Exporters and Exchange Rates*

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Abstract

We present a dynamic model of demand accumulation by plants with heterogenous costs which may participate in multiple export markets. Based on the model, we use 10 years of plant-level data for Ireland to estimate how export entry and exit depend on the level of the nominal exchange rate. Our identification strategy exploits the fact that we observe sales in two precisely identified export markets, allowing us to clean out the first-order effect of unobserved heterogeneity in costs using fixed effects. We find that the probability of entry is increasing in the level of the exchange rate and the probability of exit is decreasing in the level of the exchange rate. Consistent with the model, the responses of entry and exit to exchange rates vary systematically with observable plant characteristics and export histories. 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

Aggregate responses to nominal exchange rate movements depend on the responses of individual firms. There is a very extensive literature that documents price responses to exchange

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rate movements at very disaggregated levels. However there is relatively little work on responses of quantities or revenues to movements in exchange rates at the level of individual producers.[1] The goal of this paper is to fill this gap, in particular focusing on the response of entry to and exit from export markets to movements in exchange rates.

Because the exchange rate is very persistent, it is important to control for all other sources of persistence in export participation in order to estimate the the sensitivity of export entry and exit to the level of the exchange. We estimate the sensitivity of export entry and exit by Irish plants to the level of the exchange rate, within the context of a dynamic model of demand accumulation by plants with heterogeneous costs. Once heterogeneity across plants with different costs and export histories is allowed for, we identify statistically significant sensitivities of entry and exit to the level of the exchange rate. The probability of entry is increasing in the level of the exchange rate and the probability of exit is decreasing in the level of the exchange rate. The economic impact of these effects is modest. At least as regards entry and exit, our evidence is consistent with plants responding more to idiosyncratic shocks than to aggregate shocks.

To motivate our empirical approach, we present a partial equilibrium model with the following features. Plants are heterogeneous in their (home currency-denominated) marginal costs of production. Within each potential target market, they face a level of demand that depends on their (foreign currency) price with constant elasticity, on an iid shock, and on the level of their accumulated "customer capital." If a plant did not participate in a particular market in the previous period, its potential customer capital resets to a low 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 may be convex costs of adjustment in accumulating customer capital, so plants need 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 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.

This model can match important facts on the dynamics of export entry and exit. In

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

particular, it can match the fact that exit hazard is declining in the number of years a plant has participated in a particular market, while the growth of sales conditional on survival is decreasing over time. Importantly for us, it predicts that the sensitivity of entry to the level of the exchange rate is heterogeneous across plants with different costs, while the sensitivity of exit to the level of the exchange rate is heterogeneous across plants with different costs and across plants with different levels of accumulated customer capital. In order to estimate the sensitivity of entry and exit to the exchange rate, we must allow for this heterogeneity.

In our empirical application, we make use of data on the plant census for Ireland for the years 1996-2005. We have all the usual plant census variables, along with export sales by market for the UK and the US markets. Our empirical strategy exploits the fact that we have exports by market for more than one precisely defined market 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 the level of the exchange rate by looking at variation in entry and exit across markets within plant-years. We allow the sensitivity of entry to the level of the exchange rate to be heterogeneous across plants with different costs and we allow the sensitivity of exit to the level of the exchange rate to be heterogeneous across plants with different costs and across plant-market-years with different levels of accumulated customer capital. We do this by including main effects (where appropriate) and interactions between the exchange rate and two sets of variables that proxy for these two different dimensions of heterogeneity.

If we do not allow the sensitivity of export entry and exit to the level of 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. A relatively depreciated exchange rate is more likely to induce entry among bigger plants than smaller plants. A relatively depreciated exchange rate reduces exit in general. The effect is nonmonotonic across the size classes considered. 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 sensitive to the exchange rate than are plants with little attachment to the relevant market. Although these effects have the predicted sign and are statistically significant, we calculate that the variation in export entry and exit that is explained by movements in exchange rates is modest.

Our work is related to several literatures. First, it is related to a 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 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 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)). Our simple model of demand accumulation has the ability to match these facts. We view it as a reduced form approximation to the more microfounded models proposed by the literature just cited. Its simplicity 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 empirical literature.

The second dimension along which we innovate is that our data allows us to identify sales to 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 is an approach that 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 data is based on the Irish Census of Industrial Production (CIP). This census of manufacturing, mining and utilities takes place annually. All plants with 3 or more employees are required to fill in a return. We make use of the data on local units in the CIP for the years 1996 to 2005 and include NACE sectors 10-36 (mining and manufacturing). Of the variables collected in the CIP, those relevant for our purposes are the 4-digit industrial classification (NACE Revision 1.1), country of ownership, value of sales, share of sales exported, share of exports destined for the UK, share of exports destined for the US, and employment.[2] We also have information on the share of exports destined for the EU and the share of exports destined for the rest of the world, but given the coarse nature of this classification, we do not make use of this information. 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.[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. Apart from the period 1932-1975, free trade in industrial products has prevailed 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, until the early 2000s, it was the biggest single export destination for Irish exports. There was a fixed exchange rate with the UK until 1979. From 1979, when it joined the

[2]We also have data on the wage bill, materials and energy expenditures and a measure of capital stock, but so far we have not exploited these.

[3]As a result, the time series pattern of total exports and exports by destination in the data set we work with does not match the pattern in official trade statistics.

ERM to 1999 when it joined the Eurozone, Ireland had its own currency (the Irish Punt) which floated against Sterling within the context of the ERM. From 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 increases over the period we examine, eventually dominating that of the UK. Since joining 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.

2.1 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. The first panel of Table 1 reports an index of the year-end level of the Sterling and dollar exchange rates for our sample period.[4] An increase indicates a devaluation of the home currency against the foreign currency. We will identify the effect of the level 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 share of the UK and US in total Irish merchandise 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 Ireland is a very open economy. 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

[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	114	110	125	125	128	120	110	110	114
US$-Irish ex. rate	100	119	114	133	143	151	127	106	98	113
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.

facts documented for large developed economies such as the US and France, and smaller developing countries such as Colombia. An additional 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 by Bernard, Redding, Jensen and Schott (2007) for US exporters. Exporters to the US are on average substantially bigger than exporters to the UK.

Table 2 reports transition rates over the period 1996-2005 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%. A non-trivial fraction of exiting exporters cease operations altogether. There is also another category of plants - new exporters who start exporting in their first year of operation. While this last phenomenon (which is not addressed by the existing literature we cite in the introduction) is interesting, we will not address it directly. 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 find that the export-sales ratio jumps on entry, and grows slowly thereafter. Figures 2 and 3 illustrate the same pictures for entrants to the UK and US markets respectively [US figure has not been cleared by CSO].

[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.

