwicka and Tamberi (2018) and Breinlich et al. (2019)) looked at how the Brexit referendum affected aggregate foreign direct investments to and from the UK, although these studies do not model uncertainty explicitly. In this paper, I investigate the impact of trade policy uncertainty on a particular type of FDI, namely export-platform FDI (EP FDI). These are firms that settle production facilities in one country within the European market and use that as a platform to sell to other countries. Since these firms export from the UK to the EU, they will be



#### Figure 2: Leave Probability and Exchange Rate

directly affected by the trade policy uncertainty surrounding the Brexit process. There is both anecdotal and empirical evidence suggesting that export-platform FDI are relevant for the British economy (see Kneller and Pisu (2004)). The English language, low corporate tax and legislation based on common law which governs international contracts make the UK a natural candidate as a platform within the EU. The most prominent users of this strategy are probably Japanese firms. Car manufacturers such as Honda and Toyota came to the UK in the 80s with the aim to sell to the whole European market. Hiroaki Nakanishi, chairman of the board of Hitachi, wrote on the Financial Times: 'We invested in [the UK] as the best base for access to the entire EU market'.<sup>5</sup> The Japanese government's letter to the United Kingdom<sup>6</sup> clearly stated that for Japanese firms in the UK frictionless access to the European market is vital for their firms.

## 2 Related Literature

#### 2.1 Export-platform FDI

Different authors have investigated theoretically export-platform investments. While initial FDI theory such as Markusen (1984) and Markusen (2004) relies on a two-country framework, models that allow for export-platform must consider a minimum of three countries. In general, the rationale for FDI arises from the trade off between variable and fixed costs that the firm incurs. There are two main ways in which EP FDI emerges in these models, and they both depend on location-specific cost functions. The first approach is based on differences in production costs across countries. This is what Ekholm, Forslid and Markusen (2007) do, where firms from a rich North country, operating in Cournot duopoly, can settle production facilities in the low wage South and then export from

 $<sup>^5 \</sup>rm Article$  'Japanese investors in Britain depend on the links to Europe', Hiroaki Nakanishi, May 11 2016. Link: https://www.ft.com/content/047c7416-12b9-11e6-91da-096d89bd2173

<sup>&</sup>lt;sup>6</sup> Japan's Message to the United Kingdom and the European Union', available online at https://www.mofa.go.jp/files/000185466.pdf

there to the North. In Yeaple (2003), EP FDI arises because of the same rationale, but this time with monopolistic competitive markets. The second approach depends on differences in trade costs across countries, and it explains how trade liberalisation between two countries can trigger EP investments from third countries. Motta and Norman (1996), probably the first to analyse EP FDI, applies this rationale and show with a game-theoretic model how economic integration can attract export-platform investment from foreign countries to take advantage of lower trade costs. In these kinds of models EP can take place even with identical countries in terms of size and production costs. In the same spirit, Ito (2013) develops a four-country model with homogeneous monopolistic competitive firms and two stages of production, and shows how export-platform can arise for final or intermediate goods, always because of differences in trade costs. Moving to models with heterogeneous firms a la M. J. Melitz (2003), one of the most comprehensive models is Grossman, Helpman and Szeidl (2006). In a three-country framework with two in the North and one in South, firms can choose among a wide range of integration strategies depending both on trade and production costs. Moreover, because firms are differentiated by productivity, multiple strategies can coexist within the same country and industry. Since the aim of this paper is to investigate the effect of the Brexit uncertainty on export-platform in the UK, I focus on differences in trade costs rather than in wages. This will allow me to keep the model parsimonious and concentrate only on trade costs, which is the main variable at stake in the future UK-EU trade relation. The EP model that I use is similar to the one presented in Mrazova and Neary (2011).

#### 2.2 Uncertainty

Uncertainty always had a prominent position in economics, both among policy makers and academics, and the literature on uncertainty and investment is vast. In international economics, the focus has been primarily on exchange rate uncertainty, as this phenomenon strongly characterised the end of the 20th century. One of the first to analyse the effect of exchange rate uncertainty on FDI is Cushman (1988), which develops a firm-level model where exchange rate uncertainty interacts with trade linkages and financing options. Campa (1993) constructs a model based on the real option theory, in which exchange rate uncertainty generates an option value to wait and reduces investments. Always using real option theory, the model of Baldwin and Krugman (1989) looks at how firms' entry and exit decisions from the export market are affected by exchange rate uncertainty. Models of real options, for which the main reference is Dixit and Pindyck (1994), are based on the idea that investment projects involve some sunk costs and that they can be delayed. More recently, the papers of Handley (2014) and Handley and Limao (2015) apply real option theory to trade models with heterogeneous firms and monopolistic competition to analyse firms' decision to export under trade policy uncertainty. One of the main advantages of the Handley (2014) and Handley and Limao (2015) framework is that it offers a simple and intuitive equation that can be tested empirically. The identification strategy relies on potential tariff increase, which differs across sectors and lends itself to a difference in differences approach. In the Brexit context, two papers investigated the role of trade policy uncertainty on British firms' decision to export to the EU. Graziano, Handley and Limão (2018) looks at the pre-referendum period, and measuring uncertainty on the referendum results using betting odds finds evidence of reduced entry in exporting. On the other hand, Crowley, Exton and Han (2018) studies entry and exit in the six months following the referendum, and again finds evidence of a negative impact of uncertainty. This paper draws from this recent literature and applies a similar modelling of uncertainty to the export-platform strategy.

## Part I

## Theory

## 3 Supply and Demand

Consider a world composed of three economies N,  $E_1$  and  $E_2$ . The two countries  $E_1$  and  $E_2$  form the ECU customs union, and trading within the ECU is cheaper than between ECU and N. There is only one stage of production and countries are homogeneous in size and wages. These simplifying assumptions allow me to focus only on trade costs between and within the customs union. Note that a single stage of production and same wages across countries rule out the possibility of intra-ECU FDI that are not horizontal. To allow for this intra-ECU vertical or exportplatform FDI I need either to make  $E_1$  different from  $E_2 - e.g.$ , in wages or sunk costs – or to consider more than one production stage. However, I keep this analysis for later as I want to put emphasis on trade costs here. The focus is on the choices of a firm in country N that wants to sell to the whole ECU market under different sales strategies.

The utility function of the representative consumer is given by  $U = Q^{\mu}q_0^{1-\mu}$ , and is identical across countries (indicated by subscript *i*), with  $q_0$  being the numeraire good freely traded internationally. Q is the sub-utility index for the differentiated goods with constant share of expenditure  $\mu$ . Preferences across varieties v are given by a CES utility function:

$$Q = \left[\int q_v^{\rho} dv\right]^{1/\rho}$$

The common elasticity of substitution across varieties is  $\sigma = 1/(1-\rho) > 1$ . Each country *i* has the same income *Y*. Consumers face the price  $p_{iv}$  and their optimal demand for each variety in each country is:

$$q_{iv} = \frac{\mu Y_i}{P_i} \left(\frac{p_{iv}}{P_i}\right)^{-\sigma}$$

where  $P_i = \left[\int p_{iv}^{1-\sigma} dv\right]^{1/(1-\sigma)}$  is the CES price index, exogenous to the firm in this partial equilibrium setting. The price faced by consumers is inclusive of iceberg trade costs (including tariffs)  $\tau_{iV} \ge 1$ , which equals 1 in the case of domestic sales. Note that trade costs are not specific to the firm v but rather to the group of products V. The price received by firms in industry V is therefore  $p_{iv}/\tau_{iV}$ .

On the production side, there are monopolistic competitive firms heterogeneous in their productivity. Let  $c_v$  be

the unit labour cost requirement such that  $1/c_v$  represents productivity. With w being salary, variable costs are given by  $c_v w$ . Considering trade costs, the operating profits that firms maximise is  $\pi_{iv} = (p_{iv}/\tau_{iV} - c_v w)q_{iv}$ . The profit maximising price is the constant mark-up over marginal cost  $p_{iv} = c_v w/\rho$ , so that the consumer is charged this optimal price augmented by the tariff:

$$p_{iv} = (c_v w/\rho)\tau_{iV}$$

Substituting the optimal price in the profit function yields the following maximised profit function:

$$p_{iv}q_{iv}/\tau_{iV} = \tau_{iV}^{-\sigma}c_v^{1-\sigma}(1-\rho)\mu Y_i\left(\frac{w}{\rho P_i}\right)^{1-\sigma}$$

Let the exogenous part be  $A_i = (1 - \rho)\mu Y_i \left(\frac{w}{\rho P_i}\right)^{1-\sigma}$  such that profit can be rewritten as:

$$\pi_{iv} = \tau_{iV}^{-\sigma} c_v^{1-\sigma} A_i$$

#### 3.1 Different Modes of Supply

Trade within the customs union – i.e., between  $E_1$  and  $E_2$  – incurs iceberg trade cost  $\tau$ , while trade outside the union faces cost  $\tau_I > \tau$ , hence trade within the union is cheaper than trade outside the union. Under these settings, a firm from country N has three options to serve the foreign ECU market:

- 1. Export to both  $E_1$  and  $E_2$  and face the external trade cost  $\tau_I$  (strategy X);
- 2. Locate facilities in  $E_1$  ( $E_2$ ) and export from there to  $E_2$  ( $E_1$ ) paying the internal trade cost  $1 < \tau < \tau_I$  (strategy EP);<sup>7</sup>
- 3. Locate facilities in both E1 and E2 (H-strategy).<sup>8</sup>

These strategies differ in the initial sunk costs – increasing from X to H – and in variable (trade) costs – decreasing from X to H. The choice of the optimal strategy depends on the firm's productivity, which has a cumulative distribution function  $G_V(1/c)$ . Following Helpman, M. Melitz and Rubinstein 2008, assume that there are no sunk costs to enter the domestic market so that I can concentrate only on serving the foreign market. In each industry V there will be a mass of firms  $n_V$ , and only a fraction of those will serve the ECU market. This fraction will depend on the productivity distribution and cut-offs. Let's now focus on a specific firm so that I can drop the subscript v. Furthermore, making N,  $E_1$  and  $E_2$  identical in terms of wage, size and income I can drop the destination country

<sup>&</sup>lt;sup>7</sup>With symmetric countries, a firm from country N choosing strategy EP is indifferent between settling in country  $E_1$  or  $E_2$ . Including more than two countries in the customs union  $(E_3, E_4, ...)$  with renegotiation taking place between  $E_1$  and the rest of the bloc will have a larger effect on the renegotiating country.

<sup>&</sup>lt;sup>8</sup>I am ruling out the possibility for firms to re-import from the parent country (i.e., vertical FDI). This happens because same wages across countries and trade costs do not make this strategy viable for any productivity level. This strategy appears to pertinent when there are strong differences in wages between the parent and host country and when the host's market is irrelevant. This description does not seem to fit the UK therefore vertical FDI should not be a large portion of UK's inward FDI.

subscript i. The problem of the firm is to choose the strategy s that maximises its value net of sunk costs, given its productivity level:

$$\Pi(c) = \max\left[0, \Pi_s(c) - F_s\right]$$

where  $F_s$  is sunk costs for strategy s. I follow Mrazova and Neary 2011 for the structure of fixed sunk costs, which have to be paid only when the firm enters the market. Here I do not consider per period sunk costs, hence exit from the market occurs only exogenously. A firm that wants to export to one ECU country incurs in sunk costs  $f_X$ , so that total sunk costs of strategy X are  $F_X = 2f_X$ . Settling in the foreign country implies sunk costs  $f_F > f_X$ , hence strategy H involves  $F_H = 2f_F$  sunk costs. Finally, sunk costs for strategy EP lay in between these two and are  $F_{EP} = f_F + f_X$ . Note that this structure is easily generalisable to include more than two countries in the ECU market, and I will come back to this later. I can now write the profit function under each strategy. For strategy X, the profit function is given by:

$$\pi_X = c^{1-\sigma} A \cdot 2\tau_I^{-\sigma} - F_X$$

On the other hand, under strategy EP the firm sells with no trade costs in the host countries and pays  $\tau$  for the other ECU country:

$$\pi_{EP} = c^{1-\sigma}A \cdot (1+\tau^{-\sigma}) - F_{EP}$$

Finally, strategy H does not involve any trade cost and its profit function is:

$$\pi_H = c^{1-\sigma} A \cdot 2 - F_H$$

It should be clear that these profit functions are increasing in sunk costs as  $F_X < F_{EP} < F_H$  and decreasing in variable costs since  $2\tau_I^{-\sigma} < 1 + \tau^{-\sigma} < 2$ . We are now ready to introduce the dynamics of uncertainty in the model and analyse the entry decision of firms with different strategies under different market conditions.

#### 3.2 Timeline

Consider a three periods model, with each period divided in many sub-periods. In each sub-period there is a wave of new firms arriving that have to choose how to serve the ECU market. In the first period (named D, for deterministic) there is no uncertainty and firms have all the information they need to take the optimal decisions. In the second period U (for uncertainty), the trade policy internal to the ECU market is renegotiated, and this creates uncertainty over the new policy that will be in place in period R (for resolution). Although firms do not know the future trade policy in period U, they form expectations. When negotiations end, we enter in period R. Uncertainty is now over and all variables are known, so firms arriving in this period behave as in period D but with a new information set. Then period R continues to infinity. Figure 3 below shows the timeline.



The new entrant has three options to serve the ECU market: exports (X), export-platform FDI (EP) and horizontal FDI (H). The only strategy directly affected by uncertainty in period U is EP as it involves intra-ECU trade costs which are subject to uncertainty, while strategies X and H are only indirectly affected.

Before proceeding with the modelling, I should write few words on the uncertainty setting. The majority of models that study investment under uncertainty consider a recurring uncertainty, affecting the firm behaviour in every period (e.g., McDonald and Siegel 1986, Baldwin and Krugman 1989, Handley (2014) and Handley and Limao 2015), while here I consider a once and for all policy change. Although this might look like an *ad hoc* choice in relation to the Brexit case, I argue that it reflects more accurately the dynamics internal to a customs union. Indeed, the main point raised by Handley and Limao 2015 – both theoretically and empirically – is that a credible trade agreement provides, along with trade costs reduction, the removal of uncertainty. In any case, results are robust to continued uncertainty after a trade agreement is signed.

### 4 Deterministic Period

A firm that arrives in the deterministic period D knows all the relevant information and chooses its strategy in order to maximise profits given its productivity which is randomly drawn from a distribution G(c). Furthermore, a firm entering in period D does not expect any renegotiation, which arrives totally unexpected, and it exits the market only if hit by the random death shock  $\delta$ . Therefore, the value of each strategy  $s \in S = [X, EP, H]$  for a firm arriving in D is given by  $\Pi_s = \sum_{t=0}^{\infty} \beta^t \pi_s(c) - F_s$  which is a geometric series, so I can find its sum:

$$\Pi_s = \frac{\pi_s(c)}{1-\beta} - F_s$$

where  $\pi_s(c)$  is profits,  $\beta = (1-\delta)/(1+r) \in [0,1]$  is the discount factor – including both the probability of death and the time preference r – and  $F_s$  represents the sunk costs. Now let  $\pi_s = c^{1-\sigma}A\nabla_s$ , where  $\nabla_s$  is the part of profits given by trade costs, which is strategy-specific (for strategy X  $\nabla_X = 2\tau_I^{-\sigma}$ , for EP it is  $\nabla_{EP} = 1 + \tau^{-\sigma}$  and for H  $\nabla_H = 2$ ). I can find the productivity cut-off that determines the entry condition for a strategy s setting  $\Pi_s = 0$ :

$$c_s^{1-\sigma} = \frac{F_s}{\nabla_s} \frac{1-\beta}{A}$$

To find the productivity cut-off between two strategies, call them s1 and s2, with  $\nabla_{s1} < \nabla_{s2}$  and  $F_{s1} < F_{s2}$ , set  $\Pi_{s2} = \Pi_{s1}$  and solve for  $c^{1-\sigma}$ :

$$c_{s2-s1}^{1-\sigma} = \frac{F_{s2} - F_{s1}}{\nabla_{s2} - \nabla_{s1}} \frac{1-\beta}{A}$$

that is, the difference in intercepts over the difference in slopes in the  $\Pi$ - $c^{1-\sigma}$  space, multiplied by the common factor. Going back to the three strategies available to the firm in country N to serve the ECU market, and considering that strategies X, EP and H are decreasing in variable costs and increasing in fixed costs we have the three productivity thresholds:

• 
$$c_X^{1-\sigma} = \frac{2f_X}{2\tau_{It}^{-\sigma}} \frac{1-\beta}{A}$$

• 
$$c_{EP-X}^{1-\sigma} = \frac{f_F - f_X}{(1+\tau_t^{-\sigma}) - 2\tau_{It}^{-\sigma}} \frac{1-\beta}{A}$$
  
•  $c_{H-EP}^{1-\sigma} = \frac{f_F - f_X}{1-\tau_t^{-\sigma}} \frac{1-\beta}{A}$ 

