Exporters and Exchange Rates*

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Abstract

We use ten years of plant-level data for Ireland to estimate how export entry and exit depend on nominal exchange rates. To guide our empirical work, we present a dynamic model of demand accumulation by plants with heterogenous costs which may participate in multiple export markets. Our identification strategy exploits the fact that we observe sales in two distinct export markets, allowing us to clean out the first-order effect of unobserved heterogeneity in costs using fixed effects. When we allow the responses of entry and exit to exchange rates to vary with plant characteristics and export histories as our model suggests, we find that exchange rate depreciations tend to induce entry and exchange rate appreciations induce exit. Our results imply that the exchange rate movements we observe over the course of our sample period explain a modest fraction of observed variation in export entry and exit.

1 Introduction

The expenditure-switching e ects of nominal exchange rate movements depend on the price and quantity responses of individual rms. There is a very extensive literature that documents disaggregated price responses to exchange rate movements. Surprisingly, there is relatively little work on the responses of export quantities or revenues at the micro level to

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movements in exchange rates.[1] The goal of this paper is to fill this gap. We work with ten years of plant census data for Ireland. To date, we focus on estimating the sensitivity of export entry and exit to the exchange rate in a reduced form framework. Eventually we plan to analyze also the response of export sales conditional on participation.

We show that to isolate entry and exit responses to the exchange rate, it is important to allow for heterogeneous responses across plants with different costs and export histories. When we allow for heterogeneous responses of this type, we identify statistically significant sensitivities of entry and exit to the exchange rate. Entry is generally increasing in the level of the exchange rate while exit is decreasing in the level of the exchange rate. The exchange rate movements we observe over the course of our sample period explain a modest fraction of observed variation in export entry and exit.

To guide our empirical strategy, we present a partial equilibrium model of dynamic demand accumulation. This choice is motivated by a series of facts that cannot be explained by more traditional models of export participation: The hazard of exit is decreasing with the number of years in the export market, while conditional on survival, sales growth in the export market falls with the number of years in the market. Demand accumulation is not the only mechanism that can explain these facts. But since the purpose of the model is to guide the empirical analysis, we choose this mechanism to keep the analysis relatively simple.

The model has the following features. Plants are heterogeneous in their (home currency-denominated) marginal costs of production. Within each target market, they face a potential level of demand that depends on their (foreign currency) price with constant elasticity, on the level of their accumulated "customer capital" and on an iid shock. Revenues from each market then depend on the plant's foreign currency price, its potential demand, and the level of the exchange rate. If a plant did not participate in a particular market in the previous period, its customer capital resets to a low baseline level. Conditional on participating in a market in the current period, the plant can expend some resources to increase its customer capital in the following period. There are decreasing returns to customer capital, implying a determinate level of steady state sales by market for every level of marginal cost. There are convex costs of adjustment in accumulating customer capital, so plants do not jump straight to their steady state sales on entry to a market. In addition, there are fixed costs of market participation that are independent of the amount sold in the market. These costs imply that plants with high costs, low idiosyncratic demand and low customer capital will not find it optimal to participate. Movements in exchange rates are perceived by the plant as shifts in

[1] Exceptions include Campa (2004) and Berman, Martin and Mayer (2009).

relative demand across markets, so the cutoff for participation depends on the level of the exchange rate, as well as a particular plant's costs and customer capital.

The key prediction of the model for us is that the sensitivity of entry to the exchange rate depends on the potential entrant's distance from the entry threshold, which in turn depends on its costs. Meanwhile, the sensitivity of exit to the exchange rate depends on the participating plant's distance from the exit threshold, which in turn depends on its costs and its level of accumulated customer capital in the market in question. In order to estimate the sensitivity of entry and exit to the exchange rate, we must allow responses to differ along these dimensions. The model also predicts that, depending on the persistence of the exchange rate, the short run response of export sales conditional on participation to movements in the exchange rate may differ from the long run response, which is mediated by investment in future customer capital. We do not yet have the data to explore this prediction.

In our empirical application, we make use of the annual plant census for Ireland for the years 1996-2005. We observe all the usual plant census variables, along with a measure of sales to the UK and the US markets. Our empirical strategy exploits the fact that we observe export status in two different markets by using plant-year fixed effects to control for the first-order effect of potentially time-varying heterogeneity in marginal costs on the probability of entry and exit. This implies that we identify the sensitivity of entry and exit to exchange rate by looking at variation in entry and exit across markets within plant-years. We allow the sensitivity of both entry and exit to the exchange rate to differ across plants and years according to costs by including interactions between the exchange rate and a set of variables that are correlated with costs. We additionally allow the sensitivity of exit to the exchange rate to differ across plant-market-years with different levels of accumulated customer capital by including interactions between the exchange rate and indicator variables for the number of years the plant has been in the market as well as lagged revenue from that market.

When we do not allow the sensitivity of export entry and exit to the exchange rate to vary across plants, we find no statistically significant effect of the exchange rate on entry and exit. Once we allow for heterogeneity in responses to the exchange rate across plants with different costs and different export histories, we find effects on entry and exit that have the predicted sign and are statistically significant. Our results suggest that exchange rate depreciations are most likely to induce entry in larger, younger, imported-intermediate-intensive non-participants who are currently exporting to other markets. Exchange rate appreciatiations tend to increase exit in general. As predicted by the model, plants that have accumulated greater customer capital in the relevant market - measured either by number of years in the market or by lagged foreign currency revenues - are less likely to exit in response to a given appreciation than are plants with little attachment to the relevant market. Somewhat surprisingly, once we control for market attachment, bigger, more capital-intensive and more productive plants are also more likely to exit in response to a given shock.

Although the effects we document are statistically significant, we calculate that the year-on-year variation in export entry and exit that is explained by observed movements in exchange rates over the course of our sample is quite modest.

Our work is related to several literatures. First, it is related to an older theoretical literature that shows that the expenditure-shifting effects of exchange rate movements may depend on sunk costs of exporting at the plant level (Baldwin (1988), Baldwin and Krugman (1989) and Dixit (1989)). More recently, several authors have estimated both reduced form and structural dynamic discrete choice models of export entry and exit with sunk costs of exporting (see Roberts and Tybout (1997), Bernard and Wagner (2001), Bernard and Jensen (2004) and Das, Roberts and Tybout (2007)). These papers do not isolate the effect of exchange rate movements (as distinct from other aggregate shocks) on entry and exit. This particular question is addressed by Campa (2004), who finds quantitatively small effects of exchange rate movements on entry and exit, and by Berman, Martin and Meyer (2009) whose empirical strategy is different from that employed by the rest of the literature.

Relative to this last literature, we innovate in two dimensions. First, recent evidence documents that the hazard of exit is declining in the number of years a plant participates in a market. Moreover, conditional on survival, recent entrants grow faster than incumbents (see Ruhl and Willis (2008a), Eaton, Eslava, Kugler and Tybout (2008)). The first generation of sunk cost models cannot match these facts, and several authors have recently proposed alternatives based on learning (Ruhl and Willis (2008b), Eaton, Eslava, Krizan, Kugler and Tybout (2010)), search (Chaney (2009)) and innovations to productivity (Arkolakis (2009)). Inspired by a series of papers in the macro literature (Foster, Haltiwanger and Syverson (2010) and Gourio and Rudanko (2010)), we propose a reduced form model of demand accumulation that has the ability to match these facts. The simplicity of the model allows us to characterize the comparative static effects of changes in different variables on entry and exit in a transparent way. These comparative statics contrast with those in the first generation of sunk cost models, in that the sensitivity to the exchange rate is heterogeneous not just across plants with different costs, but also across plants with different levels of attachment to the export market. This motivates us to use a different empirical specification from that used in the previous literature.

The second dimension along which we innovate is that our data allows us to identify participation in two distinct export markets at an annual frequency. This allows us to more precisely identify the effect of exchange rates on entry and exit than the previous literature, which either did not observe a breakdown of exports by destination and therefore could not identify any exchange rate effects (e.g. Roberts and Tybout (1997), Bernard and Wagner (2001) Bernard and Jensen (2004)) or did not observe this breakdown every year, affecting precision (e.g. Campa (2004)). Moreover, in our empirical strategy, we exploit the fact that we observe exports in multiple markets to control for the first-order effect of heterogeneity in costs on entry and exit using plant-year fixed effects. This approach has been used in the price literature (e.g. Knetter (1989), Fitzgerald and Haller (2010)) but not so far in the literature on export entry and exit.

The first section of the paper describes our data. The second section presents the model. The third section of the paper describes our empirical strategy. The fourth section describes our results. The final section concludes.

2 Data

Our work makes use of the Irish Census of Industrial Production (CIP). This census of manufacturing, mining and utilities takes place annually. Firms are required to fill in a return for all plants with 3 or more. We make use of the data for the years 1996 to 2005 and for NACE Revision 1.1 sectors 10-36 (manufacturing and mining). Of the variables collected in the CIP, those relevant for our purposes are the 4-digit industrial classification, country of ownership, value of sales, share of sales exported, share of exports destined for the UK, share of exports destined for the US, investment (and a measure of capital stock that we have constructed based on investment), employment, wage bill, expenditures on intermediates and share of intermediates imported. We also have the share of exports destined for the EU (EU-15 to 2003 and EU-25 thereafter) and the share of exports destined for the rest of the world, but given the coarse and time-varying nature of this classification, we do not make use of this breakdown. We construct a plant age variable based on information in the CIP and administrative records.

Given the importance of the export destination variable, it is worth noting that in the survey, plants are asked to report both exports and the destination breakdown of exports in percentage form. As a result, the value of sales to each identified market (both home and foreign markets) is measured with error.[2] However we think measurement error is likely to be less of a problem for indicators of presence in a market based on these percentages, and this is why to date, we focus on entry and exit. In future work, we plan to merge customs data with our data at the plant level. This will improve our measurement of the value of exports to the UK and US, and in addition, allow us to make use of other destination markets. It may also allow us to refine our analysis of the timing of responses to exchange rate movements.

We drop plants that have a zero value for total sales or the number of employees in more than half of their years in the sample. We also drop plants if more than half of their observations were estimated or imputed by the Central Statistics Office due to non-response or incomplete returns. This affects small plants more than big plants.[3] Further details on the data and how we have cleaned it are provided in the data appendix.

Since we focus in particular on the UK and US markets, it is worth saying something about their importance for Irish exporters and potential exporters. The Irish and UK markets are unusually well-integrated. Ireland was part of the UK until 1922. After a trade war begun in 1932, tariffs on imports from the UK were reduced from 1957, until by 1975, there was once again free trade in industrial products between the two countries. The UK has traditionally accounted for the bulk of Irish exports and imports. Although its importance as a trading partner has declined substantially since Ireland joined the EEC in 1973, it remained the biggest single export destination for Irish industry until the early 2000s. There was a fixed exchange rate with the UK until 1979. From 1979, when it joined the Exchange Rate Mechanism (ERM) to 1999, Ireland had its own currency (the Irish Punt) with a floating exchange rate against Sterling. Since 1999, Ireland has used the Euro, which also floats against Sterling.

The US has traditionally been a more peripheral export destination for Ireland, though its importance in terms of sales increased over the period we examine, eventually dominating that of the UK. Since Ireland joined the EEC in 1973, trade policy between the two countries has been negotiated at the EU level. The Uruguay round introduced a new series of tariff cuts on EU imports into the US that took place over the period 1995-1999.

[2]This is apparent from the fact that the distributions of these percentages are not smooth, but have pronounced spikes at numbers divisible by 10.

[3]The time series pattern of aggregate exports and exports by destination based on CIP data does not match the pattern in official trade statistics.