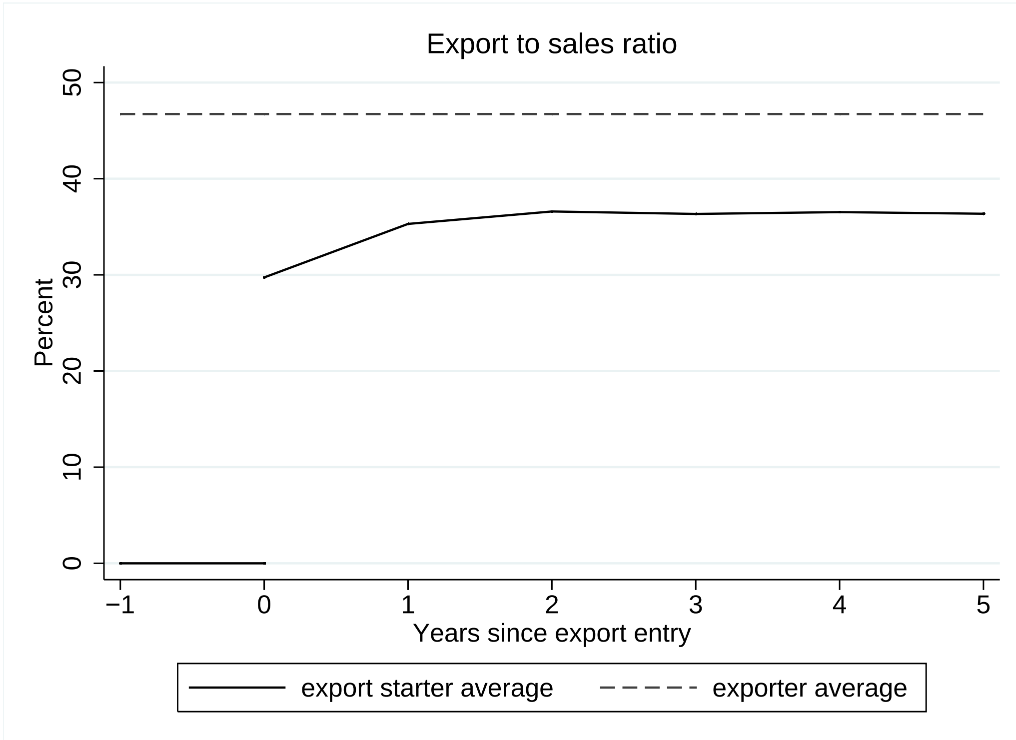

Figure 1: Export-sales ratios for export entrants

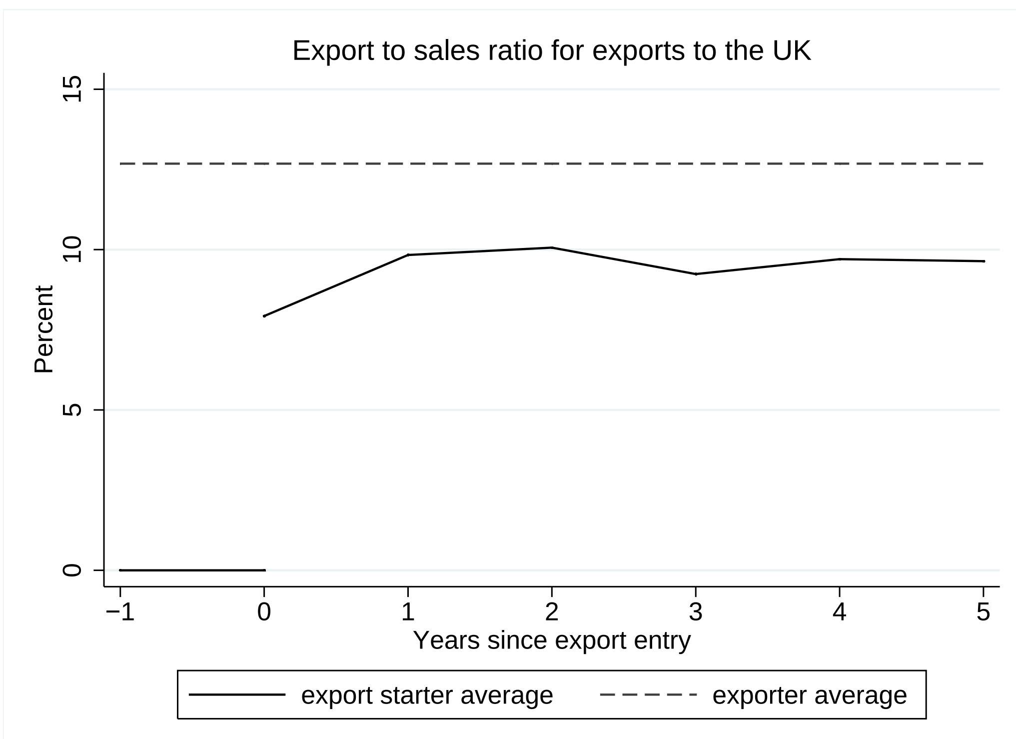

Figure 2: Export-sales ratios for entrants to UK market

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

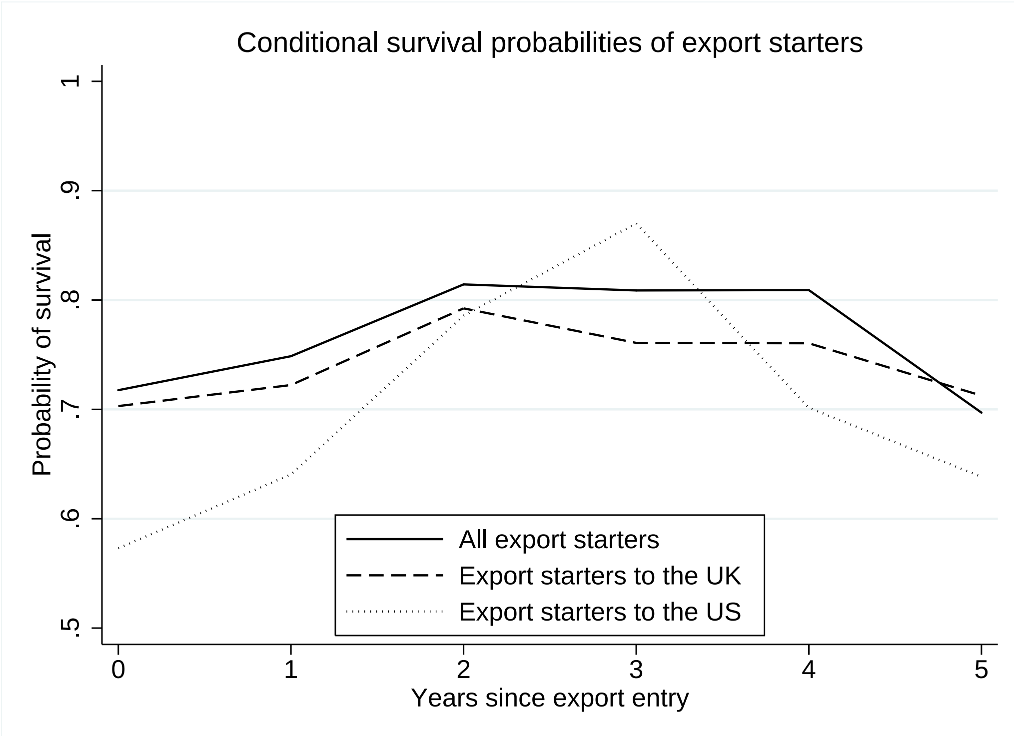

Figure 4: Survival probabilities

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, though this may be linked 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.