Depending on its productivity the firm chooses the strategy that maximises its profit and will keep doing this for the rest of its existence, and the investment region is the upper envelope of the three values  $\max_{s \in S} [\Pi_s(c) - F_s]$  as in Décamps, Mariotti and Villeneuve (2006). Figure 4 plots the three value functions in period D against productivity. It is clear that  $\Pi_X$  is flatter than  $\Pi_{EP}$  because exporting has higher trade costs than export-platform, which in turn is flatter than  $\Pi_H$  since H does not involve trade costs, while fixed costs are increasing from X to H. Firms with productivity to the left of X will not serve the ECU market and remain domestic, those in between X and EP-X will export to both countries in ECU from home, those in between EP-X and H-EP will do export-platform FDI. Finally, those with productivity above H-EP will choose the H-FDI strategy. In order to observe each strategy within an industry, we need to set some conditions for fixed and trade costs. Because  $\Pi_{EP}$  is steeper than  $\Pi_X$  and it has a lower intercept, we need  $c_X^{1-\sigma} < c_{EP-X}^{1-\sigma}$  for strategy X to be optimal for some firms in the industry:

$$c_X^{1-\sigma} = \frac{F_X}{\nabla_X} \frac{1-\beta}{A} < \frac{F_{EP} - F_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A} = c_{EP-X}^{1-\sigma}$$

which yields the condition:

$$\frac{F_X}{F_{EP}} < \frac{\nabla_X}{\nabla_{EP}}$$

or, substituting  $F_X = 2f_x$  and  $F_{EP} = f_X + f_F$  I have  $\frac{f_X}{f_F} < \frac{\nabla_X}{2\nabla_{EP} - \nabla_X}$ . Second, if  $\Pi_X$  is higher than  $\Pi_{EP}$  when it meets  $\Pi_H$ , strategy EP is always outperformed by one of the other two strategies. Therefore, we need the EP strategy to outperform the X strategy before the H becomes the most profitable. The other condition to set is:

$$c_{EP-X}^{1-\sigma} = \frac{F_{EP} - F_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A} < \frac{F_H - F_{EP}}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A} = c_{H-EP}^{1-\sigma}$$

which, after substituting  $F_X = 2f_X$ ,  $F_{EP} = f_X + f_F$  and  $F_H = 2f_F$  yields  $\frac{f_F - f_X}{\nabla_{EP} - \nabla_X} < \frac{f_F - f_X}{\nabla_H - \nabla_{EP}}$  which is  $\frac{\nabla_H - \nabla_{EP}}{\nabla_{EP} - \nabla_X} < 1$ . Substitute the definitions of  $\nabla_s$  and rearrange to get  $\tau < \tau_I$  which is true by definition. Thence, it





always exists a productivity range in which EP is the preferred strategy as far as internal trade costs are strictly smaller than external ones – i.e. if the customs union exists – and the only condition we have to impose to the model to allow the three strategies to be observable is the one to observe X. The proof can be easily extended to consider m countries in the customs union.<sup>9</sup> With two countries in the customs union the export-platform can settle in only one of the two countries. What happens when there are more than two countries in the ECU market? Mrazova and Neary 2011 show that, with identical countries within the union, the choice of FDI will take place either in one or in every country inside the ECU market, and I report their demonstration in the appendix.

#### 4.1 Comparative statics: Trade Costs in the Deterministic Period

Before introducing uncertainty, it is interesting to review some of the comparative statics for the deterministic model. The log-transformed thresholds that determine the productivity regions in which firms prefer the EP strategy are:

• 
$$\ln c_{EP-X} = \frac{1}{\sigma-1} \ln \left[ \frac{A}{(f_F - f_X)(1-\beta)} \right] + \frac{1}{\sigma-1} \ln \left[ 1 + \tau^{-\sigma} - 2\tau_I^{-\sigma} \right]$$
  
•  $\ln c_{H-EP} = \frac{1}{\sigma-1} \ln \left[ \frac{A}{(f_F - f_X)(1-\beta)} \right] + \frac{1}{\sigma-1} \ln \left[ 1 - \tau^{-\sigma} \right]$ 

To see what happens when the extra-bloc trade costs increase we can look at the elasticity of the cut-off with respect to the external trade cost. We have  $\frac{\partial}{\partial \ln \tau_I} \ln c_{EP-X} = \frac{\sigma}{\sigma-1} \frac{2\tau_I^{-\sigma}}{1+\tau^{-\sigma}-2\tau_I^{-\sigma}} > 0$ , hence the EP strategy becomes more attractive to less productive firms – those with a higher unit cost value. In line with the tariff-jumping rationale, the increase in external trade costs increases FDI in the customs union. Furthermore, FDI are increasing with trade

<sup>&</sup>lt;sup>9</sup>Whether we will *observe* all the three strategy in a given sector depends on firms having the required productivity level.

liberalisation within the ECU, and EP strategy becomes more attractive relative to both exporting and horizontal FDI, ceteris paribus. To see this, note that  $-\frac{\partial}{\partial \ln \tau} \ln c_{EP-X} = \frac{\sigma}{\sigma-1} \frac{\tau^{-\sigma}}{1+\tau^{-\sigma}-2\tau_{I}^{-\sigma}} > 0$  and  $-\frac{\partial}{\partial \ln \tau} \ln c_{H-EP} = -\frac{\sigma}{\sigma-1} \frac{\tau^{-\sigma}}{1-\tau^{-\sigma}} < 0$ . Referring back to figure 4, a reduction in the internal trade cost makes the  $\Pi_{EP}$  steeper and moves the EP-X cut-off to the left and the H-EP one to the right. As a result, the productivity region  $(c_{H-EP}, c_{EP-X})$  where EP is the optimal strategy widens, and more firms choose this strategy to serve the ECU market.

#### 4.2 Comparative statics: Countries in the Union

Another interesting aspect of the model is how the the number of countries within the customs union affects the firm optimal decision. Consider as above that the union counts m member states such that the trade and sunk costs become:

- Strategy X:  $\nabla_X = m \cdot \tau_I^{-\sigma}$  and  $F_X = m \cdot f_X$
- Strategy EP:  $\nabla_{EP} = 1 + (m-1) \cdot \tau^{-\sigma}$  and  $F_{EP} = f_F + (m-1) \cdot f_X$
- Strategy H:  $\nabla_H = m$  and  $F_H = n \cdot f_F$

Then the cut-off between strategy EP and X becomes  $c_{EP-X}^{1-\sigma} = \frac{f_F - f_X}{1-\tau^{-\sigma} + m \cdot (\tau^{-\sigma} - \tau_I^{-\sigma})} \frac{A}{1-\beta}$ , and because  $\tau^{-\sigma} - \tau_I^{-\sigma} > 0$ we have  $\frac{\partial c_{EP-X}^{1-\sigma}}{\partial m} < 0$ . The gain of the EP strategy over strategy X is increasing in the number of member states, and the productivity cut-off above which EP is preferred to X is now lower. On the other hand, the H-EP cut-off is not affected by the number of countries in the union. This is because the gain in profits/sunk costs is the same for each additional member state. For the X-EP choice, the difference in sunk  $f_F - f_X$  costs is related to the platform country only, while the difference in slopes occurs for m-1 countries and it changes with m. For the H-EP choice, the difference in sunk costs occurs for (m-1) countries – all but the platform – as well as the difference in slopes, hence the number of countries does not affect the cut-off. These two results ensure that the productivity range in which EP is optimal increases with the number of member states in the union. I can now introduce the uncertainty and see how the productivity thresholds for the EP strategy are affected.

## 5 Uncertainty Period

I assume that once a firm chooses its strategy and pays the sunk cost, it will never change it in the future (the possibility of switching strategy is considered in the appendix). In this setting, the only way for a firm to exit a strategy – and the market – is to be hit by the exogenous death shock  $\delta$ . We have seen already the decision of the strategy for a firm arriving in period D, and we will now look at firms arriving in period U.<sup>10</sup>

A firm arriving in the market in period U faces different market conditions from one arriving in D. The values of the X and H strategies are unchanged – because they do not involve the internal trade cost – but this is not true for the EP strategy. In period U, the firm forms expectations over the value that internal trade costs could take

<sup>&</sup>lt;sup>10</sup>The process for a firm arriving in R is the same as in D but based on a new information set.

in period R. The structure of uncertainty is the same as in Handley (2014). There is a probability  $\gamma \in [0, 1]$  that the internal trade policy will change in the next sub-period, which measures the uncertainty about the timing of the policy change. Once the policy changes, firms do not expect it to change again. Moreover, there is uncertainty about the magnitude of the policy change. The new internal trade cost  $\tau'$  is drawn from a distribution  $\lambda(\tau')$ . Hence, the value function of a firm arriving in period U that chooses strategy EP is given by:

$$\Pi_{EP}(\tau) = \pi_{EP}(\tau) + \beta \left[ \gamma E \Pi_{EP}(\tau') + (1 - \gamma) \Pi_{EP}(\tau) \right]$$
(1)

Here  $\pi_{EP}(\tau)$  is the immediate profits, while the term in square brackets is the continuation value. In the next period, there is a probability  $\gamma$  that the internal policy will change, hence the firm expects  $E\Pi_{EP}(\tau')$ . On the other hand, there is a probability  $(1 - \gamma)$  that the policy will not change, and in this case the firm will face the same conditions as today because the  $\tau$  did not change and a shock is still expected with probability  $\gamma$ . Note that this gives a recursive a structure to the value function, which, after solving for  $\Pi_{EP}$ , can be written as:

$$\Pi_{EP}(\tau) = \frac{\pi_{EP}(\tau)}{1 - \beta(1 - \gamma)} + \frac{\beta\gamma}{1 - \beta(1 - \gamma)} E\Pi_{EP}(\tau')$$
(2)

Compared to the deterministic case in which immediate profits are discounted by  $\beta$ , under uncertainty immediate profits are discounted by  $\beta$  and by the probability of no change  $(1 - \gamma)$ , which determines for how long the firm expects to make profits  $\pi_{EP}(\tau)$  before the policy changes. The conditional expected value of EP is given by:

$$E\Pi_{EP}(\tau') = E\pi_{EP}(\tau') + \beta \left[\gamma E\Pi_{EP}(\tau') + (1-\gamma)E\Pi_{EP}(\tau')\right]$$

which becomes

$$E\Pi_{EP}(\tau') = E\pi_{EP}(\tau') + \beta E\Pi_{EP}(\tau')$$

Note that the expectation operator is time invariant. This is because the distribution of  $\tau$  is assumed to be time invariant, hence the ex-ante expected value is time invariant. Then, I have a recursive form again which allows me to write  $E\Pi_{EP}(\tau') = \frac{E\pi_{EP}(\tau')}{1-\beta}$ , and substituting into (2) I can write:

$$\Pi_{EP}(\tau) = \frac{\pi_{EP}(\tau)}{1 - \beta(1 - \gamma)} + \frac{\beta\gamma}{1 - \beta} \frac{E\pi_{EP}(\tau')}{1 - \beta(1 - \gamma)}$$
(3)

I should write a few words on the unconditional expected profit  $E\pi_{EP}(\tau')$ , where the expectation refers to the internal trade costs  $E(\tau^{-\sigma})$  – the rest of the profit function is not uncertain. The unconditional expected trade cost is a weighted average of  $\tau^{-\sigma}$ :  $E(\tau^{-\sigma}) = \int_{\tau_{min}}^{\tau_{max}} \tau^{-\sigma} d\lambda$ . Note that depending on where the current  $\tau$  is in the distribution  $\lambda(\tau')$ ,  $E(\tau^{-\sigma})$  can be either lower or higher than the current  $\tau^{-\sigma}$ . This is a standard result in the literature on investment under uncertainty, for which the NPV rule is ambiguous on whether uncertainty increases or reduces investments. However, in the practical application to the Brexit case, current trade costs are at the minimum of their distribution. Thence, since  $E(\tau^{-\sigma}) = \int \tau^{-\sigma} d\lambda$  is a probability weighted average of which  $\tau^{-\sigma}$  is

its maximum, we have  $E(\tau^{-\sigma}) \leq \tau^{-\sigma}$ , where the equality occurs in the case in which the probability of the new trade costs being at the current level equals 1. To keep things simple, I assume  $\lambda(\tau')$  to be a binary distribution:

$$E(\tau^{-\sigma}) = \underbrace{\lambda \cdot \tau^{-\sigma}}_{FTA} + \underbrace{(1-\lambda) \cdot \tau_I^{-\sigma}}_{no-deal}$$

There is a probability  $\lambda$  that the UK and the EU sign a free trade agreement, essentially keeping internal trade costs unchanged. Then with probability  $(1 - \lambda)$  the two parties do not reach an agreement and the UK exits with no-deal. In this case, it becomes a third country to the customs union and UK exports to the EU would face the external trade cost  $\tau_I$ . Hence, the introduction of uncertainty – assuming that internal trade costs are at the minimum – lowers the value of strategy EP. What happens to the productivity cut-offs with the other two strategies? To see this, set the value of EP under uncertainty equal to the values of X and H, respectively, and solve for productivity. This yields:

$$(c_{EP-X}^{U})^{1-\sigma} = \left[\frac{f_F - f_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A}\right] \left[\frac{1-\beta+\beta\gamma}{1-\beta+\beta\gamma\omega_X}\right]$$
(4)

$$(c_{H-EP}^{U})^{1-\sigma} = \left[\frac{f_F - f_X}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A}\right] \left[\frac{1-\beta+\beta\gamma}{1-\beta+\beta\gamma\omega_H}\right]$$
(5)

Where  $\omega_X = \frac{E\nabla_{EP}(\tau') - \nabla_X}{\nabla_{EP} - \nabla_X} < 1$  and  $\omega_H = \frac{\nabla_H - E\nabla_{EP}(\tau')}{\nabla_H - \nabla_{EP}} > 1$ . Hence the cut-offs under uncertainty can be expressed as the deterministic ones (first term in brackets) multiplied by a measure of uncertainty (second term):  $c_{EP-X}^U = c_{EP-X}^D \cdot U_X$  for the EP-X choice and  $c_{H-EP}^U = c_{H-EP}^D \cdot U_H$  for the H-EP one. Because internal trade costs are currently at the minimum of the trade cost distribution, we have that  $U_X > 1$  and  $U_H < 1$ , and so the productivity region in which EP is the preferred one shrinks from both ends. It is useful to show some characteristics of these cut-offs. First, an increase in the parameter  $\gamma$  enhances the movement of the two cut-offs. Their semi-elasticities with respect to the shock arrival are:

$$\frac{\partial \ln c_{EP-X}^{U}}{\partial \gamma} = \frac{1}{\sigma - 1} \frac{\partial U_X}{\partial \gamma} = \frac{1}{\sigma - 1} \left[ \frac{\beta \omega_X}{1 - \beta + \beta \gamma \omega_X} - \frac{\beta}{1 - \beta - \beta \gamma} \right] < 0$$
$$\frac{\partial \ln c_{H-EP}^{U}}{\partial \gamma} = \frac{1}{\sigma - 1} \frac{\partial U_H}{\partial \gamma} = \frac{1}{\sigma - 1} \left[ \frac{\beta \omega_H}{1 - \beta + \beta \gamma \omega_H} - \frac{\beta}{1 - \beta - \beta \gamma} \right] > 0$$

Note that these changes look at the unit cost parameter c that determines productivity 1/c. Another aspect to study is whether the impact of uncertainty is larger in sectors where  $\tau_I$  is higher. Indeed, the empirical analysis wants to exploit variation in trade costs across sectors, and it is therefore necessary to check that there are no ambiguities in this sense. To see this, I derive the semi-elasticity of the uncertainty terms with respect to  $\tau_I$ :

$$\frac{\partial}{\partial \tau_I} \frac{1}{\sigma - 1} \ln U_X = \frac{1}{\sigma - 1} \frac{\beta \gamma \omega'_X}{1 - \beta + \beta \gamma \omega_X} < 0$$

$$\frac{\partial}{\partial \tau_I} \frac{1}{\sigma - 1} \ln U_H = \frac{1}{\sigma - 1} \frac{\beta \gamma \omega'_H}{1 - \beta + \beta \gamma \omega_H} > 0$$

where  $\omega'$  indicates the first derivative with respect to  $\tau_I$ . The signs of the semi-elasticities indicate that the reduction in the productivity space in which EP is optimal due to uncertainty is larger in sectors where the external trade cost  $\tau_I$  is larger. These semi-elasticities show the effect relative to the deterministic cut-offs. Note that if the trade policy renegotiation could involve a reduction in internal trade cost, this result might not hold. While this does not constitute a problem for the empirical analysis of the Brexit case, it makes the model less generalisable to other cases of trade policy renegotiation.

