How Exporters Grow*

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Abstract

We provide evidence of a role for investment in customer base in explaining how exporters grow. Using firm and customs data for Ireland, we show that conditional on costs, the initial years of long export spells are characterized by steep growth in revenues and quantities, while prices remain flat. At the same time, higher initial quantities predict longer export spells, but there is no relationship between initial prices and spell length. These facts cannot be explained purely by learning about demand. They point to a role for non-price actions of the firm, such as marketing and advertising, in driving the accumulation of customer base, which in turn drives the behavior of quantities. We estimate a model with both investment in customer base and learning about demand to match our empirical findings. Our estimates imply an important role for costs of adjustment in customer base in explaining the dynamics of quantities.

1 Introduction

We provide evidence of an important role for costly accumulation of customer base in explaing how exporters grow. This is important for two reasons. First, we draw attention to the

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potential role of customer base accumulation in explaining firm dynamics, and quantify the importance of this mechanism in the context of exporting. Second, we confirm that there is an important dynamic component to firms' decision-making that goes beyond capital accumulation, R&D and sticky prices, and which may magnify the dependence of firms' responses to macro shocks on their volatility and persistence.

We first use very rich data on firms and exports for Ireland to document a novel set of facts on the dynamic evolution of quantities and prices post-export-entry. Conditional on costs, we find that initial export quantities are positively correlated with export spell length, and quantities grow rapidly with market tenure in successful spells. However initial prices do not forecast spell length, and prices are flat with respect to market tenure. In sum, striking dynamics of quantities are accompanied by no dynamics of prices.

We argue that these facts are difficult to reconcile with popular explanations for post-entry-export dynamics based solely on learning about demand, as they require falling prices to explain rising quantities with tenure. They are not consistent with growing market-specific quality, as this would imply prices should rise with quantities. They are instead strongly suggestive of a role for customer base, which is accumulated not through past sales, as this would imply prices rising with export tenure, but through non-price actions of the firm such as advertising and marketing.

Second, we estimate a model with costly and irreversible investment in customer base through advertising and marketing, together with learning about demand, to match our quantity and price facts, and additional facts about the dynamics of exit conditional on costs. The model can match all the key facts, and parameter estimates imply a quantitatively important role for customer base, and in particular, for costs of adjusting customer base. Moreover, although we do not use data on advertising and marketing expenditures to discipline the model, we obtain reasonable estimates of the share of revenue devoted to such expenditures, and key parameter estimates are in line with the literature on advertising.

Our work is related to several literatures. We build on the work of Roberts and Tybout (1997), Das, Roberts and Tybout (2007), Eaton et al (2008), Ruhl and Willis (2014), Eaton et al (2014), Timoshenko (2014) on documenting facts about export entry and post-entry export dynamics. There is a recent and growing literature on the role of learning about demand in explaining these facts. See, e.g. Albornoz et al (2012), Berman et al (2015), Fernandes and Tang (2012), Timoshenko (2014) and (2015). Arkolakis et al (2014) have a model of firm dynamics with learning about demand which also has implications for post-entry export dynamics. We need to incorporate a learning dimension into our model to match the behavior of exit, but note that learning alone cannot explain the facts we document.

We provide evidence that what is often labelled "quality" in trade models (as in, e.g. Hottman, Redding and Weinstein (2014)) may have a customer base component. Our work is also related to Arkolakis (2010), who develops a static model of costs of acquiring customers in export markets. We estimate a model that shares many of the features of Eaton et al (2014), but is simpler to work with, and does not require transaction-level data to estimate.

Finally, our work is also related to a macro literature on customer base, both empirical (Foster, Haltiwanger and Syverson (2013)), and theoretical (Gourio and Rudanko (2014) and Drozd and Nosal (2012)). By showing there are no post-entry dynamics of prices, we point to non-price mechanisms for accumulating customer base, as in Drozd and Nosal, and in contrast to Foster, Haltiwanger and Syverson and Gourio and Rudanko, who posit that firms distort markups downwards initially in order to acquire customer base, implying that prices should increase with market tenure. Like Drozd and Nosal, we pursue an open economy macroeconomics application for our findings, and our findings complement theirs.

The paper is organized as follows. In the second section, we briefly describe our data and summary statistics. In the third section we describe our empirical strategy. In the fourth section we describe our findings about post-entry dynamics of quantities, prices, products and exit. In the fifth section we describe a model that incorporates both costly investment in customer base and learning about export demand, and has the potential to match the facts we document. In the sixth section we estimate the model and report our estimation results. The final section concludes.

2 Data description

We make use of three sources of confidential micro data made available to us by the Central Statistics Office in Ireland: the Irish Census of Industrial Production (CIP), Irish customs records, and the Irish Prodcom survey. Here, we note the key points about each data set. The data is described in detail in the appendix to Fitzgerald and Haller (2015).

2.1 Census of Industrial Production

The CIP, which covers manufacturing, mining and utilities, takes place annually. Firms with 3 or more persons engaged are required to file returns.[1] We make use of data for

[1] Multi-plant firms also fill in returns at the level of individual plants, but we work with the firm-level data since this is the level at which the match with customs records can be performed.

the years 1996-2009 and for NACE Revision 1.1 sectors 10-40 (manufacturing, mining and utilities). Of the variables collected in the CIP, those relevant for our purposes are the country of ownership, firm age, total revenue, share of revenue that is exported, investment, employment, wage bill, expenditures on intermediates and imported share of intermediates.

In constructing our sample for analysis, we drop firms with a zero value for total revenue or zero employees in more than half of their years in the sample. We perform some recoding of firm identifiers to maintain the panel dimension of the data, e.g. in cases where ownership changes.

2.2 Customs records

Our second source of data is customs records of Irish merchandise exports for the years 1996 to 2014. The value (Euros) and quantity (tonnes)[2] of exports is available at the level of the VAT number, the Combined Nomenclature (CN) 8-digit product, and the export market (country), aggregated to an annual frequency. These data are matched by the CSO to CIP firms using a correspondence between VAT numbers and CIP firm identifiers, along with other confidential information. The CSO informs us that their ability to match customs records to firm identifiers is best for the period 2000-2009. For this period, customs records that match to a firm identifier account for 76% of published merchandise exports. The appendix to Fitzgerald and Haller (2015) provides additional summary statistics on this match.

A key feature of customs in the EU is that data for intra-European and extra-European trade are collected separately, using two different systems called Intrastat and Extrastat. For Ireland, the reporting threshold for intra-European exports (635,000 Euro per year in total shipments within the EU) is much higher than the reporting threshold for extra-European exports (254 Euro per transaction).[3]

A final important feature of the customs data is that the 8-digit CN classification system changes every year. We concord the product-level data over time at the most disaggregated level possible following the approach of Pierce and Schott (2012) and van Beveren, Bernard and Vandenbussche (2012).[4] For our baseline analysis, we restrict attention to the period 1996-2009, for which we have firm and product level data in addition to customs data. In

[2]The value is always available, but the quantity is missing for about 10% of export records.

[3]Intra-European exports below the threshold are recovered based on VAT returns. The destination within the EU is not recorded for these returns.

[4]Van Beveren, Bernard and Vandenbussche (2012) show that once the data is appropriately concorded, there is less product churn than naive calculations based on raw data would suggest.

some robustness checks we examine the full sample period, 1996-2014. We perform the concordance separately for the two different sample periods, as dictated by the Pierce and Schott approach.

As a result, we have annual data on revenue, quantity and price (unit value) at the firm-product-market level, where the product is defined at the 8-digit (concorded) level.

2.3 Prodcom survey

Our third source of data is the Prodcom survey for the years 1996 to 2009. This is an annual survey of the value (and volume) of all products manufactured by the firm and sold in the relevant year. The survey basis is all firms in the CIP, excluding some mining sectors (the survey covers on average 94% of total CIP turnover). Products are classified at the 8-digit level according to the Prodcom classification. We concord the product-level data over time at the most disaggregated level possible following the approach of Pierce and Schott (2012) and van Beveren, Bernard and Vandenbussche (2012). The firm identifier in this data set is the same as that in the CIP, allowing us to merge the two data sets.

As a result, we have annual data on revenue, quantity and price (unit value) at the firm-product level, where the product is defined at the 8-digit (concorded) level.

2.4 Summary statistics

Table 1 shows summary statistics on the firms in our data, focusing in particular on exporting behavior. In this paper, we exploit the fact that export participation is high, and many firms participate in multiple export markets. These facts are typical of small open European economies. Apart from the relatively high rate of export participation and the high intensity of exporting conditional on participation, the broad facts about exporting are similar to those documented for large developed countries such as the US and France, and for developing countries like Colombia. As documented by Lawless (2009) for a subset of the firms in our data, there is a good deal of steady state churn in the set of firms participating in individual markets, and at the level of firms, in the number (and identity) of markets they participate in. This is illustrated in Table 2 which reports the average percentage of exporters by change in the number of markets from year-to-year. This churn induces cross-sectional variation within firm-years in both market tenure, and completed export spell length which we exploit this in our empirical strategy.

3 Empirical strategy

We now describe our empirical strategy. Our goal here is to characterize stylized facts rather than provide causal analysis.

3.1 Firm-product-market analysis

At the firm-product-market level, we observe revenue, quantity (tonnes) and price (unit value). As illustrated by Table 2, entry and exit is not synchronized across markets within exporting firms. As a result, at a given point in time, there is a good deal of within-firm-product cross-market heterogeneity in market tenure. There is also a good deal of within-firm-product heterogeneity in the eventual length of export spells that start at the same time. We exploit this heterogeneity to characterize the evolution of revenue, quantity and price with market tenure, conditional on eventual spell length, conditional on firm-product-year effects (a proxy for marginal cost), and conditional on market or market-year effects.

Conditioning on firm-product-year effects allows us to identify effects that come from the demand rather than cost side. Conditioning on eventual spell length is key to understanding dynamics of quantity and price, as this is what allows us to separate out within-spell dynamic evolutions from the effect of selection. Conditioning on market or market-year effects allows us to deal with varying attractiveness of different markets at the macro level.

Mechanically, we implement this as follows. We set market tenure at 1 in the first year firm i exports product j to market k after not exporting in the previous period. We do not observe market tenure if exports are positive in the first year of our sample. Tenure is incremented by 1 for each subsequent year of continuous participation. If the firm-product exits the market for some period (i.e. we observe zero exports for one or more years), market tenure is reset to 1 in the first subsequent year of participation. An export spell is defined as a period of continuous export participation. If we observe zero exports for one or more years after some positive exports, any re-entry is counted as part of a distinct export spell.

Let w_t^{ijk} be log revenue, log quantity or log price. Let a_t^{ijk} be a vector of indicator variables for firm i's tenure in market k with product j. Let s_t^{ijk} be a vector of indicators for the total length of the relevant spell. This indicator does not vary within a spell, but is indexed by t to capture the fact that we may observe multiple export spells of different length for firm i, product j and market t over the period of our panel. We topcode both market tenure and spell length at 7 years in our baseline specification. We cannot make use of spells whose length is right-censored at a level below the topcode.[5] We also include an indicator ($cens^{ijk}$) for spells which are both left- and right-censored (i.e. spells with positive exports in all years in the panel). We then estimate:

$$w_t^{ijk} = \delta^k + c_t^{ij} + \beta' \left(a_t^{ijk} \otimes s_t^{ijk} \right) + cens^{ijk} + \varepsilon_t^{ijk} \quad (1)$$

Here, δ^k is a set of market fixed effects (our baseline results are robust to generalizing this to market-year fixed effects, and eventually we plan to make the specification with market-year effects our baseline). c_t^{ij} is a set of firm-product-year fixed effects. $\otimes$ indicates the kronecker product - of course we do not observe tenures of greater than s for a spell that lasts exactly s years, so the redundant interactions are dropped.