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. All of these models derive the dynamic patterns from first principles, but 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. 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 age distribution of plants, as 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), Gourio and Rudanko (2010) and Foster, Haltiwanger and Syverson (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

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

where $\alpha \in (0,1)$ and $\theta > 1$. The last two terms of this expression are standard (prices are expressed in foreign currency). We assume that η_t^{ik} is an iid lognormally distributed random variable that captures idiosyncratic shocks to demand. We interpret D_t^{ik} as "customer capital." It is subject to decreasing returns. At time t, D_t^{ik} is predetermined. D_t^{ik} accumulates according to the law of motion:

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

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 base. We assume that for all plants that produce and sell something to the home market, $D(1)^{ik} \leq \bar{D}_t^{ik}$, where $\bar{D}_t^{ik}$ is steady state D, which depends on plant characteristics and the aggregate state, but not on η_t^{ik}.[8] 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 $D(1)^{ik}$.[9]

3.2 Costs

We assume that plant i faces marginal cost $\tau^k (W_t/z_t^i)$ expressed in domestic currency of serving market k. The first term, τ^k, is a cost that is specific to a given market but does not vary across plants or over time. 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. We also allow for 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. This captures the idea that by spreading out the accumulation of customer base over time, the plant can take advantage of word-of-mouth to accumulate customers more cheaply.

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.

[8] We can guarantee that this is the case if $D(1)^{ik}$ is sufficiently low and the fixed costs of selling in the dometic market are sufficiently high.

[9] 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, but given 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.

3.3 Static optimization

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

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

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. The optimal price is

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

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

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

and flow profits can be written

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

3.4 Dynamic optimization

As is standard in the literature on export entry and exit, we ignore the plant existence decision, instead conditioning on some positive lagged level of sales in the home market, assuming that this is the "easiest" market to enter.[10] 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 Θ_t^k denote the vector of aggregate shocks $\left\{ E_t^k, W_t \right\}$. 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 $D(1)^{ik}$. The value of being in market k is:

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

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

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

The value of not being in market k (i.e. waiting until later to enter) is:

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

Because we assume that customer capital is reset to $D\left(1\right)^{ik}$ following exit, $V^{out}\left(z_t^i, \Theta_t^k\right)$ does not depend on D_t^{ik}.

A potential entrant will enter if

$$V^{in}\left(D\left(1\right)^{ik}, \eta_t^{ik}, z_t^i, \Theta_t^k\right) > V^{out}\left(z_t^i, \Theta_t^k\right)$$

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

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

There is an underlying asymmetry in these decisions that arises out of the accumulation of customer capital.

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: $V^{in}\left(D_t, \eta_t, z_t, \Theta_t\right)$ is monotonically increasing in D.

Proof: First, let $\Omega_t = \{\eta_t, z_t, \Theta_t\}$. Suppose we have a plant that enters period t with D^1. Let $\{I_t^1\left(D^1, \Omega_t | X_t = 1\right), \ldots\}$ and $\left\{X_{t+1}^1\left(\left(1-\delta\right) D^1 + I_t^1\left(D^1, \Omega_t | X_t = 1\right), \Omega_{t+1} | X_t = 1\right), \ldots\right\}$ denote the infinite sequences of optimal investment and participation decisions conditional on participation at t (i.e. conditional on $X_t = 1$). $V^{in}\left(D^1, \Omega_t\right)$ 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 $\tilde{V}^{in}(D^2, \Omega_t; D^1)$ 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

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

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 $R(D, \Omega)$ is increasing in D and $\phi'(\cdot) \geq 0$, under all histories such that the D^1-plant particpates continuously in the market, the flow value of the D^2-plant is greater than the flow 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

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

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

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

This implies that

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

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

Corollary: $V^{in}(D_t, \eta_t, z_t, \Theta_t) - V^{out}(z_t, \Theta_t)$ is increasing in D_t, for $D_t > D(1)$. This follows directly from the fact that given $D(1)$, $V^{out}(z_t, \Theta_t)$ is invariant to D_t.

Proposition: $V^{in}(D_t, \eta_t, z_t, \Theta_t)$ 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 $V^{in}(D_t, \eta_t, z_t, \Theta_t)$ is through $R_t(D_t, \eta_t, z_t, \Theta_t)$, which is increasing in η_t. Hence, $V^{in}(D_t, \eta_t, z_t, \Theta_t)$ is increasing in η_t.■

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

Proposition: If a plant's productivity draw z is date- and state-invariant (constant), then $V^{in}(D_t, \eta_t, z, \Theta_t) - V^{out}(z, \Theta_t)$ is increasing in z.

Proof: To be completed.

Conjecture: Under less restrictive conditions on the stochastic process for z, we will still have $V^{in}(D_t, \eta_t, z, \Theta_t) - V^{out}(z, \Theta_t)$ increasing in z.

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

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

3.6 Exit hazard and sales growth conditional on survival

The model we have just laid out is able to match the fact that the hazard of exit is decreasing in the length of time a plant has been in a market. This follows from the fact a plant that entered more recently will have a lower D than an otherwise identical plant that entered further in the past. 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 decline over time.

4 Empirical strategy

One could certainly investigate the responsiveness of entry and exit to the level of the exchange rate by making a number of additional assumptions and structurally estimating the model we describe above. Since we view our model as an already reduced form representation of dynamics that are due to more fundamental search or learning processes, we prefer to use a reduced form strategy based on the comparative statics we describe in the previous section.

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. However it is important to note that this excludes two important classes of potential entrants and one important class of potential exiters, as we exclude plants that are "born to export" from our analysis of the entry decision, and we exclude plants that export 100% of sales from our analysis of both entry and exit decisions.

The comparative statics we document above imply that the probability of participation in a given market depends on both costs and demand. By assumption, costs have a component that is specific to a market, a component that is common to all plants at a given point in time, and a component that is common to all markets for a given plant at a given point in time. 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. We need to control for both costs and demand in order to estimate the sensitivity of the participation decision to the exchange rate (which is also highly persistent). Moreover, we must take account of the fact that the effect of the exchange rate on the probability of participation in a given market is not symmetric across plants. The effect is greater for plants that are close to their entry or exit thresholds. These thresholds vary across plants along the dimension of both costs and demand. In addition, because of the sunk nature of investments in customer capital, 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. We now describe these in turn.