A second effect of uncertainty is to introduce an option value to wait if the firm has the possibility to delay the investment. In this case, the firm foregoes profits in period U and waits until new information arrives to decide the entry mode. For a firm that has to decide between strategy EP and X, the value of waiting is:

$$\Pi_{WX} = 0 + \beta \gamma \left[ \lambda (E \Pi_{EP}(\tau' | \tau' < \bar{\tau}) - F_{EP}) + (1 - \lambda) (\Pi_X - F_X) \right] + \beta (1 - \gamma) \Pi_{WX}$$

$$\tag{6}$$

If the firm waits, it gets zero profit today. Then the continuation value – the terms multiplied by the discount factor  $\beta$  – says that with probability  $\gamma\lambda$  the trade policy will change, but the new internal cost will be lower than  $\bar{\tau}$ , the threshold of the internal cost below which EP is the preferred strategy, so the firm pays the sunk cost  $F_{EP}$  and starts the EP strategy. With probability  $\gamma(1 - \lambda)$  the new internal cost will be too high, and so the firm pays  $F_X$  and starts strategy X. Finally, with probability  $(1 - \gamma)$  the trade policy does not change and the firm will face the same problem tomorrow. Note that under the binary distribution assumption the threshold  $\bar{\tau}$  has a simple solution: it is the external trade cost. Indeed, if  $\tau' = \tau_I$ , then no firm would find strategy EP to be optimal. The expected value of starting the EP strategy conditional on the internal costs being lower than the threshold is:

$$E\Pi_{EP}(\tau'|\tau'<\bar{\tau}) = E\pi_{EP}(\tau'|\tau'<\bar{\tau}) + \beta E\Pi_{EP}(\tau'|\tau'<\bar{\tau})$$

that is,  $E\Pi_{EP}(\tau'|\tau' < \bar{\tau}) = \frac{E\pi_{EP}(\tau'|\tau' < \bar{\tau})}{1-\beta}$ . This expected value does not involve expectations of further changes in the trade policy. The result comes from assuming that having an internal cost lower than the threshold is the result of a free trade agreement, and that this trade agreement is a credible one.<sup>11</sup> Proceed solving (6) for  $\Pi_{WX}$ and substitute  $E\Pi_{EP}(\tau'|\tau' < \bar{\tau})$  and  $\Pi_X$  to get:

$$\Pi_{WX} = \frac{\beta\gamma}{1 - \beta(1 - \gamma)} \left[ \lambda \left( \frac{E\pi_{EP}(\tau' | \tau' < \bar{\tau})}{1 - \beta} - F_{EP} \right) + (1 - \lambda) \left( \frac{\pi_X}{1 - \beta} - F_X \right) \right]$$
(7)

For firms with productivity close to the H-EP threshold, waiting implies contemplating entry under either H or EP strategy. Then this value of waiting is:

$$\Pi_{WH} = 0 + \beta \gamma \left[ \lambda (E \Pi_{EP}(\tau' | \tau' < \bar{\tau}) - F_{EP}) + (1 - \lambda) (\Pi_H - F_H) \right] + \beta (1 - \gamma) \Pi_{WH}$$

<sup>&</sup>lt;sup>11</sup>The model can be extended to considering uncertainty even after signing a trade agreement.

which, similarly as above, can be written as:

$$\Pi_{WH} = \frac{\beta\gamma}{1-\beta(1-\gamma)} \left[ \lambda \left( \frac{E\pi_{EP}(\tau'|\tau'<\bar{\tau})}{1-\beta} - F_{EP} \right) + (1-\lambda) \left( \frac{\pi_H}{1-\beta} - F_H \right) \right]$$
(8)

Setting the values of waiting equal to the value of strategy EP minus its sunk costs and solving for productivity yields the productivity cut-offs in between which strategy EP is preferred to waiting. For the X-EP choice this is:

$$\left(c_{EP-WX}^{U}\right)^{1-\sigma} = \left[\frac{f_F - f_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A}\right] \left[\frac{(1-\beta)(1+\Omega_{FX}) + \beta\gamma(1-\lambda)}{(1-\beta)(1+\Omega_X) + \beta\gamma(1-\lambda)\omega_{WX}}\right]$$
(9)

where  $\omega_{WX} = \frac{E\nabla_{EP}(\tau'|\tau \geq \bar{\tau}) - \nabla_X}{\nabla_{EP} - \nabla_X}$  measures the potential profit loss,  $\Omega_{FX} = \frac{F_X}{f_F - f_X}$  and  $\Omega_X = \frac{\nabla_X}{\nabla_{EP} - \nabla_X}$ . As before the uncertainty threshold is equal to the deterministic one multiplied by a measure of uncertainty. Note how the cut-off between EPU and WX follows the bad news principle as it does not depend on the probability of a positive change in internal trade policy. For the choice H-EP the cut-off is:

$$\left(c_{WH-EP}^{U}\right)^{1-\sigma} = \left[\frac{f_F - f_X}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A}\right] \left[\frac{(1-\beta)(1-\Omega_{FH}) + \beta\gamma(1-\lambda)}{(1-\beta)(1-\Omega_H) + \beta\gamma(1-\lambda)\omega_{WH}}\right]$$

where  $\omega_{WH} = \frac{\nabla_H - E \nabla_{EP}(\tau' | \tau \geq \bar{\tau})}{\nabla_H - \nabla_{EP}}$ ,  $\Omega_{FH} = \frac{F_H}{f_F - f_X}$  and  $\Omega_H = \frac{\nabla_H}{\nabla_H - \nabla_{EP}}$ . As for the immediate action cut-offs  $c_{EP-X}^U$  and  $c_{H-EP}^U$ , the cut-offs for waiting can be expressed as the deterministic ones multiplied by a measure of uncertainty:  $c_{EP-WX}^U = c_{EP-X}^D \cdot U_{WX}$  for the EP-X choice and  $c_{WH-EP}^U = c_{H-EP}^D \cdot U_{WH}$  for the H-EP choice, and again they imply a reduction of the productivity region in which EP is the optimal strategy. Another interesting result is that all these measures of uncertainties are increasing in the external trade cost (potential increase). Hence, in a comparison across sectors the reduction in the number of EP firms will be larger where the external trade cost is larger.

Figure 5 shows what happens to the value functions under uncertainty, focusing on the EP-X choice to simplify the picture. The value of strategy X is unaffected because it does not involve the internal trade cost  $\tau$ . The dashed line represents the value of strategy EP in absence of uncertainty. Because of the possibility of an increase in  $\tau$ , this value is now lower – denoted by  $\Pi_{EPU}$  in the figure – and the cut-off between EP and X moved to the right. The marginal firm in period D – the one at the intersection of  $\Pi_X$  and the dashed  $\Pi_{EP}$  – which was indifferent between the two strategies, will now prefer exporting. Finally, the red line shows the value of waiting. When firms wait, there is a further reduction in the EP productivity range. The choice between H and EP looks similar, but with the cut-off moving to the left and the marginal firm under no uncertainty preferring strategy H to EP.

#### 5.1 Regretful firms

Taking a decision under uncertainty might lead some firms to regret their choice once uncertainty is over. To see this, consider the binary distribution of trade costs  $E(\tau^{-\sigma}) = \lambda \tau^{-\sigma} + (1-\lambda)\tau_I^{-\sigma}$  and ignore for the moment the possibility to wait. As shown above, in case of negative shock – in which case the internal cost equals the external one – the EP strategy would not be optimal for any firm. Hence, a firm that arrives in period U with productivity





in between  $(c_{EP-X}^U)^{1-\sigma}$  and  $(c_{H-EP}^U)^{1-\sigma}$  and chooses strategy EP will regret its choice in period R if a negative shock arrives. Similarly, some firms will regret their choice in case of a positive shock. For the EP-X choice, firms with productivity in between the deterministic cut-off  $(c_{EP-X}^D)^{1-\sigma}$  and the uncertainty one  $(c_{EP-X}^U)^{1-\sigma}$  choose strategy X in period U. However, if they were to arrive in period R after a positive shock occurred, the optimal strategy would have been EP, and they regret their choice. For the H-EP choice, firms arriving in period U with productivity in between  $(c_{H-EP}^U)^{1-\sigma}$  and  $(c_{H-EP}^D)^{1-\sigma}$  find strategy H to be optimal, but in case of positive shock they would regret their choice. The option to wait, which does not always arise, would reduce the productivity space in which firms regret their choice, and there would be fewer regretful firms in period R.

#### 5.2 Other Countries

The previous section analysed what happens to the country that triggers renegotiation. With two countries inside the union the effect is the same on both member states. Considering a customs union formed by m member states the effect is larger for the renegotiating member. In the deterministic period, each country is identical and the firm from country N is indifferent for the choice of the platform country. With uncertainty affecting only one country in the union, the EP value functions from any other member state i is less affected than the one of the renegotiating member. The expected profit of EP is:

$$E\nabla_{EP}^{i} = 1 + (m-2)\tau^{-\sigma} + E(\tau^{-\sigma}) > 1 + (m-1)E(\tau^{-\sigma}) = E\nabla_{EP}^{UK}$$

Hence, compared to the renegotiating country, other member states experience either a smaller decline than the renegotiating member or an increase in the EP. In the model with m identical countries inside the union, uncertainty

drives all EP-FDI away from the renegotiating country because  $\Pi_{EP}^{UK} < \Pi_{EP}^{i}$ , for any productivity value. A simple tweak to the model to keep having some EP FDI under uncertainty in the renegotiating member is to make countries different in terms of sunk costs. Consider for instance that because of the English language and common law, which applies to international contracts, the UK has slightly smaller sunk costs for FDI:  $f_F^{UK} < f_F^i$ . In this case, it will attract all EP FDI in the deterministic scenario, but under uncertainty some of the EP would go to other member states. In the empirical analysis, we can expect the UK to be more affected than other EU countries by uncertainty. Moreover, if firms shifted location from the UK to continental Europe, other member states might even see an increase in export-platform investments, hence predictions on other member states are ambiguous.

#### 5.3 Waiting vs immediate action

Whether waiting occurs or firms take an immediate decision depends on the value of parameters in the model. In a model with only one strategy the option to wait would deter entry under uncertainty. However, considering alternative options which are not subject to uncertainty waiting will not always emerge. In particular, waiting does not occur when uncertainty is low and when the potential increase in trade costs is limited. The reason for this is that there are alternative strategies which yield a certain profit. Considering the level of uncertainty as given, a small external trade cost means that in case of negative shock things will not be so much worse than today. At the same time, the value of strategy X is higher because exporting incurs in smaller trade costs, so one of the alternatives becomes more valuable. I can find the threshold of the external trade cost (i.e., the potential internal increase) for which a firm is indifferent between waiting and immediate action setting  $U_X = U_{WX}$  for the EP-X choice and  $U_H = U_{WH}$  for the H-EP choice.<sup>12</sup> This yields:

$$\bar{\tau}_{I}^{X} = \tau \cdot \left[\frac{2(1-\beta)(1-\beta+\beta\gamma)}{\beta\gamma\lambda\cdot\beta\gamma(1-\lambda)} + 1\right]^{1/\sigma}$$
$$\bar{\tau}_{I}^{H} = \tau \cdot \left[\frac{\beta\gamma(1-\lambda)\left[\beta\gamma\lambda+2(1-\beta)\right]}{\beta\gamma\lambda\left[\beta\gamma(1-\lambda)-2(1-\beta)\right] - 2(1-\beta)^{2}}\right]^{1/\sigma}$$

Note that while the threshold for the EP-X choice is finite for any value of  $\gamma > 0$ , the threshold of the H-EP choice is negative for small values of  $\gamma$ , it goes to infinity when  $\beta \gamma \lambda \left[\beta \gamma (1-\lambda) - 2(1-\beta)\right] = 2(1-\beta)^2 - i.e.$ , the denominator equals zero – and has positive values only when the denominator is positive, which depends on  $\gamma$  and  $\lambda$ . Setting the denominator greater than zero and solving the quadratic inequality to find the thresholds of  $\gamma$  for which the denominator is positive we have:

$$\gamma_{1,2} = \frac{(1-\beta) \cdot \left[\lambda \pm \sqrt{\lambda(2-\lambda)}\right]}{\beta\lambda(1-\lambda)}$$

<sup>&</sup>lt;sup>12</sup>These results are obtained assuming that the sunk costs of exporting are zero,  $f_X = 0$ . This does not change the overall structure of the model but simplifies the exposition. See the appendix for the conditions considering  $f_X > 0$ .

Since the solution with the negative sign is smaller than  $zero^{13}$ , we can drop it, and we are left with only one acceptable solution:

$$\gamma = \frac{(1-\beta) \cdot \left[\lambda + \sqrt{\lambda(2-\lambda)}\right]}{\beta\lambda(1-\lambda)} \tag{10}$$

This is the threshold of  $\gamma$  below which the H-EP decision will be immediate. Hence, we need a relatively high level of uncertainty for firms to wait in the H-EP choice. Figure 6 plots the two thresholds of  $\tau_I$  above which waiting occurs in the EP-X and the H-EP choice as a function of  $\gamma$ , the probability of a policy change (evaluated at  $\lambda = 1/2$ ). Note how the threshold for waiting in the H-EP choice is much higher than the one for the EP-X choice, meaning that waiting is less likely to occur in the former. This result is interesting from a theoretical perspective and it has implications for the empirical analysis. As mentioned before, one theoretical prediction is that the decrease in the EP productivity region is larger where the external trade cost is larger. Moreover, a high external trade cost  $\tau_I$  makes waiting more likely. The discussion on immediate action vs waiting highlighted the presence of two discontinuity points in the external trade cost  $\tau_I$ .

Figure 6:  $\bar{\tau}_I^H$  and  $\bar{\tau}_I^X$  as a function of  $\gamma$ 



The firm's decision can be decomposed in three parts. For low uncertainty and  $\tau_I < \bar{\tau}_I^X$ , waiting does not occur

<sup>&</sup>lt;sup>13</sup>Consider:  $\gamma = \frac{(1-\beta) \cdot \left[\lambda - \sqrt{\lambda(2-\lambda)}\right]}{\beta \lambda(1-\lambda)}$ . This is negative if  $\lambda < \sqrt{\lambda(2-\lambda)}$ . Squaring both terms and rearranging we have  $2\lambda^2 < 2\lambda$ , that is  $\lambda < 1$ , which is true by definition.

in any choice and the reduction in the productivity space where EP is the optimal strategy is given by the movement of the immediate choice cut-offs. The threshold for the shock arrival parameter is  $\gamma < \frac{(1-\beta) \cdot \left[\lambda + \sqrt{\lambda(2-\lambda)}\right]}{\beta \lambda(1-\lambda)}$  taking  $\beta$ and  $\lambda$  as given. At intermediate level of uncertainty, still with  $\gamma$  below that threshold but  $\tau_I > \bar{\tau}_I^X$ , firms wait in the EP-X choice but take immediate decision in the H-EP choice. Finally, for high level of uncertainty, which is defined as  $\gamma > \frac{(1-\beta)\cdot \left[\lambda + \sqrt{\lambda(2-\lambda)}\right]}{\beta\lambda(1-\lambda)}$ , waiting occurs in both decisions. In this last scenario the productivity space in which EP is optimal has two discontinuity points in the external trade cost:  $\bar{\tau}_{I}^{X}$  and  $\bar{\tau}_{I}^{H}$ . Figure 7 plots a numerical evaluation of the productivity space in which EP is the optimal choice under the three levels of uncertainty. The space is defined as the difference between the lower and upper productivity cut-offs. Hence for the low uncertainty case it is  $(c_{H-EP}^U)^{1-\sigma} - (c_{EP-X}^U)^{1-\sigma}$ , for the intermediate case if is  $(c_{H-EP}^U)^{1-\sigma} - (c_{EP-WX})^{1-\sigma}$  and for the high uncertainty scenario it is given by  $(c_{WH-EP})^{1-\sigma} - (c_{EP-WX})^{1-\sigma}$ . The resulting productivity space optimal for EP is then plotted as a function of the external trade cost  $\tau_I$ . The grey dotted line represents the productivity space under no uncertainty, and it is always larger than the one under uncertainty. For the intermediate case, the dashed vertical line represent the threshold above which waiting occurs in the EP-X choice, and represents a discontinuity point  $\bar{\tau}_I^X$ . For the high uncertainty case the first dashed vertical line is again  $\bar{\tau}_I^X$ , while the second one (reading left to right) is the threshold above which waiting occurs also in the H-EP choice  $\bar{\tau}_{I}^{H}$ . To see clearly that the reduction in the EP productivity space increases in the external trade cost  $\tau_I$ , figure 8 plots the difference between the deterministic and the uncertainty EP productivity space. For the low uncertainty case, the function is given by:

$$\left[\left(c_{H-EP}^{U}\right)^{1-\sigma} - \left(c_{EP-X}^{U}\right)^{1-\sigma}\right] - \left[\left(c_{H-EP}^{D}\right)^{1-\sigma} - \left(c_{EP-X}^{D}\right)^{1-\sigma}\right]$$

and it represents the wedge between the solid and dotted lines in figure 7.