The vector of coefficients β is identified by cross-market variation within a firm-product-year in both market tenure and completed spell length. These are the coefficients of interest. Exponentiated, the estimates of β allow us to characterize both variation in initial revenue, quantity and price with completed spell length, and the evolution of revenue, quantity and price with market tenure over the lifetime of spells of different length.

To characterize the distribution of spell length at the firm-product-market level conditional on firm-product-year and market effects, we adopt a similar strategy. Let X_t^{ijk} be an indicator for participation of firm i with product j in market k at date t. We then estimate:

$$\Pr \left[X_{t+1}^{ijk} = 0 | X_t^{ijk} = 1 \right] = \delta^k + c_t^{ij} + \beta' a_t^{ijk} + \varepsilon_t^{ijk} \quad (2)$$

δ^k, c_t^{ij} and a_t^{ijk} are as above, and as above, β is the vector of coefficients of interest.

3.2 Firm-market analysis

At the firm-market level, we observe both revenue and the number of products a firm sells to a destination. We use the hetoregeneity in market tenure and spell length described above to characterize how these variables evolve with market tenure, conditional on eventual spell length, firm-year effects and market or market-year effects.

The construction of market tenure and spell length at the firm-market level is analagous to the approach at the firm-product-market level. Let w_t^{ik} be log revenue or log number of

[5] Since we have a panel of 14 years duration, the longest uncensored spell age is 13 years. However allowing the full range of market tenures and spell ages would not allow us to separately identify the impact of market tenure and spell age, would reduce the sample size, and would also confound cohort effects with the impact of these variables. The choice to topcode at 7 years is a compromise. In our full panel of data which lasts for 19 years, we show that all results are robust to increasing the topcode to 10 years.

products. Let a_t^{ik} be a vector of indicator variables for firm i's tenure in market . Let s_t^{ik} be a vector of indicators for the total length of the relevant spell. Let $cens^{ik}$ be an indicator for spells which are both left- and right-censored. We then estimate:

$$w_t^{ik} = \delta^k + c_t^i + \beta' \left(a_t^{ik} \otimes s_t^{ik} \right) + cens^{ik} + \varepsilon_t^{ik} \tag{3}$$

As above, δ^k is a set of market effects, while c_t^i is a set of firm-year fixed effects.

Exponentiated, the estimates of β allow us to characterize both variation in inital revenue and number of products with completed spell length, and the evolution of revenue and number of products with market tenure over the lifetime of spells of different length.

To characterize the distribution of spell length at the firm-market level we adopt a similar strategy. Let X_t^{ik} be an indicator for participation of firm i in market k at date t. We then estimate:

$$\Pr \left[X_{t+1}^{ik} = 0 | X_t^{ik} = 1 \right] = \delta^k + c_t^i + \beta' a_t^{ik} + \varepsilon_t^{ik} \tag{4}$$

3.3 Firm-product analysis

At the firm-product level we observe revenue, quantity (tonnes) and price (unit value). We construct market tenure and spell length at the firm-product level, and estimate the following two equations:

$$w_t^{ij} = c^{ij} + \alpha_t + \beta' \left(a_t^{ij} \otimes s_t^{ij} \right) + \varepsilon_t^{ij} \tag{5}$$

and

$$\Pr \left[X_{t+1}^{ij} = 0 | X_t^{ij} = 1 \right] = \alpha_t + \beta' a_t^{ij} + \varepsilon_t^{ij} \tag{6}$$

Because on average there is much less within-firm churn in number of products than number of markets we do not use firm-year fixed effects.

3.4 Firm analysis

At the firm level we observe revenue, number of products, number of markets (as well as other variables of interest such as employment and TFP). We construct market tenure and spell length at the firm level and estimate the following two equations:

$$w_t^i = c^i + \alpha_t + \beta' \left(a_t^i \otimes s^i \right) + \varepsilon_t^i \tag{7}$$

and

$$\Pr\left[X_{t+1}^i = 0 | X_t^i = 1\right] = \alpha_t + \beta' a_t^i + \varepsilon_t^i \tag{8}$$

4 Empirical findings

In this section, we first report our findings, and briefly discuss their interpretation.

4.1 Firm-product-market analysis

Table 3 reports results for the baseline estimation of equation (1), with log revenue, log quantity and log price as the dependent variable. Note that the omitted category in all regressions is export spells which last exactly one year. The log of the dependent variable for each of these spells is hence normalized to 0. We organize our results into initial values conditional on spell length, and spell trajectories, normalizing the start of each spell to 0. These results are illustrated in Figures 1, 2 and 3, which graph the trajectories of revenues, quantities and prices implied by taking the exponential of the relevant sums of coefficients from Table (3).[6]

We find the following: (1) Higher initial quantities predict longer spell durations. For spells lasting between 1 and 4 years, all pairwise comparisons of initial quantities are statistically different. (2) Prices do not forecast spell durations, at least up to a horizon of 13 years. (3) Quantities grow with market tenure during "successful" export spells (defined as spells that last at least 7 years). This growth is statistically significant up to a horizon of four years, and is not driven by part-year effects (there is statistically and economically significant growth between years 2 and 4). (4) In the first 6 years of "successful" export spells, prices are invariant to market tenure, though prices are lower on average for the longest spells (7+ years), a fact that may be driven by either selection or dynamics.

Our results are qualitatively and quantitatively unchanged when we include market-year effects. We also check what happens when we make use of a subsample of products and firms for which a second measure of quantity (other than tonnes) is reported, constructing quantities and unit values using this alternative measure. For this subsample, which accounts for about 1/6 of the original sample, we find that lower initial prices weakly predict that export spells will last longer than 1 year. However all other results are unchanged. We

[6]We graph the standard errors for all revenue and quantity trajectories, but for price trajectories we graph only the standard errors on the longest spell to make the figure easier to read. None of the points on the price trajectories are significantly different from 1.

also vary the level at which spell lengths and market tenure are topcoded, in the range 5 to 8 in our 14-year sample, and in the range 7 to 10 in our 19-year sample. The results are unchanged. These results are reported in an online Appendix to the paper.

We also estimate equation (1) on a variety of sub-samples of the data. First, we split the sample between domestic and foreign-owned firms. As we report in Table 4, we find greater dispersion in initial quantities and faster growth in quantities in successful spells for foreign compared to domestic-owned firms. We find no difference in initial prices or in the evolution of prices (full results are reported in an online Appendix to the paper).

Next, we split the sample into industry groups, aggregating 4-digit NACE industries into consumer food, consumer non-food non-durables, intermediates and capital goods (we exclude consumer durables and energy, as there are very few firms in these categories). Our findings as regards quantities are very similar across these industry groups: higher initial quantities predict longer export spells, and quantities grow rapidly with market tenure in the initial years of successful export spells. As regards prices, for capital goods, there is some evidence that in successful export spells, prices fall between the first and second years of the spell. But there is no evidence for price dynamics beyond this point. For consumer food, there is some evidence that prices are lower in the later years of successful spells than in the earlier years. These findings are reported in Tables 5 and 6 (full results are reported in an online Appendix to the paper).

Table 7 reports results for the baseline estimation of equation (2). The probability of exit declines swiftly with market tenure, flattening out after 4 years in a market. Figure 4 illustrates these findings.

Table 7 also reports results splitting the sample into domestic and foreign-owned firms. The decline in the probability in exit is very similar for the two groups of firms. Table 8 reports results splitting the sample into the same industry groups as Tables 5 and 6. The evolution of exit probability with market tenure is very similar across all industry groups.

We undertake a number of other robustness checks of our results, which are reported in an online Appendix to the paper.

4.2 Firm-market analysis

Table 9 reports the results from the baseline estimation of equation (3) with log revenue and log number of products as the dependent variable in turn. The results are reported in the same format as in Table 3. These results are illustrated in Figures5 and 6. The evolution of revenue at the firm-market level is qualitatively very similar to the evolution of revenue at the firm-product-market level, though the trajectories are somewhat steeper, reflecting the fact that the number of products per market also evolves with market tenure. However, focusing on the longest spells, 76% of the growth of revenue at the market level between year 1 and year 5 is accounted for by within-product growth in quantities, indicating that the within-product margin is of first order importance in explaining export growth.

Table 10 reports the results from the baseline estimation of the firm-market exit equation (4). The evolution of exit at the market level is very similar to the evolution of exit at the product-market level, with the exception that the baseline rate of exit at the product-market level is substantially higher. Figure 4 illustrates the evolution of the probability of exit with market tenure at the firm-market level, with the corresponding evolution at the firm-product-market level for comparison.

4.3 Firm-product analysis

Table 11 reports the results from the baseline estimation of equation (5), with log revenue, log quantity and log price as the dependent variable in turn. Because we include firm-product fixed effects, all trajectories are normalized to start at 0. Figures 7 and 8 illustrate the results for quantity and price. We find that at the firm-product level, quantity dynamics are much less striking than at the firm-product-market level (they are also much noisier, as we have fewer observations). Interestingly, many of the short trajectories turn negative prior to exit, something we do not observe at the firm-product-market level, and which may be suggestive of the existence of sunk costs at the firm-product but not firm-product-market level. As regards price, we are not controlling for firm-specific time variation in marginal cost (since we have only firm-product and time effects in the regression). Unconditionally, the behavior of prices at the firm-product level is consistent with behavior at the firm-product-market level: with the exception of the second year of two-year spells, there are no statistically significant dynamics in prices.

Table 12 reports the results from the baseline estimation of the firm-product exit equation (6). Figure 9 illustrates the results. The reduction in exit probability with market tenure is less striking at the firm-product level than it is at the firm-product-market level.

4.4 Firm analysis

Table 13 reports the results from estimating equation (7) with log revenue, log number of markets and log number of products as the dependent variable. We restrict attention to firms entering in-sample, for which we have better-quality measures of firm age. Figure 10 shows the evolution of total revenue with firm age, conditional on age on exit, at the firm level. The dynamics in this figure are driven by the evolution of costs as well as overall demand faced by the firm. We make two observations about this picture. First, the relationship between age and exit and initial growth rates is much more murky than at the level of the individual export market. Second, conditional on success, the growth rate of revenue at the firm level is much less steep than the growth rate of revenue at the firm-market level. However it is worth noting that the dynamics of revenue for successful foreign-owned firms are almost identical to the the dynamics of revenue in successful firm-market export spells (results reported in the online Appendix).

As regards markets and products, the number of markets increases only modestly with tenure in successful firms, while the number of products does not increase at all. As a result, 70% of revenue growth between year 1 and year 6 in successful firms can be attributed to within-market growth of revenue.

Finally, Table 14 reports the results from estimating the exit equation (8). Figure 9 illustrates the results. The decline in the probability of exit with firm age is again much less striking than the decline of exit probability with market tenure at the firm-market level, and does not exhibit a tendency to flatten out within our time horizon.