4.1 Entry

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

$$V^{in}\left(D\left(1\right)^{ik}, \eta_t^{ik}, z_t^i, \Theta_t^k\right) > V^{out}\left(z_t^i, \Theta_t^k\right)$$

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

$$\Pr\left[\text{Enter}_t^{ik}\right] = G\left(\alpha^k + c_t^i + \boldsymbol{\gamma}'\mathbf{x}_t^k + \boldsymbol{\delta}'\boldsymbol{x}_t^k c_t^i + d^{ik} + \eta_t^{ik}\right) \tag{1}$$

Here, α^k is a time-invariant market-specific effect which is intended to capture the effect of τ^k, scaling of the exchange rate and foreign aggregate price and demand variables, and any component of $D\left(1\right)^{ik}$ that is common across plants. The term c_t^i is a plant-year effect, intended to capture the first-order effect of W_t/z_t^i as well as any component of $D\left(1\right)^{ik}$ that is common across markets for a given plant. $\mathbf{x}_t^k$ is a vector, the elements of which may include the log of the nominal exchange rate (e_t^k), a measure of foreign demand (y_t^k) and the log of the foreign price level relative to the home price level (p_t^{k*}). We include an interaction between $\mathbf{x}_t^k$ and c_t^i, intended to capture asymmetries in the effect of aggregate shocks across plants depending on their distance from the entry threshold. For the lack of better notation, the way this is specified here places strong restrictions on the nature of the interaction. However we are less parametric when it comes to the implementation. The term d^{ik} captures any heterogeneity at the plant-market level in the initial draw of customer capital $D\left(1\right)^{ik}$. In principle, there should be an interaction between $\mathbf{x}_t^k$ and d^{ik} as well as between $\mathbf{x}_t^k$ and c_t^i, but as we do not have observable variables that are correlated with $D\left(1\right)^{ik}$ for potential entrants, we will not be able to control for this effect in the entry equation.[11]

The sample at risk for entry consists of all plant-market-years such that lagged participation equals zero ($X^{ik}_{t-1} = 0$). In implementing (1) we exploit the fact that we observe the participation decision for two precisely defined export markets by using a fixed effects strategy to control for the first order effect of c^i_t. That is, we identify the coefficient on the exchange rate (and other market-specific aggregate shocks) 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. In order to be clear about the size of the sample on which identification is based, we exclude all plant-years with only one market at risk for entry from the estimation sample.

Because of the incidental parameter problem, our desire to make use of fixed effects to control for c^i_t restricts the functional form we can choose for $G(\cdot)$. We consider two alternatives. We can estimate 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. Cases where there is entry in neither market or entry in both markets are dropped from the estimation. This both restricts the size of the sample, reducing precision, and also discards useful information in the sample that can be used to identify the parameters of interest. Alternatively, we can estimate a linear probability model, 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.

Because of degrees of freedom considerations, as a baseline, we consider the case where the only element in the vector $\mathbf{z}^k_t$ is the log of the nominal exchange rate, e^k_t. We test the robustness of our results to this restriction.

In order to control for the interaction between e^k_t and c^i_t, we do the following. We do not directly observe marginal costs (which is why we use a fixed effects strategy to control for the first-order effect of costs). Instead, we make use of variables (such as number of employees, plant age, foreign ownership and presence in other export markets besides the UK and US) which are theoretically correlated with costs. For the continuous variables (employees and plant age), we divide plants into bins.[12] We then interact e^k_t with a rich set of indicator variables ($\mathbf{s}^i_t$), lagged one year because of simultaneity concerns. This nonparametric approach allows for the fact that the impact of shocks on the probability of entry may be nonlinear in costs, though it is clearly less general than our treatment of the

[11]We also ignore any potential interactions between c^i_t and d^{ik}.

[12]We have also experimented with using plant age.

first-order effects of cost heterogeneity.

Finally, we have to decide to do about the d^{ik} term, which captures the fact that there may be a persistent component to the attractiveness of a potential entrant's products in each export market. If we take the conditional logit approach, there are relatively few cases where we make use of the same plant more than once in order to identify the parameters of interest. This implies that as long as d^{ik} is uncorrelated with observables, we can treat it in the same way as the idiosyncratic error term η_t^{ik}. Since (apart from the aggregate variables) we do not have any market-k specific variables, we hope that this assumption is not too much of a stretch. In the linear probability model specification that makes use of the broader sample for identification, however, d^{ik} is a concern since we do make use of repeated observations on the same plant-market for identification. We could pursue either a random effects or a fixed effects strategy to deal with this issue. So far, we have worked under the assumption that all variation in d^{ik} is captured either by α^k or c_t^i. In future work we hope to address this issue.

To summarize, we estimate two specifications. First, we use only the subsample of at-risk plant-years where we observe precisely one entry to estimate a conditional logit, using the conditioning procedure to clean out c_t^i:

$$\Pr\left[\text{Enter}_t^{ik}\right] = \Lambda\left(\alpha^k + c_t^i + \gamma e_t^k + \delta' \mathbf{s}_{t-1}^i e_t^k\right) \tag{2}$$

Second, we estimate the linear probability model:

$$\Pr\left[\text{Enter}_t^{ik}\right] = \alpha^k + c_t^i + \gamma e_t^k + \delta' \mathbf{s}_{t-1}^i e_t^k + \eta_t^{ik} \tag{3}$$

We estimate the linear probability model on the broader sample of all plant-years where both markets are at risk for entry. We can also estimate it on the narrow sample used for the conditional logit estimation.

4.2 Exit

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

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

We approximate the probability of exit as follows:

$$\Pr\left[\text{Exit}_t^{ik}\right] = G\left(\alpha^k + c_t^i + \boldsymbol{\gamma}'\mathbf{x}_t^k + \lambda d_t^{ik} + \boldsymbol{\delta}'\mathbf{x}_t^k c_t^i + \rho'\mathbf{x}_t^k d_t^{ik} + \eta_t^{ik}\right) \tag{4}$$

All variables are as in the entry equation, with the exception of d_t^{ik}. The comparative statics in the previous section imply that we should include the log of customer capital both as a main effect and as an interaction with aggregate variables.[13]

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, in implementing (4) we exploit the fact that we observe the participation decision in two precisely defined export markets by using a fixed effects strategy to control for the first order effect of c_t^i. We identify the coefficient on the exchange rate (and other market-specific aggregate shocks) from within-plant-year variation in the entry decision. Only plant-years with lagged participation equal to one in *both* export markets will be used to identify the coefficients of interest. In order to be clear about the size of the sample on which identification is based, we exclude all plant-years with only one market at risk for exit from the estimation sample. As in the case of entry, we estimate both conditional logit and linear probability models.