#### Figure 7: The EP productivity space under uncertainty





Figure 8: The EP productivity space reduction under uncertainty

#### 5.4 Discussion

The introduction of uncertainty on internal trade cost changes the cut-offs in between which export-platform is the optimal strategy. Following a process of renegotiation in which one member state seeks to leave the customs union, the value of strategy EP is unambiguously reduced because internal trade costs can only increase. For low values of uncertainty, the choice among different strategies is immediate, and firms that do not engage in the EP strategy choose strategies X or H, depending on their productivity level. For higher values of uncertainty, a value of waiting emerges and the investment decision region becomes dichotomous. This implies a further reduction of the productivity space in which EP is the optimal strategy. In the appendix I consider the possibility to switch strategy, and I show that results are similar.

On the other hand, when the internal trade costs are not at the minimum of their distribution the theory is not clear on whether there will be more or less export-platform investment. Although this does not apply to the empirical application of Brexit since internal costs are at the minimum of the distribution, the model suffers in terms of generality. EP FDI are reduced only under certain conditions about sunk costs, trade costs and the probability parameters. Compared to the model of Handley and Limao (2015), where the firm decides only whether to export or not, the introduction of alternative strategies which are not subject to uncertainty leads to less general theoretical predictions.

# Part II Empirical Analysis

## 6 Empirical approach

In this section I derive an empirical equation to estimate the model. The assumption about the internal trade cost distribution is the binary one outlined above. This allows me to focus on the probability of a no-deal Brexit, under which after the United Kingdom exits the EU and trade between the two parties falls under WTO terms. To derive an empirical equation, I assume a Pareto distribution for productivity and use the cut-offs derived above to look at what happens to the number of firms choosing strategy EP. The Pareto distribution is given by  $G(c) = \left(\frac{c}{c_V}\right)^{\alpha}$ , where  $c_V$  is its minimum and  $\alpha$  the shape parameter. Evaluating the distribution at a given cut-off gives the share of firms that have productivity above that cut-off, and multiplying this by the total number of firms n that could serve the market gives the number of firms above the cut-off  $n \cdot \left(\frac{c}{c_V}\right)^{\alpha}$ . The aim is to measure what happens to firms in the EP productivity range. Figure 9 plots the Pareto distribution and the cut-offs in between which EP is optimal.





The total number of firms in this productivity space is given by all those above the EP-X cut-off – that is, all FDI – minus those above the H-EP threshold, which are horizontal investments. This gives:

$$n_{EP} = n \cdot \left(\frac{c_{EP-X}^U}{c_V}\right)^{\alpha} - n \cdot \left(\frac{c_{EP-X}^U}{c_V}\right)^{\alpha}$$

However, in order to have a tractable form that can be easily manipulated, I consider the ratio of total FDI (i.e., the firms above the  $1/c_{EP-X}^U$  cut-off) over the firms choosing the H strategy (those above  $1/c_{H-EP}^U$ ), which is still informative about the number of EP firms. To identify the effect of uncertainty in the data, I consider a small increase in the probability of a policy change  $\gamma$  from the point of no uncertainty  $\gamma = 0$ . As shown before, waiting does not occur for small values of  $\gamma$ , hence the cut-offs to consider are those for immediate action. This gives:

$$n_{FDI} = n \cdot \left(\frac{c_{EP-X}^U}{c_V}\right)^{\alpha}$$
$$n_H = n \cdot \left(\frac{c_{H-EP}^U}{c_V}\right)^{\alpha}$$

And their ratio is:

$$\frac{n_{FDI}}{n_H} = \left(\frac{c_{EP-X}^U}{c_{H-EP}^U}\right)^{\alpha}$$

Then take the log transformation:

$$\ln\left(\frac{n_{FDI}}{n_H}\right) = \alpha \left[\ln c_{EP-X}^U - \ln c_{H-EP}^U\right] \tag{11}$$

Remember that the uncertainty cut-offs are the deterministic ones multiplied by a measure of uncertainty  $c^U = c^D \cdot U$ , hence uncertainty is log separable from the deterministic part. I take the first order log-linear approximation of the cut-offs around the point of no uncertainty ( $\gamma = 0$ ):

$$\ln c_{EPU-X|\gamma=0} = \frac{1}{\sigma-1} \ln c_{EP-X} - \gamma \frac{1-\lambda}{\sigma-1} \frac{\beta}{1-\beta} \left[ \frac{\tau^{-\sigma} - \tau_I^{-\sigma}}{1+\tau^{-\sigma} - 2\tau_I^{-\sigma}} \right] + e_X$$
$$\ln c_{H-EPU|\gamma=0} = \frac{1}{\sigma-1} \ln c_{H-EP} + \gamma \frac{1-\lambda}{\sigma-1} \frac{\beta}{1-\beta} \left[ \frac{\tau^{-\sigma} - \tau_I^{-\sigma}}{1-\tau^{-\sigma}} \right] + e_H$$

where the  $e_s$  are the reminder terms of the approximation. Then I substitute the approximations in equation (11) to get:

$$\ln\left(\frac{n_{FDI}}{n_{H}}\right) = \underbrace{\frac{\alpha}{\sigma - 1}\left[\ln c_{EP-X} - \ln c_{H-EP}\right]}_{deterministic} - \underbrace{\alpha\gamma\frac{1 - \lambda}{\sigma - 1}\frac{\beta}{1 - \beta}(\tau^{-\sigma} - \tau_{I}^{-\sigma})\left[\frac{1}{1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma}} + \frac{1}{1 - \tau^{-\sigma}}\right]}_{uncertainty} + e$$

where  $e = e_X - e_H$ . Finally, I take the difference in time from the deterministic to the uncertainty period to get rid of the deterministic cut-offs:

$$\Delta \ln\left(\frac{n_{FDI}}{n_H}\right) = -\underbrace{\alpha\gamma(1-\lambda)\frac{\beta}{1-\beta}}_{coefficient}\underbrace{\frac{(\tau^{-\sigma}-\tau_I^{-\sigma})}{\sigma-1}\left[\frac{1}{1+\tau^{-\sigma}-2\tau_I^{-\sigma}}+\frac{1}{1-\tau^{-\sigma}}\right]}_{dependent variable} + \epsilon$$

Substituting the definition of the deterministic part into  $[\ln c_{EP-X} - \ln c_{H-EP}]$  yields  $[\ln (1 + \tau^{-\sigma} - 2\tau_I^{-\sigma}) - \ln (1 - \tau^{-\sigma})]$  which depends only on trade costs. Since the EU MFN tariff did not change in the period considered and no major reforms internal to the EU market took place, I can safely assume that the deterministic part did not change in time and eliminate it through first difference. The assumptions on which the identification strategy relies on is that the probability of policy change  $\gamma$  and the distribution of trade cost is the same across industries. Moreover, I also assume that the shape parameter of the Pareto distribution and the elasticity of substitution across varieties are common across industries. Then the empirical equation that I estimate is a double-difference that can be written as:

$$\Delta y_{iV} = b \cdot T_V + a_i + u_{iV} \tag{12}$$

where  $\Delta y_{jV} = \Delta \ln \left(\frac{n_{FDI}}{n_H}\right)$  from country j in sector V, the slope coefficient to be estimated is  $b = -\alpha\gamma(1-\lambda)\frac{\beta}{1-\beta}$ and the dependent variable is  $T_V = \frac{(\tau^{-\sigma} - \tau_I^{-\sigma})}{\sigma - 1} \left[\frac{1}{1+\tau^{-\sigma} - 2\tau_I^{-\sigma}} + \frac{1}{1-\tau^{-\sigma}}\right]$ . The OLS estimation includes origin country fixed-effects  $a_j$  to account for any (log-separable) unobserved heterogeneity across countries not captured by the theoretical equation, and  $u_{jV}$  is an error term.

#### 7 Data and measurement

#### 7.1 FDI data

FDI data come from the Financial Times fDi Markets database, which records announcements of greenfield investments at the transaction level, i.e., the number of investment projects. The database records the name of the investing firm, its origin country, business sector (e.g., chemicals, automotive, ...) and the business activity (e.g., manufacturing, R&D, headquarters, ...) among other indicators. The sectoral classification is not a standard one, although fDi markets provides on request a concordance table between the its business sector classification and NAICS 2007 classification. I rely on this concordance table to match the FDI data to trade costs data. For the analysis of the goods market I select only the 'manufacturing' business activity. Indeed, the headquarters of a manufacturing firm will not be involved in the shipment of goods, and the potential tariff increase might not affect the cost of managing the business from the UK.

Information recorded in the FDI database does not distinguish whether an FDI is export-platform or horizontal in nature. Although the database records information on the market served by the investing firm, the information is available only for a small subset of investments and cannot be used to identify EP investments. To do so, I rely on theory. Under the assumption of symmetric countries, the model predicts that an export-platform FDI will take place only in one country within the customs union, and not more. Hence, I select firms that within a year invested only in the UK and not in other EU countries.<sup>14</sup> The choice of one year comes from assuming that this corresponds to the fiscal year, the time period in which a firm takes decision in the budget allocation. For robustness, I also consider 2 and 5 years periods.

Using this criterion, I am able to identify EP and H FDI. Figure 10 shows the share of horizontal FDI across industries (at a higher aggregation level than the one used for the empirical analysis). The three sectors with the largest shares of horizontal FDI are Real Estate, Consumer Products and Hotel & Tourism which are largely non-traded sectors. On the other hand, sectors such as Plastics, Chemicals and Automotive are among the least horizontal sectors.

Figure 10: Share of UK Horizontal FDI



Figure 11 plots the share of UK EP FDI on total FDI over time. Consistently with the theoretical model, the figure shows that horizontal FDI account for a minority of total investments, since only the most productive firms engage in this strategy. The share of EP FDI floated around 90%, with a trough at the time of the financial crisis in 2009. Note how the share dropped since 2016, suggesting that there has been a shift from EP to horizontal FDI following the referendum, which is in line with what the theory predicts.

 $<sup>^{14}</sup>$ I do not consider all 28 EU countries, but a subset that is more similar to the UK in terms of observables. These are Austria, Belgium, Denmark, Germany, Spain, France, Ireland, Italy, Netherlands, Portugal and Sweden.

Figure 11: Share of UK EP FDI over time



#### 7.2 Trade costs data

I measure trade costs using the EU MFN tariff in 2015. This is downloaded at the HS 10 digits level (EU classification) and matched to NAICS sectors using the concordance table provided by Pierce and Schott (2009). The concordance table is based on the US HS classification, which is identical to the EU one at the 6 digits level. Hence, tariff data are first collapsed at the HS 6 digits (trade-weighted average using COMEXT data on UK exports to the EU average 2014-15) and then matched to NAICS sectors. From there, I match tariffs data to the fDi business sectors, such that each sector has its own associated MFN tariff level. Once I aggregated the EU MFN tariff at the fDi markets sectoral level, the mean tariff is 4.8%. The minimum is zero, which occurs for biological products and asphalt paving. At the maximum of the distribution, which is above 40%, there are food industries. However, if I consider only matched sectors for new investment projects, which are the core of the analysis, the maximum tariff is 23.7%, which is again for food industries. Figure 12 shows the mean value of the EU MFN tariff across industry sectors, a higher level of aggregation compared to the one at which the empirical analysis is carried on. The values plotted include only sectors for which there are FDI data, reflecting the level of the tariff in the sample used for the analysis.



Figure 12: Tariff across Industries

I construct the independent variable  $T_V$  at the CN 8 digits level and then take averages – both simple and trade-weighted – at the fDi markets business sectors level to account for the non-linearity of  $T_V$  in trade costs.

#### 7.3 Measurement

This section discusses the measurement of both the independent and dependent variable. Recall that the equation to be estimated is:

$$\Delta y_{iV} = b \cdot T_V + a_i + u_{iV}$$

The dependent variable derived from the theoretical model is  $\Delta y = \Delta \ln \left(\frac{n_{FDI}}{n_H}\right)$  for each sector V and origin j. Although the methodology used to identify EP investments allows me to identify horizontal investments as well, the latter variable has many zeros, and computing the ratio of total FDI  $n_{FDI}$  on horizontal ones  $n_H$  would result in dropping many sectors. To overcome this problem, I approximate  $\Delta \ln \left(\frac{n_{FDI}}{n_H}\right)$  with the growth rate of EP FDI. Note that  $\frac{n_{FDI}}{n_H} = \frac{n_{EP} + n_H}{n_H} = \frac{n_{EP}}{n_H} + 1$ . The theory suggests that the reduction in EP FDI should be larger in sectors where the external trade  $\tau_I$  cost is higher. At the same time, horizontal FDI will increase in those same sectors, hence the ratio  $\frac{n_{FDI}}{n_H}$  will move in the same direction of  $n_{EP}$ , but with larger variation. Approximating  $\Delta \ln \left(\frac{n_{FDI}}{n_H}\right) \simeq \Delta \ln (n_{EP})$  will then result in a conservative approximation, and I should not be worried about having inflated coefficients. A further approximation is to consider the mid-point growth rate rather than the firstdifference in logs. This is again to account for the presence of zeros in the number of EP FDI  $n_{EP}$ , which would imply dropping observations – in particular I would drop those observations that are zero in the pre-referendum period and positive in the post-referendum period, biasing the growth rate towards negative values. Hence, for each sector V and origin country j the dependent variable is:

$$\Delta y = 2 \cdot \frac{n_{EP,t} - n_{EP,t-1}}{n_{EP,t} + n_{EP,t-1}}$$

This is the same approach used by Crowley, Exton and Han (2018), and it is a preferable measure of growth rate when the variable contains zeros. As shown by Steven J. Davis and Haltiwanger (1992) the mid-point growth rate is very similar to the standard growth rate for small changes. To measure  $\Delta y$  I use data for the period 2014-18, with  $n_{EP,t-1}$  being the sum of all EP FDI projects in UK from January 2014 to June 2016, while  $n_{EP,t}$  is the sum of EP FDI projects from July 2016 to December 2018. The dependent variable is:

$$T_V = \frac{(\tau^{-\sigma} - \tau_I^{-\sigma})}{\sigma - 1} \left[ \frac{1}{1 + \tau^{-\sigma} - 2\tau_I^{-\sigma}} + \frac{1}{1 - \tau^{-\sigma}} \right]$$

Where the internal trade cost  $\tau$  is assumed constant across sectors – a distance cost – and it is assumed to be 1.05. The elasticity of substitution is assumed to be  $\sigma = 3$ , a common value in the literature. The external trade cost is  $\tau_I = \tau + MFN$ , where MFN is the EU MFN tariff. Because of non-linearities in  $\tau_I$ , the variable is computed at the 8 digits product level and then aggregated at the fDi Markets sectors with both simple and trade-weighted average.

## 8 Estimation

The results are presented in table 1. The first column shows the baseline estimate. As the model speaks about new firms arriving, I should consider only new investments and not expansions of existing investments. This is what the two columns under the caption 'New FDI' reports. The first column reports the estimation on all sectors matched. There is a reason to believe that the UK is not used as an export-platform by the food industry, considering the small domestic production and the small trade with the continent occurring in these sectors. To control whether this sector biases the analysis I exclude it in column two. Results are robust and the coefficient is larger. As a first robustness, I include all investments – i.e., new projects, expansions of existing ones and co-locations – in column 3 and 4. Column 3 reports results for all sectors. Although the sign of the coefficient is still negative, significance vanishes. In this case, excluding the food industries does make a difference. In column 4, where food is excluded, the coefficient on all projects is much larger than the one in column 3 and statistically significant. In each regression, standard errors are bootstrapped with 1000 replication.

	New FDI		All FDI	
	All	Ex. Food	All	Ex. Food
Т	-3.349***	-3.933***	-0.284	-1.621**
	(0.961)	(1.159)	(0.404)	(0.600)
Origin FE	Yes	Yes	Yes	Yes
N	55	48	184	153
$R^2$	0.461	0.465	0.114	0.194

 Table 1: Manufacturing Estimation

#### 8.1 Robustness and sensitivity

The construction of both the dependent variable and the independent one rely on some assumptions, and it is good practice to see how these assumptions affect results. In this section I report a series of robustness checks to show that the main results are stable.

#### 8.1.1 Time period for the selection of EP FDI

A first concern with the estimation could be the period in which I consider an investment to be EP – one year in table 1. To test whether this makes a substantial difference, tables 2 and 3 report results for EP time windows of 2 and 5 years, respectively. Considering a 2-year period does not make any difference for the identification of EP FDI for new projects, and little difference for all projects. On the other hand, there is some difference when considering a 5-year period. The coefficients for new FDI are slightly smaller, but in the same range of magnitude and significance is substantially unaffected. The big difference occurs for all projects including food investments, with the coefficients getting very small, although still with a negative sign.