5 A model of post-entry export dynamics

5.1 Mechanisms for generating post-entry export dynamics

In a world with monopolistic competition, a limited set of mechanisms can generate post-entry export dynamics conditional on firm-year effects.[7] We illustrate them as follows. Suppose that firm i faces demand in market k at time t given by:

$$\frac{Q_t^{ik}}{Q_t^k} = d\left(P_t^{ik}, Z_t^k, D_t^{ik}, \exp\left(\eta_t^{ik}\right)\right) \tag{9}$$

Q_t^{ik} is the quantity firm i sells in market k. P_t^{ik} is the price firm i charges to buyers from k at the factory gate. Z_t^k is a vector that includes competitors' prices in market k (which we assume are unaffected by the actions of firm i) and frictions such as trade costs. D_t^{ik} is a variable which depends on actions taken by the firm (at t or in previous periods), and

[7] Since we find that within-product mechanisms are responsible for the bulk of the dynamic evolution of revenue, we focus on within-product mechanisms and leave aside the extensive margin of products.

which shifts demand conditional on price. η_t^{ik} is an idiosyncratic demand shock. Q_t^k is aggregate demand in market k. Post-entry dynamics in export revenue ($P_t^{ik} Q_t^{ik}$) conditional on firm-year and market-year effects can arise due to dynamics in P_t^{ik} , D_t^{ik} or η_t^{ik}.

Post-entry export dynamics can be generated purely through the process for η_t^{ik}, and indeed this force is at work in all models where there is an idiosyncratic component to demand. However for market shares to be bounded between 0 and 1, there cannot be a random walk component to η_t^{ik}, and this places restrictions on the dynamics that it can generate.

Following the work of Jovanovic (1982), there is a large and growing trade literature that models post-entry export dynamics as arising from *learning* about the process from which η_t^{ik} is drawn.[8] Learning is an appealing mechanism, because it has the potential to rationalize the large number of export spells that involve very small quantities, and that last only one period. Learning about the process for η_t^{ik} can also induce post-entry dynamics in prices (and hence in quantities and revenues). In the Appendix we show that pure learning about demand can generate dynamics in quantities *only* if there are corresponding dynamics in prices, and hence is incapable of generating the pattern of quantities and prices we document in the data. Moreover, pure learning about demand would imply that higher initial prices should forecast longer spells. In the data, to the extent that prices and spell length are correlated, lower initial prices forecast longer spells (prices are significantly lower for spells which are both left- and right-censored).

There are several papers which model firm (and export) dynamics as arising from actions the firm takes which shift its demand conditional on its price, through the variable we label D_t^{ik}.[9] We refer to these as *investment* models. If past prices or quantities affect D_t^{ik} (as in Foster, Haltiwanger and Syverson (2013)), then price dynamics accompany quantity dynamics. In particular, in Foster, Haltiwanger and Syverson (2013), young firms charge lower markups in order to attract customers, and markups (and prices, since TFP is flat) rise with firm age. If D_t^{ik} affects the price elasticity of demand, then price dynamics will again accompany quantity dynamics. However in the case of CES demand where D_t^{ik} depends on non-price actions of the firm (such as expenditures on marketing and advertising), there may

[8]See, e.g. Albornoz et al (2012), Berman et al (2015), Fernandes and Tang (2012), Timoshenko (2014) and (2015). Arkolakis et al (2014) have a model of firm dynamics with learning about demand which also has implications for post-entry export dynamics.

[9]These include Ruhl and Willis (2014), who assume that demand depends on the history of participation, Foster et al (2013), who focus on firm dynamics and assume that demand depends on the history of sales, and Eaton et al (2014), who present and estimate a model of post-entry dynamics with both learning and investment. Rauch and Watson (2003) have an earlier model with both investment and learning.

be post-entry dynamics of quantities without any dynamics in prices. Qualitatively, a model with this feature has the potential to generate the pattern we document in the data. However it requires some force that slows down accumulation of D_t^{ik}, be it costs of adjustment (as in Arkolakis (2010) and Eaton et al. (2014)) or learning about demand (as in Eaton et al (2014)).

We now describe a simple partial equilibrium model that incorporates both costly investment in customer base, and one-period learning about export demand. A priori, this model has the potential to match the facts we document about quantities, prices and exit post-export-entry. Our model has many of the essential features of Eaton et al (2014), but does not require data at the shipment level to estimate. It is also relatively tractable, as we illustrate when we apply it to analyzing exporter responses to real exchange rates.

5.2 A model with costly investment in customer base and learning about demand

Firm i has marginal cost, C_t^i, in terms of some numeraire.[10] It faces a random fixed cost of participating in market k given by F_t^{ik}. With probability $1-\omega$ (independent across firms, markets and over time), the fixed cost is equal to $F<\infty$. With probability ω, the fixed cost is equal to infinity. It also faces a random sunk cost S_t^{ik} of participating in market k. With probability λ (independent across firms, markets and over time) the sunk cost is equal to $S<\infty$. With probability $1-\lambda$, the sunk cost is infinity. These random costs stand in for entry and exit that is triggered by macro factors that we do not model, as well as entry and exit that is idiosyncratic to the firm and the market.

Demand for firm i in market k takes the following form:

$$Q_t^{ik} = \left(P_t^{ik}\right)^{-\theta} \left(D_t^{ik}\right)^{\alpha} \exp\left(\varepsilon_t^{ik}\right) \tag{10}$$

where $\varepsilon_t^{ik} = \nu^{ik} + \eta_t^{ik}$, $\nu^{ik} \sim N\left(0, \sigma_\nu^2\right)$ and $\eta_t^{ik} = \rho\eta_{t-1}^{ik} + \zeta_t^{ik}$, with $\zeta_t^{ik} \sim N\left(0, \sigma_\zeta^2\right)$. Customer base D_t^{ik} accumulates as follows:

$$D_t^{ik} = (1-\delta) X_{t-1}^{ik} D_{t-1}^{ik} + A_t^{ik} \tag{11}$$

where A_t^{ik} is investment, which is subject to both quadratic costs of adjustment and irre-

[10]Since we are matching moments estimated conditional on firm-year effects, in estimating the model, we assume that all firms face the same constant marginal cost. Eventually we plan to introduce cost shocks.

versibility:

$$c\left(D_t^{ik}, A_t^{ik}\right) = \begin{cases} A_t^{ik} + \phi\left(\frac{A_t^{ik}}{D_t^{ik}} - \delta\right)^2 D_t^{ik} & \text{if } A_t^{ik} > 0 \\ \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

We assume irreversibility, as it seems reasonable to think that expenditures on advertising and marketing are sunk.

The structure of information is as follows. At date t, conditional on having sold in the market in the previous period (i.e. $X_{t-1}^{ik} = 1$), the firm observes C_t^i, S_t^{ik} (not that this matters), ν^{ik} and η_{t-1}^{ik} before deciding (a) whether to continue to export to market k, (b) how much to invest and (c) what price to set conditional on participation (we assume price setting rather than quantity setting). The firm knows the distribution for η_t^{ik} conditional on η_{t-1}^{ik}. At date t, potential entrants ($X_{t-1}^{ik} = 0$) observe C_t^i, F_t^{ik} and S_t^{ik}. All potential entrants, irrespective of export status at periods before $t-1$, draw their idiosyncratic demand ε_t^{ik} from the unconditional distribution of $\nu^{ik} + \eta_t^{ik}$ (i.e. on exiting the market, the firm loses its current draw of ν^{ik} and η_{t-1}^{ik}), and they know this distribution. The firm's information set I_t^{ik} is therefore a state variable of its problem:

$$I_t^{ik} = \begin{cases} \left\{\nu^{ik}, \eta_{t-1}^{ik}\right\} & \text{if } X_{t-1}^{ik} = 1 \\ \\ \varnothing & \text{if } X_{t-1}^{ik} = 0 \end{cases} \tag{13}$$

Because of the Poisson assumption on F_t^{ik} and S_t^{ik}, current realizations provide no information about the future.

Under price setting, the firm always sets prices equal to the statically optimal markup over marginal cost ($\frac{\theta}{\theta-1}$). Assuming that it discounts the future at rate β, we can then write its intertemporal optimization problem as follows:

$$V\left(D_{t-1}^{ik}, X_{t-1}^{ik}, I_t^{ik}, \nu^{ik}, \eta_{t-1}^{ik}, F_t^{ik}, S_t^{ik}, C_t^i\right) =$$

$$\max_{\substack{X_t^{ik} \in \{0,1\} \\ A_t^{ik}}} \left\{ \begin{array}{c} X_t^{ik} \frac{(\theta-1)^{\theta-1}}{\theta^\theta} \left(C_t^i\right)^{1-\theta} \left(D_t^{ik}\right)^\alpha \mathbb{E}\left(\exp\left(\nu^{ik} + \eta_t^{ik}\right) | I_t^{ik}\right) \\ \\ -X_t^{ik}\left(F_t^{ik} + \left(1 - X_{t-1}^{ik}\right) S_t^{ik}\right) - c\left(D_t^{ik}, A_t^{ik}\right) \\ \\ +\beta\mathbb{E}\left(V\left(D_t^{ik}, X_t^{ik}, I_{t+1}^{ik}, \nu^{ik}, \eta_t^{ik}, F_{t+1}^{ik}, S_{t+1}^{ik}, C_{t+1}^i\right) | I_t^{ik}\right) \end{array} \right\} \tag{14}$$

subject to (a) the accumulation equation for D, (b) the cost of investment and (c) the updating of information.

Although this model is reduced form, it can be interpreted as follows. The price elasticity of demand for individual customers is given by $-\theta$. The firm must "meet" customers in order for them to buy. There is a distribution of customers by expenditure on the type of goods supplied by the firm, and as the firm goes deeper and deeper into the distribution of customers, this expenditure decreases. Hence there are diminishing returns to having a larger and larger customer base, and $\alpha < 1$. Meanwhile, there are increasing costs of meeting marginal customers, and hence $\phi > 0$.

6 Model estimation and results

6.1 Estimation

Given a set of parameters β, α, δ, ϕ, θ, σ_ν^2, ρ, σ_ζ^2, F, ω, λ, and a process for C_t^i, we can discretize both exogenous and endogenous states, and use value function iteration to solve for the optimal policies $X_t^{ik} = X\left(D_{t-1}^{ik}, X_{t-1}^{ik}, I_{t-1}^{ik}, \nu^{ik}, \eta_{t-1}^{ik}, F_t^{ik}, S_t^{ik}, C_t^i\right)$ and $A_t^{ik} = A\left(\left(D_{t-1}^{ik}, X_{t-1}^{ik}, I_{t-1}^{ik}, \nu^{ik}, \eta_{t-1}^{ik}, F_t^{ik}, S_t^{ik}, C_t^i\right)\right)$. Using the model parameters and the corresponding optimal policies, we can then construct the population equivalents of the moments we estimate in Section 4.

The goal of our estimation is to choose the vector of parameters that best matches the following subset of the moments estimated in the previous section: the ratios of initial quantities across spells of different length; the evolution of quantities with market tenure within spells of different length; the average exit rate in the first year in a market (we pick the US market); and the evolution of exit probabilities with market tenure, all of these conditional on costs. We do not target moments based on quantities in the first and last year of a spell relative to other years of the spell, as part-year effects may be at work, and this is not captured by our model. The full set of moments is reported in Table 15. We also match exactly the average rate of entry into exporting in our data (6%).