As in the case of entry, as a baseline we restrict the vector $\mathbf{x}_t^k$ to a single element, e_t^k. We use the same approach as in the entry case to controlling for the interaction between costs and e_t^k. As regards d_t^{ik}, our model suggests that d_t^{ik} increases with the number of years a plant participates in a market. For plants that enter export markets over the lifetime of the sample, we can observe the number of years in the market (and hence, for exiters, the number of years they would have been in the market had they not exited). For plants that were already participating at the beginning of the sample, we can place a lower bound on the number of years in the market. This motivates the use of a variety of sets of indicator variables for age-in-market.[14] In addition, plants with higher d_{t-1}^{ik} are likely to have higher d_t^{ik}. This suggests that we may want to use r_{t-1}^{ik*}, the lag of log foreign currency sales, as a proxy for d_t^{ik}. The use of this variable may raise some concerns, so we consider both specifications that exclude and include this variable. Our results are qualitatively similar under both specifications. We label the vector that may include both age indicators and the lagged revenue variable $\mathbf{a}_t^{ik}$

To summarize, we estimate the exit equation using two different specifications. First, we

[13]There should also be an interaction with costs, which for the moment we will ignore.

[14]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 precisely it measures d_t^{ik}, but the bigger the sample size.

use only the subsample of at-risk plant-years where we observe precisely one exit to estimate a conditional logit, using the conditioning procedure to clean out c_t^i:

$$\Pr\left[\text{Exit}_t^{ik}\right] = \Lambda\left(\alpha^k + c_t^i + \gamma e_t^k + \boldsymbol{\lambda}'\mathbf{a}_t^{ik} + \delta'\mathbf{s}_{t-1}^i e_t^k + \boldsymbol{\rho}'\mathbf{a}_t^{ik} e_t^k\right) \tag{5}$$

Second, we estimate the linear probability model:

$$\Pr\left[\text{Exit}_t^{ik}\right] = \alpha^k + c_t^i + \gamma e_t^k + \boldsymbol{\lambda}'\mathbf{a}_t^{ik} + \delta'\mathbf{s}_{t-1}^i e_t^k + \boldsymbol{\rho}'\mathbf{a}_t^{ik} e_t^k + \eta_t^{ik} \tag{6}$$

We estimate the linear probability model on the broader sample of all plant-years where both markets are at risk for exit. We also estimate it on the narrow sample used to estimate the conditional logit model.

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

This section reports the results on entry. The results based on estimating the conditional logit and restricted-sample linear probability models are very similar to each other. In each case, the sample size is small, and as a result the estimates are imprecise. As a result, these results are relegated to the Appendix, while we focus on the results from estimating the linear probability model based on the broader sample, reported in Table 3. These results have the advantage over the restricted sample estimates that it is relatively easy to understand their economic significance. Qualitatively, the implications are quite similar to those we obtain from the restricted sample estimates.[15]

When we do not allow for heterogeneous sensitivities to the exchange rate (column (1) of Table 3), 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 five different plant size categories

[15] We have yet to investigate the share of predicted probabilities that lie outside the $[0, 1]$ range.

Table 3: Entry: Linear probability, broad sample

	(1)		(2)	
	coeff	s.e.	coeff	s.e.
e_t^k	0.02	(0.02)	0.02	(0.02)
$I\left(10 \leq emp_{t-1}^i \leq 19\right) e_t^k$			0.02	(0.01)**
$I\left(20 \leq emp_{t-1}^i \leq 49\right) e_t^k$			0.03	(0.01)**
$I\left(50 \leq emp_{t-1}^i \leq 99\right) e_t^k$			0.04	(0.02)**
$I\left(emp_{t-1}^i \geq 100\right) e_t^k$			0.09	(0.03)**
$I\left(8 \leq age_t^i \leq 14\right) e_t^k$			-0.02	(0.01)*
$I\left(15 \leq age_t^i \leq 23\right) e_t^k$			-0.01	(0.01)
$I\left(age_t^i \geq 24\right) e_t^k$			-0.02	(0.01)**
$I\left(forown_{t-1}^i = 1\right) e_t^k$			0.00	(0.03)
$I\left(exother_{t-1}^i = 1\right) e_t^k$			0.15	(0.04)**
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		3512	
# plant-years	17449		17449	
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.

(1-9 employees, 10-19 employees, 20-49 employees, 50-99 employees and 100+ employees), four different plant age categories (1-7 years, 8-14 years, 15-23 years and 24+ years), an indicator for foreign ownership, and an indicator that the plant exports to markets other than the UK and US. All of these (except the plant age indicators) are lagged one year. Note that the excluded category is plants with 9 or fewer employees, in existence for 7 years or less, Irish owned and not exporting to any market besides the UK and US.

We find that the sensitivity of plant entry to the level of the exchange rate is increasing in plant size (note that this is conditional on not already participating in the relevant market) and that entry for these plants is more likely in periods where the exchange rate is relatively depreciated than in periods where it is relatively appreciated. Compared with plants aged 7 years or less, older plants are less sensitive to the level of the exchange rate in terms of their entry decision. Plants that export to markets besides the UK and US are particularly sensitive to the level of the exchange rate, again with entry for these plants more likely in periods where the exchange rate is relatively depreciated than in periods where it is relatively appreciated.

5.2 Exit

This section reports the results on exit. The results based on estimating the conditional logit and restricted-sample linear probability models are very similar to each other. In each case, the sample size is small, and as a result the estimates are imprecise. Sample sizes are smaller here than in the case of entry, because our identification strategy obliges us to focus on plant-years at risk for exit in both UK and US markets. This requires lagged participation in both markets, and the number of plants participating in both of these two markets is much smaller than the number of plants not exporting to either of the two markets. As a result, we relegate the restricted-sample results to the Appendix, and focus on the results from estimating the linear probability model based on the broader sample, reported in Tables 4 and 5. These results have the advantage over the restricted sample estimates that it is relatively easy to understand their economic significance. Qualitatively, the implications are quite similar to those we obtain from the restricted sample estimates.

As mentioned above, we experiment with different sets of plant age interactions, as there is a tradeoff between the precision of our measure of plant age and the size of the sample we can apply it to. We present results for three alternative sets of indicator variables for age. The first set distinguishes only between cases where the plant completed one year in the market prior to the current period and cases where the plant completed two or more years in the market prior to the current period. The second set distinguishes between cases where the plant completed one year, two years or three or more years in the market prior to the current period. The third indicator set distinguishes between cases where the plant completed one, two, three or four or more years in the market prior to the current period. We have experimented with richer sets of indicators, and find the results qualitatively unchanged, though less precise. The measure we use of lagged foreign currency revenues is constructed by dividing lagged home currency-denominated sales in the relevant market by the lag of the relevant exchange rate. All reveues 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 level of the exchange rate on the probability of exit. This can be seen in column (1) of Table 4. This is consistent with what we observe in the raw data. However when we allow the sensitivity to the level of the exchange rate to vary across plants according to their export histories (as measured by number of years in the relevant market and lagged foreign currency revenues from the relevant market) and plant size, age, ownership and export status, we do find significant effects of the level of the exchange rate on exit probabilities. Note that the excluded category is plants with 9 or fewer employees, aged 7 or less, Irish owned, not exporting to any market besides the UK and US and having exported to the relevant market for one year only.

