

# New Exporter Dynamics\*

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## Abstract

Models of heterogeneous firms making decisions about entering foreign markets in the face of sunk entry costs have become standard tools for understanding the firm exporting decision. These models induce a discrete choice between exporting and only serving the domestic market. In this paper we study how well these discrete choice models account for the data on new export entrants. Using Colombian data on manufacturing plants, we document the time paths of new entrants to the export market and find that, though there is a discrete nature to the growth in exports, there is also a substantial amount of adjustment that continues after entry, which is contrary to the standard model.

We construct a dynamic discrete choice model of exporting and calibrate it to the Colombian manufacturing sector. We find that the standard heterogeneous firm model cannot replicate the behavior of new exporters; in the model, new exporters grow too large, too quickly. The model also cannot generate the downward sloping exit hazard that is evident in the data. We assess the quantitative importance of the slow adjustment of new exporters by fitting an export demand function to the data. When the slow growth of new exporters is taken into account, the present value of being an exporting firm falls dramatically. As a result, the entry costs needed to account for the data are 8 times smaller than the value in the benchmark model.

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# 1 Introduction

Models of heterogenous firms making decisions about entering foreign markets in the face of sunk entry costs have become an important tool for studying international trade patterns, flows, and policy. These models initially focused on steady state analysis, as in Melitz (2003), and have been successful in replicating key features of the plant level data such as the low export participation rate and the fact that exporters are larger than nonexporters.

While the steady state properties of this class of models have provided insight into the export decision of firms, the presence of sunk entry costs makes the dynamic content of these models extremely rich. Recently, this type of industrial structure has been incorporated into stochastic general equilibrium models. The key innovation in the dynamic models is that firms enter and exit the foreign market in response to changes in relative prices and productivity. For example, Melitz and Ghironi (2005) and Alessandria and Choi (2007a) use these types of models to study how the inclusion of firm exporting decisions affects real exchange rate and net export dynamics and Ruhl (2004) demonstrates how export entry can produce asymmetric responses to temporary and permanent changes in expected export profits. Das, Roberts and Tybout (2007) estimate a dynamic structural model of export entry and exit and use it to study the impact of trade policy. These models have focused on the aggregate implications of export entry and exit.

In this paper, we focus on the ability of this class of models to reproduce the dynamics of new exporters. Using data on Colombian manufacturing firms, we document that new exporters begin by exporting small amounts and—conditional on continuing as an exporter—gradually adjust export sales over a period of several years. We also show that new exporters are more likely to exit the export market, than are firms that have exported for several years. We construct a dynamic stochastic model of firm export decisions and calibrate it to the cross-sectional facts that are typically used to parameterize these models. We find that the model cannot—neither qualitatively nor quantitatively—reproduce the gradual adjustment of new exporters that we see in the data.

The failure of the model to capture the growth path of new exporters is important: the

present value of exporting is determined by both how long a plant expects to stay in the export market and when the export profits are realized. The present value of exporting is fundamental to understanding the costs and benefits of trade policy and in measuring export barriers, such as costs of entry.

In the baseline model, a firm enters the export market in response to positive shocks, either to the real exchange rate, its idiosyncratic productivity, or both. These shocks are persistent, so the firm expects the state of the world to continue to be favorable for the periods following entry. The fixed nature of the entry cost implies that, upon entry, a new exporter immediately adjust its exports to the optimal level. These two factors load much of the present value of exporting into the first few periods following entry.

In an extension to the baseline model, we specify a foreign demand function that grows with the number of years an plant has been exporting. We calibrate the model so that the export growth path of new exporters matches that in the data. In this model a new exporter starts small and grows over several periods, pushing the profits from exporting into the future. In the future, the favorable shocks that are realized currently will have decayed away, both decreasing the period profit and increasing the likelihood that the firm will exit the export market. Loading the profits into the future decreases the present value of exporting. The impact of this difference is most striking in the export entry costs in the two models. To be able to replicate the low export participation rate in the model, the baseline model needs an entry cost more than 8 times as large as the one in the model with gradual adjustment.

There is a large literature that establishes the relevance of sunk entry costs for export decisions. Early models, such as Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989) focused on the hysteresis implied by the sunk nature of the entry costs. Empirically, much of the evidence of sunk export entry costs came from reduced form specifications such as Roberts and Tybout (1997) and Bernard and Jensen (2004), which established that entry costs were important in accounting for the persistent nature of a plant's export status, but these reduced form models could not estimate the magnitudes of such costs.

Our work is closely related to that of Das et al. (2007) who also estimate a structural model of plant export decisions using Colombian data. An advantage of the structural nature of their model and ours is that we can recover estimates of the size of the export entry costs. In the baseline model, our estimates of entry costs are similar to those found in Das et al. (2007), but direct comparisons should be made with caution, as their model includes unobserved shocks to the entry costs, so costs actually paid in their model are likely to be much lower.

Our findings suggest that, while there is a discrete nature to the export entry decision, there is also a substantial amount of adjustment that continues after the plant has entered the foreign market. While the entry cost model is successful in explaining some aspects of the data, the dynamics of export entry require a different approach. Ruhl and Willis (2008) combine a cost of entry, to induce the jump in export sales in the period of entry, with a model in which firms learn about their profitability from exporting through time, as in Jovanovic (1982). Arkolakis (2007) builds a model with convex costs of advertising that leads to gradual growth in exporter market share.

## 2 Data

In this section, we lay out two sets of facts. First, we summarize the features of the data that are frequently used to parameterize models based on their cross sectional characteristics. These include the export participation rate and the entry and exit rates of exporters. Second, we highlight the transitional dynamics of new exporters, which is the focus of this paper.