	New FDI		Al	l FDI
	All	Ex. Food	All	Ex. Food
Т	-3.349***	-3.933***	-0.239	$-1.558^{**}$
	(0.974)	(1.169)	(0.411)	(0.584)
Origin FE	Yes	Yes	Yes	Yes
N	55	48	183	152
$R^2$	0.461	0.465	0.112	0.190
Prob. no-deal	0.18	0.21	0.01	0.08
p-value	0.001	0.001	0.562	0.008

Table 2: Manufacturing Estimation 2-year

Bootstrapped standard errors (1000 reps) in parentheses

\* p < 0.05,\*\* p < 0.01,\*\*\* p < 0.001

	New FDI		All FDI	
	All	Ex. Food	All	Ex. Food
Т	-3.062**	-3.666**	-0.00186	$-1.707^{**}$
	(1.089)	(1.197)	(0.402)	(0.600)
Origin FE	Yes	Yes	Yes	Yes
N	52	46	175	146
$R^2$	0.460	0.456	0.120	0.212
Prob. no-deal	0.16	0.19	0.00	0.09
p-value	0.005	0.002	0.996	0.004

Table 3: Manufacturing Estimation 5-year

Bootstrapped standard errors (1000 reps) in parentheses

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

#### 8.1.2 Number of countries in the union

A second potential concern is that the model simplified the analysis considering only two countries in the customs union, and that this is driving results. As mentioned above, the model is easily extendible to consider any number of countries within the customs union. With m member states, the dependent variable becomes:

$$T_V = \frac{(\tau^{-\sigma} - \tau_I^{-\sigma})}{\sigma - 1} \left[ \frac{m - 1}{1 + (m - 1) \cdot \tau^{-\sigma} - m \cdot \tau_I^{-\sigma}} + \frac{1}{1 - \tau^{-\sigma}} \right]$$

I compute the dependent variable considering m = 8, m = 12 and m = 28. The choice of 12 member states is to reflect the fact that new members are different in observables compared to the original members of the EU (GDP per capita, culture, institutions, ...), and reflects the number of countries used to identify EP investments. The choice of 28 member states reflects the current size of the EU. The choice of m = 8 has a different rationale. The theoretical model considers identical countries in terms of size, but EU member states are clearly different. To capture this, I compute the Herfindahl index for GDP of the 28 EU member states (average 2014-16)  $H = \sum_{i=1}^{28} s_i^2$ , where  $s^2$  is the square root of GDP share for each EU member state. I then derive the number of equivalent size countries consistent with the concentration level as 1/H = 8. Estimation results are reported in table 4 for new projects across all sectors. Sign and significance of the slope coefficient are unchanged, although it is slightly smaller compared to the b = -3.349 of the baseline estimate.

	New FDI				
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	$\mathrm{m}=28$	
Т	-3.349***	$-2.913^{***}$	$-2.862^{***}$	-2.800***	
	(0.961)	(0.804)	(0.786)	(0.765)	
Origin FE	Yes	Yes	Yes	Yes	
N	55	55	55	55	
$R^2$	0.461	0.465	0.466	0.465	

Table 4: Manufacturing Estimation Number of Countries

#### 8.1.3 Measure of internal costs

Another potential issue in the construction of the independent variable is the assumption that the internal trade cost is common across all sector and that its difference from the external cost is given only by the tariff. To overcome this problem, I use the information on CIF/FOB ratio to compute intra-EU transport costs and extra-EU transport costs. Data on CIF and FOB prices come from the OECD International Transport and Insurance Cost (ITIC) database<sup>15</sup>, which contains data on CIF/FOB ratio at HS 4 digit product for more than 180 reporters and partners. For the computation, I select a subset of reporters (Australia, France, Germany, Italy, Japan, South Korea, Netherlands, Norway, Switzerland, UK and USA) and OECD countries as trade partners, for the year 2014. The CIF/FOB ratio is computed as:

$$ratio_{ij,V} = \frac{CIF_{ij,V} - FOB_{ij,V}}{CIF_{ij,V}}$$

I take the simple average at the HS 4 digits for intra-EU trade  $(ratio_{EU,V})$  and for exports of non-EU countries to EU members  $(ratio_{non-EU,V})$ . I compute the internal trade cost as  $\tau_V = 1 + ratio_{EU,V}$  and the external trade cost as  $\tau_I = 1 + ratio_{non-EU,V} + MFN_V$ . As expected, internal trade costs are lower than external ones. The mean value of the intra-EU cost is 3.6% with a minimum 0.8% and a maximum of 7.5%. On the other hand, the external trade cost has a mean of 5.5%, a minimum of 1.4% and a maximum of 12.1%. The dependent variable is then constructed at the HS 6 digits level, with the EU MFN varying at the 6 digits level while the CIF/FOB ratio is common at the HS 4 digits products. Potentially, I can create the variable at a more disaggregated level (HS 10 digits) always keeping the CIF/FOB at HS 4 digits. Estimation results are reported in table 5. The estimation is done with  $\sigma = 3$  and considering 2, 8, 12 and 28 countries in the customs union. Coefficient estimates are all statistically significant and in the same range of magnitude.

<sup>&</sup>lt;sup>15</sup>Data are available from the OECD page. For a description of the methodology, see Miao and Fortanier (2017).

		New	FDI	
	$\mathrm{m}=2$	$\mathrm{m}=8$	$\mathrm{m}=12$	$\mathrm{m}=28$
Т	$-2.136^{**}$	$-2.139^{**}$	$-2.172^{**}$	$-2.242^{**}$
	(0.748)	(0.768)	(0.774)	(0.777)
Origin FE	Yes	Yes	Yes	Yes
N	55	55	55	55
$\mathbb{R}^2$	0.396	0.394	0.395	0.398

Table 5: Internal Trade Costs

#### 8.1.4 Elasticity of substitution

I consider different values for the elasticity of substitution  $\sigma$ , as this plays a role in determining the size of the independent variable. Table 6 reports the results of the OLS regression for  $\sigma = 2, 3$  and 4. Together with the values of  $\sigma$ , I also compute a trade-weighted average of the dependent variable, that should reflect the current undistorted trade pattern between the UK and the EU27 – trade-weights are UK exports to the EU27 using COMEXT data. Results for the weighted average are reported in table 7. The size of the elasticity of substitution plays an important role in determining the size of the estimated coefficient. The trade-weighted dependent variable yields slightly smaller coefficient estimates, with same signs and statistical significance, but they are a bit more precisely estimated.

	New FDI, $m = 2$				
	$\sigma=2$	$\sigma=3$	$\sigma=4$		
Т	$-1.522^{***}$	$-3.349^{***}$	$-5.461^{***}$		
	(0.442)	(0.961)	(1.550)		
Origin FE	Yes	Yes	Yes		
N	55	55	55		
$R^2$	0.461	0.461	0.460		

Table 6: Manufacturing Estimation Elasticity of Substitution

Bootstrapped standard errors (1000 reps) in parentheses \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

	New FDI, $m = 2$				
	$\sigma=2$	$\sigma=3$	$\sigma=4$		
Т	$-1.291^{***}$	$-2.961^{***}$	$-4.983^{***}$		
	(0.292)	(0.665)	(1.128)		
Origin FE	Yes	Yes	Yes		
N	55	55	55		
$R^2$	0.475	0.480	0.482		

Table 7: Manufacturing Estimation Elasticity of Substitution – trade weighted

All empirical evidences are pointing in the same direction, showing that the uncertainty triggered by the Brexit referendum had an impact on EP FDI in UK. The sensitivity analysis shows that the values of parameters play some role in determining the magnitude of the estimated coefficient. Note however that, once I assessed that firms behaved accordingly to the model, the objective is to use the estimated coefficient to compute a counterfactual for the number of EP firms in UK, and this will depend again on the parameters values but in an opposite manner to the estimated coefficient. Hence, the counterfactual estimate is robust to the parameters values.

#### 8.1.5 Other EU countries

What about other EU member states? I re-estimate the model as done for the UK for other EU countries and test the other theoretical prediction stating that other EU countries should be less affected by the Brexit uncertainty, and might also gain in terms of export-platform investments. As done for the identification of export-platform FDI, I do not consider the whole EU, but the same subset of countries. These are Austria, Belgium, Denmark, Germany, Spain, France, Ireland, Italy, Netherlands, Portugal and Sweden. The equation that I estimate is the following:

$$\Delta y_{ijV} = bT_V + a_i + a_j + e_{ijV}$$

Where  $\Delta y_{ijV}$  is the mid-point growth of EP FDI projects from country j to country i in sector V, and  $T_V$  is the dependent variable as described above. Then  $a_i$  and  $a_j$  are a set of destination and origin country fixed effects, and  $e_{ijV}$  is the error term. Table 8 reports the estimation of the model on new investment projects, considering  $\sigma = 3$ . Results in the first column are based on T computed with two countries and taking the simple average of T from CN 8 digits to fDi markets sectors, while in the second column T is aggregated using a trade-weighted average. The other three columns report results for simple average but considering 8, 15 and 28 countries inside the customs union.

	New FDI					
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	$\mathrm{m}=28$		
Т	$0.881^{*}$	$0.747^{*}$	$0.729^{*}$	$0.706^{*}$		
	(0.379)	(0.347)	(0.344)	(0.342)		
Origin FE	Yes	Yes	Yes	Yes		
Destination FEs	Yes	Yes	Yes	Yes		
N	226	226	226	226		
$R^2$	0.203	0.199	0.198	0.197		

Table 8: Other EU countries

Bootstrapped standard errors (1000 reps) in parentheses

\* p < 0.05,\*\* p < 0.01,\*\*\* p < 0.001

All coefficients are positive and statistically significant. Note how the number of observations per country is smaller than for the UK, which is the largest recipient of foreign investment in the EU. The theory predicts that when one member state renegotiate its position, other members, which are less affected by uncertainty, might attract some of the export-platform FDI that were oriented to the renegotiating member otherwise. Hence, the results of table 8 suggest that firms substituted location away from the UK to other EU countries following the Brexit referendum. Note also how the magnitude of coefficients is smaller compared to the regressions for the UK, indicating that not all firms switched countries. A potential explanation is that some started other strategies rather than EP.

A second way to exploit information about other EU countries is to control for industry-specific trends estimating a triple difference model. The three differences are in time (growth rate), across sectors  $(T_V)$  and across destinations (UK and EU). The regression model is:

$$\Delta y_{iV}^{UK} - \Delta y_{iV}^{EU} = bT_V + a_i + e_{iV} \tag{13}$$

where  $\Delta y_{jV}^{UK}$  is the mid-point growth of EP FDI in UK,  $\Delta y_{jV}^{EU}$  is the growth in the EU considered as a single country – i.e., summing FDI across all destinations listed above. Note that the match occurs at the origin-sector level. In many cases, a country *j* that invested in the UK in sector *V* did not invest in the EU in the same sector. This means that for many matched country-sectors FDI are zero in both the pre and post Brexit period. Unfortunately, this leaves an insufficient number of observations, and I am not able to estimate the triple difference model.

#### 8.1.6 Placebo in time

I perform another robustness check by running some placebos in times, i.e., shifting the date of the Brexit referendum. In particular, I move the Brexit referendum date to two different dates: June 2007 and June 2012. In each case I consider two and a half year before and after and compute the growth rate across the two periods. Hence, in the first case the pre-break period is Jan 2005-Jun 2007 and the post-break is Jul 2007-Dec 2010. For the other placebo with the break date in June 2012, the pre-break period is Jan 2010-Jun 2012 and the post period is Jul 2012-Dec 2015. If the coefficients estimated in previous sections are driven by the uncertainty generated by Brexit, I should not find any statistically significant result for these placebos in time.

Results are reported in tables 9 and 10 for the two time periods. In either cases the null hypothesis of no uncertainty - i.e., b = 0 - cannot be rejected at conventional levels of significance. This corroborates results obtained in the previous sections and indicates that the uncertainty generated by the Brexit referendum is driving firms' decision about export-platform FDI in the UK.

	New FDI				
	$\mathrm{m}=2$	m = 8	m = 12	m=28	
Т	1.069	0.964	0.956	0.948	
	(0.755)	(0.695)	(0.690)	(0.685)	
Origin FE	Yes	Yes	Yes	Yes	
N	68	68	68	68	
$R^2$	0.293	0.293	0.293	0.293	

Table 9: Placebo in time 2005-2010

Bootstrapped standard errors (1000 reps) in parentheses \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

p < 0.001, p < 0.001, p < 0.001

		New	' FDI	
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	m=28
Т	-0.0671	-0.0568	-0.0610	-0.0686
	(1.088)	(0.975)	(0.965)	(0.954)
Origin FE	Yes	Yes	Yes	Yes
N	54	54	54	54
$R^2$	0.313	0.313	0.313	0.313
		(1000	\ <b>.</b>	

Bootstrapped standard errors (1000 reps) in parentheses \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

### 8.2 Interpretation

The model estimation found evidence that uncertainty affected the decisions of EP firms, and that these behaved accordingly to the theoretical model. How to interpret the results? Remember that the estimated coefficient is:

$$b = lpha \cdot \gamma (1 - \lambda) \cdot rac{eta}{1 - eta}$$

where  $\alpha$  is the Pareto shape parameter,  $\gamma(1 - \lambda)$  is the probability of a no-deal Brexit and  $\beta = \frac{1-\delta}{1+R}$  is the intertemporal discount factor, composed of the exogenous probability of death  $\delta$  and the interest rate on an alternative project R. Assuming values for  $\alpha$  and  $\beta$  will allow me to impute the probability of no-deal Brexit. For the Pareto distribution, I follow the estimates of Nigai (2017), which uses a large sample of French firms and finds  $\alpha = 3$ .<sup>16</sup>For the discount factor, I assume an exogenous probability of exiting the market of 5% ( $\delta = 0.05$ ) and an interest rate of 10%, the NASDAQ average. This yields  $\beta = 0.86$ .<sup>17</sup> Using these values, I can compute the probability of no-deal  $\gamma(1-\lambda)$ . The baseline estimate yields a perceived probability of no-deal Brexit by foreign firms of 18%, and considering the various robustness tests the value is in between 12% and 18% with  $\sigma = 3$ . According to Reuters, before October 2019 JP Morgan gave a no-deal Brexit at 25% <sup>18</sup>, while considering other banks in January 2019 and before, the average is around 17%.<sup>19</sup> It is remarkable how close these values are to the no-deal probability estimated in this paper.

#### 8.3 Counterfactual

I can now use the estimated no-deal probability  $\gamma(1-\lambda)$ , together with the values for the parameters  $\alpha$ ,  $\beta$  and  $\sigma$  to construct a counterfactual. The counterfactual measures the number of EP firms that would have entered the UK in the absence of uncertainty (i.e., if  $\gamma$  was set to zero). To do so, I first have to distinguish between the probability of policy change  $\gamma$  and the probability of higher trade costs  $(1-\lambda)$ . Considering that the policy change is the result of a referendum, I assume  $\gamma = 0.9$ , which means that the change is almost certain but not perfectly anticipated. Because of non-linearities in uncertainty, I will not compute the counterfactual based on the linear approximation. Consider first firms that choes strategy X rather than EP under uncertainty. With no uncertainty, those that choose EP over X are given by  $n_{FDI}^D = n_V \cdot \left(\frac{c_{EP-X}}{c_V}\right)^{\alpha}$ , while under uncertainty they are  $n_{FDI}^U = n_V \cdot \left(\frac{c_{EP-X} \cdot U_X}{c_V}\right)^{\alpha}$ . Take the log-difference of the two to have:

$$\ln n_{FDI}^D - \ln n_{FDI}^U = -\frac{\alpha}{\sigma - 1} \ln \left( \frac{1 - \beta + \beta \gamma \omega_X}{1 - \beta + \beta \gamma} \right)$$
(14)

I plug the values of  $\alpha$ ,  $\sigma$  and  $\beta$  in equation (14) and the value of  $\lambda$  into  $\omega_X = \frac{1 + (m-1) \cdot [\lambda \tau^{-\sigma} + (1-\lambda)\tau_I^{-\sigma}] - m \cdot \tau_I^{-\sigma}}{1 + (m-1) \cdot \tau^{-\sigma} - m \cdot \tau_I^{-\sigma}}$ , where m is the number of countries in the customs union. I then compute this measure for each industry, take the average across industries and compute the percentage change as:

$$\Delta n_{FDI}\% = \left[e^{-\frac{\alpha}{\sigma-1}\ln\left(\frac{1-\beta+\beta\gamma\omega_X}{1-\beta+\beta\gamma}\right)} - 1\right]$$

Similarly, for the choice between H and EP I use:

<sup>&</sup>lt;sup>16</sup>Nigai considers both a Pareto distribution and a mixed distribution that is log-normal for the left tail and Pareto for the right tail. The value  $\alpha = 3$  comes from the mixed distribution, which yields better fit for both tails of the distribution. Because FDI firms are towards the right tail, it is reasonable to consider the Pareto distribution. Considering only the Pareto distribution, Nigai finds  $\alpha = 1.9$ . <sup>17</sup>Handley and Limao (2015) assume  $\beta = 0.85$ .