Focusing on columns (2), (3) and (4) of Table 5 which include both demand and cost variables, we find that exit is in general less likely when the plant has been in the market for longer and has a high level of lagged sales in the market. The baseline category is significantly less likely to exit when the exchange rate is depreciated compared with when it is appreciated. However exit is less sensitive to the exchange rate for plants that have been in the export market for longer, or have high lagged sales in the market. Somewhat surprisingly, the probability of exit for plants in the 20-49, 50-99 and 100+ size categories is significantly more sensitive to the exchange rate than that of the baseline category. Here again, exit is less likely when the exchange rate is relatively depreciated and more likely when the exchange rate is relatively appreciated. Interactions with plant age, ownership and export status do not have significant effects on exit.

5.3 Economic significance

To illustrate the economic significance of our findings on entry and exit, we perform the following exercises. For all plant-market-years in our sample that at risk for entry,[16] 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 that makes use of the broader sample:[17]

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

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:

$$\sum_i \Delta \Pr \widehat{\left[\text{Enter}_t^{ik}\right]}$$

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

[17]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 4: Exit I: Linear probability, broad sample

	(1)		(2)		(3)		(4)		(5)	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	-0.09	(0.08)	-0.16	(0.09)	-0.23	(0.10)*	-0.27	(0.11)*	-0.28	(0.11)**
$revenue_{t-1}^{ik*}$			-0.06	(0.00)**						
$revenue_{t-1}^{ik*} e_t^k$			0.01	(0.01)						
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$					-0.15	(0.03)*				
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$					0.13	(0.08)				
$I\left(yrmkt_{t-1}^{ik} = 2\right)$							-0.06	(0.04)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right)$							-0.16	(0.03)**		
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$							0.12	(0.11)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right) e_t^k$							0.17	(0.08)*		
$I\left(yrmkt_{t-1}^{ik} = 2\right)$									-0.04	(0.04)
$I\left(yrmkt_{t-1}^{ik} = 3\right)$									-0.11	(0.04)**
$I\left(yrmkt_{t-1}^{ik} \geq 4\right)$									-0.16	(0.03)**
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$									0.15	(0.11)
$I\left(yrmkt_{t-1}^{ik} = 3\right) e_t^k$									0.07	(0.13)
$I\left(yrmkt_{t-1}^{ik} \geq 4\right) e_t^k$									0.19	(0.08)*
Market f.e.	yes		yes		yes		yes		yes	
Plant-year f.e.	yes		yes		yes		yes		yes	
UK exit rate	0.06		0.06		0.06		0.06		0.07	
US exit rate	0.14		0.14		0.14		0.15		0.15	
# plants	1007		1007		969		922		891	
# plant-years	3799		3799		3419		3041		2696	
R^2	0.57		0.60		0.59		0.62		0.64	
R^2-adj	0.15		0.21		0.18		0.22		0.26	

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.

Table 5: Exit II: Linear probability, broad sample

	(1)		(2)		(3)		(4)	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	-0.13	(0.10)	-0.29	(0.12)**	-0.28	(0.12)**	-0.23	(0.13)*
$revenue_{t-1}^{ik*}$			-0.05	(0.00)**	-0.05	(0.00)**	-0.05	(0.00)**
$revenue_{t-1}^{ik*} e_t^k$			0.02	(0.01)*	0.01	(0.01)	0.01	(0.01)
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$			-0.09	(0.03)**				
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$			0.12	(0.08)				
$I\left(yrmkt_{t-1}^{ik} = 2\right)$					-0.04	(0.04)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right)$					-0.10	(0.03)**		
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$					0.09	(0.11)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right) e_t^k$					0.16	(0.08)**		
$I\left(yrmkt_{t-1}^{ik} = 2\right)$							-0.03	(0.04)
$I\left(yrmkt_{t-1}^{ik} = 3\right)$							-0.08	(0.04)**
$I\left(yrmkt_{t-1}^{ik} \geq 4\right)$							-0.09	(0.03)**
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$							0.12	(0.11)
$I\left(yrmkt_{t-1}^{ik} = 3\right) e_t^k$							0.04	(0.12)
$I\left(yrmkt_{t-1}^{ik} \geq 4\right) e_t^k$							0.20	(0.08)**
$I\left(10 \leq emp_{t-1}^{i} \leq 19\right) e_t^k$	-0.04	(0.05)	-0.04	(0.05)	-0.04	(0.05)	-0.07	(0.05)
$I\left(20 \leq emp_{t-1}^{i} \leq 49\right) e_t^k$	-0.11	(0.04)**	-0.17	(0.05)**	-0.18	(0.05)**	-0.19	(0.05)**
$I\left(50 \leq emp_{t-1}^{i} \leq 99\right) e_t^k$	-0.06	(0.05)	-0.13	(0.06)**	-0.15	(0.06)**	-0.15	(0.06)**
$I\left(emp_{t-1}^{i} \geq 100\right) e_t^k$	-0.09	(0.05)*	-0.19	(0.06)**	-0.18	(0.07)**	-0.19	(0.07)**
$I\left(8 \leq age_t^i \leq 14\right) e_t^k$	-0.03	(0.04)	-0.00	(0.04)	-0.01	(0.05)	-0.02	(0.05)
$I\left(15 \leq age_t^i \leq 23\right) e_t^k$	0.03	(0.04)	0.04	(0.04)	0.02	(0.05)	0.01	(0.05)
$I\left(age_t^i \geq 24\right) e_t^k$	-0.00	(0.04)	-0.01	(0.04)	-0.01	(0.04)	-0.01	(0.04)
$I\left(forown_{t-1}^{i} = 1\right) e_t^k$	0.00	(0.03)	-0.00	(0.03)	0.01	(0.03)	0.00	(0.03)
$I\left(exother_{t-1}^{i} = 1\right) e_t^k$	0.09	(0.05)*	0.03	(0.05)	0.04	(0.05)	0.03	(0.06)
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		0.15		0.15	
# plants	1007		969		922		891	
# plant-years	3799		3419		3041		2696	
R^2	0.58		0.62		0.64		0.66	
R^2-adj	0.15		0.23		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.