We draw our data from an annual census of manufacturing plants in Colombia. The data were originally collected as a sequence of cross sections by the Departamento Administrativo Nacional de Estadística and were cleaned and linked into a panel as described in Roberts (1996). The census covers all manufacturing plants with 10 or more employees and includes variables about revenues, input costs, employment, and exporting revenue and cover the period 1981-1991. This time period, and the data we are using, have been previously studied

in Roberts and Tybout (1996), Roberts and Tybout (1997), and Das et al. (2007). In this paper we focus on the decision of an existing plant to enter the export market, so we balance the panel by dropping any plant that did not have at least 15 employees in each year of the sample. This gives us a sample of 1888 plants over 11 years.

## 2.1 Exporter Entry and Exit

We characterize a plant as an *exporter* in year  $t$  if export revenues for the plant are positive. A plant that enters the export market in year  $t$ , an *export starter*, is a plant that was not an exporter in year  $t - 1$  and is an exporter in year  $t$ . Analogously, an *export stopper* in year  $t$  is a plant that exported in  $t - 1$  and does not export in year  $t$ . In our data 24.7 percent of firms, on average, are exporters.<sup>1</sup> That only 25 percent of all firms export anything has been an important fact in shaping the development of trade models. Discrete choice models, which have become workhorses in international trade, are ideally suited to generate this cross-sectional fact. If firms are heterogenous, a large enough fixed exporting cost can shut out a fraction of the firms from the export market.

While many firms do not export, there is a significant amount of turnover in the export market: The average export starter rate (the number of export starters at  $t$  divided by the number of nonexporters at  $t - 1$ ) is 3.7 percent, and the average export stopper rate (the number of export stoppers at  $t$  divided by the number of exporters at  $t - 1$ ) is 12.7 percent. Modeling this turnover requires a dynamic model with some underlying process that drives entry and exit. Alessandria and Choi (2007b) use firm level idiosyncratic productivity shocks and Das et al. (2007) introduce idiosyncratic shocks to a firm's export profits. In these papers, as in this one, export entry is driven by firm's receiving favorable shocks.

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<sup>1</sup>We are reporting unweighted statistics. An alternative would be to weight firms by their employment size, so that the outcomes of larger firms are more important—an approach frequently used in closed economy industry studies. Weighting by employment does not qualitatively change the results, and quantitatively the biggest difference is in the export participation rate, which is almost 46 percent when weighted by employment, reflecting the fact that exporters tend to be larger firms. In the productivity literature, whether to weight or not is still an unsettled matter, see, for example, Foster, Haltiwanger and Syverson (2008).

## 2.2 Dynamics of New Exporter Growth

The purpose of this study is to evaluate how well heterogenous firm models replicate the dynamics of the export decision. Here we focus on one aspect of the decision to export, the firm’s decision about how much to produce for the export market. The now standard models, based on Melitz (2003), feature fixed costs of exporting, which induce a discrete decision regarding entry into the export market. This class of models has the feature that when a firm enters the export market it immediately adjusts its export quantity to the optimal level. Do we see this pattern in the data?

In Figure 1 we plot the average export to total sales ratio for new exporters in the Colombian data. For each plant in the panel that enters the export market, we compute the export to sales ratio of the plant for the year it entered—period 0 on the x-axis—and the years preceding and succeeding the entry, conditional on a firm remaining in the export market for the 5 years following entry. We restrict the sample to include only the firms that continued to export in the 5 years following entry to eliminate selection effects from the figure. In this way, we are capturing the growth within a firm as it transitions from a new exporter to an established exporter. From the figure we see the discrete nature of the entry decision, as exports jump from zero to about 3.5 percent of total sales upon entry. The discrete jump is not the complete picture, though. Exports continue to grow over the years following entry. The dashed line in Figure 1 is the average export to sales ratio for all exporting firms: It takes a new exporter about 6 years to reach the average export to sales ratio.

In Table 1 we check this pattern for robustness. In the first column of results, we report the OLS coefficients for a regression of the export to total sales ratio on the number of years the firm has been exporting. These are the coefficients plotted in Figure 1. Next, we check for cohort effects. Cohort effects may be important; plants that enter in a better than average year may be able to initially sell more in export markets, changing the pattern described in Figure 1. The second column of results reports a specification that includes the number of years a plant has exported and the year it entered the market: the plant’s

Table 1: Export-Total Sales Ratio Growth for New Exporters

	<b>Export-Sales Ratio</b>	<b>Export-Sales Ratio</b>	<b>Export-Sales Ratio</b>
<b>Entry</b>	0.0370 (0.0120)	0.0279 (0.0200)	0.0257 (0.0148)
<b>Age=1</b>	0.0480 (0.0120)	0.0389 (0.0200)	0.0368 (0.0148)
<b>Age=2</b>	0.0491 (0.0120)	0.0400 (0.0200)	0.0378 (0.0148)
<b>Age=3</b>	0.0639 (0.0120)	0.0548 (0.0200)	0.0526 (0.0148)
<b>Age=4</b>	0.0900 (0.0120)	0.0808 (0.0200)	0.0787 (0.0148)
<b>Age=5</b>	0.1168 (0.0120)	0.1077 (0.0200)	0.1055 (0.0148)
<b>Cohort Effects</b>	No	Yes	No
<b>Ind Effects</b>	No	No	Yes
<b><math>R^2</math></b>	0.0117	0.0244	0.1611

Employment-weighted OLS regression of the export to total sales ratio on the number of years a firm has exported (its *age*), industry, and cohort fixed effects. The sample consists of firms that entered in the years 1982–86 and continued to export for the next 5 years. Standard errors are reported in parentheses.

cohort. Controlling for cohort effects changes little. The values of the coefficients are very similar across the two specifications, and the r-squared improves only slightly. The third set of results controls for the industry of the plant.<sup>2</sup> Controlling for the plant's industry does improve the fit of these regressions; there is an industry-specific component to export behavior. Controlling for industry effects, however, does not change the relationship between an exporter's age and the amount that it exports. The coefficients on age are very similar across all three specifications.