<sup>&</sup>lt;sup>18</sup> https://www.reuters.com/article/us-britain-eu-jpmorgan/jpmorgan-cuts-probability-of-oct-31-brexit-to-15-from-40-

idUSKBN1WG490

 $<sup>^{19} \</sup>rm https://fingfx.thomsonreuters.com/gfx/editorcharts/GLOBAL-MARKETS/0H001NPW54C9/index.html and the state of the s$ 

$$\ln n_H^D - \ln n_H^U = -\frac{\alpha}{\sigma - 1} \ln \left( \frac{1 - \beta + \beta \gamma \omega_H}{1 - \beta + \beta \gamma} \right)$$

and following the same methodology I compute the percentage change as:

$$\Delta n_H \% = \left[ e^{-\frac{\alpha}{\sigma-1} \ln\left(\frac{1-\beta+\beta\gamma\omega_X}{1-\beta+\beta\gamma}\right)} - 1 \right]$$

I use the observed values of  $n_{FDI}^U$  (the observed number of FDI in the post-referendum period) and  $n_H^U$  (the observed number of H FDI) and estimate the counterfactual for total FDI  $\tilde{n}_{FDI}^D = n_{FDI}^U \cdot \Delta n_{FDI} \%$  and for H FDI  $\tilde{n}_H^D = n_H^U \cdot \Delta n_H \%$ . Finally, I compute the counterfactual for EP firms as  $\tilde{n}_{EP}^D = \tilde{n}_{FDI}^D - \tilde{n}_H^D$ , and the percentage change as:

$$\Delta n_{EP}\% = \frac{n_{EP}^U - \tilde{n}_{EP}^D}{\tilde{n}_{EP}^D}$$

where  $n_{EP}^U$  is the observed number of EP FDI. The results of the calculations are reported in table 11.

Table 11: Estimated % change in EP firms,  $\sigma = 3$ 

	No. of countries					
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	$\mathrm{m}=28$		
Pareto shape						
lpha=2	-5.99	-13.82	-15.28	-17.40		
lpha=3	-5.91	-13.46	-14.85	-16.86		

Calculations are done considering 2, 8, 12 and 28 countries in the EU (using the respective coefficient estimate) and for two values of the Pareto shape parameter ( $\alpha = 2$  and  $\alpha = 3$ ), asuming  $\sigma = 3$ . While results are not very sensitive to the value of the shape parameter, they vary substantially with the number of countries considered in the EU. Because the theoretical model considers countries of identical size, the preferred number of countries is 8, the inverse of the Herfindahl index of EU28 GDP, which gives the number of equivalent size countries in the EU. This results in a loss of 13.5% export-platform FDI due to trade policy uncertainty. To test whether results are robust to different values of the parameters, I compute these measures for a range of values – see tables 12-16 in the appendix. In particular, I consider  $\alpha = 2$  and 3 following Nigai (2017)'s estimates of the Pareto shape parameter. For the elasticity of substitution I consider  $\sigma = 2$ , 3 and 4 while for the number of countries I consider m = 2, 8, 12 and 28. Finally, I also use CIF/FOB data to compute the counterfactual. For each value of  $\sigma$  and m for the computation of the independent variable T. The value of  $\beta$  is assumed to be 0.86 for every computation. Results are robust to these different values of the parameters. With m = 8 being the preferred number of countries inside the customs union, estimates for the reduction of EP investments are in the range 12.3-18%.

## 9 Conclusion

The paper provides a theoretical framework to study the impact of the Brexit uncertainty on firms' decision to invest into export-platform in the United Kingdom. When I test the model empirically using data on manufacturing FDI I find that non-EU firms behaved accordingly to the theoretical model and had a perceived probability of no-deal Brexit in between 12% and 18%. This uncertainty deterred entry as export-platform, and I estimate that in the absence of uncertainty EP FDI would have been some 13.5% higher than what we observe. Moreover, I find evidence that firms substituted the UK with other EU countries as export-platform for the European market.

Given the importance of the services sector for the UK and for FDI in general, I plan to extend the empirical analysis to test the impact of uncertainty on services firms. A limitation on this side is the lack of a ready measure of *ad valorem* equivalent of trade costs for services. On the theoretical side, the model can be extended to include multiple stages of production and look at the impact of trade policy uncertainty on FDI involving trade in intermediates.

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# Appendix

## 10 Theory Appendix

#### 10.1 Number of export-platform in the customs union

I report the demonstration of Mrazova and Neary (2011) for the optimal number of export-platform within the union. Consider *m* identical members of the customs union, such that the value function of strategies X and H are  $\Pi_X = m \cdot \pi(\tau_I)(1-\beta)^{-1} - m \cdot f_X$  and  $\Pi_H = m \cdot \pi(1)(1-\beta)^{-1} - m \cdot f_F$ , respectively, where  $\pi(1)$  is profits from domestic sales for which  $\tau = 1$ . Consider now the export platform strategy. If the firm decides to set plants in *l* countries its value function will be:

$$\Pi_{EP} = l \left[ \frac{\pi(1)}{1-\beta} - f_F \right] + (m-l) \left[ \frac{\pi(\tau)}{1-\beta} - f_X \right]$$

where  $\pi(\tau)$  is profits from exporting at the internal trade costs. To demonstrate that FDI will take place in either one or *m* countries, but not in *l* with 1 < l < m, rewrite  $\Pi_{EP}$  as:

$$\Pi_{EP} = l \left[ \frac{\pi(1)}{1-\beta} - f_F \right] + (m-l) \left[ \frac{\pi(\tau_I)}{1-\beta} - f_X \right] + (m-l) \frac{\pi(\tau) - \pi(\tau_I)}{1-\beta}$$

where the second term is profits from exports at the extra-union trade costs while the last term is the gain from exporting at the internal trade cost. Then subtract  $\Pi_X$  from the expression above and write:

$$\Pi_{EP} - \Pi_X = f(l) = l \cdot \theta + (m - l) \cdot \phi \tag{15}$$

where  $\theta = [\pi(1) - \pi(\tau_I)](1 - \beta)^{-1} - (f_F - f_X)$  is the gain from domestic sales and  $\phi = [\pi(\tau) - \pi(\tau_I)](1 - \beta)^{-1}$  is the gain from exporting at the internal vs the external cost. Equation 15 is linear in *l* therefore it has a corner solution in the number of plants: it is optimal to settle in either one ECU country or *m*. Rewriting  $f(l) = l(\theta - \phi) + m\phi$ , we can see that if  $\theta - \phi < 0$  it is optimal to minimise the number of plants, that is  $l^* = 1$ , while if  $\theta - \phi > 0$  it is optimal to maximise the number of plants, and  $l^* = m$ .

#### 10.2 Immediate uncertainty cut-offs

#### 10.2.1 Derivation of cut-offs

For the EP-X choice, the immediate investment cut-off is derived setting:

$$\Pi_{EP} - \Pi_X = F_{EP} - F_X$$

 $\frac{\pi_{EP}}{1-\beta+\beta\gamma} + \frac{\beta\gamma}{1-\beta} \frac{E\pi_{EP}(\tau')}{1-\beta+\beta\gamma} - \frac{\pi_X}{1-\beta} = f_F - f_X$   $\frac{(1-\beta)(\pi_{EP}-\pi_X)+\beta\gamma(E\pi_{EP}(\tau')-\pi_X)}{(1-\beta+\beta\gamma)(1-\beta)} = f_F - f_X$ Then solve for productivity to get:  $c^{1-\sigma} = \frac{(f_F-f_X)(1-\beta+\beta\gamma)}{(1-\beta)(\nabla_{EP}-\nabla_X)+\beta\gamma(E\nabla_{EP}(\tau')-\nabla_X)} \frac{1-\beta}{A}$ Let  $\omega_X = \frac{E\nabla_{EP}(\tau')-\nabla_X}{\nabla_{EP}-\nabla_X}$  and write:

$$c^{1-\sigma} = \frac{f_F - f_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A} \frac{1-\beta+\beta\gamma}{1-\beta+\beta\gamma\omega_X}$$

For the choice between EP and H set:

$$\Pi_H - \Pi_{EP} = F_H - F_{EP}$$

 $\begin{array}{l} \frac{\pi_H}{1-\beta} - \frac{\pi_{EP}}{1-\beta+\beta\gamma} - \frac{\beta\gamma}{1-\beta} \frac{E\pi_{EP}(\tau')}{1-\beta+\beta\gamma} = f_F - f_X \\ c^{1-\sigma} = \frac{(f_F - f_X)(1-\beta+\beta\gamma)}{(1-\beta)(\nabla_H - \nabla_{EP}) + \beta\gamma(\nabla_H - E\nabla_{EP}(\tau'))} \frac{1-\beta}{A} \\ \text{Let } \omega_X = \frac{\nabla_H - E\nabla_{EP}(\tau')}{\nabla_H - \nabla_{EP}} \text{ and rearrange to write:} \end{array}$ 

$$c^{1-\sigma} = \frac{f_F - f_X}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A} \frac{1-\beta+\beta\gamma}{1-\beta+\beta\gamma\omega_H}$$

#### 10.2.2 Semi-elasticity w.r.t. $\gamma$

Write  $\ln c_{EP-X} = \frac{1}{\sigma-1} \ln c_{EP-X}^D + \frac{1}{\sigma-1} \ln U_X$  and then take the partial derivative w.r.t.  $\gamma$ :

$$\frac{\partial \ln c_{EP-X}^U}{\partial \gamma} = \frac{1}{\sigma - 1} \frac{\partial U_X}{\partial \gamma} = \frac{1}{\sigma - 1} \left( \frac{\beta \omega_H}{1 - \beta + \beta \gamma \omega_X} - \frac{\beta}{1 - \beta + \beta \gamma} \right)$$

If uncertainty reduces entry as EP, the cut-off must decrease hence we need  $\frac{\beta\omega_H}{1-\beta+\beta\gamma\omega_X} - \frac{\beta}{1-\beta+\beta\gamma} < 0$  such that 1/c increases.

$$\frac{\omega_X}{1-\beta+\beta\gamma\omega_X} < \frac{1}{1-\beta+\beta\gamma}$$

 $(1-\beta)\omega_X < 1-\beta$  that is  $\omega_X < 1$  which is true. Hence, the semi-elasticity is  $\frac{\partial \ln c_{EP-X}^U}{\partial \gamma} > 0$ . Similarly for the H-EP cut-off we have:

$$\frac{\partial \ln c_{H-EP}^U}{\partial \gamma} = \frac{1}{\sigma - 1} \frac{\partial U_H}{\partial \gamma} = \frac{1}{\sigma - 1} \left( \frac{\beta \omega_H}{1 - \beta + \beta \gamma \omega_H} - \frac{\beta}{1 - \beta - \beta \gamma} \right)$$

And here we want to show that  $\frac{\beta\omega_H}{1-\beta+\beta\gamma\omega_H} - \frac{\beta}{1-\beta-\beta\gamma} > 0$  that boils down to  $\omega_H > 1$ , which is shown above.

#### 10.2.3 Effect of $\tau_I$ on uncertainty

When comparing different sectors V with different external barriers  $\tau_{IV}$ , the effect of uncertainty on the cut-off is larger for sectors with larger external barriers – i.e., with higher potential increase. To see this, consider the elasticity of the uncertainty terms with respect to  $\tau_I$ :

$$\frac{\partial}{\partial \tau_I} \frac{1}{\sigma - 1} \ln U_X = \frac{1}{\sigma - 1} \frac{\beta \gamma \omega'_X}{1 - \beta + \beta \gamma \omega_X} < 0$$

where the results follows from  $\omega'_X = \frac{\partial \omega_X}{\partial \tau_I}$  that is:

$$\begin{array}{l} \frac{\partial}{\partial \tau_{I}} \frac{1 + \lambda \tau^{-\sigma} + (1-\lambda)\tau_{I}^{-\sigma} - 2\tau_{I}^{-\sigma}}{1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma}} = \\ \frac{[\sigma 2\tau_{I}^{-\sigma-1} - \sigma(1-\lambda)\tau_{I}^{-\sigma-1}] (1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma}) - \sigma 2\tau_{I}^{-\sigma-1} [1 + \lambda \tau^{-\sigma} + (1-\lambda)\tau_{I}^{-\sigma} - 2\tau_{I}^{-\sigma}]}{(1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma})^{2}} = \\ \frac{-\sigma(1-\lambda)\tau_{I}^{-\sigma-1} (1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma}) + \sigma 2\tau_{I}^{-\sigma-1} (1-\lambda)(\tau^{-\sigma} - \tau_{I}^{-\sigma})}{(1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma})^{2}} = \\ -\frac{\sigma(1-\lambda)\tau_{I}^{-\sigma-1} (1 - \tau^{-\sigma})}{(1 + \tau^{-\sigma} - 2\tau_{I}^{-\sigma})^{2}} < 0 \end{array}$$

Hence the semi-elasticity of uncertainty w.r.t.  $\tau_I$  is larger for sectors where the external trade cost is larger in the EP-X choice. For the H-EP cut-off we have:

$$\frac{\partial}{\partial \tau_I} \frac{1}{\sigma - 1} \ln U_H = \frac{1}{\sigma - 1} \frac{\beta \gamma \omega'_H}{1 - \beta + \beta \gamma \omega_H} > 0$$

And we have  $\omega'_H = \frac{\partial \omega_H}{\partial \tau_I}$ :

$$\frac{\partial}{\partial \tau_I} \frac{1 - \lambda \tau^{-\sigma} - (1 - \lambda)\tau_I^{-\sigma}}{1 - \tau^{-\sigma}} = \sigma (1 - \lambda)\tau_I^{-\sigma - 1} \left(1 - \tau^{-\sigma}\right) > 0$$

Again, the effect is larger in sectors where the external barrier is higher. These two results show that the reduction of the productivity space in which EP is optimal due to uncertainty is larger in sectors where the external trade cost  $\tau_I$  is larger.

#### 10.3 Waiting cut-offs

For the choice EP-X, set:

$$\Pi_{EP} - \Pi_{WX} = F_{EP}$$

$$\frac{\pi_{EP}}{1-\beta+\beta\gamma} + \frac{\beta\gamma}{1-\beta} \frac{E\pi_{EP}(\tau')}{1-\beta+\beta\gamma} - \frac{\beta\gamma}{1-\beta+\beta\gamma} \left(\lambda \frac{E\pi_{EP}(\tau'|\tau'<\bar{\tau})}{1-\beta} + (1-\lambda)\frac{\pi_X}{1-\beta}\right) = F_{EP} - \frac{\beta\gamma}{1-\beta+\beta\gamma} \left(\lambda F_{EP} + (1-\lambda)F_X\right)$$
$$\frac{\pi_{EP}(1-\beta) + \beta\gamma E\pi_{EP}(\tau') - \beta\gamma\lambda E\pi_{EP}(\tau'|\tau'<\bar{\tau}) - \beta\gamma(1-\lambda)\pi_X}{(1-\beta+\beta\gamma)(1-\beta)} = \frac{F_{EP}(1-\beta) + \beta\gamma(1-\lambda)(F_{EP}-F_X)}{1-\beta+\beta\gamma}$$

Consider that  $E\pi_{EP}(\tau') - \lambda E\pi_{EP}(\tau'|\tau' < \bar{\tau}) = (1-\lambda)E\pi_{EP}(\tau'|\tau' \ge \bar{\tau})$  and write:

$$\frac{\pi_{EP}(1-\beta)+\beta\gamma(1-\lambda)\left[E\pi_{EP}(\tau'|\tau'\geq\bar{\tau})-\pi_X\right]}{(1-\beta)} = F_{EP}(1-\beta)+\beta\gamma(1-\lambda)(f_F-f_X)$$

$$c^{1-\sigma} = \frac{F_{EP}(1-\beta)+\beta\gamma(1-\lambda)(f_F-f_X)}{\nabla_{EP}(1-\beta)+\beta\gamma(1-\lambda)[E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})-\nabla_X]}\frac{1-\beta}{A}$$

This cut-off is a function of the threshold above which the EP strategy becomes profitable. To express it as a function of the EP-X cut-off, add and subtract  $F_X(1-\beta)$  at the numerator and  $\nabla_X(1-\beta)$  at the denominator. Then let  $\Omega_{FX} = \frac{F_X}{f_F - f_X}$ ,  $\Omega_X = \frac{\nabla_X}{\nabla_{EP} - \nabla_X}$  and finally  $\omega_{WX} = \frac{E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau}) - \nabla_X}{\nabla_{EP} - \nabla_X}$ :

$$c^{1-\sigma} = \frac{f_F - f_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A} \frac{(1-\beta)\left(1+\Omega_{FX}\right) + \beta\gamma(1-\lambda)}{(1-\beta)\left(1+\Omega_X\right) + \beta\gamma(1-\lambda)\omega_{WX}}$$