Table 6: 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	9	0.13	89	32	0.17
1998	127	-2	-0.03	100	-7	-0.04
1999	133	9	0.13	78	27	0.15
2000	125	0	0.00	104	14	0.08
2001	105	2	0.03	162	10	0.05
2002	149	-5	-0.07	75	-27	-0.17
2003	151	-6	-0.08	89	-29	-0.19
2004	134	0	0.00	122	-11	-0.08
2005	107	2	0.03	68	20	0.14
avg abs val	128	4	0.06	99	20	0.12

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.

In Table 6 we compare this with the actual number of entries for plants that continue to participate in the Irish market, and 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. However overall, the effect of exchange rate movements on plant entry appears to be relatively limited. It is also worth noting that the sales of entrants are small relative to the sales of incumbents, further dampening the economic significance of entry and exi due to exchange rate movements.

Similarly for exit, for all plant-market-years in the sample at risk for exit,[18] 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 that makes use of the broader sample:

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

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

Table 7: Economic significance: Exit

	UK			US		
year	# exits	$\sum \Delta \Pr[\text{Exit}]$	Δe_t^{UK}	# exits	$\sum \Delta \Pr[\text{Exit}]$	Δe_t^{US}
Estimates based on Equation (2)						
1998	99	9	-0.03	72	1	-0.04
1999	106	-32	0.13	85	-4	0.15
2000	96	1	0.00	57	-2	0.08
2001	139	-7	0.03	78	-2	0.05
2002	116	17	-0.07	95	7	-0.17
2003	140	21	-0.08	105	5	-0.19
2004	123	0	0.00	94	1	-0.08
2005	132	-6	0.03	68	-3	0.14
avg abs val	119	12	0.05	82	3	0.11

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 columns (2), (3) and (4) of Table 5. 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.

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:

$$\sum_i \Delta \Pr\left[\hat{\text{Exit}}_t^{ik}\right]$$

We do this for the specification of the exit equation that maximizes the number of sample years for which the exercise can be implemented (equation (2) in Table 5). In Table 7, we compare the forecast number of exits based on the exchange rate change 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 findings 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. However as in the case of entry, the effect of exchange rate movements on plant exit appers to be relatively limited. As with the case of entrants, the sales of exiting exporters tend to be lower than those of plants that will survive in the export market, further dampening the economic impact of exit due to movements in exchange rates.

6 Conclusion

The empirical literature on the behavior of prices at a very disaggregated level finds that responses to aggregate shocks such as exchange rate movements are much more muted than responses to shocks that appear to be idiosyncratic to the plant and market. We explore a different dimension of producers' responses to exchange rate shocks - their propensity to enter or exit export markets.

In order to identify the sensitivity of entry and exit to the level of the exchange rate, which is a very persistent variable, we must appropriately control for all sources of persistence in exporting behavior. Our ability to do this satisfactorily depends on 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 are designed to match the fact that the value to recent entrants of being in a particular market appears to be less than that of plants with strong and long-lasting attachments to the same market.

We present a stylized model that can match this fact, and 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. 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. Entry is more likely the more depreciated the exchange rate. Exit is less likely the more depreciated the exchange rate. Plants closer to the thresholds for entry and exit are more sensitive to the level of the exchange rate. However the overall 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. 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.

References

[1] Arkolakis, C. (2008), "Market Penetration Costs and the New Consumers Margin in International Trade," mimeo.

[2] Arkolakis, C. (2009), "A Unified Theory of Firm Selection and Growth," mimeo.

[3] Baldwin, R. (1988), "Hysteresis in Import Prices: The Beachhead Effect," *American Economic Review* 78 (4), 773-85.

[4] Baldwin, R. and P. Krugman (1989), "Persistent Trade Effects of Large Exchange Rate Shocks," *Quarterly Journal of Economics* 104 (4), 635-54.

[5] Berman, N., P. Martin and T. Mayer (2009), "How do Different Exporters React to Exchange Rate Changes? Theory, empirics and aggregate implications," mimeo.

[6] Bernard, A. and B. Jensen (2004), "Why Some Firms Export," *Review of Economics and Statistics* 86 (2), 561-569.

[7] Bernard, A., S. Redding, B. Jensen and P. Schott (2007), "Firms in International Trade," *Journal of Economic Perspectives*, Summer.

[8] Bernard, A. and J. Wagner (2001), "Exports and Success in German Manufacturing," *Weltwirtschaftliches Archiv* 133 (1), 134-157.

[9] Campa, J. (2004), "Exchange Rates and Trade: How Important is Hysteresis in Trade?" *European Economic Review* 48, 527-548.

[10] Chaney, T. (2010), "The Network Structure of International Trade," mimeo.

[11] Das, M., M. Roberts and J. Tybout (2007), "Market Entry Costs, Producer Heterogeneity and Export Dynamics," *Econometrica* 75 (3), 837-873.

[12] Dixit, A. (1989) "Entry and Exit Decisions Under Uncertainty," *Journal of Political Economy* 97 (3), 620-38.

[13] Drozd, L. and J. Nosal (2010), "Understanding International Prices: Customers as Capital," mimeo.

[14] Eaton, J., M. Eslava, C. Krizan, M. Kugler and J. Tybout (2010), "A Search and Learning Model of Export Dynamics," mimeo.

[15] Eaton, J., M. Eslava, M. Kugler and J. Tybout (2008), "The Margins of Entry into Export Markets: Evidence From Colombia," in E. Helpman, D. Marin, and T. Verdier, eds., *The Organization of Firms in a Global Economy,* Cambridge, MA: Harvard University Press.

[16] Fitzgerald, D. and S. Haller (2010), "Pricing-to-Market: Evidence From Producer Prices," mimeo.

[17] Foster, L., J. Haltiwanger and C. Syverson (2010), "The Slow Growth of New Plants: Learning About Demand," mimeo.

[18] Gourio, F. and L. Rudanko (2010), "Customer Capital," mimeo.

[19] Knetter, M. (1989), "Price Discrimination by U.S. and German Exporters," *American Economic Review* 79 (1), 198-210.

[20] Melitz, M. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica* 71 (6), 1695-1725.

[21] Roberts, M. and J. Tybout (1997), "The Decision to Export in Colombia: An Empirical Model of Entry With Sunk Costs," *American Economic Review* 87 (4), 545-564.

[22] Ruhl, K. and J. Willis (2008a), "New Exporter Dynamics," mimeo.

[23] Ruhl, K. and J. Willis (2008b), "Learning About New Exporters," mimeo.