Our data only contains information on total export revenues: We do not know to how many countries a plant exports. While most exporters export to only one country, as documented in Eaton, Kortum and Kramarz (2004), some of the growth we see in the new exporter export-sales ratio is a result of a firm adding new export markets, as documented in Eaton, Eslava, Kugler and Tybout (2007). Since we cannot separate the growth in exports that arise from new markets we will model the firm as choosing to export to a single global market.

Exporting is a persistent condition. In our data, if a plant exports in the current period there is an 89 percent chance that it will still be exporting in the next period. The "persistence" of the exporting decision is evidence in favor of models with sunk entry costs, such as those developed in Baldwin (1988) and Roberts and Tybout (1997). The unconditional survival probability, however, is much different from the survival probabilities of new exporters. Figure 2 plots the survivor rates for exporters – the percentage of plants of a given age that continue to be exporters in the following period. For new exporters, the probability of remaining in the export market for an additional period is 62 percent. This survivor probability increases to 90 percent for plants that have been exporting for 3 periods, and remains at or above that level for subsequent periods. This pattern indicates that there is a higher level of uncertainty for new exporters regarding future participation in the export market than for more established exporters. The high rate of turnover among new exporters is also documented in Eaton et al. (2007).

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<sup>2</sup>See the appendix for details on which industries are included in the sample.

### 3 Baseline Model

In this section we describe a model in which heterogenous firms make decisions about export entry under uncertainty. Our focus is on the decisions made by plants in response to changes in relative prices and productivity, and thus we abstract from general equilibrium effects by assuming a constant wage and domestic price level. We model Colombia as a small open economy that takes the real exchange rate as exogenous. In what follows, we suppress the time subscript on variables unless needed for clarity.

#### 3.1 Demand

A representative agent in the domestic economy supplies labor inelastically and has preferences over the set of differentiated goods of the constant elasticity of substitution form,

$$U(c_1, \dots, c_J) = \left( \sum_{j=1}^J c_j^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (1)$$

where  $\theta$  is the elasticity of substitution between goods and  $J$  is the number of available varieties. The consumer chooses consumption of each variety to maximize utility subject to the budget constraint

$$\sum_{j=1}^J c_j p_j = I, \quad (2)$$

where  $I$  is the consumer's income. Taking prices as given, the representative agent's demand for variety  $j$  is

$$c_j = \left( \frac{p_j}{P} \right)^{-\theta} C, \quad (3)$$

where  $C$  is defined as a unit of the aggregated consumption,

$$C = \left( \sum_{j=1}^J c_j^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (4)$$

and  $P$  is the price of a unit of the aggregated consumption as defined in the usual way,

$$P = \left( \sum_{j=1}^J p_j^{1-\theta} \right)^{\frac{1}{1-\theta}}. \quad (5)$$

The rest of the world is populated by a representative consumer with an analogous utility function and budget constraint. Foreign demand for variety  $j$  is

$$c_j^* = \left( \frac{p_j^*}{P^*} \right)^{-\theta} C^*. \quad (6)$$

Note that we have assumed that the representative agents in the domestic country and the rest of the world have the same elasticity of substitution,  $\theta$ .

### 3.2 Plant's Static Problem

There are  $n$  monopolistically competitive plants, each producing a differentiated good. A plant chooses how much to produce for the domestic market,  $y_i$ ,  $i = \{1, \dots, n\}$ , and how much to produce and export to the rest of the world,  $y_i^*$ ,  $i = \{1, \dots, n\}$ . Plants produce output using labor as the only input. The production function is

$$f(\tilde{\epsilon}_i, n_i) = \tilde{\epsilon}_i n_i^\alpha, \quad (7)$$

where  $\tilde{\epsilon}_i$  is an idiosyncratic productivity shock and  $n_i$  is the amount of labor employed by plant  $i$ .

In each period the plant choose prices, production, labor demand, and export status ( $X_i = 0$  if not exporting and  $X_i = 1$  if exporting) to maximize the value of the plant. The plant's problem can be divided into two subproblems: a static problem in which the plant chooses prices, employment, and output given its export status and a dynamic problem in which the plant chooses its export status. We layout the static problem in this section and the dynamic problem in the next.

A plant's profits are measured relative to the domestic basket of goods. Contemporaneous profits gross of exporting costs are based on revenue obtained from sales in the domestic market and world market (if exporting) less labor costs

$$\Pi_i = \frac{p_i}{P} y_i + I(X_i = 1) Q \frac{p_i^*}{P^*} y_i^* - w n_i \quad (8)$$

where  $Q = \frac{eP^*}{P}$  is the real exchange rate,  $e$  is the nominal exchange rate (domestic currency/foreign currency), and  $w$  is the price of labor relative to the price of consumption. The plant is subject to a feasibility constraint,

$$y_i + y_i^* = \tilde{\epsilon}_i n_i^\alpha. \quad (9)$$

In models with linear production functions, such as Melitz (2003), the constant marginal cost of production separates the export decision from the domestic production decision. Our assumption of plant level decreasing returns to scale ties together the export and domestic production decisions. We assume that plants satisfy the demand in the markets they choose to enter ( $c_i = y_i$  and  $c_i^* = y_i^*$  if  $X_i = 1$ ) and substitute the demand functions into the profit function. The plant's static maximization problem is

$$\Pi_i = \max_{y_i, y_i^*} \left\{ C^{\frac{1}{\theta}} y_i^{\frac{\theta-1}{\theta}} + I(X_i = 1) Q C^{*\frac{1}{\theta}} y_i^{*\frac{\theta-1}{\theta}} - w n_i \right\} \quad (10)$$

subject to

$$y_i + y_i^* = \tilde{\epsilon}_i n_i^\alpha \quad (11)$$

Maximization yields expressions for the quantities shipped domestically and abroad,

$$y_i^* = \frac{1}{1 + Q^{-\theta} \frac{C}{C^*}} \tilde{\epsilon}_i n_i^\alpha \quad (12)$$

$$y_i = \frac{Q^{-\theta} \frac{C}{C^*}}{1 + Q^{-\theta} \frac{C}{C^*}} \tilde{\epsilon}_i n_i^\alpha \quad (13)$$