Similarly, for the choice between H and EP we have:

$$\Pi_{WH} - \Pi_{EP} = -F_{EP}$$

$$\frac{\beta\gamma}{1-\beta+\beta\gamma} \left(\lambda \frac{E\pi_{EP}(\tau'|\tau'<\bar{\tau})}{1-\beta} + (1-\lambda)\frac{\pi_H}{1-\beta}\right) - \frac{\pi_{EP}}{1-\beta+\beta\gamma} - \frac{\beta\gamma}{1-\beta}\frac{E\pi_{EP}(\tau')}{1-\beta+\beta\gamma} = \frac{\beta\gamma}{1-\beta+\beta\gamma} \left(\lambda F_{EP} + (1-\lambda)F_H\right) - F_{EF} + \frac{\beta\gamma\lambda E\pi_{EP}(\tau'|\tau'<\bar{\tau}) + \beta\gamma(1-\lambda)\pi_H - \pi_{EP}(1-\beta) - \beta\gamma E\pi_{EP}(\tau')}{(1-\beta+\beta\gamma)(1-\beta)} = \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{1-\beta+\beta\gamma} + \frac{\beta\gamma(1-\lambda)\left[\pi_H - E\pi_{EP}(\tau'|\tau'\geq\bar{\tau})\right] - \pi_{EP}(1-\beta)}{(1-\beta)} = \beta\gamma(1-\lambda)\left(f_F - f_X\right) - F_{EP}(1-\beta) + \frac{\beta\gamma(1-\lambda)(f_F - f_X) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - F_{EP}(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H - E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})] - \nabla_{EP}(1-\beta)} + \frac{\beta\gamma(1-\lambda)(F_H - F_{EP}) - \frac{\beta\gamma(1-\lambda)(F_$$

As for the EP-WX cut-off, add and subtract  $F_H(1-\beta)$  at the numerator and  $\nabla_H(1-\beta)$  at the denominator. Call  $\Omega_{FH} = \frac{F_H}{f_F - f_X}$ ,  $\Omega_H = \frac{\nabla_H}{\nabla_{EP} - \nabla_H}$  and  $\omega_{WH} = \frac{\nabla_H - E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau})}{\nabla_H - \nabla_{EP}}$ :

$$c^{1-\sigma} = \frac{f_F - f_X}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A} \frac{(1-\beta)\left(1-\Omega_{FH}\right) + \beta\gamma(1-\lambda)}{(1-\beta)\left(1-\Omega_H\right) + \beta\gamma(1-\lambda)\omega_{WH}}$$

#### 10.4 First order approximation

For the empirical application I take a log-linear approximation of the cut-offs around the point of no uncertainty  $(\gamma = 0)$ . To do so, I rely on the immediate investment cut-offs. For the choice between EP and X we have:

$$\ln c_{EP-X|\gamma=0}^{U} = \frac{1}{\sigma-1} \ln c_{EP-X|\gamma=0}^{D} + \frac{1}{\sigma-1} \ln U_{X|\gamma=0} + (\gamma-0) \frac{1}{\sigma-1} \frac{\partial \ln c_{EP-X|\gamma=0}^{D}}{\partial \gamma} + (\gamma-0) \frac{1}{\sigma-1} \frac{\partial \ln U_{X|\gamma=0}}{\partial \gamma}$$

Note that  $U_X = 1$  for  $\gamma = 0$  and the deterministic cut-off is not a function of  $\gamma$ , hence this is:

$$\ln c_{EP-X|\gamma=0}^{U} = \frac{1}{\sigma-1} \ln c_{EP-X|\gamma=0}^{D} + \gamma \frac{1}{\sigma-1} \frac{\ln U_{X|\gamma=0}}{\partial \gamma}$$

The partial derivative with respect to  $\gamma$  is:  $\frac{\partial \ln U_{X|\gamma=0}}{\partial \gamma} = \frac{\partial}{\partial \gamma} \ln \left[ \frac{1-\beta+\beta\gamma\omega_X}{1-\beta+\beta\gamma\omega_X} \right] =$ 

$$\frac{\frac{\partial \ln U_{X|\gamma=0}}{\partial \gamma}}{\frac{\partial \omega_X}{1-\beta+\beta\gamma\omega_X}} = \frac{\partial}{\partial\gamma} \ln \left[ \frac{1-\beta+\beta\gamma\omega_X}{1-\beta+\beta\gamma} \right] = \frac{\beta\omega_X}{1-\beta+\beta\gamma\omega_X} - \frac{\beta}{1-\beta+\beta\gamma} = \frac{\beta}{1-\beta} \left( \omega_X - 1 \right)$$

Where the last step follows from setting  $\gamma = 0$ . The term in parenthesis is:

$$\begin{split} \omega_X - 1 &= \frac{E\nabla_{EP}(\tau') - \nabla_X}{\nabla_{EP} - \nabla_X} - 1 = \\ \frac{1 + \lambda \tau^{-\sigma} + (1 - \lambda)\tau_I^{-\sigma} - 2\tau_I^{-\sigma} - 1 - \tau^{-\sigma} + 2\tau_I^{-\sigma}}{1 + \tau^{-\sigma} - 2\tau_I^{-\sigma}} = \\ - \frac{(1 - \lambda)(\tau^{-\sigma} - \tau_I^{-\sigma})}{1 + \tau^{-\sigma} - 2\tau_I^{-\sigma}} \end{split}$$

So that the approximation of the cut-off can be written as:

$$\ln c^U_{EP-X|\gamma=0} = \frac{1}{\sigma-1} \ln c^D_{EP-X} - \gamma \frac{1-\lambda}{\sigma-1} \frac{\beta}{1-\beta} \frac{\tau^{-\sigma} - \tau_I^{-\sigma}}{1+\tau^{-\sigma} - 2\tau_I^{-\sigma}}$$

Similarly, for the H-EP cut-off I take:

$$\ln c_{H-EP|\gamma=0}^{U} = \frac{1}{\sigma-1} \ln c_{H-EP|\gamma=0}^{D} + \frac{1}{\sigma-1} \ln U_{H|\gamma=0} + (\gamma-0) \frac{1}{\sigma-1} \frac{\partial \ln c_{H-EP|\gamma=0}^{D}}{\partial \gamma} + (\gamma-0) \frac{1}{\sigma-1} \frac{\partial \ln U_{H|\gamma=0}}{\partial \gamma}$$

Where the partial derivative of the log of uncertainty is given by:

$$\frac{\partial \ln U_{H|\gamma=0}}{\partial \gamma} = \frac{\partial}{\partial \gamma} \left[ \frac{1 - \beta + \beta \gamma \omega_H}{1 - \beta + \beta \gamma} \right] = \frac{\beta}{1 - \beta} \left( \omega_H - 1 \right)$$
  
And the term  $\omega_H - 1$  is:  
 $\omega_H - 1 = \frac{\nabla_H - E \nabla_{EP}(\tau')}{\nabla_H - \nabla_{EP}} - 1 = \frac{(1 - \lambda)(\tau^{-\sigma} - \tau_I^{-\sigma})}{1 - \tau^{-\sigma}}$ 

Hence the approximated cut-off is:

$$\ln c_{H-EP|\gamma=0}^U = \frac{1}{\sigma-1} \ln c_{H-EP}^D + \gamma \frac{1-\lambda}{\sigma-1} \frac{\beta}{1-\beta} \frac{\tau^{-\sigma} - \tau_I^{-\sigma}}{1-\tau^{-\sigma}}$$

These are the cut-offs used in the text to derive the empirical equation.

## **10.5** Waiting region assuming $f_X = 0$

#### 10.5.1 EP-X choice:

Assuming  $f_X = 0$  does not change the overall structure of the model, nor the effect of uncertainty if I do not allow for strategy switch. All firms will find exporting profitable regardless of their productivity. The cut-offs among alternatives are the same but with  $f_X = 0$ . This assumption simplifies the derivation of conditions to observe waiting. I will then derive the conditions to observe waiting with  $f_X > 0$ . For the EP-X choice, the condition is  $\left(c_{EP-X}^U\right)^{1-\sigma} < \left(c_{EP-WX}\right)^{1-\sigma}$ , which results in:

$$\frac{(1-\beta+\beta\gamma)}{(\nabla_{EP}-\nabla_X)(1-\beta)+\beta\gamma(E\nabla_{EP}(\tau')-\nabla_X)} < \frac{(1-\beta+\beta\gamma-\beta\gamma\lambda)}{\nabla_{EP}(1-\beta)+\beta\gamma(1-\lambda)(E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau})-\nabla_X)}$$

Re-arranging and using the binary distribution for internal trade costs, under which  $E\nabla_{EP}(\tau'|\tau'<\bar{\tau})=\nabla_{EP}$ , we have:

$$\beta\gamma\beta\gamma\lambda\left[E\nabla_{EP}(\tau') - E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right] < -\nabla_X\left(1-\beta\right)\left(1-\beta+\beta\gamma\right)$$

Substitute in  $E\nabla_{EP}(\tau') = 1 + \lambda \tau^{-\sigma} + (1-\lambda)\tau_I^{-\sigma}$ ,  $E\nabla_{EP}(\tau'|\tau' < \bar{\tau}) = 1 + \tau^{-\sigma}$  and  $\nabla_X = 2\tau_I^{-\sigma}$  and rearrange to get the expression in the text:

$$\tau_{I} > \tau \left[ \frac{2\left(1-\beta\right)\left(1-\beta+\beta\gamma\right)}{\beta\gamma\cdot\beta\gamma\lambda\left(1-\lambda\right)} + 1 \right]^{1/\sigma}$$

#### 10.5.2 H-EP choice:

For the H-EP choice, the condition can be expressed in two ways. If the sunk cost of strategy EP are smaller than those of waiting, which occurs if  $(1 - \beta) < \beta \gamma (1 - \lambda)$ , then the condition can be expressed as  $(c_{WH-EP})^{1-\sigma} < (c_{H-EP}^U)^{1-\sigma}$ :

$$\frac{(1-\beta+\beta\gamma)}{(\nabla_H-\nabla_{EP})(1-\beta)+\beta\gamma(\nabla_H-E\nabla_{EP}(\tau'))} < \frac{\beta\gamma(1-\lambda)(1-\beta)}{\beta\gamma(1-\lambda)(\nabla_H-E\nabla_{EP}(\tau'|\tau'\geq\bar{\tau}))-(1-\beta)\nabla_{EP}(\tau')}$$

Noting that  $E\nabla_{EP}(\tau')$  is the only term that depends on  $\tau_I$ , after solving for the external cost we have:

$$\tau_{I} < \tau \cdot \left[\frac{\beta\gamma(1-\lambda)\left[2(1-\beta)+\beta\gamma\lambda\right]}{\beta\gamma\lambda\left[\beta\gamma(1-\lambda)-2(1-\beta)\right]-2(1-\beta)^{2}}\right]^{1/\sigma}$$

For this condition to be possible we need the denominator to be positive. This can be written as:

$$2(1-\beta)^2 < \beta\gamma\lambda \left[\beta\gamma(1-\lambda) - 2(1-\beta)\right]$$

$$(1-\beta) \cdot 2\left(1+\frac{1-\beta}{\beta\gamma\lambda}\right) < \beta\gamma\left(1-\lambda\right)$$
(16)

Noting that  $2\left(1+\frac{1-\beta}{\beta\gamma\lambda}\right) > 1$ , if condition (16) is satisfied than it must be true that  $(1-\beta) < \beta\gamma(1-\lambda)$  hence the sunk cost of EP is smaller than the one of WH and the inequality  $(c_{WH-EP})^{1-\sigma} < (c_{H-EP}^U)^{1-\sigma}$  is a sufficient condition for waiting to emerge. Another possible approach to the problem is to derive the condition for which  $(c_{WH-H})^{1-\sigma} > (c_{H-EP}^U)^{1-\sigma}$  is true.

#### **10.6** Waiting region assuming $f_X > 0$

For waiting to occur in the EP-X choice we need  $(c_{EP-X}^U)^{1-\sigma} < (c_{EP-WX})^{1-\sigma}$ , which simplifies to  $U_X < U_{WX}$ :

$$U_X = \frac{1 - \beta + \beta \gamma}{1 - \beta + \beta \gamma \omega_X} < \frac{(1 - \beta)(1 + \Omega_{FX}) + \beta \gamma (1 - \lambda)}{(1 - \beta)(1 + \Omega_X) + \beta \gamma (1 - \lambda) \omega_{WX}} = U_{WX}$$

That becomes:

$$\frac{\left(f_F - f_X\right)\left(1 - \beta + \beta\gamma\right)}{\left(\nabla_{EP} - \nabla_X\right)\left(1 - \beta\right) + \beta\gamma\left(E\nabla_{EP}(\tau') - \nabla_X\right)} < \frac{f_F\left(1 - \beta + \beta\gamma - \beta\gamma\lambda\right) + f_X\left(1 - \beta - \beta\gamma + \beta\gamma\lambda\right)}{\nabla_{EP}\left(1 - \beta\right) + \beta\gamma(1 - \lambda)\left(E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau}) - \nabla_X\right)}$$

Rearrange and use the binary distribution of internal trade costs to write the condition under which waiting emerges in the EP-X choice is:

$$\frac{(1-\beta)\nabla_X + \beta\gamma \left[\nabla_X + \frac{\beta\gamma\lambda}{1-\beta} \left(E\nabla_{EP}(\tau') - E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)\right]}{(1-\beta)\left(2\nabla_{EP} - \nabla_X\right) + \beta\gamma \cdot \left[2E\nabla_{EP}(\tau') - \nabla_X\right] + \frac{\beta\gamma\beta\gamma\lambda}{1-\beta}\left(E\nabla_{EP}(\tau') - E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)} < \frac{f_X}{f_F}$$

Substituting the definitions of  $\nabla_s$  this becomes:

$$\frac{\left(1-\beta\right)2\tau_{I}^{-\sigma}+\beta\gamma\left[2\tau_{I}^{-\sigma}-\frac{\beta\gamma\lambda}{1-\beta}(1-\lambda)\left(\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)\right]}{\left(1-\beta\right)2\left(1+\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)+\beta\gamma\cdot2\left[1+\lambda\left(\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)-\frac{\beta\gamma\lambda}{1-\beta}(1-\lambda)\left(\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)\right]} < \frac{f_{X}}{f_{F}}$$

Note that with no uncertainty (i.e.,  $\gamma = 0$ ) the condition becomes  $\frac{\nabla_X}{2\nabla_{EP}-\nabla_X} < \frac{f_X}{f_F}$  which is never true if strategy X is the optimal choice for some firms along the productivity distribution. The study of this condition in the text is carried out under the assumption of  $f_X = 0$ , which does not imping the main result but simplifies the analysis of the condition.

#### 10.6.1 Waiting in the H-EP choice

To derive this condition I set  $(c_{H-EP}^U)^{1-\sigma} < (c_{H-WH})^{1-\sigma}$  which is:

$$\frac{\left(f_F - f_X\right)\left(1 - \beta + \beta\gamma\right)}{\left(\nabla_H - \nabla_{EP}\right)\left(1 - \beta\right) + \beta\gamma\left(\nabla_H - E\nabla_{EP}(\tau')\right)} < \frac{2f_F\left(1 - \beta\right) + \beta\gamma\lambda\left(f_F - f_X\right)}{\nabla_H\left(1 - \beta\right) + \beta\gamma\lambda\left(\nabla_H - E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau})\right)}$$

Rearranging and applying the binary distribution of internal trade costs I have:

$$\frac{(1-\beta)\left(2\nabla_{EP}-\nabla_{H}\right)+\beta\gamma\left[\lambda\left(\nabla_{EP}-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)-\left(\nabla_{H}-2E\nabla_{EP}(\tau')\right)+\frac{\beta\gamma\lambda}{1-\beta}\left(E\nabla_{EP}(\tau')-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)\right]}{(1-\beta)\nabla_{H}+\beta\gamma\left[\lambda\left(\nabla_{EP}-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)+\nabla_{H}+\frac{\beta\gamma\lambda}{1-\beta}\left(E\nabla_{EP}(\tau')-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)\right]} < \frac{f_{X}}{f_{F}}$$

And substituting the  $\nabla_s$ :

$$\frac{\left(1-\beta\right)\left(2\tau^{-\sigma}\right)+\beta\gamma\left[2\left(\lambda\tau^{-\sigma}+\left(1-\lambda\right)\tau_{I}^{-\sigma}\right)\right]-\frac{\beta\gamma\beta\gamma\lambda}{1-\beta}\left(1-\lambda\right)\left(\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)}{2\left(1-\beta+\beta\gamma\right)-\frac{\beta\gamma\beta\gamma\lambda}{1-\beta}\left(1-\lambda\right)\left(\tau^{-\sigma}-\tau_{I}^{-\sigma}\right)}<\frac{f_{X}}{f_{F}}$$

Figure 13 shows the waiting region, with  $\frac{f_X}{f_F}$  on the vertical axis and  $\gamma$  on the horizontal axis. Panel a plots the boundary conditions for  $\lambda = 0.5$ . The grey area above the black horizontal line is the  $\frac{f_X}{f_F}$  space in which it is never optimal to invest in strategy X as it is outperformed by EP. This is derive in the text as  $\frac{f_X}{f_F} < \frac{\nabla_X}{2\nabla_{EP} - \nabla_X}$ . The two green lines are the boundary conditions, with the bottom one being the condition for EP-X and the top one the condition for H-EP. If  $\frac{f_X}{f_F}$  is below the boundary line the investment is immediate, while if it is above waiting occurs. The white area is where strategy X exists and the investment decision is immediate. The light-red area shows the region where waiting occurs for the EP-X choice but it is immediate in the H-EP decision. Note how the two conditions decrease with  $\gamma$  and have a minimum in  $\gamma = 1$ . Panel b plots the same boundary conditions but evaluated at  $\lambda = 0.3$  and high level of  $\tau_I$ . Note how waiting in the EP-X choice occurs at smaller values of  $\gamma$  compared to the figure in panel a. This is because the external tariff is higher. In panel b, waiting in the H-EP choice occurs, but only for very high values of  $\gamma$ .