2.1 Exporters and non-exporters

We now present some summary statistics on important features of our data. These statistics are reported for the sample cleaned as described above. We do not restrict attention to a balanced panel, as this would exclude a substantial portion of the variation in the data. The first panel of Table 1 reports an index of the annual average Sterling and dollar exchange rates for our sample period.[4] An increase indicates a devaluation of the home currency against the foreign currency. We identify the effect of the exchange rate on entry and exit using within-plant-year variation in the timing of entry and exit across markets, so it is important that though the broad pattern is similar across currencies, the size and timing of exchange rate movements differ between the Sterling and Dollar exchange rates. The second panel of Table 1 also reports the UK and US shares in total Irish manufacturing and mining exports over the sample period. This illustrates the substantial (though declining) importance of the UK, and the growing importance of the US as a destination market.[5]

Table 1 also reports for the sample we make use of in our empirical exercise an index of the value of all exports and exports by destination,[6] the number of plants exporting and the number of plants exporting by destination, the share of plants exporting and the share of plants exporting by destination, and the mean and median shares of sales accounted for by exports and by exports by destination. This table illustrates the fact that the Irish industrial sector is very open. On average 50% of plants in the sample export, and the average share of sales exported by exporters is between 40 and 50%. This contrasts with the stylized facts documented for large developed economies such as the US and France, and smaller developing countries such as Colombia. An additional unusual feature of the Irish market is the substantial fraction of exporters who report zero sales in the domestic market.

There is a clear hierarchy of destinations, in the sense that conditional on exporting, the probability of exporting to the UK is much higher than the probability of exporting to the US. However this does not mean that all plants who export to the US also export to the UK, a fact we exploit in our empirical strategy. Table 1 also reports the mean and median number of employees in all plants, in exporters and in exporters by destination. Exporters are bigger than non-exporters, though the exporter size premium is half that documented

[4] Source: Central Bank of Ireland. Rates are Sterling-Punt and Dollar-Punt for 1995-1998 and Sterling-Euro and Dollar-Euro for 1999-2005, with the fixed Euro conversion rate used to convert Euros to Punt.

[5] Source: OECD.

[6] Sales are converted to Euros and deflated by the Irish CPI.

Table 1: Summary statistics

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Stg-Irish ex. rate	100	111	119	123	133	130	128	117	119	118
US$-Irish ex. rate	100	106	112	118	137	141	134	112	101	101
UK share in merch exports	0.25	0.25	0.23	0.22	0.21	0.23	0.23	0.18	0.17	0.17
US share in merch exports	0.09	0.11	0.14	0.15	0.19	0.17	0.16	0.21	0.20	0.19
Exports to all dest.	100	118	122	154	174	172	175	163	161	160
Exports to UK	100	112	103	120	138	117	111	96	93	88
Exports to US	100	141	166	238	291	361	317	256	247	250
# Plants	3882	4055	4107	4154	4198	4140	4260	4187	3946	3773
# Exporters	1991	2098	2155	2156	2138	2111	2124	2078	1961	1825
# Exporters to UK	1767	1861	1886	1897	1905	1827	1841	1797	1698	1549
# Exporters to US	572	622	653	636	705	795	751	721	692	644
Sh of plants exporting	0.51	0.52	0.52	0.52	0.51	0.51	0.50	0.50	0.50	0.48
Sh of exporters ex to UK	0.90	0.88	0.88	0.88	0.88	0.86	0.86	0.86	0.86	0.85
Sh of exporters ex to US	0.29	0.29	0.31	0.29	0.33	0.37	0.36	0.34	0.36	0.35
Sh of ex to US ex to UK	0.86	0.86	0.84	0.84	0.85	0.79	0.80	0.79	0.77	0.76
Sh of ex to UK ex to US	0.28	0.29	0.29	0.28	0.32	0.35	0.33	0.31	0.31	0.32
Sh of ex not selling in Irl	0.12	0.12	0.11	0.12	0.12	0.11	0.11	0.11	0.12	0.12
Avg sh of ex. in sales	0.51	0.50	0.48	0.48	0.46	0.46	0.45	0.44	0.44	0.44
Avg sh of UK ex in sales	0.15	0.14	0.14	0.13	0.12	0.12	0.12	0.12	0.11	0.12
Avg sh of US ex in sales	0.14	0.14	0.14	0.14	0.14	0.13	0.14	0.14	0.12	0.13
Med sh of ex in sales	0.48	0.45	0.41	0.38	0.36	0.34	0.33	0.31	0.30	0.30
Med sh of UK ex in sales	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03
Med sh of US ex in sales	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.06	0.05	0.05
Avg emp all plants	54	55	56	56	56	56	52	50	52	53
Avg emp exporters	86	88	88	88	89	88	84	82	85	87
Avg emp ex UK	86	87	83	84	84	84	80	76	80	78
Avg emp ex US	131	140	129	139	140	126	119	120	120	125
Med emp all plants	19	18	19	19	18	18	17	16	16	17
Med emp exporters	35	36	35	35	33	33	31	30	31	32
Med emp ex UK	36	36	35	35	32	33	32	30	31	32
Med emp ex US	54	54	51	56	49	41	38	38	32	37
Avg emp UK entrant	n.a.	39	37	67	38	56	57	31	63	36
Avg emp US entrant	n.a.	88	58	110	80	70	67	77	44	72
Avg emp UK exiter	n.a.	53	100	54	46	47	48	50	41	81
Avg emp US exiter	n.a.	80	118	60	69	100	82	60	79	55
Med emp UK entrant	n.a.	18	16	18	13	16	17	13	16	14
Med emp US entrant	n.a.	37	28	35	21	13	27	28	17	25
Med emp UK exiter	n.a.	27	18	20	23	16	14	16	14	15
Med emp US exiter	n.a.	26	35	25	27	43	25	19	33	25
Sh plants foreign owned	0.17	0.17	0.16	0.16	0.15	0.16	0.16	0.16	0.15	0.15
Sh exporters for owned	0.31	0.30	0.29	0.28	0.28	0.29	0.29	0.28	0.27	0.28
Sh ex to UK for owned	0.29	0.28	0.27	0.26	0.25	0.26	0.27	0.26	0.24	0.25
Sh ex to US for owned	0.47	0.46	0.43	0.43	0.41	0.39	0.40	0.42	0.40	0.42

Notes: Exchange rate indices are calculated based on year-end exchange rates from the Central Bank of Ireland. Shares of UK and US in Irish merchandise exports are calculated based on data from the OECD Monthly Statistics of International Trade. Statistics on plants are based on all reporting plants in NACE Rev 1.1 sectors 10-36, excluding plants that have a zero value for total sales or the number of employees in more than half of their years in the sample. We also drop plants if more than half of their observations were estimated or imputed by the Central Statistics Office due to non-response or incomplete returns.

Table 2: Transitions into and out of exporting

t	t+1	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	avg
		Exporting anywhere									
ex	ex	0.95	0.94	0.91	0.91	0.94	0.93	0.90	0.87	0.87	0.91
	nex	0.02	0.03	0.04	0.04	0.04	0.03	0.05	0.05	0.05	0.04
	die	0.03	0.03	0.06	0.05	0.03	0.04	0.05	0.08	0.08	0.05
nex	ex	0.06	0.06	0.05	0.05	0.05	0.06	0.06	0.05	0.05	0.05
	nex	0.89	0.91	0.87	0.89	0.91	0.89	0.86	0.83	0.85	0.88
	die	0.06	0.03	0.07	0.06	0.04	0.05	0.08	0.12	0.10	0.07
born	ex	0.31	0.44	0.32	0.29	0.29	0.17	0.13	0.19	0.00	0.24
	nex	0.69	0.56	0.68	0.71	0.71	0.83	0.88	0.81	1.00	0.76
		Exporting to the UK									
exuk	exuk	0.93	0.91	0.88	0.89	0.89	0.89	0.87	0.85	0.83	0.88
	nexuk	0.05	0.06	0.06	0.06	0.08	0.07	0.09	0.07	0.09	0.07
	die	0.03	0.03	0.06	0.05	0.03	0.04	0.05	0.08	0.08	0.05
nexuk	exuk	0.07	0.06	0.07	0.06	0.05	0.07	0.07	0.06	0.05	0.06
	nexuk	0.88	0.90	0.86	0.87	0.91	0.88	0.86	0.82	0.85	0.87
	die	0.05	0.04	0.07	0.06	0.04	0.05	0.08	0.12	0.10	0.07
born	exuk	0.27	0.34	0.28	0.26	0.29	0.17	0.13	0.17	0.00	0.21
	nexuk	0.73	0.66	0.72	0.74	0.71	0.83	0.88	0.83	1.00	0.79
		Exporting to the US									
exus	exus	0.85	0.83	0.76	0.85	0.85	0.81	0.79	0.75	0.80	0.81
	nexus	0.13	0.14	0.16	0.10	0.13	0.14	0.15	0.15	0.12	0.13
	die	0.02	0.03	0.08	0.06	0.02	0.05	0.06	0.10	0.08	0.06
nexus	exus	0.03	0.04	0.03	0.04	0.05	0.03	0.03	0.04	0.02	0.03
	nexus	0.92	0.93	0.91	0.91	0.91	0.93	0.90	0.86	0.88	0.91
	die	0.04	0.03	0.06	0.06	0.04	0.04	0.07	0.10	0.09	0.06
born	exus	0.08	0.12	0.13	0.13	0.09	0.03	0.08	0.06	0.00	0.08
	nexus	0.92	0.88	0.87	0.87	0.91	0.97	0.93	0.94	1.00	0.92

Notes: Statistics are based on all reporting plants in NACE Rev 1.1 sectors 10-36, excluding plants that have a zero value for total sales or the number of employees in more than half of their years in the sample. We also drop plants if more than half of their observations were estimated or imputed by the Central Statistics Office due to non-response or incomplete returns.

by Bernard, Redding, Jensen and Schott (2007) for US exporters. However exporters to the US are substantially bigger than exporters to the UK.

Table 2 reports transition rates into and out of exporting in general, and exporting to the UK and US markets in particular. The average rate at which previously existing non-exporters start to export over the period is 5%, while the average rate at which exporters continue to export is 91%. Over half of exiting exporters cease operations altogether. At the same time, around a quarter of new plants start exporting in their first year of operation. While the "born global" phenomenon is interesting, we will not address it directly here.

It is not immediately obvious from the time-series pattern of entry and exit that there is a relationship between entry and exit and the level of the Sterling and US dollar exchange rates. This motivates our exploration of heterogeneous sensitivities to exchange rates.

2.2 Dynamics of new exporter growth

Eaton, Eslava, Kugler and Tybout (2008) and Ruhl and Willis (2008a) document an interesting set of facts about the dynamics of new exporter growth using Colombian data. We observe some of the same patterns in our data. In Figure 1, we plot the average export to total sales ratio for new exporters, conditioning on the plant continuing to export for at least 5 years. This is based on the sample where we observe entry in the period 1997-2001.[7] We include plants that are born global. We find that the export-sales ratio jumps on entry, and grows slowly over the first two years in a market before levelling off. Figures 2 and 3 illustrate the same pictures for entrants to the UK and US markets respectively.[8]

[7] Since our sample starts in 1996, 1997 is the first year in which we can observe entry, and if we are to observe export participation for at least 5 years, the last year for which we can make use of entries is 2001.

[8] Note that these figures are based on the export share and destination share variables, which we have reason to believe are measured with error.