Substituting these expression into the (10) gives profits as a function of exporting choice and employment level,

$$\Pi(n_i, X_i; \epsilon_i, Q) = \left(1 + I(X_i = 1) Q^\theta \frac{C^*}{C}\right)^{\frac{1}{\theta}} C^{\frac{1}{\theta}} \tilde{\epsilon}_i^{\frac{\theta-1}{\theta}} n_i^{\frac{\alpha(\theta-1)}{\theta}} - wn_i \quad (14)$$

We normalize the size of domestic aggregate demand,  $C = 1$ , so that  $C^*$  is the size of world aggregate demand relative to domestic aggregate demand. Since the idiosyncratic shocks,  $\epsilon$ , will be stationary, we define  $\epsilon_i = \tilde{\epsilon}_i^{\frac{\theta-1}{\theta}}$ , and the mean of the  $\epsilon$  process is normalized to one.

### 3.3 Dynamic Programming Problem

The presence of sunk export entry costs makes the plant's export decision a dynamic one. The plant faces costs of entering and maintaining an export operation. When a plant enters the export market having not exported in the previous period—export entry—a sunk cost,  $f_{X_0}$ , is paid. This sunk cost represents the initial outlays required to set up exporting operations discussed in section 1. If the plant has exported in the previous period and wishes to continue to export it must pay  $f_{X_1}$ . The cost of maintaining exporting operations will induce some plants to exit the export market when the discounted expected value from exporting becomes low enough. The exporting cost function is given by

$$C_X(X_i, X'_i) = f_{X_0} I(X'_i = 1 | X_i = 0) + f_{X_1} I(X'_i = 1 | X_i = 1). \quad (15)$$

The plant's state variables are the individual state variables  $(\epsilon_i, X_i)$  and the aggregate state variable  $Q$ . The random variables  $Q$  and  $\epsilon_i$  are modeled as time invariant AR(1) processes,

$$\ln \epsilon_t = \rho_\epsilon \ln \epsilon_{t-1} + \omega_{\epsilon,t}, \quad \omega_{\epsilon} \sim N(0, \sigma_\epsilon^2) \quad (16)$$

$$\ln Q_t = \rho_Q \ln Q_{t-1} + \omega_{Q,t}, \quad \omega_Q \sim N(0, \sigma_Q^2). \quad (17)$$

In each period the plant makes a discrete choice about its export status. A plant's dynamic

decision problem is given by the Bellman equation,

$$V(\epsilon_i, X_i, Q) = \max_{n_i, X'_i} \{ \Pi(n_i, X'_i; \epsilon_i, Q) - C_X(X_i, X'_i) + \beta E_{\epsilon'_i, Q'} V(\epsilon'_i, X'_i, Q') \}. \quad (18)$$

The value function in (18) does not admit an analytic solution due to the presence of fixed costs, so many of the techniques for quickly solving value functions are not applicable. To solve (18) we discretize the state space and iterate on the value function directly.

## 4 Estimation

Our intent is to parameterize the model so that it replicates the cross sectional features of the data, and then ask how well the model accounts for new exporter dynamics. To do so, we need to jointly find the costs associated with exporting and the parameters that govern the production process. We accomplish this by using an indirect inference estimation strategy, as in Gourieroux and Monfort (1996). In that approach, an auxiliary model is specified to capture key elements from the data. For expositional convenience, we will refer to the auxiliary model as a collection of moments from the data.

The structural parameters are then estimated by matching the moments from the simulated data to moments from the observed data. Within the estimation procedure, the dynamic programming problem is resolved for each guess of parameters and a corresponding dataset is then simulated from which moments are computed for the moment-matching exercise. The identification of the structural parameters comes from the selection of appropriate moments, which are discussed below. The next subsection discusses the parametrization and simulation of the model.

### 4.1 Parametrization and Simulation

To solve the model specified above, we need to calibrate a number of parameters. We take the discount factor,  $\beta$  to be 0.99. This choice is consistent with a period length of one quarter.

We cannot separately identify the elasticity of substitution,  $\theta$ , from the curvature parameter of the production function,  $\alpha$ . So we set  $\theta = 5$ , which is consistent with other micro-level estimates, and we will estimate the value of  $\alpha$  below. The parameters that describe the exogenous shock process for the real exchange rate,  $(\rho_Q, \sigma_Q)$ , are taken from the data. We estimate the AR(1) process for  $Q$  using quarterly data on the real effective exchange rate for Colombia from 1980-2005. We find  $\rho_Q = 0.93$  with a standard error of 0.11 and  $\sigma_Q = 0.04$ . The value of the real wage is calibrated to match the average size of a plant in our sample. From our model, the steady-state wage for a non-exporting plant is expressed as

$$w = \left( \frac{\alpha(\theta - 1)}{\theta} \right) \bar{n}^{\frac{\alpha + \theta(1 - \alpha)}{-\theta}} \quad (19)$$

where  $\bar{n}$  is the steady-state level of employment of a non-exporting plant. In the Colombian dataset, the median non-exporting plant has approximately 50 workers. Within our estimation procedure, we solve for the wage in each parameter iteration using (19) with  $\bar{n} = 50$ .

For a given vector of parameters we solve the Bellman equation in (18) and find the policy functions of the plant. We simulate a panel of 2000 plants for 600 quarters. We drop the first 200 quarters and use the remaining periods to compute the moments in our simulations as we do in the data. We have parameterized the model as a quarterly model, but the data is collected annually. We aggregate the data from our model to an annual panel before computing the moments.