To estimate the model parameters, we proceed as follows. We first preset some parameters. Since our data is annual, we set $\beta = 1.05^{-1}$. For the moment, we try to match only moments which are estimated conditional on costs in the data, so we normalize $C_t^i = 1$.[11]

[11] Eventually the distribution of costs in the population of firms can be paramaterized, and moments such as export participation and the distribution of number of export markets per firm added to the set of moments to match.

θ is not well identified by the set of moments we currently use (or rather, ϕ and θ are not separately identified) so we pick $\theta = 2$. This is consistent with a markup over *marginal* cost (which does not include fixed costs of production or costs related to marketing and advertising) of 100%. Eventually we may add additional moments in order to better pin down θ. Given the structure of our model, the export entry rate is equal to $\lambda(1-\omega)$, while the exit rate converges to ω as market tenure gets very large. Based on an annual rate of entry into exporting of 6%[12], we set $\lambda = 0.06/(1-\omega)$ to exactly hit this target. For the moment, we also set $S = 0$. Eventually we will estimate a value for S also.

This leaves us with eight parameters, $\{\alpha, \delta, \phi, \sigma_\nu^2, \rho, \sigma_\varepsilon^2, F, \omega\}$. We choose these parameters to minimize the criterion function $m'Vm$, where m is the difference between the data moments and the equivalent population moments in the model, and V is a diagonal matrix, where the term in entry ii is the inverse of the standard deviation of the estimate of data moment i (we do not include the entry rate in this matrix, as we hit this target by construction). Eventually we plan to use the optimal weighting matrix. We first do a global grid search of the parameter space, and then use a derivative-free algorithm to optimize starting from local minima of the global grid search.[13]

6.2 Results

Table 15 reports the data moments in the first column and the corresponding moments from the baseline model in the second column. Figures 11 and 12 illustrate the fit of the model in terms of quantities and exit.[14] The estimated model can generate dispersion in initial quantities that is positively correlated with spell length, quantities that increase with market tenure in successful spells, and an exit hazard that declines substantially between the first and second year in a market. However it has some difficulty generating a slow decline in this exit hazard. We hypothesize that this may be due to the fact that in our model, learning lasts only one period. We plan eventually to estimate a version of the model with multi-period learning.

Table 16 reports our estimated parameters (we do not yet have standard errors). The key finding is that we estimate a value of α, the elasticity of sales with respect to customer base, that at 0.55, is greater than zero. This indicates that there is a significant role for

[12] This is at the level of exporting as a whole, not at the level of individual markets.

[13] We use a combination of a genetic algorithm and the simplex method.

[14] Note that for ease of comparison with Figure 2 we normalize the fitted trajectories by the data ratio of the quantity in year 2 of the relevant spell to year 1 of a 1-year spell. This is not a moment we target in the model. The exit figure also fails to capture the fact that we do not hit our target for the exit rate.

customer base in explaining post-entry export dynamics.

This customer base is accumulable, though it depreciates at a relatively rapid rate. Our estimate of δ, 0.63, is in line with the findings reported in Bagwell (2007) of an empirical literature on the annual depreciation rates of brand advertising.

Our estimated value of ϕ is large, consistent with substantial adjustment costs a la Arkolakis (2010). In order to provide some intuition for the magnitude of ϕ, we calculate average expenditure on marketing and advertising $\left(A_t^{ik} + c\left(D_t^{ik}, A_t^{ik}\right)\right)$ as a share of expected revenue. Table 17 shows how the average share evolves with market tenure for "successful" export spells, i.e. those lasting at least 7 years. Firms spend a higher fraction of revenues on marketing and advertising in the initial years in a market, but conditional on success, this fraction declines. Our estimates suggest that a non-trivial fraction of revenue is devoted to investment in customer base, but at least for ultimately successful spells, this fraction is below the 10% average for manufacturing reported by the Duke University CMO (Chief Marketing Officer) Survey (2015).

Meanwhile, we find that there is a non-trivial variance of both permanent and mean-reverting idiosyncratic demand shocks. Idiosyncratic demand shocks are persistent, but not strikingly so.

We find that there are fixed costs of export participation, but they are not strikingly large, amounting to only 4% of expected revenue in the initial year in a market. This contrasts sharply with the share of expected revenue devoted to expenditures on advertising and marketing, which act to some extent like a fixed cost.

Finally, we estimate a modest probability of the firm-market experiencing a "death shock," since $\omega = 0.03$. Most of the exit out to 7 years in the market is endogenous.

6.3 Inspecting the mechanism

In order to illustrate the role of customer base accumulation in matching the facts we document, we re-estimate the model imposing $\alpha = 0$. The final column of Table 15 reports the fit and 16 reports the estimated parameter. The constrained model can generate an increasing relationship between initial quantities and spell length, and a reduction in exit hazard with market tenure. But it generates flat quantity profiles with tenure. Accumulation of customer base is key to matching the striking growth of quantity with tenure in successful spells.

Eventually, we plan to re-estimate the model imposing in turn $\phi = 0$, and $\phi = 0$ with full reversibility of investment in customer base, in order to further understand what are the key elements of the model in matching the different moments of the data.

7 Conclusion

We use the joint dynamics of prices, quantities and exit post-export entry to provide evidence of a role for investment in customer base in explaining how exporters grow. We show that conditional on costs and completed spell length, the initial years of a successful export spell are characterized by steep growth in revenues and quantities, while there are no dynamics in prices. At the same time, higher quantities on entry predict longer export spells, but there is no relationship between initial prices and spell length.

The fact that quantities grow while prices do not change points strongly to a non-price mechanism through which firms expand their demand. This suggests a role for activities such as advertising and marketing in the accumulation of customer base, rather than a dependence of customer base on lagged sales. We estimate a model with these features in addition to learning about the components of idiosyncratic demand. Our model can match the facts we document, and implies reasonable estimates of the share of revenue devoted to expenditures on advertising and marketing. We show that the accumulation of customer base is key to explaining the growth of quantities in successful export spells.

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Table 1: Summary statistics: Firms and exports - averages 1996-2009

Mean number of firms per year	4748
Mean employees	50
Mean age (years)	17
Share of firms foreign owned	0.12
Share of multi-plant firms	0.03
Mean number of concorded products per firm	4
Share of firms exporting	0.44
Probability of entry into exporting	0.06
Probability of exit from exporting	0.12
Exporter size premium (employees, mean)	1.65
Exporter size premium (revenue, mean)	1.85
Mean export share conditional on exporting	0.32
Mean number of markets per exporter	6.6

Notes: Statistics are for our cleaned dataset of CIP firms. Firms are defined as exporters if they are matched to positive concorded product exports from customs data. Export revenue is concorded product export revenue from Customs data. Export intensity is calculated as total concorded product exports from customs divided by sales reported in the CIP. Values greater than 1 are replaced by 1. Source: CSO and authors' calculations.

Table 2: Summary statistics: % of exporters by change in # of markets year-to-year

Change	<-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	>6
%	2	1	2	3	5	11	51	12	5	3	2	1	3

Notes: Statistics are for our cleaned dataset of CIP firms. Firms are defined as exporters if they are matched to positive concorded product exports from customs data. Export revenue is concorded product export revenue from Customs data. There are 140 export markets. Source: CSO and authors' calculations.

Table 3: Dynamics of firm-product-market revenue, quantity and price, by export spell length and market tenure

	Revenue		Quantity		Price	
Spell duration	Spell intercept					
2 years	0.51	(0.02)**	0.52	(0.02)**	-0.01	(0.01)
3 years	0.76	(0.03)**	0.76	(0.04)**	0.00	(0.02)
4 years	0.95	(0.05)**	0.95	(0.05)**	0.00	(0.02)
5 years	1.07	(0.06)**	1.08	(0.07)**	-0.01	(0.03)
6 years	1.13	(0.08)**	1.09	(0.08)**	0.04	(0.03)
7-13 years	1.39	(0.05)**	1.39	(0.05)**	0.01	(0.02)
14+ years	3.66	(0.03)**	3.70	(0.03)**	-0.04	(0.01)**
Market tenure	2-year spell					
2 years	-0.03	(0.03)	-0.03	(0.03)	0.00	(0.02)
Market tenure	3-year spell					
2 years	0.44	(0.04)**	0.45	(0.05)**	-0.01	(0.02)
3 years	-0.05	(0.05)	-0.05	(0.05)	0.00	(0.02)
Market tenure	4-year spell					
2 years	0.53	(0.06)**	0.55	(0.06)**	-0.02	(0.03)
3 years	0.55	(0.06)**	0.60	(0.06)**	-0.05	(0.03)*
4 years	-0.02	(0.07)	-0.01	(0.07)	-0.01	(0.03)
Market tenure	5-year spell					
2 years	0.63	(0.09)**	0.62	(0.09)**	0.01	(0.04)
3 years	0.70	(0.09)**	0.69	(0.09)**	0.01	(0.04)
4 years	0.57	(0.09)**	0.61	(0.09)**	-0.04	(0.04)
5 years	-0.01	(0.09)	0.01	(0.09)	-0.02	(0.04)
Market tenure	6-year spell					
2 years	0.74	(0.11)**	0.78	(0.11)**	-0.04	(0.05)
3 years	0.87	(0.11)**	0.95	(0.11)**	-0.07	(0.05)
4 years	0.85	(0.11)**	0.92	(0.11)**	-0.07	(0.05)
5 years	0.71	(0.11)**	0.75	(0.11)**	-0.04	(0.05)
6 years	0.12	(0.11)	0.14	(0.11)	-0.02	(0.05)
Market tenure	7+ year spell					
2 years	0.85	(0.06)**	0.88	(0.06)**	-0.03	(0.03)
3 years	1.16	(0.06)**	1.20	(0.06)**	-0.03	(0.03)
4 years	1.31	(0.06)**	1.34	(0.06)**	-0.03	(0.03)
5 years	1.34	(0.06)**	1.37	(0.06)**	-0.04	(0.03)
6 years	1.30	(0.06)**	1.33	(0.07)**	-0.03	(0.03)
7-13 years	1.28	(0.06)**	1.35	(0.06)**	-0.07	(0.03)**
N	312952		312952		312952	
rsq	0.76		0.82		0.90	
rsq-adj	0.58		0.69		0.82	

Notes: Dependent variable is in turn log revenue, log quantity and log unit value at the firm-product-market-year level. Full set of firm-product-year and market effects included in all regressions. Omitted category is spells that last one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 4: Dynamics of firm-product-market quantities and prices: Domestic vs foreign-owned firms