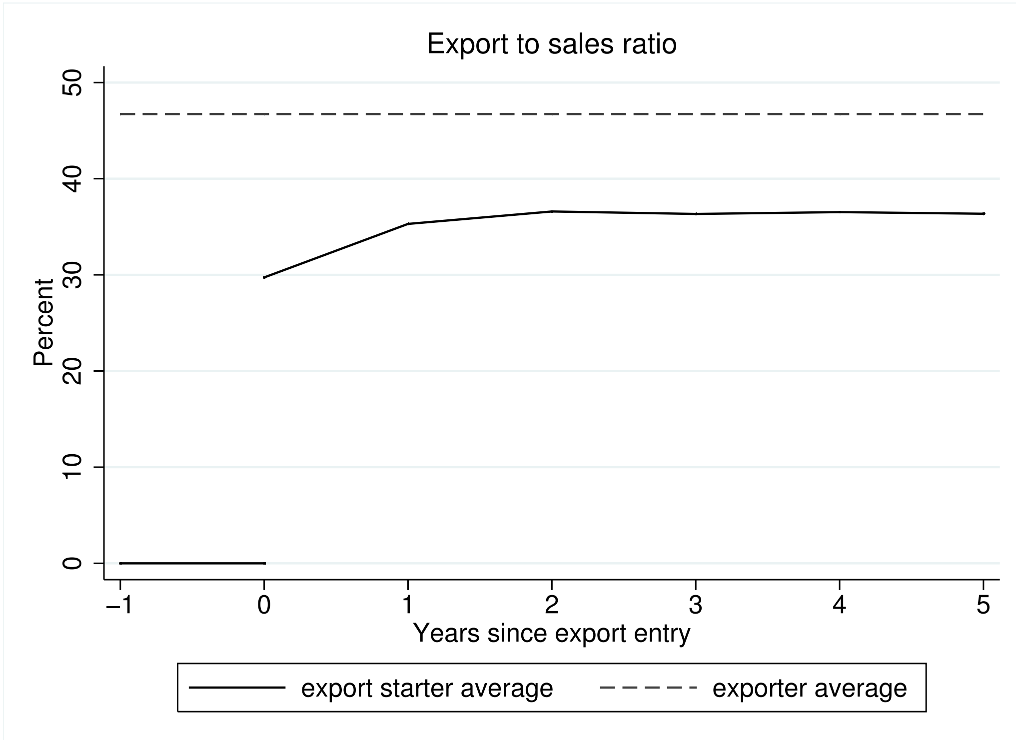

Figure 1: Export-sales ratios for export entrants

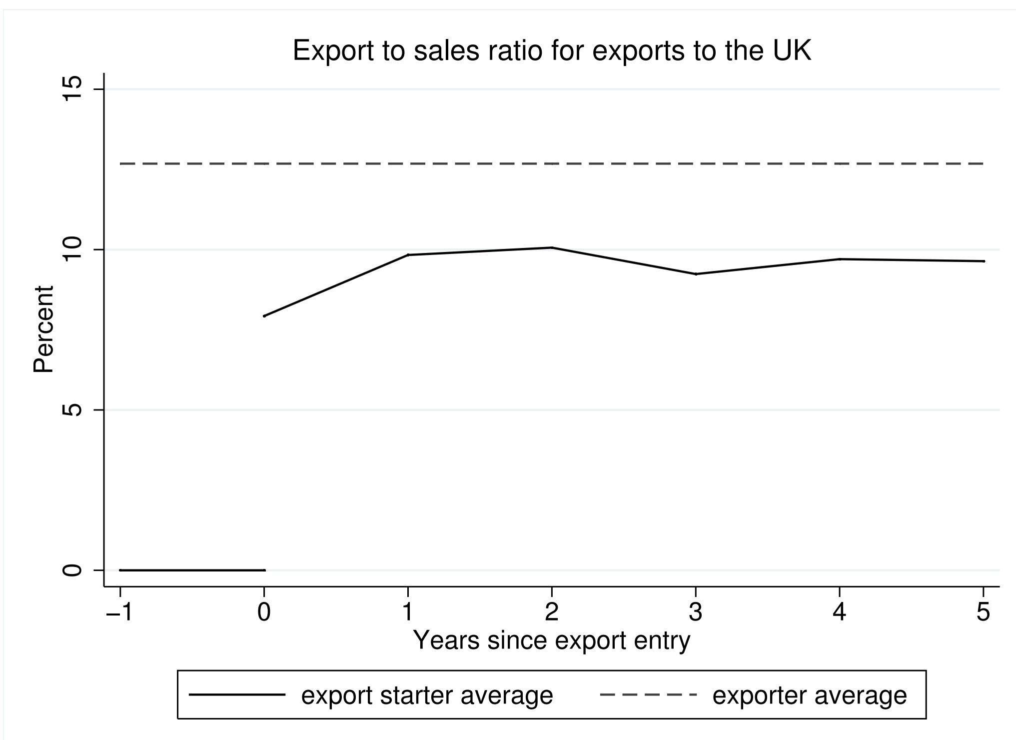

Figure 2: Export-sales ratios for entrants to UK market

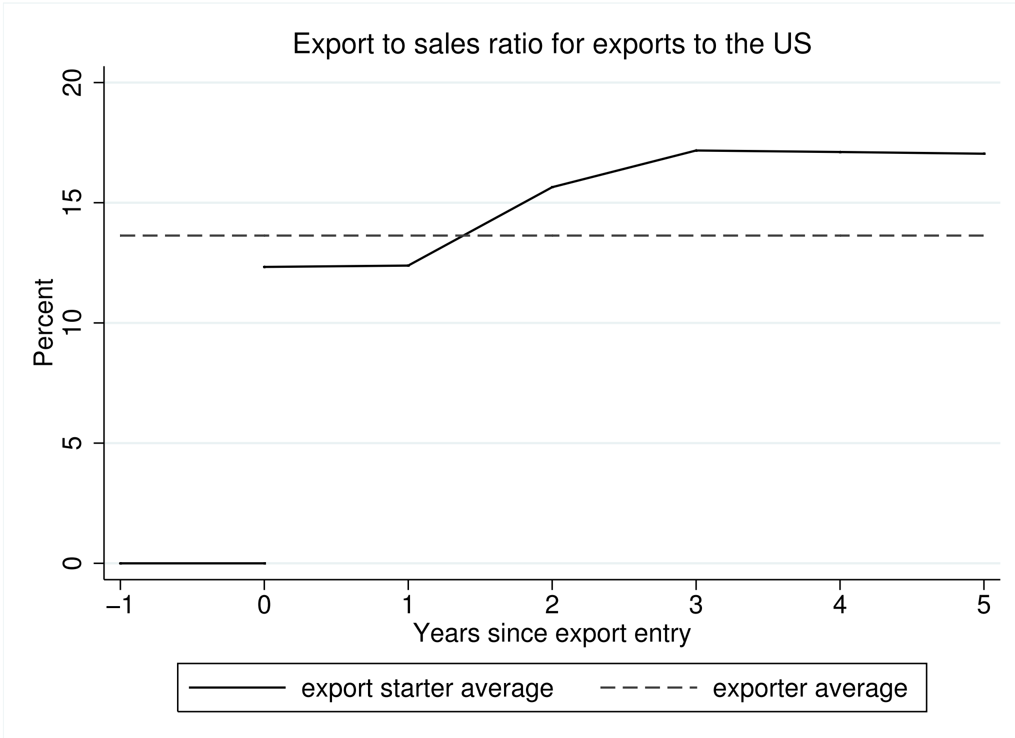

Figure 3: Export-sales ratios for entrants to US market

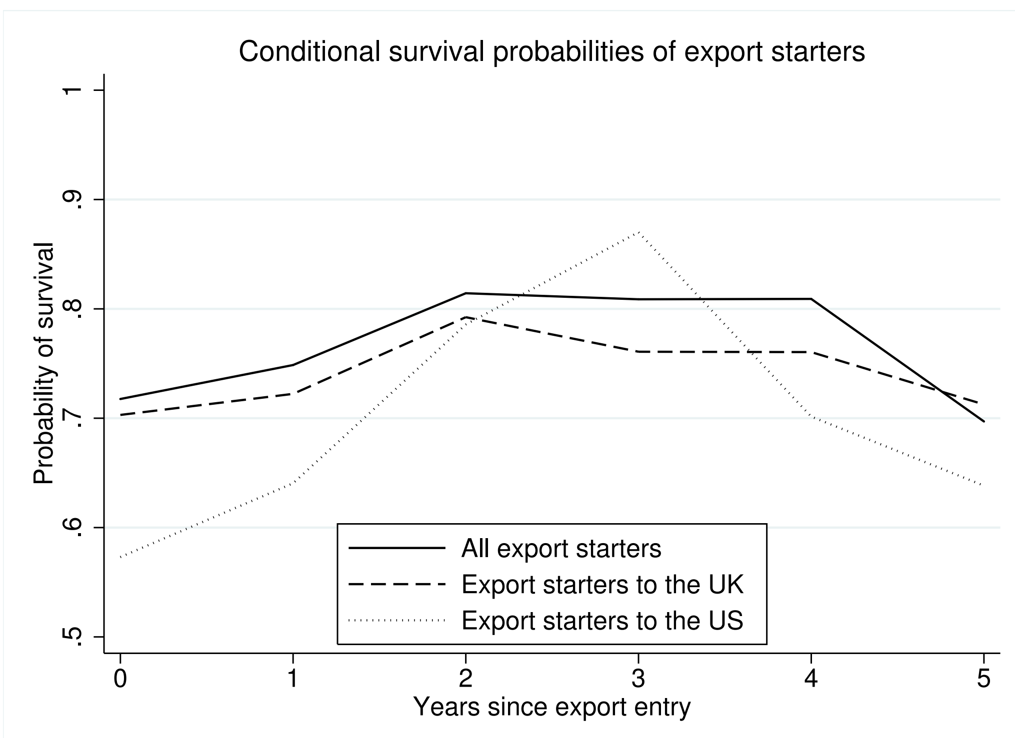

Figure 4: Survival probabilities

In Figure 4, we plot the survivor rate for exporters to the UK and US markets. For all markets, the survivor probability is initially increasing in the number of years since entry. Thereafter there is a decline, possibly related to the fact that we observe declining survivor probabilities for all export participants (unconditional on years since entry) over the period 2001-2005. Given the short sample we work with, this is the period of years over which survivor probabilities conditional on participating 5 years in the export market are identified.

To summarize, the evidence of new exporter dynamics in our data is somewhat less striking than those presented by, say, Ruhl and Willis (2008). Nevertheless, it suggests that it may be worthwhile to allow for these dynamics in estimating the effect of the exchange rate on entry, exit and sales.

3 A dynamic model of demand accumulation

Motivated by facts such as those we describe above, several authors have recently taken up the challenge of building models that can match the dynamic patterns of export expansion. Several of these (Ruhl and Willis (2008), Eaton et al (2010)) propose models that are based on plants learning about their demand in foreign markets. Others such as Arkolakis (2009) are based on plants learning about their productivity. Yet others (Chaney (2010)) involve search models of buyers meeting sellers. These authors derive the dynamic patterns from first principles, but their models have the disadvantage of being relatively complicated. Since our main interest is in identifying the effect of exchange rate movements on entry and exit, while allowing for the dynamic patterns of export expansion that we and others document, we propose a reduced form alternative. Our formulation has the advantage that it is relatively straightforward to characterize comparative statics on entry and exit.

Our model has the following features. We assume that plants invest today in future customer base that generates demand through a decreasing returns technology.[9] Decreasing returns imply that there is a steady state level of customer base (conditional on market participation) that depends on plant characteristics and the aggregate state. We also assume that there are convex adjustment costs that slow down convergence to steady state; it is cheaper to build up customer base gradually rather than doing it all at once. We show in an appendix that in the case without idiosyncratic demand shocks, our setup leads to a generalization of Melitz (2003) with a determinate steady state distribution of plant age, as

[9] The decreasing returns arise from the fact that demand also depends on current prices.

well as a steady state distribution of productivity and size conditional on age. Our model is related to those of to Arkolakis (2008) in the trade literature, and Drozd and Nosal (2010), Foster, Haltiwanger and Syverson (2010) and Gourio and Rudanko (2010) in the macro literature.