## 4.2 Estimation Results

We use an indirect inference method which chooses the model's parameters so that key moments generated by the model match those in the Colombian data. This procedure solves

$$L(\phi) = \min_{\phi} (m_s(\phi) - m_d)' W (m_s(\phi) - m_d). \quad (20)$$

where  $\phi$  be the vector of parameters we wish to find,  $m_s(\phi)$  is the vector of moments from

Table 2: Data moments.

<b>Moment</b>	<b>Data</b>
<b>Fraction of Plants that Export</b>	0.2468
<b>Starter Rate</b>	0.0378
<b>Stopper Rate</b>	0.1269
<b>1 Year Exporter Survival Rate</b>	0.8894
<b>Average Export-Sales Ratio</b>	0.1254
<b>Exporter Size Premium</b>	2.7865

Note: Values are averages from 1981-1991.

the simulations,  $m_d$  is the vector of moments from the data, and weighting matrix,  $W$ , is the identity matrix. The function  $L(\phi)$  is neither analytically tractable nor well behaved, so we use a simulated annealing algorithm to solve (20).

We estimate the parameter vector  $\phi = (\alpha, \rho_\epsilon, \sigma_\epsilon, f_{x_0}, f_{x_1}, C^*)$ . To identify these 6 parameters, we choose 6 moments that are informative about the parameters. Based on the analysis in section 2 we choose the fraction of plants that are exporters, the fraction of plants that begin exporting (the starter rate), the fraction of plants that stop exporting (the stopper rate), the fraction of plants that continue to export from one year to the next (the 1 year survival rate), the ratio of the average employment of exporting firms to the average employment of non-exporting firms (the exporter size premium) and the average export-sales ratio. We average these statistics across the sample, 1981-1991, though not all statistics are defined for each year. We have chosen these moments not only because they are informative about the model's parameters, but because they are features of the data that are often used in parameterizing discrete choice exporting models.

The model does not admit a clear mapping of each parameter to each particular moment; the parameters jointly determine the moments. The cost of entering the export market,  $f_{x_0}$ , affects the fraction of exporters and the starter rate but also influences the stopper rate, as the higher barrier to entry implies that, on average, more productive plants will choose to be exporters, making them less likely to exit. The serial correlation of the idiosyncratic shocks has a clear effect on the survival rate of exporters, but it also influences the starter

Table 3: Moments from the data and the simulated model.

Moment	Data	Baseline Model	Exog. Demand Model
<b>Fraction of Plants that Export</b>	0.247	0.233	0.230
<b>Starter Rate</b>	0.0378	0.0307	0.0264
<b>Stopper Rate</b>	0.1268	0.1466	0.1282
<b>1 Year Exporter Survival Rate</b>	0.889	0.869	0.884
<b>Average Export-Sales Ratio</b>	0.126	0.102	0.104
<b>Exporter Size Premium</b>	2.787	2.730	2.898
$L(\phi)$		0.0049	0.0288

Note: Data values are averages from 1981-1991. The third column reports the results from the baseline model and the fourth column reports the results from the model in which export demand grows as slowly as in the data.

and stopper rates, as plants have stronger reactions to more persistent shocks. The standard deviation of the idiosyncratic shocks, along with the curvature of the production function determines, among other things, the size of a plant. The relative size of aggregate demand,  $C^*$  controls the mean level of exports to domestic sales, which impacts the profitability of export opportunities.

## 5 Results

The moments from the simulated model are reported in Table 3. The model fits the data well, although plants are more likely to leave the export market in the model than they are in the data. This manifests itself as a stopper rate that is too high and a survival rate and entry rate that are too low.

The estimated parameter values are shown in Table 4. The persistence in export status that we observe in the data is commonly attributed to two causes: sunk investments made in entering the export market, and persistent unobservable productivity. The estimation places weight on both of these factors. The idiosyncratic shock is strongly serially correlated, though the standard deviation of the innovations to the shocks is large as well. There is also

Table 4: Parameter values for the baseline model.

	$\alpha$	$\rho_\epsilon$	$\sigma_\epsilon$	$f_{x_0}$	$f_{x_1}$	$C^*$
<b>Baseline Model</b>	0.562	0.961	0.161	0.386	0.0419	0.130
<b>Exog. Demand Model</b>	0.516	0.954	0.230	0.0474	0.0209	0.145

Note: The entry cost,  $f_{x_0}$  and the continuation cost,  $f_{x_1}$  are measured as a fraction of the median plant's sales.

a significant sunk aspect of the exporting cost structure. The entry cost is almost 10 times as large as the continuation cost of exporting.

## 5.1 New Exporter Dynamics

We plot the export-sales ratio for new exporters in Figure 3. The export ratio for new exporters displays a large jump: in the first year as an exporter, the firm exports, on average, almost 11 percent of output. This increases slightly in the second year as an exporter and remains roughly constant thereafter. The dynamics from the model are in sharp contrast to the data, in which exports grow over a period of years. The pattern of export behavior in the model is driven by the large sunk entry costs. Once a firm enters the export market, there are no further costs to adjusting the export-sales ratio, so it immediately adjusts exports to the optimal level.

Firms enter the export market for two reasons: favorable movements in the real exchange rate, and positive shocks to productivity. Both of these shocks are persistent, which impacts the behavior of the firm. The peak in the export-sales ratio that follows entry is driven by the behavior of the real exchange rate. A firm is more likely to enter the export market when the real exchange rate is high. As the innovation to the real exchange rate deteriorates, the export-sales ratio returns to its average level. Implications of the shock process can further be seen in Figure 4, which plots the conditional survivor probabilities for new entrants. The probabilities in the model inherit the persistence of the shocks. Firms enter the export market in response to a good shock; as the shock dies out, firms are more likely to exit the

market. Thus, the probability of survival is high initially, and falls through time. This is in contrast to the data, in which we see firms more likely to drop out of the export market initially.