	Quantity				Price			
	Domestic		Foreign		Domestic		Foreign	
Spell duration	Spell intercept							
2 years	0.54	(0.04)**	0.51	(0.03)**	-0.02	(0.02)	0.00	(0.02)
3 years	0.76	(0.06)**	0.77	(0.04)**	-0.02	(0.03)	0.00	(0.02)
4 years	0.92	(0.08)**	0.98	(0.06)**	0.02	(0.03)	-0.01	(0.03)
5 years	1.05	(0.11)**	1.12	(0.08)**	0.00	(0.05)	-0.01	(0.04)
6 years	1.02	(0.15)**	1.15	(0.10)**	0.05	(0.06)	0.03	(0.04)
7-13 years	1.34	(0.08)**	1.44	(0.06)**	-0.02	(0.03)	0.01	(0.03)
14+ years	3.50	(0.05)**	3.75	(0.04)**	-0.08	(0.02)**	-0.01	(0.02)
Market tenure	7+ year spell							
2 years	0.84	(0.10)**	0.89	(0.08)**	0.00	(0.04)	-0.04	(0.03)
3 years	1.02	(0.10)**	1.27	(0.08)**	0.01	(0.04)	-0.06	(0.03)
4 years	1.17	(0.11)**	1.41	(0.08)**	-0.02	(0.04)	-0.04	(0.03)
5 years	1.22	(0.11)**	1.43	(0.08)**	-0.03	(0.04)	-0.04	(0.04)
6 years	1.17	(0.11)**	1.40	(0.08)**	-0.04	(0.04)	-0.03	(0.04)
7-13 years	1.14	(0.10)**	1.45	(0.07)**	-0.07	(0.04)**	-0.07	(0.03)**
N	120235		192717		120235		192717	
rsq	0.89		0.78		0.94		0.86	
rsq-adj	0.77		0.64		0.88		0.77	

Notes: Dependent variable is in turn log quantity and log unit value at the firm-product-market-year level. Full set of firm-product-year and market effects included in all regressions. Omitted category is spells that last one year. Individual profiles for spells lasting 2 to 6 years are also estimated, but not reported here for brevity. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 5: Dynamics of firm-product-market quantities: Industry groups

	Consumer Food		Consumer non-food non-durable		Intermediates		Capital goods	
Spell duration	Spell intercept							
2 years	0.50	(0.06)**	0.68	(0.06)**	0.54	(0.05)**	0.43	(0.04)**
3 years	0.74	(0.09)**	0.98	(0.09)**	0.78	(0.07)**	0.66	(0.06)**
4 years	0.84	(0.11)**	1.01	(0.12)**	1.04	(0.10)**	0.86	(0.08)**
5 years	0.80	(0.14)**	1.38	(0.15)**	1.17	(0.13)**	1.02	(0.11)**
6 years	1.09	(0.19)**	1.54	(0.19)**	1.09	(0.17)**	0.97	(0.13)**
7-13 years	1.24	(0.10)**	1.46	(0.12)**	1.47	(0.10)**	1.25	(0.09)**
14+ years	3.61	(0.06)**	3.56	(0.08)**	3.92	(0.07)**	3.60	(0.06)**
Market tenure	7+ year spell							
2 years	0.78	(0.12)**	0.73	(0.15)**	0.89	(0.13)**	1.00	(0.11)**
3 years	1.16	(0.12)**	1.11	(0.15)**	1.14	(0.13)**	1.31	(0.11)**
4 years	1.33	(0.12)**	1.22	(0.15)**	1.41	(0.13)**	1.36	(0.11)**
5 years	1.38	(0.12)**	1.27	(0.15)**	1.44	(0.13)**	1.37	(0.11)**
6 years	1.33	(0.12)**	1.15	(0.15)**	1.37	(0.14)**	1.35	(0.11)**
7-13 years	1.33	(0.11)**	1.27	(0.14)**	1.25	(0.13)**	1.45	(0.11)**
N	49005		46249		90145		111161	
rsq	0.80		0.78		0.84		0.75	
rsq-adj	0.65		0.64		0.68		0.59	

Notes: Dependent variable is in turn log quantity and log unit value at the firm-product-market-year level. Full set of firm-product-year and market effects included in all regressions. Omitted category is spells that last one year.Individual profiles for spells lasting 2 to 6 years are also estimated, but not reported here for brevity. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 6: Dynamics of firm-product-market prices: Industry groups

	Consumer Food		Consumer non-food non-durable		Intermediates		Capital goods	
Spell duration	Spell intercept							
2 years	-0.01	(0.02)	-0.03	(0.04)	0.02	(0.02)	0.00	(0.02)
3 years	-0.02	(0.03)	-0.02	(0.05)	0.00	(0.03)	0.00	(0.03)
4 years	-0.06	(0.04)	-0.02	(0.07)	0.03	(0.05)	0.02	(0.04)
5 years	-0.02	(0.04)	0.01	(0.08)	-0.03	(0.06)	-0.03	(0.05)
6 years	0.04	(0.06)	-0.14	(0.09)	0.10	(0.07)	0.03	(0.06)
7-13 years	0.02	(0.03)	0.02	(0.06)	-0.03	(0.05)	0.02	(0.04)
14+ years	0.04	(0.02)**	0.04	(0.04)	-0.05	(0.03)	-0.14	(0.03)**
Market tenure	7+ year spell							
2 years	0.00	(0.04)	0.03	(0.07)	0.01	(0.06)	-0.08	(0.04)*
3 years	-0.03	(0.04)	-0.01	(0.07)	0.03	(0.06)	-0.10	(0.05)**
4 years	-0.04	(0.04)	-0.06	(0.07)	0.04	(0.06)	-0.06	(0.05)
5 years	-0.07	(0.04)*	-0.05	(0.08)	0.00	(0.06)	-0.04	(0.05)
6 years	-0.05	(0.04)	-0.05	(0.08)	0.02	(0.06)	-0.06	(0.05)
7-13 years	-0.06	(0.04)*	-0.07	(0.07)	-0.05	(0.06)	-0.09	(0.04)**
N	49005		46249		90145		111161	
rsq	0.88		0.82		0.91		0.84	
rsq-adj	0.79		0.69		0.82		0.74	

Notes: Dependent variable is in turn log quantity and log unit value at the firm-product-market-year level. Full set of firm-product-year and market effects included in all regressions. Omitted category is spells that last one year.Individual profiles for spells lasting 2 to 6 years are also estimated, but not reported here for brevity. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 7: Evolution of firm-product-market exit probability with market tenure: All, domestic- and foreign-owned firms

Market tenure	All		Domestic		Foreign	
2 years	-0.13	(0.00)**	-0.14	(0.01)**	-0.13	(0.00)**
3 years	-0.20	(0.00)**	-0.21	(0.01)**	-0.19	(0.00)**
4 years	-0.24	(0.00)**	-0.25	(0.01)**	-0.23	(0.01)**
5 years	-0.25	(0.01)**	-0.25	(0.01)**	-0.24	(0.01)**
6 years	-0.24	(0.01)**	-0.23	(0.01)**	-0.24	(0.01)**
7-13 years	-0.24	(0.00)**	-0.23	(0.01)**	-0.23	(0.01)**
N	381452		152589		228863	
rsq	0.70		0.74		0.67	
rsq-adj	0.47		0.45		0.48	

Notes: Dependent variable is an indicator for exit in the next period. Full set of firm-product-year and market effects included in all regressions. Omitted category is market tenure equal to one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 8: Evolution of firm-product-market exit probability with market tenure: Industry groups

Market tenure	Consumer Food		Consumer non-food non-durable		Intermediates		Capital goods	
2 years	-0.14	(0.01)**	-0.13	(0.01)**	-0.14	(0.01)**	-0.12	(0.00)**
3 years	-0.21	(0.01)**	-0.18	(0.01)**	-0.20	(0.01)**	-0.19	(0.01)**
4 years	-0.24	(0.01)**	-0.22	(0.01)**	-0.25	(0.01)**	-0.22	(0.01)**
5 years	-0.24	(0.01)**	-0.22	(0.01)**	-0.25	(0.01)**	-0.23	(0.01)**
6 years	-0.24	(0.01)**	-0.21	(0.01)**	-0.24	(0.01)**	-0.23	(0.01)**
7-13 years	-0.24	(0.01)**	-0.21	(0.01)**	-0.23	(0.01)**	-0.22	(0.01)**
N	58119		56301		108031		137319	
rsq	0.67		0.71		0.72		0.68	
rsq-adj	0.44		0.49		0.45		0.49	

Notes: Dependent variable is an indicator for exit in the next period. Full set of firm-product-year and market effects included in all regressions. Omitted category is market tenure equal to one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 9: Dynamics of firm-product-market revenue, quantity and price, by export spell length and market tenure

	Revenue		# Products	
Spell duration	Spell intercept			
2 years	0.40	(0.04)**	0.10	(0.01)**
3 years	0.74	(0.06)**	0.15	(0.01)**
4 years	0.84	(0.07)**	0.18	(0.02)**
5 years	1.09	(0.09)**	0.19	(0.02)**
6 years	1.15	(0.11)**	0.25	(0.03)**
7-13 years	1.32	(0.05)**	0.28	(0.01)**
14+ years	3.98	(0.03)**	0.91	(0.01)**
Market tenure	2-year spell			
2 years	-0.02	(0.05)	-0.00	(0.01)
Market tenure	3-year spell			
2 years	0.48	(0.07)**	0.11	(0.02)**
3 years	0.02	(0.07)	0.01	(0.02)
Market tenure	4-year spell			
2 years	0.61	(0.09)**	0.13	(0.02)**
3 years	0.57	(0.09)**	0.12	(0.02)**
4 years	0.19	(0.10)*	0.01	(0.02)
Market tenure	5-year spell			
2 years	0.71	(0.12)**	0.16	(0.03)**
3 years	0.74	(0.12)**	0.19	(0.03)**
4 years	0.59	(0.12)**	0.19	(0.03)**
5 years	0.05	(0.12)	0.05	(0.03)
Market tenure	6-year spell			
2 years	0.68	(0.14)**	0.21	(0.04)**
3 years	0.90	(0.14)**	0.21	(0.04)**
4 years	1.03	(0.14)**	0.24	(0.04)**
5 years	0.75	(0.14)**	0.14	(0.04)**
6 years	0.11	(0.15)	0.00	(0.04)
Market tenure	7+ year spell			
2 years	1.01	(0.07)**	0.21	(0.02)**
3 years	1.35	(0.07)**	0.28	(0.02)**
4 years	1.51	(0.07)**	0.32	(0.02)**
5 years	1.60	(0.07)**	0.33	(0.02)**
6 years	1.59	(0.07)**	0.32	(0.02)**
7-13 years	1.64	(0.06)**	0.33	(0.02)**
N	113912		113912	
rsq	0.65		0.56	
rsq-adj	0.58		0.47	

Notes: Dependent variable is in turn log revenue and log number of products at the firm-market-year level. Full set of firm-year and market effects included in all regressions. Omitted category is spells that last one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 10: Evolution of firm-market exit probability with market tenure

Market tenure	All	
2 years	-0.16	(0.00)**
3 years	-0.22	(0.01)**
4 years	-0.25	(0.01)**
5 years	-0.27	(0.01)**
6 years	-0.27	(0.01)**
7-13 years	-0.26	(0.01)**
N	103297	
rsq	0.47	
rsq-adj	0.34	

Notes: Dependent variable is an indicator for exit in the next period. Full set of firm-year and market effects included in all regressions. Omitted category is market tenure equal to one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 11: Dynamics of product revenue, quantity and price at the firm level