Figure 13: Waiting region numerical evaluation



#### 10.7 Strategy Switching

In this section I extend the model allowing the firm to switch strategy. A firm that starts a strategy  $s_1$  in period U can switch to a strategy  $s_2$  after new information arrives. To switch, the firm must pay additional sunk costs, while continuation in  $s_1$  has no per period sunk costs. This implies that it is never optimal to switch to a strategy with higher variable costs – i.e., a flatter value function. Hence, because  $\nabla_H > \nabla_{EP} > \nabla_X$  it is never optimal to switch from H to EP nor from EP to X. Moreover, not all firms will consider switching. A firm with productivity  $c_v^{1-\sigma} < c_{EP(\tau_{min})-X}^{1-\sigma}$  would not prefer EP to X even when the internal trade cost is at its minimum  $\tau_{min}$ . Similarly, a firm with productivity below  $c_{H-EP(\tau_{min})}^{1-\sigma}$  would never consider switching from EP to H. I consider sunk costs to be complementary. A firm that paid  $F_X = 2f_X$  would pay only the sunk cost for FDI  $f_F$  if it switched to EP. For the EP-H switch, the firm would have to pay only  $f_F$  rather than  $F_H = 2f_F$ . I assume that a firm must serve both countries at the same time, but the model could be extended to allow for the possibility to serve one country only in period U and decide how to serve the second country when new information arrives.

#### 10.7.1 The EP-X choice

Consider again a once and for all change in the internal trade policy. The value of strategy X is composed as:

$$\begin{cases} \Pi_X = \pi_X + \beta \Pi_X & \text{if } c^{1-\sigma} < c_{X^{sw}}^{1-\sigma} \\ \Pi_X^{sw} = \pi_X + \beta \gamma \left[ \lambda \left( E \Pi_{EP}(\tau' | \tau' \le \bar{\tau}) - f_F \right) + (1-\lambda) \Pi_X \right] + \beta (1-\gamma) \Pi_X^{sw} & \text{if } c^{1-\sigma} > c_{X^{sw}}^{1-\sigma} \end{cases} \end{cases}$$

where  $\Pi_X^{sw}$  is the value considering switching. Starting X in period U the firm gets an immediate profit  $\pi_X$ . In case of good news the firms switches to EP paying  $f_F$ , while in case of bad news the firm does not expect the policy to change again, hence it will make  $\Pi_X$ . If nothing changes the firm will faces the same problem tomorrow. The equilibrium values are:

$$\begin{cases} \Pi_X = \frac{\pi_X}{1-\beta} & \text{if } c^{1-\sigma} < c_{X^{su}}^{1-\sigma} \\ \Pi_X^{sw} = \frac{\pi_X}{1-\beta+\beta\gamma} + \frac{\beta\gamma}{1-\beta+\beta\gamma} \left[ \lambda \left( \frac{E\pi_{EP}(\tau'|\tau'<\bar{\tau})}{1-\beta} - f_F \right) + (1-\lambda) \frac{\pi_X}{1-\beta} \right] & \text{if } c^{1-\sigma} > c_{X^{sw}}^{1-\sigma} \end{cases}$$

Define  $c_{X^{sw}}^{1-\sigma}$  as the cut-off above which a firm considers switching, given by solving  $\Pi_X^{sw} - F_X = \Pi_X - F_X$ :

$$c_{X^{sw}}^{1-\sigma} = \frac{f_F}{E\nabla_{EP}(\tau'|\tau'<\bar{\tau}) - \nabla_X} \frac{1-\beta}{A} > \frac{f_F - f_X}{\nabla_{EP}(\tau_{min}) - \nabla_X} \frac{1-\beta}{A} = c_{EP(\tau_{min})-X}^{1-\sigma}$$

Where the inequality indicates that only firms that would find EP optimal at the minimum value of the internal cost  $\tau = \tau_{min}$  consider switching. The cut-off between X considering switching and EP is given by:

$$\Pi_{EP} - \Pi_X^{sw} = F_{EP} - F_X$$

$$c_{EP-X^{sw}}^{1-\sigma} = \frac{\left(f_F - f_X\right)\left(1 - \beta\right) + \beta\gamma\left(\left(1 - \lambda\right)f_F - f_X\right)}{\left(\nabla_{EP} - \nabla_X\right)\left(1 - \beta\right) + \beta\gamma\left(1 - \lambda\right)\left(E\nabla_{EP}\left(\tau'|\tau' \ge \bar{\tau}\right) - \nabla_X\right)} \frac{1 - \beta}{A}$$

Let  $\Omega_{FX}^{sw} = \frac{(1-\lambda)f_F - f_X}{f_F - f_X}$  and  $\omega_X^{sw} = (1-\lambda)\frac{E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau}) - \nabla_X}{\nabla_{EP} - \nabla_X}$ . Then the cut-off can be expressed as:

$$c_{EP-X^{sw}}^{1-\sigma} = \frac{f_F - f_X}{\nabla_{EP} - \nabla_X} \frac{1-\beta}{A} \frac{1-\beta + \beta \gamma \Omega_{FX}^{sw}}{1-\beta + \beta \gamma \omega_X^{sw}}$$

The condition under which this cut-off is larger than the deterministic one is  $\frac{1-\beta+\beta\gamma\Omega_X^{sw}}{1-\beta+\beta\gamma\omega_X^{sw}} > 1$  which implies  $\Omega_{FX}^{sw} > \omega_X^{sw}$ :

$$\frac{f_X}{f_F} < \frac{(1-\lambda)\left(\nabla_{EP} - E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau})\right)}{\left(\nabla_{EP} - \nabla_X\right) - (1-\lambda)\left(E\nabla_{EP}(\tau'|\tau' \ge \bar{\tau}) - \nabla_X\right)}$$

Note that the term on the RHS is positive but smaller than one. With zero sunk costs for exporting, this condition is always verified. However, if sunk costs for exporting are positive switching to EP is not always considered. This is because  $f_X$  sunk costs paid for exporting to the platform-country will be 'lost' – i.e., non-complementary to EP. With low  $f_X$  relative to  $f_F$  switching is considered and the cut-off is moved to the right. The value of waiting in the EP-X choice is the same as for the case with no switching allowed.

#### 10.7.2 The H-EP choice

A firm that is around the H-EP cut-off can consider starting strategy EP and then switch to H in case of bad news. Hence, the value of EP with the possibility to switch can be written as:

$$\begin{cases} \Pi_{EP} = \pi_X + \beta \gamma E \Pi_{EP}(\tau') + \beta (1-\gamma) \Pi_{EP} & \text{if } c^{1-\sigma} < c_{EP^{su}}^{1-\sigma} \\ \Pi_{EP}^{sw} = \pi_{EP} + \beta \gamma \left[ \lambda E \Pi_{EP}(\tau'|\tau' < \bar{\tau}) + (1-\lambda) \left( \Pi_H - f_F \right) \right] + \beta (1-\gamma) \Pi_{EP}^{sw} & \text{if } c^{1-\sigma} > c_{EP^{sw}}^{1-\sigma} \\ \Pi_{EP}^{sw} = \frac{\pi_{EP}}{1-\beta+\beta\gamma} + \frac{\beta \gamma}{1-\beta+\beta\gamma} \left[ \lambda \frac{E \pi_{EP}(\tau'|\tau' < \bar{\tau})}{1-\beta} + (1-\lambda) \left( \frac{\pi_H}{1-\beta} - f_F \right) \right] \end{cases}$$

The value of EP with the possibility of switching has higher sunk costs than the value of EP without switching but steeper slope because in case of bad news the firm can switch to H. This implies that the possibility to switch in case of bad news attenuate the reduction of the productivity space in which EP is optimal under uncertainty compared to the case where switching is not allowed. To derive the cut-off above which firms consider switching set  $\Pi_{EP}^{sw} - F_{EP} = \Pi_{EP} - F_{EP}$  and solve for productivity:

$$c_{EP^{sw}}^{1-\sigma} = \frac{f_F}{1 - E(\tau' | \tau' \ge \bar{\tau})} \frac{1-\beta}{A} > \frac{f_F - f_X}{1 - \tau_{max}^{-\sigma}} \frac{1-\beta}{A} = c_{H-EP(\tau_{max})}^{1-\sigma}$$

This means that only firms that would prefer H to EP when  $\tau = \tau_I$  will consider switching. Note moreover that  $c_{H-EP(\tau_I)}^{1-\sigma} = c_{H-X(\tau_I)}^{1-\sigma}$ , hence only firms that would prefer H to X will consider switching from EP to H in case of bad news. The cut-off above which the firm prefers H to EP with switching allowed is given by:

$$\Pi_H - \Pi_{EP}^{sw} = F_H - F_{EP}$$

$$c_{H-EP^{sw}}^{1-\sigma} = \frac{\left(f_F - f_X\right)\left(1 - \beta\right) + \beta\gamma\left(\lambda f_F - f_X\right)}{\left(\nabla_H - \nabla_{EP}\right)\left(1 - \beta\right) + \beta\gamma\lambda\left[\nabla_H - E\nabla_{EP}(\tau'|\tau' < \bar{\tau})\right]} \frac{1 - \beta}{A}$$

Let  $\Omega_{FH}^{sw} = \frac{\lambda f_F - f_X}{f_F - f_X}$  and  $\omega_H^{sw} = \lambda \frac{\nabla_H - E \nabla_{EP}(\tau' | \tau' < \bar{\tau})}{\nabla_H - \nabla_{EP}}$  and write:

$$c_{H-EP^{sw}}^{1-\sigma} = \frac{f_F - f_X}{\nabla_H - \nabla_{EP}} \frac{1-\beta}{A} \frac{1-\beta + \beta\gamma \Omega_{FH}^{sw}}{1-\beta + \beta\gamma \omega_H^{sw}}$$

Under the binary distribution assumption  $\omega_H^{sw} = \lambda$  and the uncertainty term becomes  $\frac{1-\beta+\beta\gamma\Omega_{FH}^{sw}}{1-\beta+\beta\gamma\lambda} < 1$ . The result follows from  $\frac{\lambda f_F - f_X}{f_F - f_X} < \lambda$ , which implies  $\lambda < 1$ , true by definition. Hence, if the internal trade cost is at the minimum of its distribution, uncertainty implies a reduction in the EP optimal productivity space even when switching strategy is allowed. To see that the possibility to switch attenuates the reduction in the EP space, set  $\left(c_{H-EP}^U\right)^{1-\sigma} < \left(c_{H-EPsw}^U\right)^{1-\sigma}$  under the binary distribution:

$$\frac{1-\beta+\beta\gamma}{1-\beta+\beta\gamma\omega_{H}} < \frac{1-\beta+\beta\gamma\Omega_{FH}^{sw}}{1-\beta+\beta\gamma\lambda}$$

That becomes:

$$\frac{f_X}{f_F} < \frac{\nabla_{EP} - E\nabla_{EP}(\tau')}{\left(\nabla_H - E\nabla_{EP}(\tau')\right) - \lambda\left(\nabla_H - \nabla_{EP}\right)} \frac{1 - \beta + 2\beta\gamma\lambda}{1 - \beta + 2\beta\gamma}$$

Substituting the values of  $\nabla_s$  we have:

$$\frac{f_X}{f_F} < \frac{\tau^{-\sigma} - \tau_I^{-\sigma}}{1 - \tau_I^{-\sigma}} \frac{1 - \beta + 2\beta\gamma\lambda}{1 - \beta + 2\beta\gamma}$$

If this condition is met, then firms find optimal to start strategy EP considering switching to H in case of bad news, and the effect of uncertainty on the EP productivity space is attenuated. Relaxing the binary distribution assumption, the condition for which switching implies less entry as EP in the H-EP choice is  $\Omega_{FH}^{sw} < \omega_H^{sw}$ :

$$\frac{\lambda f_F - f_X}{f_F - f_X} < \lambda \frac{\nabla_H - E \nabla_{EP}(\tau' | \tau' < \bar{\tau})}{\nabla_H - \nabla_{EP}}$$

That becomes:

$$f_F \lambda \left( E \nabla_{EP}(\tau' | \tau' < \bar{\tau}) - \nabla_{EP} \right) < f_X \left[ \left( \nabla_H - \nabla_{EP} \right) - \lambda \left( \nabla_H - E \nabla_{EP}(\tau' | \tau' < \bar{\tau}) \right) \right]$$

Here multiple scenarios arise:

• If  $E(\tau^{-\sigma}|\tau<\bar{\tau})<\tau^{-\sigma}$  and  $\frac{\nabla_H-\nabla_{EP}}{\nabla_H-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})}<\lambda$ , the condition is:

$$\frac{f_X}{f_F} < \frac{\lambda \left( \nabla_{EP} - E \nabla_{EP} (\tau' | \tau' < \bar{\tau}) \right)}{\lambda \left( \nabla_H - E \nabla_{EP} (\tau' | \tau' < \bar{\tau}) \right) - \left( \nabla_H - \nabla_{EP} \right)}$$

• If  $E(\tau^{-\sigma}|\tau < \bar{\tau}) > \tau^{-\sigma}$  and  $\frac{\nabla_H - \nabla_{EP}}{\nabla_H - E\nabla_{EP}(\tau'|\tau' < \bar{\tau})} > \lambda$ , the inequality implies

$$\frac{\lambda \left(E\nabla_{EP}(\tau'|\tau'<\bar{\tau})-\nabla_{EP}\right)}{\left(\nabla_{H}-\nabla_{EP}\right)-\lambda \left(\nabla_{H}-E\nabla_{EP}(\tau'|\tau'<\bar{\tau})\right)} < \frac{f_X}{f_F}$$

• If  $E(\tau^{-\sigma}|\tau<\bar{\tau}) > \tau^{-\sigma}$  and  $\frac{\nabla_H - \nabla_{EP}}{\nabla_H - E\nabla_{EP}(\tau'|\tau'<\bar{\tau})} < \lambda$  the inequality is never true.

This section shows that the possibility to switch strategy does not change results drastically. Under the assumption that internal trade costs are at the minimum of the distribution all results show a reduction in the EP space. Whether switching strategy occurs depends on the relative values of sunk and variable costs. An important characteristic of both the waiting and the switching cut-offs is that their measure of uncertainty depends on both variable and sunk costs, while for the immediate investment cut-offs the uncertainty terms depend on variable trade costs. Given the lack of a measure of sunk costs, their absence from the uncertainty term represents a great advantage for the empirical analysis, and I can measure uncertainty only in terms of trade costs.

## **11** Estimation Appendix

### 11.1 Counterfactual

Tables 12 and 13 report the counterfactuals measured with  $\sigma = 2$  and 4, respectively. In both cases internal trade costs are assumed to be constant at 5% such that  $\tau = 1.05$ .

Table 12: Counterfactual for $\sigma = 2$ , constant interna	$l \cos t$
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	No. of countries			
	$\mathrm{m}=2$	m = 8	m=12	m=28
Pareto shape				
lpha=2	-5.45	-12.50	-13.81	-15.68
lpha=3	-5.41	-12.36	-13.63	-15.46

Table 13: Counterfactual for  $\sigma = 4$ , constant internal cost

	No. of countries			
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	$\mathrm{m}=28$
Pareto shape				
lpha=2	-6.52	-15.23	-16.89	-19.31
lpha=3	-6.39	-14.57	-16.09	-18.28

Tables report the counterfactual for values of  $\sigma = 2, 3$  and 4 respectively. In this case I measure trade costs using CIF/FOB data as described in the text.

	No. of countries			
	$\mathrm{m}=2$	m = 8	m = 12	m=28
Pareto shape				
lpha=2	-6.59	-13.64	-14.66	-15.92
lpha=3	-6.55	-13.48	-14.48	-15.71

Table 14: Counterfactual for  $\sigma = 2$ , CIF/FOB for internal cost

Table 15: Counterfactual for  $\sigma = 3$ , CIF/FOB for internal cost

	No. of countries			
	$\mathrm{m}=2$	m = 8	$\mathrm{m}=12$	$\mathrm{m}=28$
Pareto shape				
lpha=2	-7.60	-15.74	-16.92	-18.38
lpha=3	-7.51	-15.31	-16.43	-17.80

Table 16: Counterfactual for  $\sigma = 4$ , CIF/FOB for internal cost

	No. of countries			
	$\mathrm{m}=2$	m = 8	m=12	$\mathrm{m}=28$
Pareto shape				
lpha=2	-8.63	-17.97	-19.34	-21.05
lpha=3	-8.43	-17.13	-18.37	-19.90