The behavior of the model in these two dimensions is sharply at odds with the data, and contributes to the large entry cost we have found. In the model, a new entrant's probability of staying in the export market is initially high, and the firm can immediately access the export market. The firm is able to immediately realize export profits, and has a high probability of staying in the market for the initial periods, so the value of being an exporter is large. The large present value of exporting requires a large entry cost to keep the export participation rate as low as it is in the data. In section 6 we will consider an extension of the model that forces exports to grow as they do in the data.

## 5.2 How Large are Export Entry Costs?

A benefit of the structural approach that we have pursued in this paper is the recovery of the size of the costs associated with exporting. In Table 4 we have reported the fixed cost parameters,  $(f_{x_0}, f_{x_1})$  as a fraction of the median plant's revenues. In the data, a median plant has 50 employees. The average value of sales for plants with 50 employees in 1986, is 52,463 thousand Pesos. The value of the entry cost is 39 percent of this, or 20,250 thousand Pesos, which at the exchange rate of 1986 (194.26 Peso per Dollar) is \$104,242. Expressed this way, the cost of continuing to export,  $f_{x_1}$  is 2,198 thousand Pesos, or \$11,316. To better place these values in the context of the model, Table 5 shows how the export entry cost compares to the profits of the plants at different points in the distribution. When compared to the 20th percentile plant, entry costs seem large, requiring more than one year's revenues, and 1.8 times one year's profits. When comparing the entry costs to the 20th percentile of exporters, entry costs look much smaller, only 33 percent of annual profits. These results reflect the fact that in the model (as in the data) most plants are small, while exporting plants are larger and more productive.

Are these results reasonable? Since we are using data that cover the same episode as

Table 5: Profits and sales from the baseline model simulations in 1986 (thousands of Pesos).

Percentile	All Plants			Exporting Plants		
	Profits	Sales	$\frac{f_{x_0}}{profit}$	Profits	Sales	$\frac{f_{x_0}}{profit}$
<b>20</b>	9,252	33,864	1.81	51,617	99,025	0.33
<b>40</b>	23,087	48,516	0.73	72,842	121,794	0.23
<b>60</b>	40,013	70,573	0.42	98,291	143,732	0.17
<b>80</b>	69,110	109,826	0.24	126,132	175,662	0.13

Das et al. (2007), (henceforth DRT) it is natural to compare our results to theirs as a check. Before we do so, we should point out some fundamental differences between our approach and theirs. DRT allow for idiosyncratic shocks to the fixed costs parameters,

$$f_{x_1} = \gamma_F - \epsilon_{it}^1 \quad (21)$$

$$f_{x_0} = \gamma_S z_i + \epsilon_{it}^1 - \epsilon_{it}^0, \quad (22)$$

and so the values they report are the average costs that plants face, but the costs actually paid by plants are likely to be lower. DRT also allow for more heterogeneity among plants than we do in this paper; the cost of entry for a plant can vary according to whether the plant is “large” or “small.” With this in mind, the estimates of average entry costs in DRT are 61,000-64,000 thousand Pesos for small producers and 51,000-59,000 thousand Pesos for large producers. Our estimate of 52,463 thousand Pesos is in the same ballpark. For the continuation costs, DRT find the average to be approximately 0, but the distribution of the shocks to the costs are bounded above 0, so continuation costs are important for plants sometimes. We also find a smaller role for the continuation costs, our continuation costs are about one-tenth of the entry costs, implying that almost the entire entry cost is sunk.

## 6 A Model with Growing Export Demand

The baseline model does a poor job of matching the path of exports for an export entrant. In this section we impose an ad hoc demand function that is increasing in the number of periods the plant has been an exporter. Our goal in this section is not to explain the slow growth of new exporters, but to quantitatively assess the importance of getting the dynamics of new exporters right.

A plant that has been an exporter for  $s$  periods, faces the demand curve

$$c_j^*(s) = \gamma_s \left( \frac{p_j^*(s)}{P^*} \right)^{-\theta} C^*. \quad (23)$$

The rest of the model remains as in the baseline model. Our specification of the demand function is meant to capture the other forces that might lead a new exporter to slowly increase its exports<sup>3</sup>. Learning has been suggested, both from the demand side, as in Rauch and Watson (2003), and the supply side, as in Ruhl and Willis (2008). Arkolakis (2007) builds a model in which firms face convex costs of advertising, which forces them to slowly build market share.

We recalibrate the model adding to the vector of parameters to find  $\gamma_0, \gamma_1, \dots, \gamma_7$ . We assume that export demand grows for the first 7 years a firms exports and is constant and equal to one thereafter. The 7 additional parameters require 7 additional moments; we choose the new exporter export-sales ratios for the first 7 years. Calibrating the model this way forces the export-sales ratio to grow as it does in the data.

The model results are summarized in Table 3 and the parameter values are listed in Table 4. This model needs larger shocks to productivity, but much smaller entry costs compared to the baseline model. The larger variance of the productivity shocks has made it more difficult for the model to match the export size premium, even with more curvature in the production function. The model's fit can be seen in Figure 5, which plots the export-sales

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<sup>3</sup>In a previous version of this paper, we experimented with convex and nonconvex costs of factor adjustment to generate a slowly growing export share. While the costs of adjustment could slow growth upon export entry, they could not quantitatively account for the data.

ratio in the baseline model, the model with exogenously growing export demand, and the data.

This version of the model has very different implications regarding the value of being an exporter. By forcing exports in the model to grow as they do in the data, a plant's export profits are pushed out into the future. Since firms discount, and shocks are persistent, but not permanent, this redistribution of profits through time lowers the present value of export entry. This is reflected in the estimated parameters: the export entry cost,  $f_{x_0}$  is 8 times smaller than that in the baseline model.

The smaller entry cost in the model with exogenously growing export demand has an impact on the conditional survivor probabilities as well. The probabilities are plotted in Figure 6. The lower entry cost allows firms with lower level of productivity to enter the market. These firms with lower productivity are more likely to exit, which decreases the survival probability of new exporters. While this makes the model closer to the data, it still does not generate the upward sloping survival probabilities in the data.