	Revenue		Quantity		Price	
Market tenure			2-year spell			
2 years	-0.03	(0.02)	0.02	(0.03)	-0.05	(0.02)**
Market tenure			3-year spell			
2 years	-0.01	(0.03)	0.02	(0.05)	-0.03	(0.04)
3 years	-0.08	(0.04)**	-0.11	(0.06)*	0.03	(0.05)
Market tenure			4-year spell			
2 years	-0.01	(0.04)	0.04	(0.07)	-0.05	(0.06)
3 years	0.00	(0.04)	0.01	(0.07)	-0.01	(0.06)
4 years	-0.06	(0.04)	-0.06	(0.07)	0.00	(0.06)
Market tenure			5-year spell			
2 years	0.01	(0.05)	0.07	(0.09)	-0.06	(0.07)
3 years	0.11	(0.05)**	0.14	(0.09)	-0.03	(0.07)
4 years	0.08	(0.05)*	0.11	(0.08)	-0.03	(0.07)
5 years	0.02	(0.05)	0.03	(0.09)	-0.00	(0.07)
Market tenure			6-year spell			
2 years	0.13	(0.08)*	0.25	(0.12)**	-0.12	(0.10)
3 years	0.10	(0.08)	0.11	(0.13)	-0.01	(0.11)
4 years	0.06	(0.08)	-0.00	(0.12)	0.06	(0.10)
5 years	-0.01	(0.07)	-0.04	(0.12)	0.03	(0.09)
6 years	-0.07	(0.09)	-0.20	(0.13)	0.13	(0.11)
Market tenure			7+ year spell			
2 years	0.18	(0.04)**	0.17	(0.06)**	0.01	(0.05)
3 years	0.22	(0.04)**	0.15	(0.07)**	0.07	(0.06)
4 years	0.24	(0.03)**	0.18	(0.06)**	0.06	(0.05)
5 years	0.24	(0.03)**	0.23	(0.06)**	0.02	(0.05)
6 years	0.23	(0.03)**	0.22	(0.06)**	0.01	(0.05)
7-13 years	0.23	(0.03)**	0.31	(0.05)**	-0.08	(0.04)*
Fixed effects			Firm-product, year			
N	46174		46174		46174	
rsq	0.93		0.93		0.92	
rsq-adj	0.91		0.91		0.89	

Notes: Dependent variable in first column is log revenue at the firm-product-year level reported in Prodcom. Dependent variables in second and third columns are in turn log quantity and log unit value at the firm-product-market-year level. Full set of firm-product and year effects included in all regressions. Omitted category is spells that last one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 12: Evolution of firm-product exit probability with market tenure

Market tenure	All	
2 years	-0.06	(0.01)**
3 years	-0.12	(0.01)**
4 years	-0.11	(0.01)**
5 years	-0.16	(0.01)**
6 years	-0.12	(0.01)**
7-13 years	-0.16	(0.01)**
N	57472	
rsq	0.18	

Notes: Dependent variable is an indicator for exit in the next period. Full set of year effects included. Omitted category is market tenure equal to one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 13: Dynamics of revenue, number of markets and number of products at the firm level

	Revenue		# Markets		# Products	
Market tenure	2-year spell					
2 years	0.04	(0.02)*	-0.03	(0.01)**	-0.06	(0.05)
Market tenure	3-year spell					
2 years	0.18	(0.04)**	-0.00	(0.02)	0.08	(0.05)
3 years	0.17	(0.04)**	0.03	(0.02)	0.02	(0.06)
Market tenure	4-year spell					
2 years	0.08	(0.04)**	0.03	(0.02)	-0.01	(0.07)
3 years	0.11	(0.04)**	0.02	(0.02)	-0.11	(0.08)
4 years	0.13	(0.04)**	0.01	(0.02)	-0.15	(0.08)*
Market tenure	5-year spell					
2 years	0.16	(0.05)**	0.01	(0.02)	0.10	(0.04)**
3 years	0.20	(0.05)**	-0.02	(0.03)	0.12	(0.04)**
4 years	0.19	(0.05)**	-0.02	(0.03)	0.11	(0.04)**
5 years	0.10	(0.05)*	-0.03	(0.04)	0.08	(0.04)*
Market tenure	6-year spell					
2 years	0.07	(0.06)*	-0.01	(0.05)	-0.17	(0.12)
3 years	0.03	(0.06)	-0.03	(0.05)	-0.26	(0.11)**
4 years	0.11	(0.06)*	-0.03	(0.05)	-0.25	(0.11)**
5 years	0.12	(0.06)**	-0.03	(0.05)	-0.23	(0.12)**
6 years	0.02	(0.07)	-0.07	(0.06)	-0.25	(0.12)**
Market tenure	7+ year spells					
2 years	0.19	(0.03)**	0.05	(0.02)**	-0.01	(0.04)
3 years	0.32	(0.03)**	0.09	(0.02)**	-0.02	(0.04)
4 years	0.41	(0.03)**	0.11	(0.02)**	-0.02	(0.04)
5 years	0.44	(0.03)**	0.12	(0.02)**	-0.03	(0.03)
6 years	0.50	(0.03)**	0.13	(0.02)**	-0.05	(0.03)
7-13 years	0.53	(0.03)**	0.14	(0.02)**	-0.03	(0.03)
Fixed effects	Firm-product, year					
N	62664		62137		49951	
rsq	0.96		0.90		0.84	
rsq-adj	0.95		0.89		0.81	

Notes: Dependent variable in first column is log revenue at the firm-year level as reported in CIP. Dependent variable in second column is log number of markets (including the home market) at the firm-year level based on merging CIP and customs data. Dependent variable in third column is log number of concorded products at the firm-year level based on merging CIP and Prodcom. Full set of firm and year effects included in all regressions. Omitted category is spells that last one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 14: Evolution of firm exit probability with market tenure

Market tenure	All	
2 years	-0.04	(0.01)**
3 years	-0.05	(0.01)**
4 years	-0.06	(0.01)**
5 years	-0.07	(0.01)**
6 years	-0.09	(0.01)**
7-13 years	-0.11	(0.01)**
N	11381	
rsq	0.02	

Notes: Dependent variable is an indicator for exit in the next period. Full set of year effects included. Omitted category is market tenure equal to one year. Robust standard errors calculated. ** significant at 5%, * significant at 10%. Source: CSO and authors' calculations.

Table 15: Data and model moments

	Data		Model	
			Baseline	$\alpha = 0$
	moment	s.e.	moment	moment
$\ln(Q_0^3/Q_0^2)$	0.25	(0.04)	0.28	0.22
$\ln(Q_0^4/Q_0^2)$	0.44	(0.05)	0.44	0.32
$\ln(Q_0^5/Q_0^2)$	0.57	(0.07)	0.56	0.45
$\ln(Q_0^6/Q_0^2)$	0.58	(0.08)	0.69	0.60
$\ln(Q_0^7/Q_0^2)$	0.88	(0.05)	0.82	0.95
$\ln(Q_3^4/Q_2^4)$	0.05	(0.06)	0.05	-0.10
$\ln(Q_3^5/Q_2^5)$	0.07	(0.08)	0.01	-0.00
$\ln(Q_4^5/Q_2^5)$	-0.01	(0.09)	0.02	-0.08
$\ln(Q_3^6/Q_2^6)$	0.17	(0.11)	0.15	0.00
$\ln(Q_4^6/Q_2^6)$	0.14	(0.11)	0.06	-0.00
$\ln(Q_5^6/Q_2^6)$	-0.03	(0.11)	0.04	-0.05
$\ln(Q_3^7/Q_2^7)$	0.32	(0.06)	0.35	0.00
$\ln(Q_4^7/Q_2^7)$	0.46	(0.06)	0.46	0.00
$\ln(Q_5^7/Q_2^7)$	0.49	(0.06)	0.47	0.00
$\ln(Q_6^7/Q_2^7)$	0.45	(0.06)	0.47	-0.01
$exit_1$	0.36	(0.007)	0.32	0.38
$exit_2 - exit_1$	-0.16	(0.005)	-0.20	-0.23
$exit_3 - exit_1$	-0.22	(0.005)	-0.23	-0.24
$exit_4 - exit_1$	-0.25	(0.006)	-0.24	-0.24
$exit_5 - exit_1$	-0.27	(0.006)	-0.25	-0.24
$exit_6 - exit_1$	-0.27	(0.007)	-0.25	-0.22

Notes: Estimates of model parameters based on 3 states each for both ν and η shocks. Quantity moments based on Table 3. Exit moments based on Table 10. $exit_1$ refers to the intercept for the US market in this regression. Parameter estimates are reported in Table 16.

Table 16: Estimated parameters from the structural model

Parameter	α	δ	ϕ	σ_{ν}^{2}	ρ	σ_{ζ}^{2}	$F/\mathbb{E}(R_1)$	ω
Baseline	0.55	0.63	24.20	0.47	0.50	2.67	0.04	0.03
$\alpha = 0$	0	n.a.	n.a.	1.03	0.11	13.16	0.18	0.09

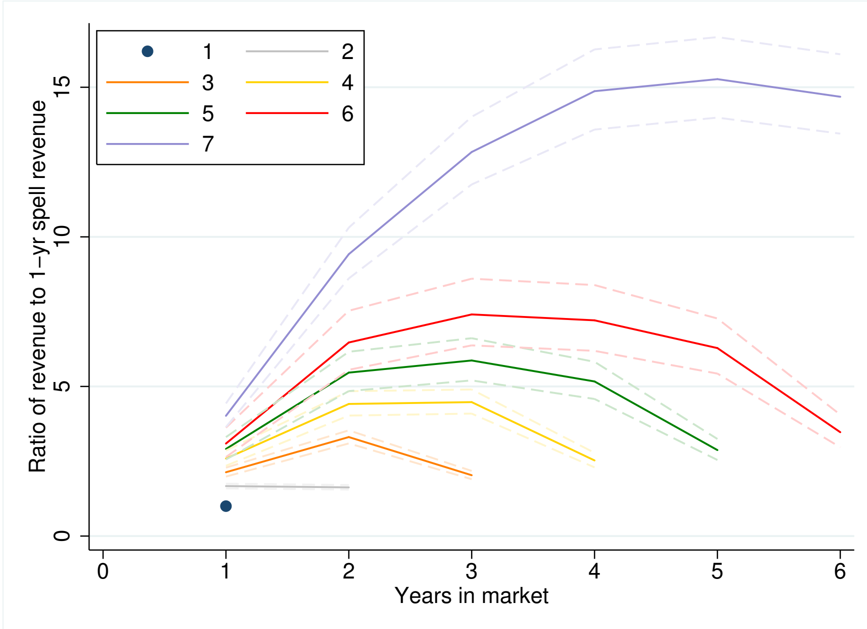
Notes: Estimates of model parameters based on 3 states each for both ν and η shocks.