Appendix

Table 8: Entry: Conditional logit

	(1)		(2)	
	coeff	s.e.	coeff	s.e.
e_t^k	-0.83	(1.17)	-0.52	(1.19)
$I\left(10 \leq emp_{t-1}^i \leq 19\right) e_t^k$			0.69	(0.46)
$I\left(20 \leq emp_{t-1}^i \leq 49\right) e_t^k$			1.63	(0.55)**
$I\left(50 \leq emp_{t-1}^i \leq 99\right) e_t^k$			1.24	(0.78)
$I\left(emp_{t-1}^i \geq 100\right) e_t^k$			3.12	(1.03)**
$I\left(8 \leq age_t^i \leq 14\right) e_t^k$			-0.02	(0.52)
$I\left(15 \leq age_t^i \leq 23\right) e_t^k$			-0.49	(0.49)
$I\left(age_t^i \geq 24\right) e_t^k$			0.11	(0.56)
$I\left(forown_{t-1}^i = 1\right) e_t^k$			-0.54	(0.65)
$I\left(exother_{t-1}^i = 1\right) e_t^k$			-2.92	(0.45)**
Market f.e.	yes		yes	
Plant-year f.e.	yes		yes	
UK entry rate	0.86		0.86	
US entry rate	0.14		0.14	
# plants	849		849	
# plant-years	1021		1021	
pseudo-R^2	0.43		0.47	

Notes: Estimation method is conditional logit. 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, where there is positive lagged and current sales in the Irish market, and where entry is observed in precisely one market. Robust standard errors are calculated. ** indicates significance at the 5% level. * indicates significance at the 10% level.

Table 9: Exit: Conditional logit I

	(1)		(2)		(3)		(4)		(5)	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	0.40	(1.14)	0.61	(1.52)	-0.16	(1.33)	-0.29	(1.30)	-0.68	(1.31)
$revenue_{t-1}^{ik*}$			-0.90	(0.09)**						
$revenue_{t-1}^{ik*} e_t^k$			-0.21	(0.11)*						
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$					-1.36	(0.25)**				
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$					0.001	(0.70)				
$I\left(yrmkt_{t-1}^{ik} = 2\right)$							-0.00	(0.42)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right)$							-1.47	(0.28)**		
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$							1.09	(1.15)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right) e_t^k$							0.37	(0.74)		
$I\left(yrmkt_{t-1}^{ik} = 2\right)$									0.13	(0.43)
$I\left(yrmkt_{t-1}^{ik} = 3\right)$									-0.81	(0.44)*
$I\left(yrmkt_{t-1}^{ik} \geq 4\right)$									-1.47	(0.29)**
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$									1.51	(1.15)
$I\left(yrmkt_{t-1}^{ik} = 3\right) e_t^k$									0.58	(1.14)
$I\left(yrmkt_{t-1}^{ik} \geq 4\right) e_t^k$									0.68	(0.77)
Market f.e.	yes		yes		yes		yes		yes	
Plant-year f.e.	yes		yes		yes		yes		yes	
UK exit rate	0.23		0.23		0.24		0.25		0.26	
US exit rate	0.74		0.77		0.76		0.75		0.76	
# plants	514		514		474		426		385	
# plant-years	608		608		551		483		424	
pseudo-R^2	0.22		0.47		0.26		0.28		0.26	

Notes: Estimation method is conditional logit. Dependent variable is an indicator for entry. Sample consists of all plant-years where plant is at risk for exit in both UK and US markets, where there is positive lagged and current sales in the Irish market, and where 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: Exit: Conditional logit II

	(1)		(2)		(3)		(4)	
	coeff	s.e.	coeff	s.e.	coeff	s.e.	coeff	s.e.
e_t^k	1.26	(1.56)	-0.74	(1.99)	-0.15	(2.04)	0.04	(2.19)
$revenue_{t-1}^{ik*}$			-0.84	(0.09)**	-0.82	(0.10)**	-0.81	(0.10)**
$revenue_{t-1}^{ik*} e_t^k$			-0.08	(0.16)	-0.07	(0.16)	-0.12	(0.17)
$I\left(yrmkt_{t-1}^{ik} \geq 2\right)$			-0.64	(0.36)*				
$I\left(yrmkt_{t-1}^{ik} \geq 2\right) e_t^k$			0.57	(0.97)				
$I\left(yrmkt_{t-1}^{ik} = 2\right)$					0.11	(0.55)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right)$					-0.65	(0.39)*		
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$					0.35	(1.60)		
$I\left(yrmkt_{t-1}^{ik} \geq 3\right) e_t^k$					0.82	(1.00)		
$I\left(yrmkt_{t-1}^{ik} = 2\right)$							0.21	(0.60)
$I\left(yrmkt_{t-1}^{ik} = 3\right)$							-0.71	(0.66)
$I\left(yrmkt_{t-1}^{ik} \geq 4\right)$							-0.49	(0.40)
$I\left(yrmkt_{t-1}^{ik} = 2\right) e_t^k$							1.27	(1.62)
$I\left(yrmkt_{t-1}^{ik} = 3\right) e_t^k$							-0.31	(1.47)
$I\left(yrmkt_{t-1}^{ik} \geq 4\right) e_t^k$							1.39	(1.03)
$I\left(10 \leq emp_{t-1}^{i} \leq 19\right) e_t^k$	-0.66	(0.56)	-0.36	(0.72)	-0.51	(0.76)	-1.04	(0.78)
$I\left(20 \leq emp_{t-1}^{i} \leq 49\right) e_t^k$	-2.49	(0.62)**	-2.36	(0.81)**	-2.85	(0.88)**	-3.11	(0.92)**
$I\left(50 \leq emp_{t-1}^{i} \leq 99\right) e_t^k$	-1.60	(0.62)**	-1.80	(0.98)*	-1.94	(0.96)**	-2.16	(1.02)**
$I\left(emp_{t-1}^{i} \geq 100\right) e_t^k$	-1.80	(0.60)**	-1.15	(1.03)	-1.51	(1.06)	-1.64	(1.08)
$I\left(8 \leq age_t^{i} \leq 14\right) e_t^k$	-0.40	(0.59)	0.02	(0.79)	-0.13	(0.80)	-0.11	(0.83)
$I\left(15 \leq age_t^{i} \leq 23\right) e_t^k$	0.32	(0.57)	0.94	(0.79)	0.48	(0.81)	0.57	(0.83)
$I\left(age_t^{i} \geq 24\right) e_t^k$	-0.63	(0.62)	-0.20	(0.81)	-0.23	(0.83)	-0.10	(0.85)
$I\left(forown_{t-1}^{i} = 1\right) e_t^k$	0.24	(0.43)	0.06	(0.65)	0.47	(0.70)	0.57	(0.72)
$I\left(exother_{t-1}^{i} = 1\right) e_t^k$	0.60	(0.73)	0.43	(0.87)	0.07	(0.88)	0.05	(1.00)
Market f.e.	yes		yes		yes		yes	
Plant-year f.e.	yes		yes		yes		yes	
UK exit rate	0.23		0.24		0.25		0.26	
US exit rate	0.77		0.76		0.75		0.74	
# plants	514		474		426		385	
# plant-years	608		551		483		424	
pseudo-R^2	0.26		0.49		0.49		0.47	

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