## 7 Conclusion

In this paper we assess the ability of sunk cost models of trade, such as those based on Melitz (2003), to account for plant level dynamics. We document the experience of new exporters in a data set on Colombian manufacturing plants and find that the export-sales ratio of new exporters grows slowly following entry. The average new exporter takes 6 years to reach the level of export sales of the (unconditional) average exporter. In addition, we show that new exporters experience a period of shake out upon entry: the probability that a new exporter is still exporting in the next year is only 62 percent. This survival probability is increasing with the exporter's tenure. These findings add to the growing body of empirical knowledge on plant level behavior.

We construct a model in which firms have persistent shocks to productivity and face fixed costs of export entry. We calibrate the model so that it replicates key cross sectional

facts that are frequently used in parameterizing this class of models. Our main result is that, as expected, models with a fixed entry cost do not replicate the gradual growth of new exporters and the pattern of firm export survival.

The failure of the model to generate these features has important implications for the value of exporting. The model front loads the profits from exporting: a new entrant is able to immediately adjust its export sales, and the autocorrelation of the shocks ensures that the good state of the world will likely continue for the first few periods. Exporting has large present value, so large entry costs are needed to keep the 75 percent of firms out of the export market that is need to match the data.

We modify the baseline model to force the export growth of new entrants to match the data. In this model firms enter the export market small, and grow as they continue as exporters. This pushes the profits from exporting further into the future. With discounting and uncertainty, the present value of these future profits is significantly lower than in the baseline model. The difference between the two models is most striking with regard to the calibrated entry costs. The model in which new exporters are forced to grow slowly has an entry cost that is 8 times smaller than that in the baseline model.

Getting the dynamics of new exporters right is important. In the data, an exporter's first few years are typically spent exporting small amounts and the probability of leaving the export market is high. When models do not generate this behavior, the value of exporting is large, and large entry costs are needed to produce the right export participation rate. A new line of research has taken up this task, and papers such as Arkolakis (2007) and Ruhl and Willis (2008) are exploring different mechanisms that may account for the behavior of new exporters.

## Appendix A: Data

Our sample covers the years 1981-1991. Following Roberts and Tybout (1997) we use data from 19 industries: 311 (Food Products), 312 (Other Food Products), 321 (Textiles), 322 (Clothing and Apparel), 323 (Leather Products excl. Clothing and Shoes), 324 (Leather Shoes), 341 (Paper), 342 (Printing and Publishing), 351 (Industrial Chemicals), 352 (Other Chemicals), 356 (Plastic Products), 362 (Glass Products), 369 (Other Products of Non-metallic Minerals), 371 (Iron and Steel), 381 (Metal Products excl. Machinery and Equipment), 382 (Machinery excl. Electrical Machinery), 383 (Electronic Machinery and Equipment), 384 (Transportation Equipment), and 390 (Miscellaneous Manufacturing Industries). We balance the panel by dropping any firm whose employment falls below 15 employees in any year of the sample.