Table 17: Marketing and advertising share of expected revenue for successful spells

Market tenure	1	2	3	4	5	6
Share	0.18	0.13	0.13	0.10	0.10	0.09

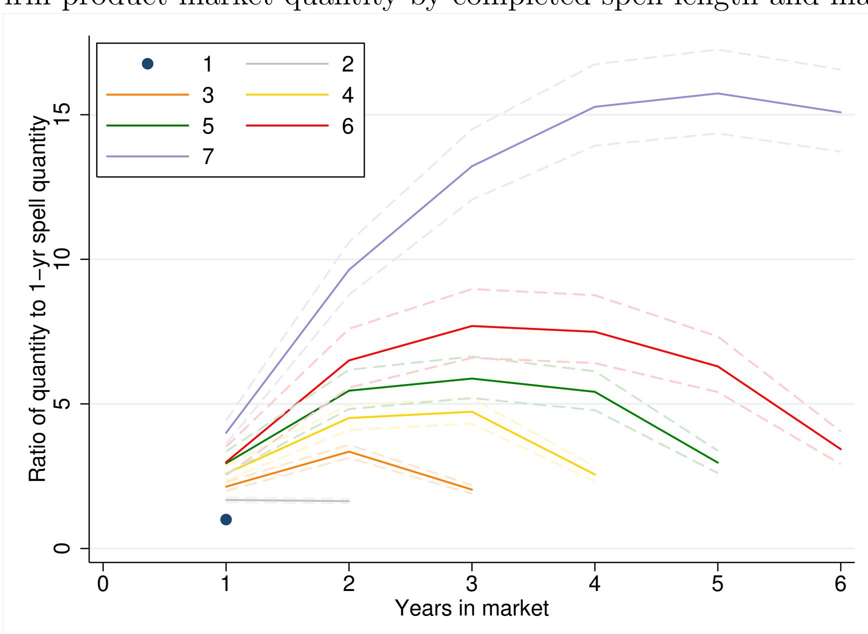
Notes: Population average of $(INV/\mathbb{E}(REV))$ for export spells lasting at least 7 periods, based on estimates in Table 16.

Figure 1: Firm-product-market revenue by completed spell length and market tenure



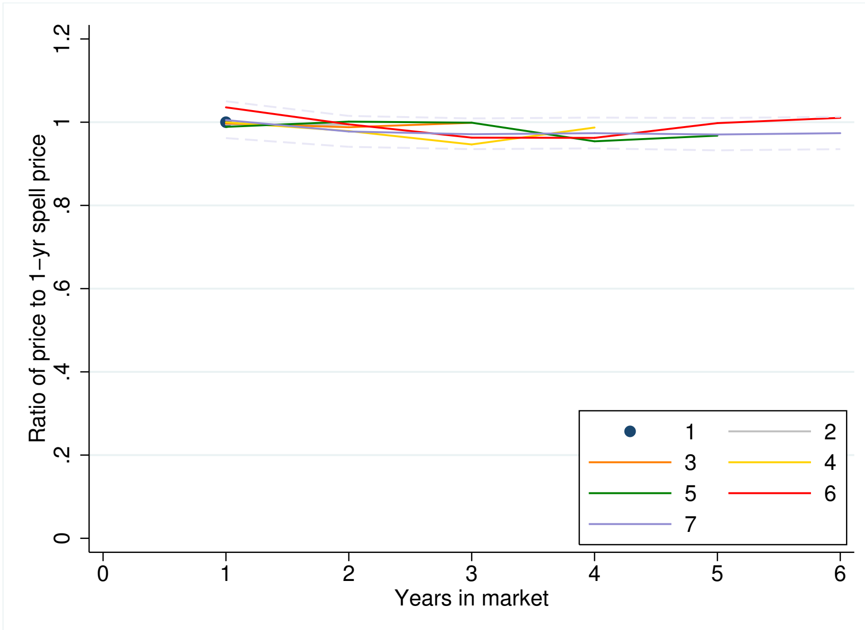
Notes: Figure shows evolution of revenue at the firm-product-market level with tenure in the market, allowing trajectories to differ with completed spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted. Source: CSO and authors' calculations.

Figure 2: Firm-product-market quantity by completed spell length and market tenure



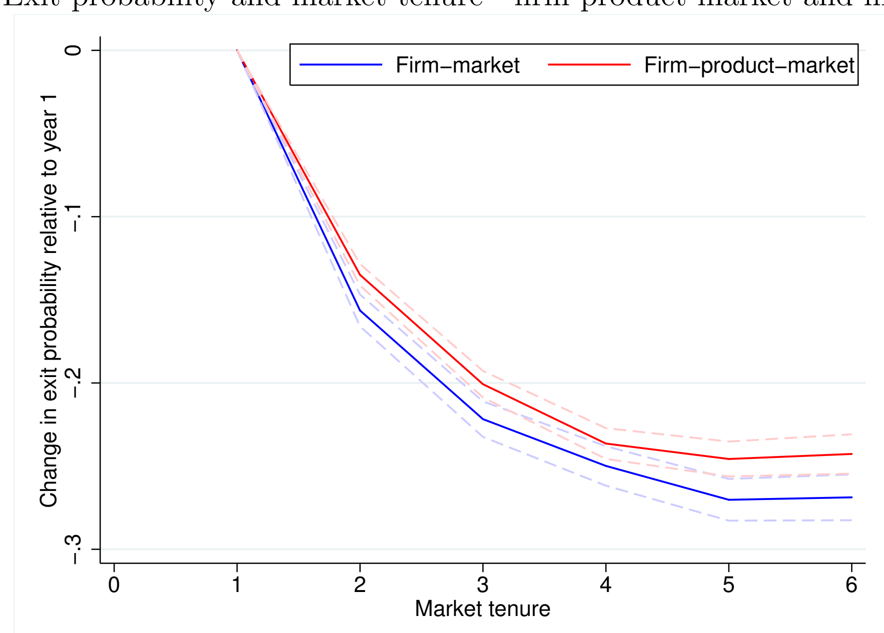
Notes: Figure shows evolution of quantities at the firm-product-market level with tenure in the market, allowing trajectories to differ with completed spell length. Trajectories are conditional on firm-product-year and market effects. 95% confidence intervals are plotted. Source: CSO and authors' calculations.

Figure 3: Firm-product-market price by completed spell length and market tenure, different scale



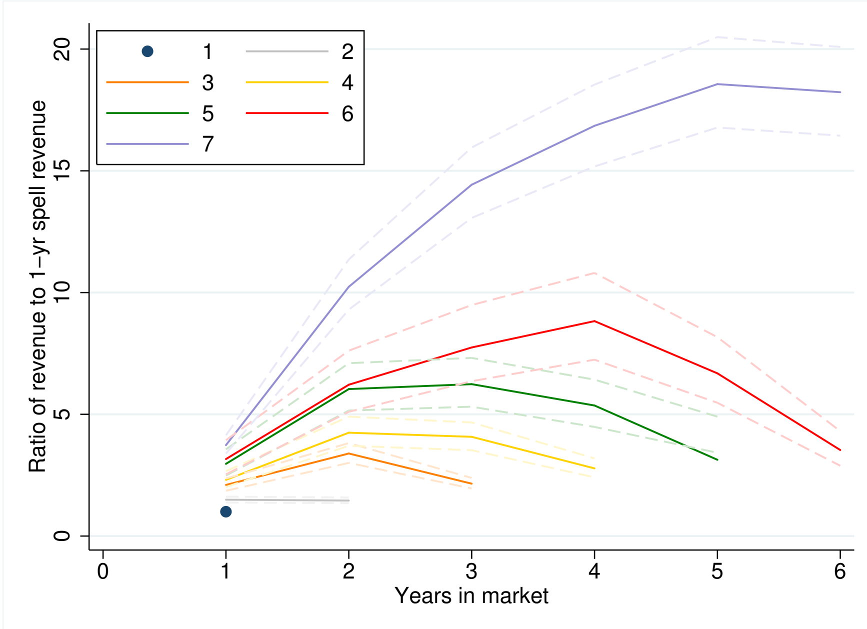
Notes: Figure shows evolution of prices at the firm-product-market level with tenure in the market, allowing trajectories to differ with completed spell length. Trajectories are conditional on firm-product-year and market effects. The 95% confidence interval for spells of 7+ years is plotted. Source: CSO and authors' calculations.

Figure 4: Exit probability and market tenure - firm-product-market and firm-market



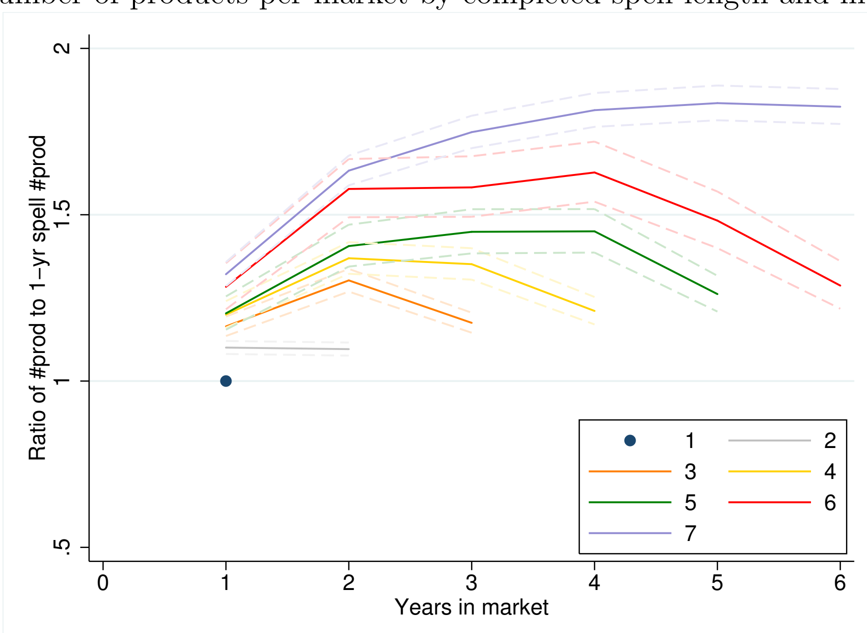
Notes: Figure shows reduction in probability of exit at the firm-market and firm-product-market levels with respect to probability of exit in the first year in a market. Trajectories are conditional on firm-year and market and firm-product-year and market effects repectively. 95% confidence intervals are plotted. Source: CSO and authors' calculations.

Figure 5: Firm-market revenue by completed spell length and market tenure



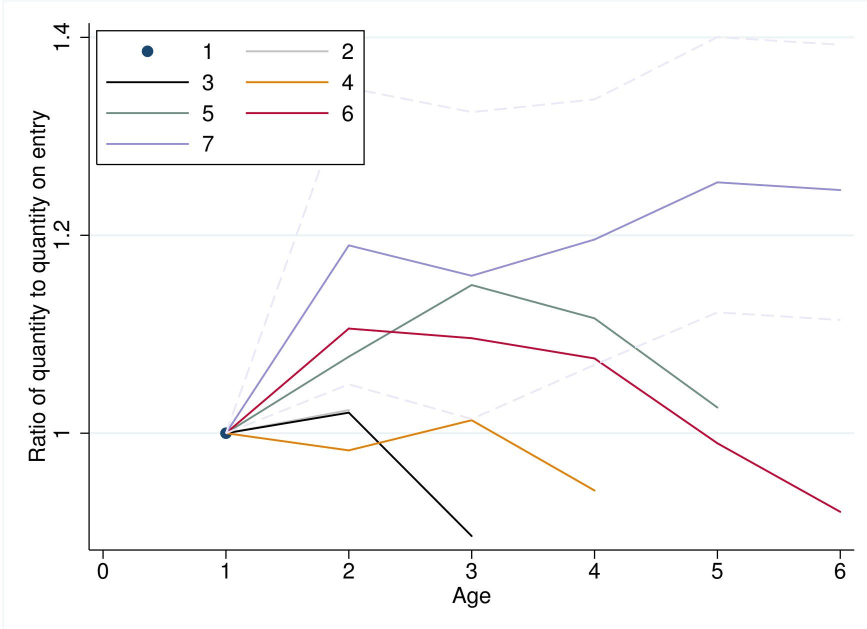
Notes: Figure shows evolution of revenue at the firm-market level with tenure in the market, allowing trajectories to differ with completed spell length. Trajectories are conditional on firm-product-year and market effects. Source: CSO and authors' calculations.