3.1 Demand

We assume that the demand faced by plant i in market k at time t is given by

$$Q_t^{ik} = Q_t^k \left(\frac{P_t^{ik*}}{P_t^{k*}}\right)^{-\theta} \left(D_t^{ik}\right)^{\alpha} \exp\left(\eta_t^{ik}\right)$$

where $\theta > 1$ and $\alpha \in (0, 1)$. The rst two terms of this expression are the standard CES demand: Q_t^k is market demand, P_t^{k*} is the market price expressed in foreign currency, and P_t^{ik*} is plant i's price in market k, expressed in foreign currency. η_t^{ik} is an iid lognormally distributed random variable that captures idiosyncratic shocks to demand. D_t^{ik} is a persistent demand shifter that we will refer to as \customer capital." It captures the fact that there may be slow-moving determinants of the level of demand unrelated to the time-t price. At time t, D_t^{ik} is predetermined. D_t^{ik} accumulates according to the law of motion:

$$D_t^{ik} = \begin{cases} (1-\delta) D_{t-1}^{ik} + I_{t-1}^{ik} & \text{if } X_{t-1}^{ik} = 1 \\ \underline{D}^{ik} & \text{if } X_{t-1}^{ik} = 0 \end{cases}$$

where δ is the rate of depreciation of customer capital, X_t^{ik} is an indicator variable for i's participation in market k, and I_t^{ik} is investment in customer capital. We assume that for all plants that produce and sell something to the home market, $\underline{D}^{ik} \leq D_t^{ik}$, where D_t^{ik} is steady state D, which depends on plant characteristics and the aggregate state, but not on η_t^{ik}.[10] Notice that exit is assumed to imply full depreciation of customer capital in the sense that irrespective of what was accumulated prior to exit, on re-entry, customer capital will be reset to $\underline{D}^{ik}$.[11]

[10]We can guarantee that this is the case if $\underline{D}^{ik}$ is sufficiently low and the fixed costs of selling in the dometic market are sufficiently high.

[11]Instead of assuming an initial draw, we could assume that plants must invest in D prior to entry. We have not yet derived the implications of varying this assumption. In addition we could potentially allow for a less stark assumption of a higher depreciation rate $\delta^H > \delta$ for plants that do not sell in a market. In the light of the evidence from the previous literature that spells of exporting previous to date $t-1$ do not greatly increase the probability of exporting at date t conditional on not exporting at $t-1$, we have not yet explored this possibility.

With this formulation, the choice of price today is a static decision, as it does not affect any future values. This simplifies the analysis considerably, though possibly at the expense of some degree of realism.[12]

3.2 Costs

We assume that plant i faces marginal cost $\tau_t^k \left(W_t/z_t^i\right)$ of serving market k. This cost is expressed in terms of domestic currency. The first term, τ_t^k, includes destination-specific and potentially time-varying tariffs and transportation costs (in our empirical analysis, we assume transportation costs are constant over the sample period). The second term, W_t/z_t^i, may vary across plants and over time but does not vary across markets for given i and t. There is also a fixed cost $W_t F^k$ of participating in market k in any period. Because of this cost, some plants will prefer not to participate in the export market.

We assume that in order to increment consumer capital in market k by amount I_t^{ik}, the plant must spend an amount given by $W_t \left[I_t^{ik} + \phi\left(I_t^{ik} - \delta D_{t-1}^{ik}\right)\right]$. The adjustment cost function is assumed to have the following properties: $\phi(x) = 0$ if $x \leq 0$, while if $x > 0$, $\phi(x) > 0$, $\phi'(x) > 0$, $\phi''(x) > 0$,. The convex cost of adjustment implies that under constant market conditions, plants do not jump straight to their steady state customer capital.

Note that investment and the fixed participation cost depend on the home currency price of the domestic input bundle, but not the foreign input bundle. This assumption could be relaxed, though we do not explore the implications of doing so here.

3.3 Static optimization

Flow profits from market k for a plant that sells a positive quantity are given by:

$$\pi_t^{ik} = E_t^k P_t^{ik*} Q_t^{ik} - \tau_t^k \frac{W_t}{z_t^i} Q_t^{ik} - W_t \left[F^k + I_t^{ik} + \phi\left(I_t^{ik} - \delta D_{t-1}^{ik}\right)\right]$$

The optimal price is

$$P_t^{ik*} = \frac{\theta}{\theta - 1} \frac{\tau_t^k W_t}{z_t^i E_t^k}$$

[12] Motivated by price evidence for relatively homogeneous goods, Foster, Haltiwanger and Syverson (2010) present a model where the choice of price is a dynamic decision. Gourio and Rudanko (2010) instead assume that producers offer the same price to new customers and old customers, but make transfers to new customers to induce them to buy. Our investments I_t^{ik} could possibly be interpreted as transfers of this type, though we have not pursued this to date.

so plant i's revenues from market k expressed in home currency can be written

$$R_t^{ik} = \left[\frac{(\theta-1)^{\theta-1}}{\theta^{\theta-1}}\right] Q_t^k \left(E_t^k P_t^{k*}\right)^\theta \left(\tau_t^k \frac{W_t}{z_t^i}\right)^{1-\theta} \left(D_t^{ik}\right)^\alpha \exp\left(\eta_t^{ik}\right)$$

and ow pro ts net of costs and investment in future customer capital can be written

$$_t^{ik} = \frac{R_t^{ik}}{\theta} - W_t\left[F^k + I_t^{ik} + \phi\left(I_t^{ik} - \delta D_{t-1}^{ik}\right)\right]$$

3.4 Dynamic optimization

As is standard in the empirical literature on export entry and exit, we ignore the plant existence decision, instead conditioning on positive lagged sales in the home market, assuming that this is the easiest market to enter.[13] We then focus on the decision to participate or not in a particular export market. We assume that the plant observes η_t^{ik}, z_t^i, E_t^k and W_t before making its decision. Let $\ _t^k$ denote the aggregate state $\left\{E_t^k, W_t, Q_t^k, P_t^{k*}, \tau_t^k\right\}$. If plant i participated in market k at $t-1$, it inherits a predetermined D_t^{ik} from the previous period. Otherwise it reverts to its initial draw $\underline{D}^{ik}$. The value of being in market k is:

$$V^{in}\left(D_t^{ik}, \eta_t^{ik}, z_t^i, \ _t^k\right) =$$

$$\max_{I_t^{ik}}\left\{\begin{array}{c} \frac{R\left(D_t^{ik},\eta_t^{ik},z_t^i,\Theta_t^k\right)}{\theta} - W_t\left[F^k + I_t^{ik} + \phi\left(I_t^{ik} - \delta D_t^{ik}\right)\right] + \\ \frac{\Pr\left[V^{in}\left((1-\delta)D_t^{ik}+I_t^{ik},\eta_{t+1}^{ik},z_{t+1}^i,\Theta_{t+1}^k\right)>V^{out}\left(z_{t+1}^i,\Theta_{t+1}^k\right)\right]}{1+r}\mathbb{E}V^{in}\left((1-\delta)D_t^{ik} + I_t^{ik}, \eta_{t+1}^{ik}, z_{t+1}^i, \ _{t+1}^k\right) \\ + \frac{\Pr\left[V^{out}\left(z_{t+1}^i,\Theta_{t+1}^k\right)>V^{in}\left((1-\delta)D_t^{ik}+I_t^{ik},\eta_{t+1}^{ik},z_{t+1}^i,\Theta_{t+1}^k\right)\right]}{1+r}\mathbb{E}V^{out}\left(z_{t+1}^i, \ _{t+1}^k\right) \end{array}\right\}$$

where the discount factor applied by the plant is given by $1/(1+r)$.[14] The value of not being in market k (i.e. waiting until later to enter) is:

$$V^{out}\left(z_t^i, \ _t^k\right) = \begin{array}{c} \frac{\Pr\left[V^{in}\left(\underline{D}^{ik},\eta_{t+1}^{ik},z_{t+1}^i,\Theta_{t+1}^k\right)>V^{out}\left(z_{t+1}^i,\Theta_{t+1}^k\right)\right]}{1+r}\mathbb{E}V^{in}\left(\underline{D}^{ik}, \eta_{t+1}^{ik}, z_{t+1}^i, \ _{t+1}^k\right) \\ + \frac{\Pr\left[V^{out}\left(z_{t+1}^i,\Theta_{t+1}^k\right)>V^{in}\left(\underline{D}^{ik},\eta_{t+1}^{ik},z_{t+1}^i,\Theta_{t+1}^k\right)\right]}{1+r}\mathbb{E}V^{out}\left(z_{t+1}^i, \ _{t+1}^k\right) \end{array}$$

Because customer capital depreciates to $\underline{D}^{ik}$ following exit, $V^{out}\left(z_t^i, \ _t^k\right)$ does not depend on D_t^{ik}.

[13] We thus ignore entry of plants that are born global and entry and exit of plants that sell only to the foreign market.

[14] If we allow this to vary, it must be included in the aggregate state vector Θ_t^k.

A potential entrant will enter if

$$V^{in}\left(\underline{D}^{ik}, \eta_t^{ik}, z_t^i, \ _t^k\right) > V^{out}\left(z_t^i, \ _t^k\right)$$

A plant with accumulated customer capital D_t^{ik} will exit if

$$V^{out}\left(z_t^i, \ _t^k\right) > V^{in}\left(D_t^{ik}, \eta_t^{ik}, z_t^i, \ _t^k\right)$$

There is an underlying asymmetry in these decisions that arises out of the accumulation of customer capital. This capital acts like a sunk cost, whose size varies across otherwise identical plants with the length of time they have been in the market.

3.5 Comparative statics

We now characterize some important comparative statics on entry and exit. In this subsection we simplify by dropping i and k superscripts.

Proposition: $V^{in}(D_t, \eta_t, z_t, \ _t)$ is monotonically increasing in D.

Proof: First, let $\ _t = \{\eta_t, z_t, \ _t\}$. Suppose we have a plant that enters period t with D^1. Let $\{I_t^1(D^1, \ _t|X_t = 1), \ldots\}$ and $\left\{X_{t+1}^1((1-\delta)D^1 + I_t^1(D^1, \ _t|X_t = 1), \ _{t+1}|X_t = 1), \ldots\right\}$ denote the in nite sequences of optimal investment and participation decisions conditional on participation at t (i.e. conditional on $X_t = 1$). $V^{in}(D^1, \ _t)$ is the value of implementing these decisions. Consider a plant with $D^2 > D^1$, but that is otherwise identical to the original plant. Let $\tilde{V}^{in}(D^2, \ _t; D^1)$ denote the value of the D^2-plant if it implements the optimal sequence of decisions of the D^1-plant. Since $D_2 > D_1$, we know that

$$(1-\delta)D^2 + I_t^1\left(D^1, \ _t|X_t = 1\right) > (1-\delta)D^1 + I_t^1\left(D^1, \ _t|X_t = 1\right)$$

and similarly, under all histories such that the D^1-plant participates continuously in the market, the customer capital of the D^2-plant will be higher than the customer capital of the D^1-plant. Moreover, since $R(D, \ )$ is increasing in D and $\phi'(\cdot) \geq 0$, under all histories such that the D^1-plant particpates continuously in the market, the ow value of the D^2-plant is greater than the ow value of the D^1 plant. The value of not participating is independent of D, so under all histories that follow an exit by the D^1-plant, the value of the D^2-plant is equal to the value of the D^1-plant. This implies that

$$\bar{V}^{in}\left(D^2, \ _t; D^1\right) > V^{in}\left(D^1, \ _t\right)$$

The D^2-plant cannot do worse by implementing its own optimal sequence of investment and entry decisions conditional on X_t = 1 instead of those of the D^1-plant, so

$$V^{in}\left(D^2, \ _t\right) \geq \bar{V}^{in}\left(D^2, \ _t; D^1\right)$$

This implies that

$$V^{in}\left(D^2, \ _t\right) > V^{in}\left(D^1, \ _t\right)$$

so $V^{in}(D_t, \ _t)$ is monotonically increasing in D. ■

Corollary: $V^{in}(D_t, \eta_t, z_t, \ _t) - V^{out}(z_t, \ _t)$ is increasing in D_t, for $D_t > \underline{D}$. This follows directly from the fact that, $V^{out}(z_t, \ _t)$ is invariant to D_t.