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Figure 1

Export Sales Ratio

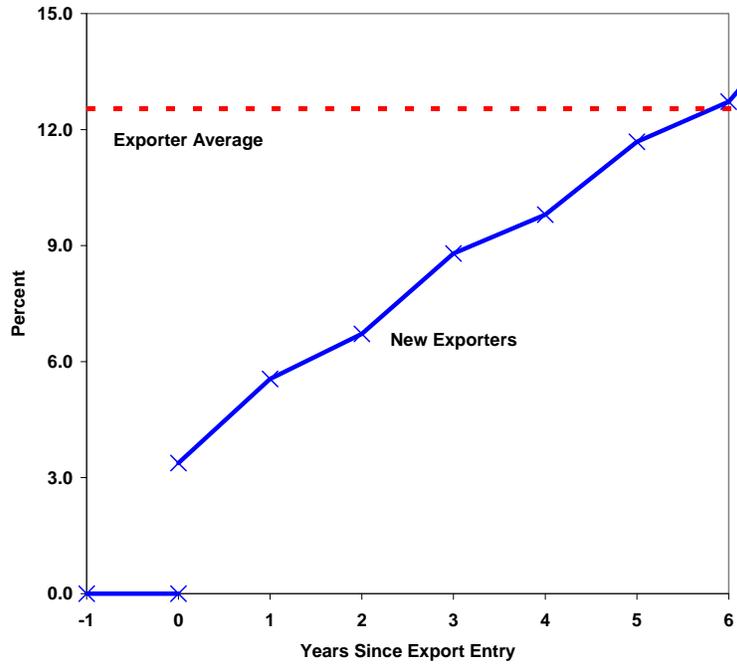


Figure 2

Conditional Survival Probabilities

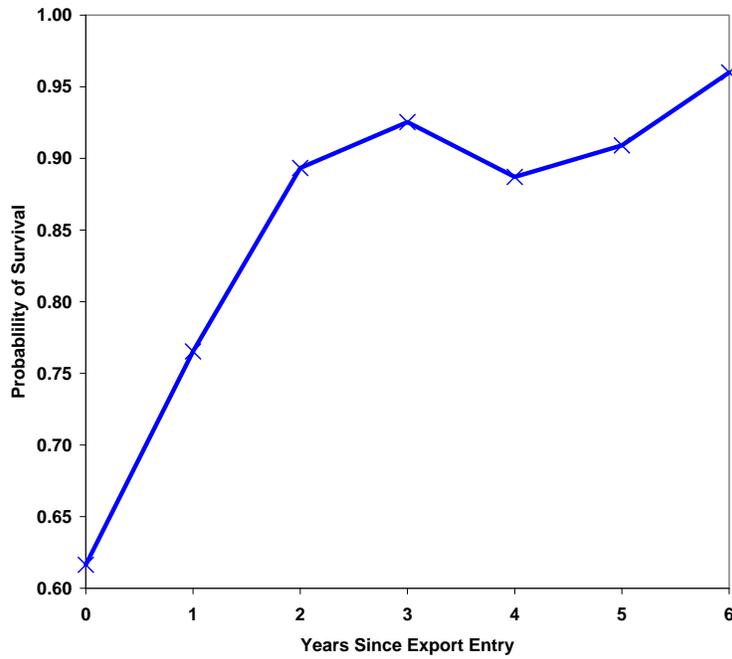


Figure 3

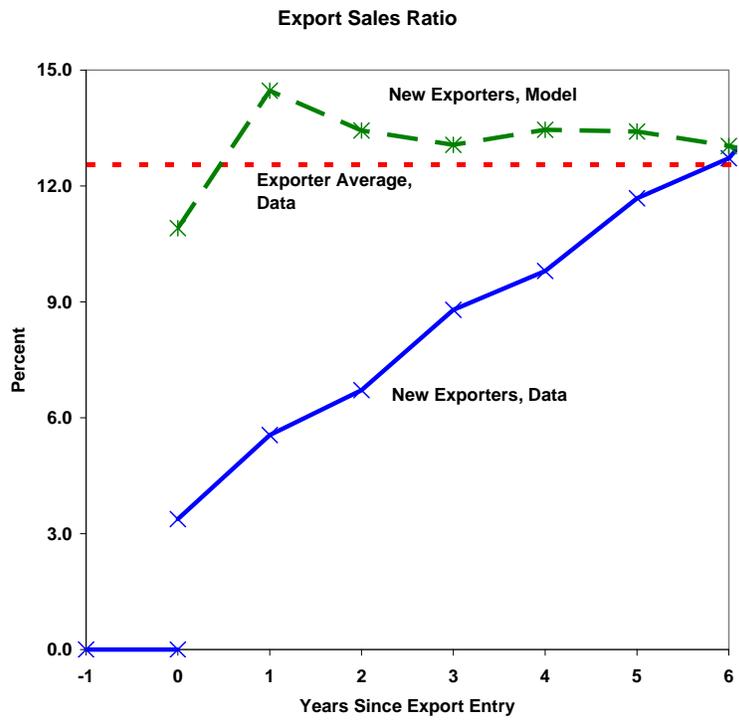


Figure 4

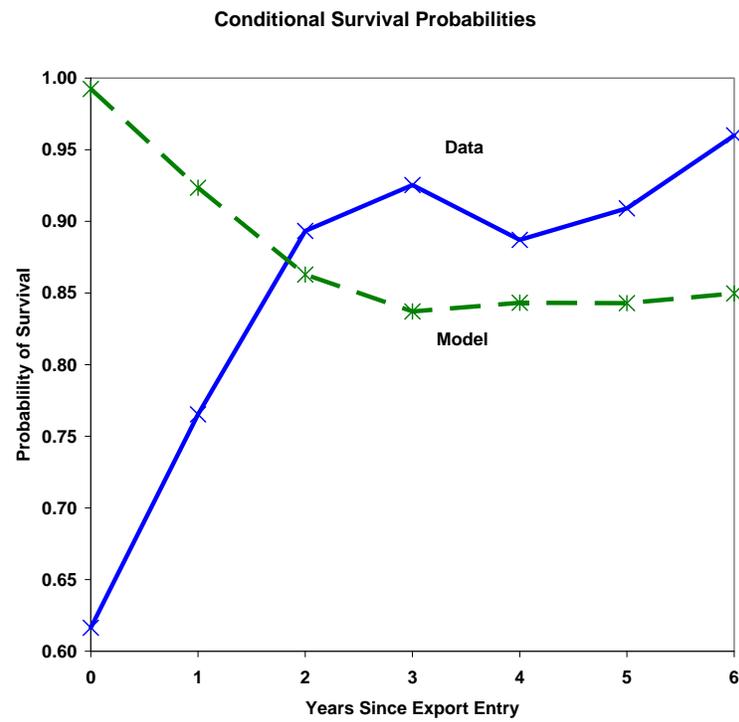


Figure 5

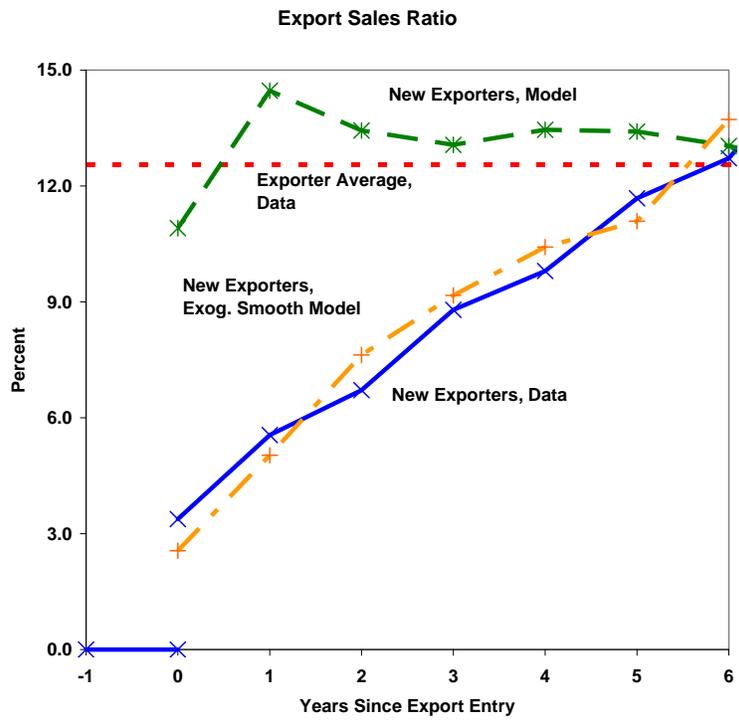


Figure 6