Figure 6: Number of products per market by completed spell length and market tenure



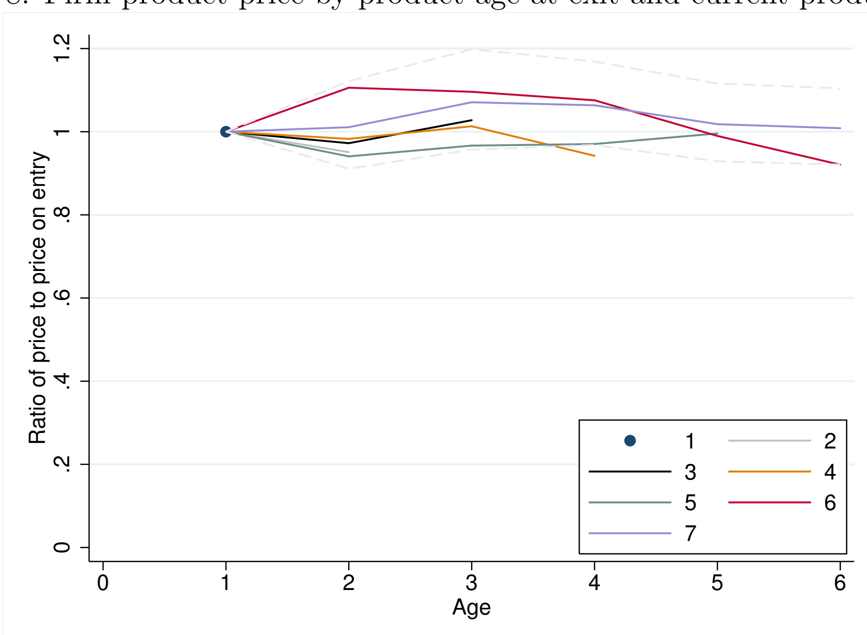
Notes: Figure shows evolution of revenue at the firm-market level with tenure in the market, allowing trajectories to differ with completed spell length. Trajectories are conditional on firm-product-year and market effects. Source: CSO and authors' calculations.

Figure 7: Firm-product quantity by product age at exit and current product age



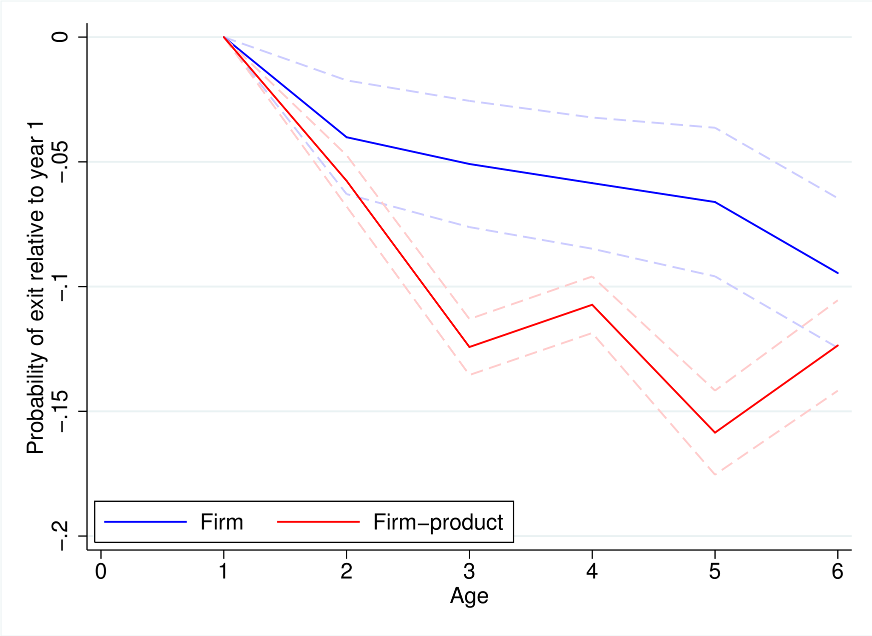
Notes: Figure shows evolution of quantity at the firm-product level with firm-product age, allowing trajectories to differ with completed product age. Trajectories are conditional on firm-product and year effects. 95% confidence interval for longest spells is plotted. Source: CSO and authors' calculations.

Figure 8: Firm-product price by product age at exit and current product age



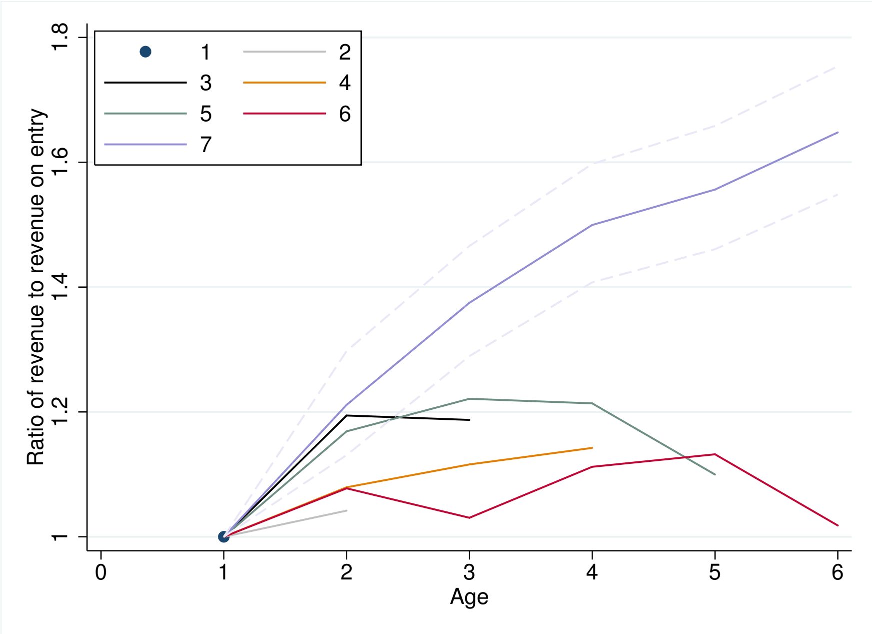
Notes: Figure shows evolution of price at the firm-product level with firm-product age, allowing trajectories to differ with completed product age. Trajectories are conditional on firm-product and year effects. 95% confidence interval for longest spells is plotted. Source: CSO and authors' calculations.

Figure 9: Evolution of exit probability with age - firm level



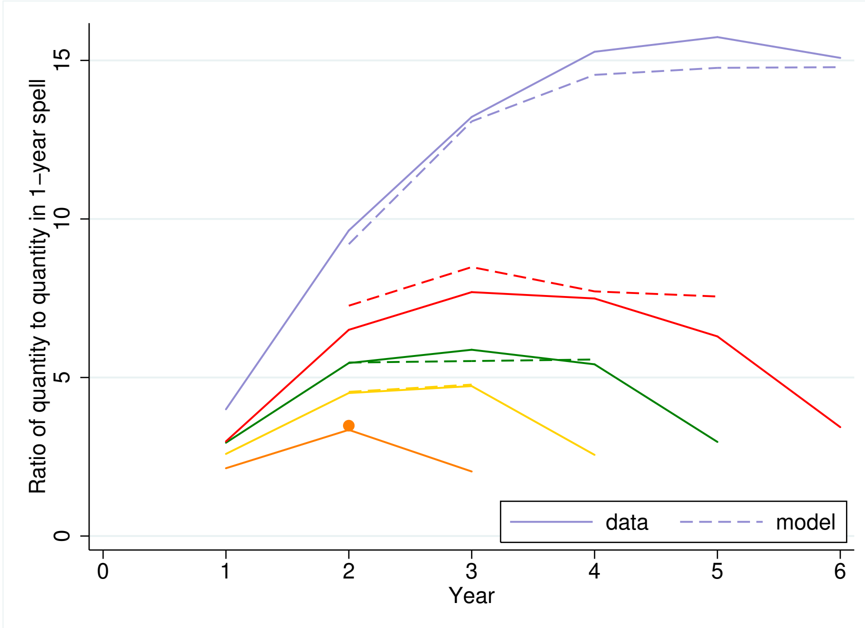
Notes: Figure shows reduction in probability of exit at the firm-product and firm level with respect to probability of exit in the first year. Trajectory is conditional on firm and year effects in each case. 95% confidence interval is plotted. Source: CSO and authors' calculations.

Figure 10: Firm revenue by age at exit and current age



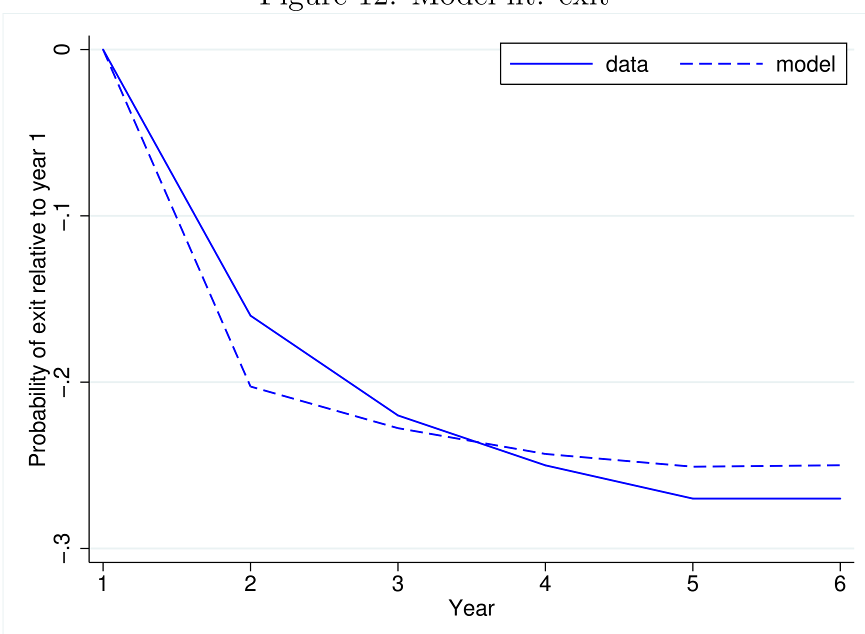
Notes: Figure shows evolution of revenue at the firm level with firm age, allowing trajectories to differ with completed firm age. Trajectories are conditional on firm and year effects. 95% confidence interval for longest spells is plotted. Source: CSO and authors' calculations.

Figure 11: Model fit: quantities



Notes: Figure shows data on evolution of quantities at the firm-product-market level with tenure by spell length, and corresponding evolution for the model. Model quantities are renormalized by ratio of spell 2 to spell 1 at year 1 and by ratio of year 2 to year 1 for relevant spell, as these moments are not targeted in the model. Source: CSO and authors' calculations.

Figure 12: Model fit: exit



Notes: Figure shows data on reduction in probability of exit at the firm-market level relative to probability of exit in the first year in a market, and corresponding evolution for the model. Figure does not illustrate exit rate in year 1. Source: CSO and authors' calculations.