Proposition: $V^{in}(D_t, \eta_t, z_t, \ _t)$ is increasing in η_t.

Proof: Since η_t is by assumption iid, it does not enter into the first order condition for the choice of I_t conditional on X_t = 1 and hence, conditional on participation, I_t is independent of η_t. Therefore the only effect of η_t on $V^{in}(D_t, \eta_t, z_t, \ _t)$ is through $R_t(D_t, \eta_t, z_t, \ _t)$, which is increasing in η_t. Hence, $V^{in}(D_t, \eta_t, z_t, \ _t)$ is increasing in η_t.■

Corollary: $V^{in}(D_t, \eta_t, z_t, \ _t) - V^{out}(z_t, \ _t)$ is increasing in η_t. This follows from the fact that $V^{out}(z_t, \ _t)$ is invariant to η_t.

Conjecture: Under reasonable conditions on the stochastic process for z_t, $V^{in}(D_t, \eta_t, z_t, \ _t) - V^{out}(z_t, \ _t)$ is increasing in z_t.

Conjecture: Under reasonable conditions on the stochastic process for E_t, $V^{in}(D_t, \eta_t, z_t, \ _t) - V^{out}(z_t, \ _t)$ is increasing in E_t.

Conjecture: Under reasonable conditions on the stochastic process for W_t,$V^{in}(D_t, \eta_t, z_t, \ _t) - V^{out}(z_t, \ _t)$ is decreasing in W_t.

3.6 Exit hazard and sales growth conditional on survival

The model we have just laid out can generate a hazard of exit that is decreasing in the length of time a plant has been in a market. This follows from the fact a recent entrant will have a lower D than an otherwise identical plant that has been in the market for some time. Hence the recent entrant will be more vulnerable to idiosyncratic demand shocks. This model is also able to match decreasing growth rates conditional on survival, as the marginal product of customer capital and hence investment in customer capital and increases in demand decline as plants approach their steady state customer capital.

4 Empirical strategy

We now describe the strategy we use to investigate the responsiveness of export entry and exit to the exchange rate. We are guided by the model we have just presented, while making use of the structure of our data set for clean identi cation. As we will demonstrate, our results both provide support for some key the predictions of the model and indicate that it is important to take these predictions into account in order to isolate responses to exchange rates. However a full structural estimation of the model is beyond the scope of this paper. This limits somewhat the conclusions we can draw from our results.

In line with the problem whose comparative statics we analyze above, we restrict our sample to plant-years with positive current and lagged sales in the home market. This allows us to abstract from additional considerations related to the plant existence decision. It also excludes two classes of potential entrants and one class of potential exiters, as we do not include plants that are born global in our analysis of the entry decision, and we do not include plants that export 100% of sales in our analysis of entry and exit decisions.

The comparative statics of the model imply that the probability of participation in a given market depends on both costs and demand. By assumption, marginal costs have a component that is speci c to a market and a point in time (τ_t^k), a component that is common to all plants at a given point in time (W_t), and a component that is common to all markets for a given plant at a given point in time (z_t^i). Our model also implies that there is a persistent component of demand that is correlated with the number of years a plant has participated in a particular market (D_t^{ik}). We need to control for both costs and demand in order to estimate the sensitivity of the participation decision to the exchange rate (since all of these variables are persistent). Moreover, we must take account of the fact that the e ect of shocks to the exchange rate on the probability of participation in a given market is not symmetric across plants. The e ect is greater for plants that are close to their entry or exit thresholds. These thresholds vary across plants and markets with both costs and demand. In addition, the cost threshold for entry need not be the same as the cost threshold for exit. This last observation leads us to separately estimate an entry equation and an exit equation.

The model also suggests some issues that must be dealt with in estimating the response of home currency sales to the exchange rate. First, it implies that (depending on the persistence of the exchange rate process), short run responses to the exchange rate may di er from long run responses, which are mediated by the investment in the latent variable D_t^{ik}. We would like to be able to separate out these two types of response. Second, we will have to deal with the fact that participation is non-random, raising the possibility of selection bias.

We now describe in turn our strategy to deal with entry and exit. We do not deal with the intensive margin, as we have not yet implemented this part of the project.

4.1 Entry

Plant i that did not participate in market k in period $t-1$, enters at date t if

$$V^{in}\left(\underline{D}^{ik}, \eta_t^{ik}, z_t^i, \quad {}_t^k\right) > V^{out}\left(z_t^i, \quad {}_t^k\right)$$

Based on the comparative statics we describe in the previous section, we approximate the probability of entry as follows:

$$\Pr\left[X_t^{ik} = 1 | X_{t-1}^{ik} = 0\right] = G\left(c_t^i + \alpha^k + \boldsymbol{\beta}'\mathbf{x}_t^k + \boldsymbol{\gamma}'\left(\boldsymbol{x}_t^k \otimes \mathbf{s}_{t-1}^i\right) + \boldsymbol{\psi}'\mathbf{s}_{t-1}^i + \varepsilon_t^{ik}\right) \quad (1)$$

The term c_t^i is a plant-year e ect which captures the rst-order e ect of W_t/z_t^i as well as any components of τ_t^k and $\underline{D}^{ik}$ that are common across markets for a given plant. α^k is a time-invariant market-speci c e ect which captures the time-invariant component of τ_t^k, scaling of the exchange rate and foreign aggregate price and demand variables, and any component of $\underline{D}^{ik}$ that is common across plants. $\mathbf{x}_t^k$ is a vector, the elements of which include the log of the nominal exchange rate (e_t^k), and may also include a measure of foreign demand, the log of the foreign price level and tari s. $\mathbf{s}_{t-1}^i$ is a vector of indicator variables for correlates of costs, lagged one year because of simultaneity concerns. The interaction between $\mathbf{x}_t^k$ and $\mathbf{s}_{t-1}^i$ allows the sensitivity of entry to the variables in $\mathbf{x}_t^k$ to vary across plants at di erent distances from the entry threshold. Depending on how we estimate the plant-year e ects c_t^i, it may or may not be necessary to include a main e ect $\mathbf{s}_{t-1}^i$. We do not have observable variables that are correlated with baseline customer capital $\underline{D}^{ik}$ for potential entrants, so we are not able to control for demand and heterogeneous e ects due to di erent baseline demand in the entry equation.[15] These appear in the error term ε_t^{ik}.

The sample at risk for entry consists of all plant-market-years such that lagged participation equals zero ($X_{t-1}^{ik} = 0$). Since we observe participation for two export markets, there are two potential approaches to controlling for c_t^i. First, we can use fixed effects. Using this approach, we identify the coefficient on the exchange rate (and other aggregate shocks) solely from within-plant-year variation in the entry decision. This implies that only plant-years with lagged participation equal to zero in *both* export markets will be used to identify the coefficients of interest. The coefficient vector $\boldsymbol{\psi}$ is not identified in this case, as $\boldsymbol{\psi}'\mathbf{s}_{t-1}^i$ is absorbed into the fixed effects. This approach is appealing, but it does restrict our choice of the $G(\cdot)$ function.

As a baseline, we estimate a linear probability model (linear $G(\cdot)$), which allows us to make use of all plant-years such that lagged participation equals zero in both markets. This has all the usual problems that using a linear probability model entails. We also experiment with a conditional logit, in which the coefficients on other variables do not depend on the fixed effects (which are not actually estimated). This has the disadvantage that only cases where we observe entry in one market but not the other are used to identify the parameters of interest. This greatly restricts the size of the sample, discarding information that can be used to identify the parameters of interest and reducing precision.

Another alternative is to estimate the c_t^i as random effects, which would allow us to use a probit or logit. However it is not reasonable to assume that c_t^i and c_{t-s}^i are uncorrelated, so we would have to specify and estimate a correlation structure for these effects. We are reluctant to go down this route, because as the specification becomes more complicated, we see fewer benefits to a reduced form as opposed to a structural approach. A simpler strategy is to assume that $\mathbf{s}_{t-1}^i$ captures all relevant time variation in costs, and estimate random effects c^i at the plant level. Here, we can make use of all plant-market-years such that lagged participation is equal to zero. We have experimented with this latter approach.

To maximize degrees of freedom, in our baseline specification we consider the case where the only element in the vector $\mathbf{x}_t^k$ is the log of the nominal exchange rate, e_t^k. We test the robustness of our results to this restriction by including measures of foreign demand, foreign prices and tariffs in this vector. These measures are calculated at the sector-market level, and since for demand and prices they are indexes, they require us to include sector-market fixed effects. The demand index is an index of the value of imports into the relevant market (UK or US) in the relevant sector from all countries except Ireland. The price indexes are

[15] We also ignore any potential interactions between costs and d^{ik}.

producer price indexes at the sector level from the relevant country (where prices are not available at the 4-digit level, 3- or 2-digit indexes are substituted). These are included in log form. Tariffs on imports from Ireland to the UK are equal to zero for all sectors throughout our sample period. For the US, we take (unweighted) MFN tariffs on 6-digit HS categories from WITS, and aggregate these up to the 4-digit NACE Rev 1.1 level by taking the simple average. The variable included in the regression is $ln\left(1 + tariff_t^{sector,k}\right)$.

The variables included in $\mathbf{s}_{t-1}^i$include indicators for employment categories, plant age categories, capital-labor ratio categories, labor productivity categories and wage categories. This approach has the advantage that it allows for nonlinear dependence of entry thresholds on the underlying continuous variables. We also include indicators for foreign ownership and exporting to a market that is not the UK or US.

Finally, in our baseline linear probability specification, we make use of repeated observations on the same plant-market for identification. So far, we have worked under the assumption that all variation in baseline customer capital $\underline{D}^{ik}$ is captured either by α^k or c_t^i. In future work we hope to address this issue.

To summarize, our baseline specification is:

$$\Pr\left[X_t^{ik} = 1 | X_{t-1}^{ik} = 0\right] = c_t^i + \alpha^k + \beta e_t^k + \gamma' \mathbf{s}_{t-1}^i e_t^k + \varepsilon_t^{ik} \tag{2}$$

We estimate this linear probability model using all plant-years where both markets are at risk for entry. We calculate robust standard errors. Our main interest is in the estimates of the coefficients β and γ.

4.2 Exit

Plant i that participated in market k at date $t-1$ exits at date t if:

$$V^{out}\left(z_t^i, \quad _t^k\right) > V^{in}\left(D_t^{ik}, \eta_t^{ik}, z_t^i, \quad _t^k\right)$$

We approximate the probability of exit as follows:

$$\Pr\left[X_t^{ik} = 0 | X_{t-1}^{ik} = 1\right] = G\left(c_t^i + \alpha^k + \boldsymbol{\beta}'\mathbf{x}_t^k + \boldsymbol{\gamma}'\left(\boldsymbol{x}_t^k \otimes \mathbf{s}_{t-1}^i\right) + \boldsymbol{\psi}'\mathbf{s}_{t-1}^i + \boldsymbol{\lambda}'\mathbf{d}_t^{ik} + \rho'\left(\mathbf{x}_t^k \otimes \mathbf{d}_t^{ik}\right) + \varepsilon_t^{ik}\right) \tag{3}$$

All variables are as in the entry equation, with the exception of $\mathbf{d}_t^{ik}$, which is a vector of variables intended to capture a plant's attachment to a particular market. We include a main effect and interaction effect for this vector. The coefficient on the main effect can always be estimated, as the attachment variables vary across markets within a plant-year. The interaction effect allows the effect of the exchange rate on exit to vary across plants with different degrees of attachment to a market.[16]

The sample at risk for exit consists of all plant-market-years such that lagged participation equals one ($X_{t-1}^{ik} = 1$). As in the case of entry, our baseline approach to estimating (3) is to choose a linear $G(\cdot)$ and to use a fixed effects strategy to control for c_t^i. We identify the coefficient on the exchange rate (and other market-specific aggregate shocks) from within-plant-year variation in the exit decision. As a result, only plant-years with lagged participation equal to one in *both* export markets are used to identify the coefficients of interest. As in the case of entry, we also experiment with conditional logit and random effects probit variants.

As in the case of entry, our baseline estimation restricts the vector $\mathbf{x}_t^k$ to a single element, e_t^k. The variables included in $\mathbf{s}_{t-1}^i$ are the same as in the entry case. As regards $\mathbf{d}_t^{ik}$, the model implies that customer capital increases with the number of years a plant participates in a market. In addition, plants with higher lagged customer capital are likely to have higher customer capital today. Motivated by these observations, the vector $\mathbf{d}_t^{ik}$ includes indicator variables for age-in-market (for exiters, the number of years they would have been in the market had they not exited).[17] We also include r_{t-1}^{ik*}, the lag of log foreign currency sales in market k, or r_{t-1}^{ik}, the lag of log home currency sales in market k. The use of this variable may raise some concerns, so we consider both specifications that exclude and include this variable.

To summarize, our baseline specification is:

$$\Pr\left[X_t^{ik} = 0 | X_{t-1}^{ik} = 1\right] = c_t^i + \alpha^k + \beta e_t^k + \boldsymbol{\gamma}'\mathbf{s}_{t-1}^i e_t^k + \boldsymbol{\lambda}'\mathbf{d}_t^{ik} + \boldsymbol{\rho}'\mathbf{d}_t^{ik} e_t^k + \varepsilon_t^{ik} \quad (4)$$

We estimate this linear probability model using all plant-years where both markets are at risk for exit. We calculate robust standard errors. Our main interest is in estimates of the coefficients β, γ and ρ.

[16] We ignore potential interactions between costs and the market attachment variables in the baseline specification.

[17] There is a tradeoff between the level at which we top-code age-in-market and sample size. The lower the number of years at which age-in-market is top-coded, the less variation, but the bigger the sample size. This is because we do not observe the precise age-in-market for plants participating in a market in the first year of the sample.

5 Results

We first present the results for entry, then the results for exit. We then discuss the economic significance of our findings.

5.1 Entry

The results from our baseline specification of the entry equation are reported in Table 3. When we do not allow for heterogeneous sensitivities to the exchange rate (column (1)), we do not find a statistically significant effect of the level of the exchange rate on the probability of entry. This is hardly surprising, given the raw data on entry rates and exchange rates. However when we allow for heterogeneous sensitivities, we do find statistically significant effects of the level of the exchange rate on the probability of entry.

The interaction terms we allow for are indicators for three plant size categories (1-14 employees, 15-29 employees, 29+ employees), three plant age categories (1-7 years, 8-20 years, 21+ years), three capital-labor ratio categories ($<$25th percentile, 25-75th percentile, $>$75th percentile),[18] three import intensity categories ($<$25th percentile, 25-75th percentile, $>$75th percentile of imported intermediate share in variable cost), three labor productivity categories ($<$25th percentile, 25-75th percentile, $>$75th percentile), three average wage categories ($<$25th percentile, 25-75th percentile, $>$75th percentile of wage bill-employee ratios), an indicator for foreign ownership, and an indicator that the plant exports to markets other than the UK and US. All of these are lagged one year. Note that the excluded category is plants with 14 or fewer employees, in existence for 7 years or less, with capital-labor ratio, import intensity, labor productivity and average wage below the 25th percentile, Irish owned and not exporting to any market besides the UK and US.[19]

Our results imply that bigger plants are more likely to enter in response to exchange rate depreciations than are smaller plants. This is consistent with depreciations inducing entry, and bigger plants being closer to the threshold for entry than smaller plants. Older plants are less likely to enter in response to exchange rate depreciations than are young plants. This is consistent with older plants being further away from the entry threshold than young plants. Entry of plants that are import-intensive and plants that export to other destinations is especially sensitive to exchange rate depreciations, with depreciations inducing entry. Again, this is consistent with import-intensive plants and plants that export

[18] At present, sample size is slightly reduced by including this variable as we have not yet constructed the capital stock variable for all plants.

[19] We have experimented with alternative cutoffs for the categories of the continuous variables.

Table 3: Entry

	(1)		(2)	
	coeff	s.e.	coeff	s.e.
e^k_t	0.00	(0.02)	-0.03	(0.03)
$emp2^i_{t-1} * e^k_t$			0.03	(0.01)**
$emp3^i_{t-1} * e^k_t$			0.04	(0.01)**
$age2^i_{t-1} * e^k_t$			-0.02	(0.01)**
$age3^i_{t-1} * e^k_t$			-0.01	(0.01)
$cap2^i_{t-1} * e^k_t$			0.01	(0.01)
$cap3^i_{t-1} * e^k_t$			0.02	(0.01)
$imp2^i_{t-1} * e^k_t$			0.08	(0.01)**
$imp3^i_{t-1} * e^k_t$			0.09	(0.03)**
$prod2^i_{t-1} * e^k_t$			0.01	(0.01)
$prod3^i_{t-1} * e^k_t$			0.02	(0.02)
$wage2^i_{t-1} * e^k_t$			0.01	(0.01)
$wage3^i_{t-1} * e^k_t$			-0.01	(0.01)
$forown^i_{t-1} * e^k_t$			-0.07	(0.05)
$exoth^i_{t-1} * e^k_t$			0.13	(0.05)**
Market f.e.	yes		yes	
Plant-year f.e.	yes		yes	
UK entry rate	0.06		0.06	
US entry rate	0.01		0.01	
# plants	3512		3094	
# plant-years	17449		15107	
R^2	0.58		0.58	
R^2-adj	0.15		0.16	

Notes: Estimation method is OLS. Dependent variable is an indicator for entry. Sample consists of all plant-years where plant is at risk for entry in both UK and US markets, and where there is positive lagged and current sales in the Irish market. Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level.

to other destinations being relatively close to the entry threshold.

To understand better the potential problems raised by the use of the linear probability model, we calculate the tted values from the model in column (2), and examine their distribution. They lie in the range [-0.10,1.09].

Inclusion of main e ects and interactions of the foreign demand, foreign price and tari variables described above leaves the general pattern of comparative statics unchanged.[20] We examine timing e ects by including a lag of the exchange rate as a main e ect and interacted with the cost variables. In this speci cation, the coe cient on the current exchange rate ips to positive and signi cant, and the point estimates on interactions with the current exchange rate become substantially bigger, with the same pattern of signs and signi cance. The signs are ipped for the main e ect and interactions of the lagged exchange rate. This

[20]When we include these variables, we also include sector-market fixed effects.

is suggestive of a \shadow" effect, where the year following an exchange rate depreciation, the pool of potential entrants is reduced. However a more careful investigation with higher frequency data is warranted before jumping to any conclusions. These results are reported in the Appendix.

We also examine robustness to alternative estimation approaches. First, we estimate the conditional logit model on the sub-sample where we observe entry in precisely one of the two at-risk markets. The results are qualitatively similar to those in the linear probability model. In the absence of interaction effects, we do not observe a statistically significant relationship between entry and the exchange rate. When we do allow for interaction effects, larger plants and plants that are imported intermediate intensive are more likely to enter in response to exchange rate depreciations. However in contrast to the linear probability results, the conditional logit estimates imply that plants that export to other markets are less likely to enter in response to depreciations than plants that do not export to other markets. We also estimate a random effects probit, with random effects at the plant level. These results are similar to those from estimating the conditional logit. These results are reported in the Appendix.

5.2 Exit

The results from our baseline specification of the entry equation are reported in Table 4. The sample size is smaller here than in the case of entry, because the number of plants participating in both markets is much smaller than the number of plants not exporting to either of them.

As mentioned in the previous section, we experiment with several sets of age-in-market indicators, as there is a tradeoff between the precision of our measure of age-in-market and the size of the sample we can apply it to. We present results for the set of indicator variables that distinguishes between cases where the plant has completed one year, two years, or three or more years in the relevant market prior to the current period. We have experimented with more parsimonious and richer sets of indicators, and find the results qualitatively unchanged. In the baseline specification, we use lagged foreign currency revenues rather than lagged home currency revenues, again with little impact on the results. This variable is constructed by dividing lagged home currency-denominated revenues from the relevant market by the lag of the relevant exchange rate. All revenues are first deflated by the Irish CPI.

As in the case of entry, when we do not allow for heterogeneous sensitivities to the exchange rate, we do not find a statistically significant effect of the exchange rate on the probability of exit. This can be seen in column (1) of Table 4.

When we allow the sensitivity to the level of the exchange rate to vary across plants according to their export histories and variables correlated with costs, we do find significant effects of the level of the exchange rate on exit probabilities. These results are reported in columns (2), (3) and (4) of Table 4. Note that in column (2) the excluded category is plants with 14 or fewer employees, in existence for 7 years or less, with capital-labor ratio, import intensity, labor productivity and average wage below the 25th percentile, Irish owned and not exporting to any market besides the UK and US, while in columns (3) and (4), the excluded category is plants with these characteristics which entered the relevant market in the previous year. For both the broader and narrower group, an exchange rate appreciation increases the probability of exit in the current period.

Focusing first on the coefficients on the lagged revenue and age-in-market variables, we see that an exchange rate appreciation is less likely to induce exit in plants which are very attached to the relevant market, as measured both by lagged sales and number of years in that market than it is in plants with little attachment to the market. This is consistent with the predictions of our model. Of the plant characteristics whose interactions with exchange rates we include, it is somewhat surprising that the statistically significant effects imply that bigger, more capital-intensive and more productive plants are more vulnerable to exit in response to exchange rate appreciations.

As in the case of entry, we calculate fitted values (including the fixed effects estimates). These lie within the range [-0.25,1.19]

Inclusion of main effects and interactions of the foreign demand, foreign price and tariff variables described above leaves the pattern of comparative statics unchanged but leads to a generalized loss of significance. Since we are controlling for lagged revenue, relative to the case of entry, it is less obvious that we should observe delayed reactions to exchange rate. When the main effect and interaction effects of the lag of the exchange rate are included, there is a general loss of significance.

We also examine robustness to alternative estimation approaches. First, we estimate the conditional logit model on the sub-sample where we observe exit in precisely one of the two at-risk markets. In this case, the sample size is greatly reduced. When we do not include the demand and cost variables and interactions, there is no statistically significant relationship between exit and the exchange rate. When we do include demand and cost interactions, the interactions of the exchange rate with lagged revenue and age-in-market variables are not

Table 4: Exit

	(1)		(2)		(3)		(4)	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	-0.12	(0.08)	-0.24	(0.12)**	-0.35	(0.17)**	-0.40	(0.16)**
$revenue_{t-1}^{ik*}$			-0.06	(0.00)**			-0.05	(0.01)**
$revenue_{t-1}^{ik*}e_t^k$			0.04	(0.01)**			0.03	(0.01)**
$I\left(yrmkt_{t-1}^{ik}=2\right)$					-0.03	(0.04)	-0.02	(0.04)
$I\left(yrmkt_{t-1}^{ik}\geq 3\right)$					-0.14	(0.03)**	-0.08	(0.03)**
$I\left(yrmkt_{t-1}^{ik}=2\right)e_t^k$					0.14	(0.14)	0.10	(0.13)
$I\left(yrmkt_{t-1}^{ik}\geq 3\right)e_t^k$					0.24	(0.10)**	0.18	(0.10)*
$emp2_{t-1}^i * e_t^k$			-0.18	(0.05)**	-0.12	(0.06)*	-0.18	(0.06)**
$emp3_{t-1}^i * e_t^k$			-0.16	(0.05)**	-0.15	(0.06)**	-0.22	(0.07)**
$age2_{t-1}^i * e_t^k$			0.05	(0.04)	0.08	(0.07)	0.11	(0.07)
$age3_{t-1}^i * e_t^k$			0.01	(0.04)	0.09	(0.07)	0.09	(0.07)
$cap2_{t-1}^i * e_t^k$			-0.10	(0.05)**	-0.18	(0.08)**	-0.15	(0.07)**
$cap3_{t-1}^i * e_t^k$			-0.12	(0.05)*	-0.15	(0.08)*	-0.11	(0.08)
$imp2_{t-1}^i * e_t^k$			-0.03	(0.04)	0.02	(0.05)	-0.01	(0.05)
$imp3_{t-1}^i * e_t^k$			-0.01	(0.05)	0.03	(0.06)	0.02	(0.06)
$prod2_{t-1}^i * e_t^k$			-0.01	(0.04)	-0.11	(0.05)**	-0.08	(0.05)
$prod3_{t-1}^i * e_t^k$			-0.10	(0.06)*	-0.14	(0.07)**	-0.15	(0.07)**
$wage2_{t-1}^i * e_t^k$			-0.06	(0.05)	0.02	(0.06)	-0.01	(0.06)
$wage3_{t-1}^i * e_t^k$			-0.07	(0.05)	0.05	(0.07)	-0.02	(0.07)
$forown_{t-1}^i * e_t^k$			0.02	(0.03)	0.03	(0.04)	0.02	(0.04)
$exoth_{t-1}^i * e_t^k$			0.12	(0.06)**	0.15	(0.08)*	0.13	(0.08)
Market f.e.	yes		yes		yes		yes	
Plant-year f.e.	yes		yes		yes		yes	
UK exit rate	0.06		0.06		0.06		0.07	
US exit rate	0.14		0.14		0.16		0.16	
# plants	1007		892		721		721	
# plant-years	3799		3258		2398		2398	
R^2	0.57		0.61		0.65		0.66	
R^2-adj	0.15		0.22		0.26		0.29	

Notes: Estimation method is OLS. Dependent variable is an indicator for exit. Sample consists of all plant-years where plant is at risk for exit in both UK and US markets, and where there is positive lagged and current sales in the Irish market. Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level.

significant. On the cost side, the interactions with the size and capital-labor ratio indicators have the same sign as in the linear probability baseline, and are statistically significant. We also estimate a random effects probit, with random effects at the plant level. These results are similar to those from estimating the conditional logit, except that in this case, the interaction of the exchange rate with lagged revenue is positive and statistically significant, as in the linear probability baseline.

5.3 Economic significance

Given our empirical strategy, extrapolating from our results to talk about overall economic significance is fraught with pitfalls. Nevertheless, we think it is worthwhile to make an attempt, however imperfect, to assess economic significance. To do so, we perform the following exercises.

For all plant-market-years in our sample that at risk for entry,[21] we use the estimated coefficients on the log of the exchange rate and the interactions of cost correlates with the log of the exchange rate to construct the predicted change in the probability of entry, given the log change in the exchange rate between the current year and the previous year. This is based on the estimates of the linear probability model:[22]

$$\Pr\left[\hat{\text{Enter}}_t^{ik}\right] \mid \; e_t^k = \hat{\beta} \; e_t^k + \hat{\gamma}' \mathbf{s}_{t-1}^i \; e_t^k$$

In the light of the fact that fitted values for probabilities in our linear probability estimation lie outside the range [0,1], this is clearly a risky business. We do note that the distribution of predicted *changes* in probability lies on the range [-0.02,0.03], which is not unreasonable, given that the theoretically possible range is [-1,1]. For each market and year, we then sum up across these predicted changes in the probability of entry for all plant-markets that are at risk of entry and continue to participate in the Irish market:

$$\sum_i \; \Pr\left[\hat{\text{Enter}}_t^{ik}\right] \mid \; e_t^k$$

In Table 5 we report the predicted change in the number of entries (rounded to an integer) along with the actual number of entries for plants that continue to participate in the Irish

[21] That is plant-market-years where lagged participation equals zero, and where both lagged and current sales in the Irish market are strictly positive.

[22] This involves some out-of-sample predictions, since our coefficients are identified only from cases where the plant is at risk for entry in both markets.

Table 5: Economic significance: Entry

	UK			US		
year	# entrants	$\sum \Delta \Pr[\text{Entry}]$	Δe_t^{UK}	# entrants	$\sum \Delta \Pr[\text{Entry}]$	Δe_t^{US}
1997	124	3	0.10	89	7	0.05
1998	127	2	0.07	100	9	0.06
1999	133	1	0.03	78	7	0.05
2000	125	2	0.08	104	18	0.14
2001	105	0	-0.02	162	3	0.03
2002	149	0	-0.01	75	-5	-0.05
2003	151	-2	-0.10	89	-18	-0.18
2004	134	0	0.02	122	-9	-0.10
2005	107	0	-0.01	68	0	0.00

Notes: Number of entrants is the number of entrants where both lagged and current sales in the home market are positive. This excludes entry of plants "born to export" and of plants who do not sell in the domestic market. The entry probabilities are calculated at the plant-market level based on the estimates reported in column (2) of Table 3. The sample for which they are calculated is all plant-market-years where lagged and current sales in the home market are positive, and lagged participation in the relevant market equals zero. The change in the exchange rate is the change in the log of the year-end exchange rate between the end of the relevant year and the end of the previous year.

market. We also report the exchange rate changes used to construct the change in probability of entry.

We find that for the UK market, only a very small fraction of changes in entry can be accounted for by movements in exchange rates. In contrast, for the US market, our estimates predict that these changes can account for a non-trivial fraction of variation over time in the number of plants entering the market. This is both because exchange rate movements are bigger, and because the mass of plants that has not yet entered the US is greater than the mass of plants that has not yet entered the UK. Overall, the effect of exchange rate movements on plant entry is relatively limited.

Similarly for exit, for all plant-market-years in the sample at risk for exit,[23] we use the estimated coefficients on the log of the exchange rate and the interaction of cost and demand correlates with the log of the exchange rate to construct the predicted change in the probability of exit, given the change in the log exchange rate between the current year and the previous year. This is based on the estimates of the linear probability model:

$$\Delta \widehat{\Pr}\left[\text{Exit}_t^{ik}\right] | \Delta e_t^k = \hat{\beta} \Delta e_t^k + \hat{\gamma}' \mathbf{s}_{t-1}^i \Delta e_t^k + \hat{\rho}' \mathbf{d}_t^{ik} \Delta e_t^k$$

Again, the distribution of predicted *changes* in probability lies on the range [-0.12,0.16], which is not unreasonable, and suggestive that exchange rate movements may explain more

[23] That is, all plant-market-years where lagged participation is positive, and lagged and current sales in the Irish market are strictly positive.

Table 6: Economic signi cance: Exit

	UK			US		
year	# exits	$\sum \Delta \Pr[\text{Exit}]$	Δe_t^{UK}	# exits	$\sum \Delta \Pr[\text{Exit}]$	Δe_t^{US}
1999	106	-12	0.03	85	-5	0.05
2000	96	-32	0.08	57	-14	0.14
2001	139	9	-0.02	78	-3	0.03
2002	116	5	-0.01	95	7	-0.05
2003	140	39	-0.10	105	21	-0.18
2004	123	-7	0.02	94	9	-0.10
2005	132	3	-0.01	68	0	0.00

Notes: Number of exits is the number of exits for plants where both lagged and current sales in the home market are positive. This excludes exits of plants who also exit the domestic market and of exporters who did not previously participate in the domestic market. The exit probabilities are calculated at the plant-market level based on the estimates reported in column (4) of Table 4. The sample for which they are calculated is all plant-market-years where lagged and current sales in the home market are positive, and lagged participation in the relevant market equals one. The change in the exchange rate is the change in the log of the year-end exchange rate between the end of the relevant year and the end of the previous year.

of the variation over time in the timing of exit than the timing of entry.

For each market and year, we then sum up across these predicted changes in the probability of entry for all plant-markets that are at risk of exit and continue to participate in the Irish market:

$$\sum_i \text{Pr}\left[\widehat{\text{Exit}}_t^{ik}\right] | \quad e_t^k$$

We do this using the estimates of an exit equation similar to those reported in column (4) of Table 4.[24] In Table 6, we report the predicted change in exits based on the exchange rate change along with the actual number of exits for plants that continue to participate in the Irish market. We also report the exchange rate changes used to construct the change in probability of exit.

In contrast with our ndings on entry, changes in exchange rates appear to account for a relatively small fraction of the variation over time in the number of plants exiting the US market, while for the UK market, the numbers involved are larger. This is due to the fact that the mass of plants present in the UK market is greater than the mass present in the US market. Although the underlying probability of exit is higher for plants in the US market than the UK market, we do not allow for di erential sensitivities to exchange rate movements. Overall, it is somewhat clearer that the exchange rate may play a role in a ecting the timing of exit than the timing of entry, as periods when exit is predicted to be low tend to be periods when exit is low, and vice versa.

[24]Because of a coding error, we report the results based on the specification that includes indicator variables for one or for two or more years in the market.

6 Conclusion

The empirical literature on the behavior of prices at a very disaggregated level finds that, although prices change relatively frequently and by large amounts, responses to aggregate shocks such as exchange rate movements are muted. This is seen as something of a puzzle. To throw more light on the mechanisms governing the expenditure-switching effect of exchange rate movements, we explore a different dimension of producers' responses - their propensity to enter and exit export markets in response to exchange rates.

Our ability to identify the sensitivity of entry and exit to the level of the exchange rate, depends how good is our underlying model of the export participation decision. Recent work in this area has uncovered a set of stylized facts that the workhorse sunk cost model is not well-equipped to match. Several alternatives have been proposed to the sunk cost workhorse, all of which imply that that the value to recent entrants of being in a particular market is less than that of plants with strong and long-lasting attachments to the same market.

We present a stylized model with this feature, and we use the model to motivate our empirical strategy. Our empirical strategy innovates on the previous literature along two dimensions. First, we make use of the fact that we observe participation in two precisely defined export markets to use fixed effects to control for the first-order effect of variation across different plant-years in costs on the probability of entry to or exit from export markets. Second, we allow the sensitivity of entry to the level of the exchange rate to vary across plants with different characteristics. In particular, we allow the sensitivity of exit to the level of the exchange rate to vary across plants with different characteristics, and across plant-market-years according to the level of attachment to the export market in question.

We find that once these two dimensions of heterogeneity are allowed for, both entry and exit are sensitive to the level of the exchange rate. Exchange rate depreciations induce entry while exchange rate appreciations induce exit. Plants closer to the thresholds for entry and exit are more sensitive to the level of the exchange rate. However the short run economic significance of these results is modest, both because the impact on plant entry and exit is limited, and because the size of potential entrants and potential exiters is small. At a one-year horizon, big expenditure-switching effects of exchange rate movements are unlikely to be driven by this channel, at least for exchange rate changes on the order of magnitude of those we observe in the sample.

Our primary goal for future work is to match customs data on exports with our plant-level data, and to use the new dataset to estimate the response of export sales to exchange rate movements. In the longer term, if the intensive margin results are supportive, it may be worthwhile implementing a full structural estimation of the model. This would complement the reduced form strategy we present here, allowing us to better understand the implications of our results for the expenditure-shifting e ects of exchange rate movements.

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Appendix

Table 7: Robustness: Other shock variables

	(1)		(2)	
	Entry		Exit	
	coeff	s.e.	coeff	s.e.
e_t^k	-0.05	(0.03)	-0.27	(0.28)
$revenue_{t-1}^{ik*}$			-0.05	(0.01)**
$revenue_{t-1}^{ik*} e_t^k$			0.03	(0.02)
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$			-0.07	(0.04)**
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$			0.16	(0.12)
$emp2_{t-1}^{i} * e_t^k$	0.02	(0.02)	-0.18	(0.12)
$emp3_{t-1}^{i} * e_t^k$	0.07	(0.02)**	-0.27	(0.12)**
$age2_{t-1}^{i} * e_t^k$	-0.02	(0.02)	0.08	(0.10)
$age3_{t-1}^{i} * e_t^k$	-0.00	(0.02)	0.03	(0.11)
$cap2_{t-1}^{i} * e_t^k$	0.01	(0.02)	-0.16	(0.16)
$cap3_{t-1}^{i} * e_t^k$	0.07	(0.03)**	-0.17	(0.17)
$imp2_{t-1}^{i} * e_t^k$	0.06	(0.02)**	0.03	(0.09)
$imp3_{t-1}^{i} * e_t^k$	0.05	(0.05)	0.01	(0.12)
$prod2_{t-1}^{i} * e_t^k$	0.01	(0.04)	0.02	(0.10)
$prod3_{t-1}^{i} * e_t^k$	0.04	(0.06)*	0.04	(0.12)
$wage2_{t-1}^{i} * e_t^k$	-0.06	(0.02)	-0.04	(0.11)
$wage3_{t-1}^{i} * e_t^k$	-0.07	(0.03)*	-0.10	(0.13)
$forown_{t-1}^{i} * e_t^k$	-0.11	(0.08)	0.10	(0.08)
$exoth_{t-1}^{i} * e_t^k$	0.08	(0.06)	0.14	(0.14)
Main effects of other shocks	yes		yes	
Interaction effects with other shocks	yes		yes	
Sector-market f.e.	yes		yes	
Plant-year f.e.	yes		yes	
# plants	3042		741	
# plant-years	14808		2611	
R^2	0.64		0.70	
R^2-adj	0.22		0.26	

Notes: Estimation method is OLS. Dependent variable is an indicator for entry or exit. Sample consists of all plant-years where plant is at risk for entry or exit in both UK and US markets, and where there is positive lagged and current sales in the Irish market. Regressions include main effects and full set of interactions with cost and demand variables for foreign demand, foreign prices and tariffs (coefficient estimates not reported for space reasons). Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level. Note: Column (2) includes indicator variables only for one year in the market and two or more years in the market. In later versions, this will be brought in line with the variables included in the baseline linear probability model.

Table 8: Robustness: Lagged exchange rate

	(1)		(2)	
	Entry		Exit	
	coeff	s.e.	coeff	s.e.
e_t^k	0.17	(0.08)**	0.33	(0.94)
$revenue_{t-1}^{ik*}$			-0.05	(0.01)**
$revenue_{t-1}^{ik*} e_t^k$			0.11	(0.05)**
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$			-0.07	(0.03)**
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$			-0.09	(0.31)
$emp2_{t-1}^i * e_t^k$	0.01	(0.09)	0.50	(0.50)
$emp3_{t-1}^i * e_t^k$	0.22	(0.12)*	-0.13	(0.50)
$age2_{t-1}^i * e_t^k$	-0.12	(0.09)	-0.25	(0.58)
$age3_{t-1}^i * e_t^k$	-0.22	(0.10)**	-0.01	(0.58)
$cap2_{t-1}^i * e_t^k$	0.09	(0.08)	-0.51	(0.63)
$cap3_{t-1}^i * e_t^k$	0.04	(0.12)	-0.33	(0.67)
$imp2_{t-1}^i * e_t^k$	-0.10	(0.11)	-0.03	(0.37)
$imp3_{t-1}^i * e_t^k$	0.56	(0.24)**	-0.18	(0.47)
$prod2_{t-1}^i * e_t^k$	-0.13	(0.08)	-0.49	(0.40)
$prod3_{t-1}^i * e_t^k$	0.01	(0.13)	-0.99	(0.52)*
$wage2_{t-1}^i * e_t^k$	0.00	(0.08)	-0.12	(0.46)
$wage3_{t-1}^i * e_t^k$	-0.21	(0.12)*	-0.25	(0.53)
$forown_{t-1}^i * e_t^k$	-0.27	(0.39)	0.20	(0.31)
$exoth_{t-1}^i * e_t^k$	-0.12	(0.41)	-0.08	(0.05)
e_{t-1}^k	-0.24	(0.09)**	-0.75	(0.93)
$revenue_{t-1}^{ik*} e_{t-1}^k$			-0.08	(0.05)
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_{t-1}^k$			0.22	(0.31)
$emp2_{t-1}^i * e_{t-1}^k$	0.02	(0.09)	-0.71	(0.51)
$emp3_{t-1}^i * e_{t-1}^k$	-0.18	(0.12)	-0.06	(0.50)
$age2_{t-1}^i * e_{t-1}^k$	0.11	(0.09)	0.37	(0.58)
$age3_{t-1}^i * e_{t-1}^k$	0.22	(0.10)**	0.07	(0.59)
$cap2_{t-1}^i * e_{t-1}^k$	-0.08	(0.08)	0.42	(0.63)
$cap3_{t-1}^i * e_{t-1}^k$	-0.02	(0.12)	0.25	(0.67)
$imp2_{t-1}^i * e_{t-1}^k$	0.19	(0.11)*	0.03	(0.38)
$imp3_{t-1}^i * e_{t-1}^k$	-0.49	(0.25)**	0.21	(0.48)
$prod2_{t-1}^i * e_{t-1}^k$	0.14	(0.08)*	0.44	(0.41)
$prod3_{t-1}^i * e_{t-1}^k$	0.02	(0.13)	0.87	(0.53)
$wage2_{t-1}^i * e_{t-1}^k$	0.00	(0.08)	0.09	(0.47)
$wage3_{t-1}^i * e_{t-1}^k$	0.21	(0.12)*	0.23	(0.54)
$forown_{t-1}^i * e_{t-1}^k$	0.20	(0.40)	-0.20	(0.31)
$exoth_{t-1}^i * e_{t-1}^k$	0.25	(0.43)	0.00	(0.61)
Market f.e.	yes		yes	
Plant-year f.e.	yes		yes	
# plants	3094		764	
# plant-years	15107		2669	
R^2	0.58		0.64	
R^2-adj	0.17		0.26	

Notes: Estimation method is OLS. Dependent variable is an indicator for entry or exit. Sample consists of all plant-years where plant is at risk for entry or exit in both UK and US markets, and where there is positive lagged and current sales in the Irish market. Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level. Note: Column (2) includes indicator variables only for one year in the market and two or more years in the market. In later versions, this will be brought in line with the variables included in the baseline linear probability model.

Table 9: Conditional logit: Entry and exit

	(1)		(2)		(3)		(4)	
	Entry		Entry		Exit		Exit	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	-1.69	(1.34)	-2.22	(1.46)	-0.39	(1.31)	-3.89	(3.92)
$revenue_{t-1}^{ik*}$							-0.86	(0.12)**
$revenue_{t-1}^{ik*} e_t^k$							0.03	(0.15)
$I\left(yrmkt_{t-1}^{ik} = 2\right)$							0.12	(0.54)
$I\left(yrmkt_{t-1}^{ik} \geq 3\right)$							-0.53	(0.44)
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$							0.20	(1.77)
$I\left(yrmkt_{t-1}^{ik} \geq 3\right) e_t^k$							1.31	(1.22)
$emp2_{t-1}^{i} * e_t^k$			0.93	(0.56)*			-3.26	(1.13)**
$emp3_{t-1}^{i} * e_t^k$			1.18	(0.62)*			-2.20	(0.95)**
$age2_{t-1}^{i} * e_t^k$			-0.02	(0.49)			3.82	(2.39)
$age3_{t-1}^{i} * e_t^k$			0.92	(0.63)			3.17	(2.43)
$cap2_{t-1}^{i} * e_t^k$			-0.04	(0.53)			-2.70	(1.10)**
$cap3_{t-1}^{i} * e_t^k$			-0.00	(0.68)			-2.70	(1.29)**
$imp2_{t-1}^{i} * e_t^k$			1.84	(0.51)**			-1.65	(0.82)**
$imp3_{t-1}^{i} * e_t^k$			0.80	(0.85)			-0.03	(0.96)
$prod2_{t-1}^{i} * e_t^k$			0.62	(0.54)			-0.11	(0.92)
$prod3_{t-1}^{i} * e_t^k$			1.48	(0.80)*			-1.52	(1.32)
$wage2_{t-1}^{i} * e_t^k$			0.58	(0.53)			-0.53	(0.90)
$wage3_{t-1}^{i} * e_t^k$			-0.68	(0.71)			-0.74	(1.31)
$forown_{t-1}^{i} * e_t^k$			-1.79	(0.73)**			0.58	(0.94)
$exoth_{t-1}^{i} * e_t^k$			-3.30	(0.53)**			0.79	(1.22)
Market f.e.	yes		yes		yes		yes	
Plant-year f.e.	yes		yes		yes		yes	
UK entry/exit rate	0.86		0.86		0.23		0.23	
US entry/exit rate	0.14		0.14		0.77		0.77	
# plants	849		749		514		316	
# plant-years	1021		905		608		361	
pseudo-R^2	0.43		0.49		0.22		0.55	

Notes: Estimation method is conditional logit. Dependent variable is an indicator for entry or exit. Sample consists of all plant-years where plant is at risk for entry or exit in both UK and US markets, where there is positive lagged and current sales in the Irish market, and where entry or exit is observed in precisely one market. Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level.

Table 10: Random e ects probit: Entry and exit

	(1)		(2)		(3)		(4)	
	Entry		Entry		Exit		Exit	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	-0.44	(0.53)	-0.87	(1.46)	-0.83	(0.63)	0.11	(0.96)
$revenue_{t-1}^{ik*}$							-0.19	(0.02)**
$revenue_{t-1}^{ik*} e_t^k$							0.10	(0.05)*
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$							-0.49	(0.09)**
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$							-0.42	(0.29)
$emp2_{t-1}^i * e_t^k$			0.34	(0.22)			-1.01	(0.35)**
$emp3_{t-1}^i * e_t^k$			0.42	(0.24)*			-0.89	(0.33)**
$age2_{t-1}^i * e_t^k$			-0.02	(0.20)			0.42	(0.34)
$age3_{t-1}^i * e_t^k$			0.21	(0.25)			0.32	(0.37)
$cap2_{t-1}^i * e_t^k$			0.11	(0.21)			-0.89	(0.35)**
$cap3_{t-1}^i * e_t^k$			-0.02	(0.28)			-0.87	(0.40)**
$imp2_{t-1}^i * e_t^k$			0.85	(0.20)**			-0.24	(0.26)
$imp3_{t-1}^i * e_t^k$			0.48	(0.37)			-0.07	(0.36)
$prod2_{t-1}^i * e_t^k$			0.45	(0.20)**			-0.48	(0.31)
$prod3_{t-1}^i * e_t^k$			0.63	(0.30)**			-0.95	(0.42)**
$wage2_{t-1}^i * e_t^k$			0.16	(0.20)			0.09	(0.33)
$wage3_{t-1}^i * e_t^k$			-0.03	(0.28)			0.18	(0.41)
$forown_{t-1}^i * e_t^k$			-0.90	(0.36)**			0.07	(0.29)
$exoth_{t-1}^i * e_t^k$			-0.93	(0.23)**			0.56	(0.39)
$\sigma\left(c^i\right)$	0.98	(0.10)**	1.01	(0.05)**	0.65	(0.15)**	0.45	(0.07)**
log likelihood	-3857		-3827		-1990		-1456	
Cost vector	yes		yes		yes		yes	
Market f.e.	yes		yes		yes		yes	
Plant r.e.	yes		yes		yes		yes	
# plants	3094		3094		892		764	
# plant-mkt-years	30214		30214		6516		5205	

Notes: Estimation method is random effects probit. Dependent variable is an indicator for entry or exit. Sample consists of all plant-years where plant is at risk for entry or exit in both UK and US markets, where there is positive lagged and current sales in the Irish market. ** indicates significance at the 5% level. * indicates significance at the 10% level. Note: Column (4) includes indicator variables only for one year in the market and two or more years in the market. In later versions, this will be brought in line with the variables included in the baseline linear probability model.